



Government of Barbados

July 2002

**A NATIONAL BIODIVERSITY STRATEGY & ACTION PLAN
FOR BARBADOS**

To the Convention on Biological Diversity (CBD)

ACKNOWLEDGEMENTS

The Ministry of Physical Development and Environment is grateful to the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF) for the technical and financial assistance provided to produce this document.

The first draft of this report was the product of a cooperative effort between Simmons & Associates Inc and the Ministry of Physical Development and Environment (formerly known as Ministry of Environment, Energy and Natural Resources). The efforts of the drafting team are acknowledged along with the contributions of the persons who participated in the two roundtable discussions, and the National Consultation on the conservation of local biodiversity.

The members of the National Biodiversity Strategy and Action Plan Committee, and the National Working Group on Biodiversity are also acknowledged for their tremendous contributions to the preparation of the final document, which was managed by Mr K. Emmanuel of the Ministry of Physical Development and Environment. Special thanks are extended to Dr J. Horrocks (UWI), Dr S. Carrington (UWI), Dr K. Watson (UWI), Dr H. Oxenford (UWI), Mr C. Parker (Fisheries Division, MAR), Ms A. Brathwaite (CZMU), Ms K. Downes (EU), Ms N. Belle (MOT), Mr B. Headley (MF), Dr R. Maitland (MAR), Mr G. Thomas (MAR), Ms I. Sylvester (Graeme Hall Bird Sanctuary), Mr R. Ward (EU), Mr R. Marshall (SSWPU), Mr T. Sinckler (ESPU), Mr. D. Springer, Mrs. M. Worrell (EU), and other technical and administrative officers of the EU for their invaluable assistance with respect to editing the first draft and preparing the final document.

MINISTER'S FOREWORD

By the Minister of Physical Development and Environment, Government of Barbados.



As Minister with responsibility for Physical Development and Environment, I have the honour of presenting Barbados' ***National Biodiversity Strategy and Action Plan (NBSAP)***, which is one of the major national initiatives in fulfilment of the objectives of the Convention on Biological Diversity (CBD).

This report is the first major document of its kind. It seeks to highlight objectives, strategies and actions necessary for the conservation and sustainable utilization of Barbados' biological resources. It is envisaged that this document will serve as a repository for local biodiversity information to all citizens, as well as international interests. The NBSAP is also designed to provide the framework for effective management of local biological diversity and to guide future activities of the biodiversity programme in the Ministry.

The principal topics examined in the NBSAP are - the local biological diversity status, the issues which affect the livelihood of terrestrial, marine and freshwater biodiversity and a conservation and sustainable management plan. The strategy and action plan takes into consideration mobilization of funding; capacity building; legislation and policy revision and formulation; research, monitoring and mitigation; public education; incentives development; land use planning; in situ and ex situ conservation; biodiversity access and benefit sharing; biosafety and biotechnology transfer; and various sectoral environmental initiatives.

As a small island state, conservation and sustainable utilization of local biological resources is vital for successful economic and social development of our people and our country. The challenges faced by SIDS with respect to environmental management and the allocation of scarce resources are now internationally recognized. Therefore it is hoped that the Secretariat will continue its much appreciated assistance, thereby ensuring sustained participation by SIDS party countries, as well as the signing, ratification and implementation of the provisions of the CBD and the Cartagena Protocol by non-party states.

Biological diversity is unevenly distributed throughout the world, with the Caribbean possessing a large variety of these living organisms. Local management efforts must therefore guard against loss of species diversity. Initiatives, such as the Gully Ecosystem Management Study, highlight the Government of Barbados' recognition of the importance of conserving the environment. Further, it is a matter of concern that adequate access to local biological diversity are guaranteed to all Barbadians, and that their intellectual property rights associated with local knowledge of, and use of these natural resources are protected.

The NBSAP is presented as an expression of the commitment of the Government of Barbados to the CBD, and the recognition of the dependence on biological diversity for sustainable development. I am grateful to the staff of the Ministry of Physical Development and Environment and the numerous other individuals and institutions both in the private and public sectors, whose efforts have made this report possible.

I look forward to your continued collaboration in future efforts.

The Hon. H. Elizabeth Thompson, M.P.
Minister of Physical Development and Environment
June 2002

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	i
MINISTER’S FOREWORD.....	ii
TABLE OF CONTENTS	iv
LIST OF TABLES.....	v
LIST OF FIGURES.....	v
LIST OF PLATES	v
LIST OF APPENDICES	v
LIST OF ACRONYMS	vi
DEFINITION OF TERMS USED IN THE DOCUMENT.....	vii
EXECUTIVE SUMMARY	x
1. BASIC DATA ON BARBADOS.....	1
2. BACKGROUND TO THE BIODIVERSITY CONSERVATION PROCESS	4
3. POLICY AND LEGAL FRAMEWORK FOR THE CONSERVATION OF BARBADOS’ BIODIVERSITY	14
4. EXISTING CAPACITY FOR THE CONSERVATION OF BIODIVERSITY IN BARBADOS	25
5. ASSESSMENT OF BIODIVERSITY RESOURCES.....	32
6. THE BIODIVERSITY STRATEGY AND ACTION PLAN	95
7. THE IMPLEMENTATION OF THE BARBADOS NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN	108
8. REFERENCES	109

LIST OF TABLES

Table ES 1	Summary of Conventions Relevant to Biodiversity Conservation to which Barbados is a Party.....	Page xii
Table 5.1	Agricultural Holdings in Barbados Distributed by Parish and Principal Agricultural Category	Page 42
Table 5.2	Area of Holdings in Barbados by Parish and Land Use	Page 43

LIST OF FIGURES

Figure 1	Barbados Wildlife.....	Page 52
Figure 2	Land Use Plan (NPDP).....	Page 78
Figure 3	Barbados System of Parks and Open Spaces (NPDP).....	Page 83

LIST OF PLATES

Plate 1	Sea Rock on the East Coast, Bathsheba (National Park Area).....	Page 34
Plate 2	The Graeme Hall Swamp.....	Page 35
Plate 3	The Graeme Hall Swamp white mangrove forest.....	Page 36
Plate 4	A rare sea cliff species, <i>Strumpfia maritime</i>	Page 39
Plate 5	Barbados black belly sheep.....	Page 47
Plate 6	A bat found in the Jack in the Box Gully, St Thomas.....	Page 49
Plate 7	The green monkey (<i>Cercopithecus aethiops sabaceus</i>).....	Page 53
Plate 8	A green turtle (<i>Chelonia mydas</i>) being observed by a diver.....	Page 59
Plate 9	A hawksbill turtle (<i>Eretmochelys imbricata</i>) being fed by a diver.....	Page 60
Plate 10	A Tidepool site at Bathsheba, East Coast.....	Page 65
Plate 11	Sponge on a Barbadian reef.....	Page 67
Plate 12	A school of striped grunts (<i>Haemulon striatum</i>).....	Page 70
Plate 13	The Caribbean Spiny Lobster (<i>Panulirus argus</i>) at the Cornwallis site in Carlisle Bay.....	Page 72
Plate 14	A Section of the National Park Area with the East Coast in the background.....	Page 81
Plate 15	Members of a tour group appreciating the natural features in the Jack in the box gully, St Thomas.....	Page 90

LIST OF APPENDICES

Appendix 1	Economic Valuation of Biodiversity in Barbados.....	Page 124
Appendix 2a	A Biodiversity Database for Barbados.....	Page 142
Appendix 2b	Information Requirements for the Biological Environment.....	Page 147
Appendix 2c	Information Requirements for Habitats and Ecosystems.....	Page 150
Appendix 3	Recommendations for Institutional Strengthening.....	Page 151

LIST OF ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ARVTU	Agronomy Research and Variety Testing Unit
BAMC	Barbados Agricultural Marketing Company Ltd.
BMHS	Barbados Museum and Historical Society
BWA	Barbados Water Authority
CARDI	Caribbean Agricultural Research and Development Institute
CBD	Convention on Biological Diversity
CBO	Community-based Organisation
CBS	West Indies Central Sugar Cane Breeding Station
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
COP	Conference of Parties
CTP	Chief Town Planner
CSEGRIN	Caribbean Seed and Germplasm Resources Information Network
CZMU	Coastal Zone Management Unit
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMLUP	Environmental Management and Land Use Planning for Sustainable Development Project
ESPU	Environmental Special Projects Unit
EU	Environmental Unit
FAO	Food and Agriculture Organisation of the United Nations
FMP	Fisheries Management Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographical Information System
GOB	Government of Barbados
HIV	Human Immunodeficiency Virus
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICMP	Integrated Coastal Management Plan
MAPEA	Marine Areas Preservation and Enhancement Act
IUCN	International Union for the Conservation of Nature and Natural Resources
MAR	Ministry of Agriculture and Rural Development
MPE	Ministry of Physical Development and Environment
NBSAP	National Biodiversity Strategy and Action Plan
NCC	National Conservation Commission
NCF	National Cultural Foundation
NGO	Non-government Organisation
NPDP	National Physical Development Plan
NRM	Natural Resources Management Programme
QEH	Queen Elizabeth Hospital
SIDS	Small Island Developing States
SPAW	Protocol (to the 1983 Cartagena Convention) Concerning Specially Protected Areas and Wildlife in the Wider Caribbean
TCDPO	Town and Country Development Planning Office
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on Law of the Sea
UNEP	United Nations Environment Programme
UWI	University of the West Indies
WBPA	Wild Birds Protection Act

DEFINITION OF TERMS USED IN THE DOCUMENT

Biodiversity. The totality of genes, species and ecosystems in a region.

Biological Resources. Those components of biodiversity of direct, indirect or potential use to humanity.

Biosafety. The precautionary measures implemented to ensure that Living Modified Organisms (LMOs) and their products are transferred, handled, used and disposed of safely. LMOs are generated through biotechnology processes including the transfer of genes between cells of related or unrelated organisms.

Biotechnology. Any technology that is applied to living organisms to make them more valuable to people.

Buffer Zones. Vegetated strips of land, or designated marine areas, that are intended to screen ecosystems from impacts such as pollution and/or disturbance around protected sites, usually with the aim of providing additional habitats for some flora or fauna.

Conservation. The management of human use of the biosphere so that it may yield the greatest sustainable benefit to current generations while maintaining its potential to meet the needs and aspirations of future generations.

Cultivar. A cultivar is a particular variety of a plant species with characteristics that make it unique and it is produced by horticulture or by human selection and /or breeding.

Cultural Diversity. Variety or multiformity of human social structures, belief systems, and strategies for adapting to situations in different parts of the world.

Ecology. The scientific study of the interactions of living things and their environment.

Ecosystem. A dynamic complex of plant, animal, fungal, and microorganism communities and their associated non-living environment interacting as an ecological unit.

Ecotourism. Travel undertaken to witness sites or regions of unique natural or ecologic quality, or the provision of services to facilitate such travel.

Endemic. Restricted to a specified region or locality.

Environmental Impact Assessment. Process by which the potential benefits and negative impacts of proposed projects are evaluated as an integral part of planning the project, alternatives are analysed, mitigation measures identified and the general public is given opportunity to comment.

Ex situ Conservation. Keeping components of biodiversity alive outside of their original habitat or natural environment.

Extant. Still surviving; opposite of extinct.

Fauna. All of the animals found in a given area.

Flora. All of the plants found in a given area.

Food Forest. An unstructured, multi-layered collection of mainly flora which provides food, medicines and ingredients for beverages, and which constitutes advantages such as constant accessibility to food and medicines, symbiotic physical, chemical and biological relationships between farmed living organisms, micro climates, agronomic soil conservation aids, and water saving characteristics.

Gene. The unit of life found within every living cell, responsible for conferring on an organism its specific characteristics.

Genetic Diversity. Variation in the genetic composition of individuals within or among species, the heritable genetic variation within and among populations.

Geographic Information Systems (GIS). A database which relates spatial data (maps) with its attribute data (characteristics). A GIS can be computerized and the database queried using two variables and the required information can be extrapolated.

Habitat. The environment in which an organism lives. Habitat can also refer to organisms and physical environment in a particular place.

Indigenous/Native Species. Plants, animals, fungi, and micro-organisms that occur naturally in a given area or region.

In situ Conservation. The conservation of biodiversity within the evolutionary dynamic ecosystem of the original habitat or natural environment.

Intellectual Property Right. A right enabling an inventor to exclude imitators from the market for a limited time.

Introduced species. A species occurring in an areas outside of its historically known range as a result of intentional or accidental dispersal by human activities (also known as exotic or alien species)

Non-governmental organisation. A non-profit group or association organised outside of institutionalised political structures to realise particular social objectives (such as environmental protection) or serve particular constituencies (such as indigenous people). NGO activities range from research, information distribution, training, local organisation and community service to

legal advocacy, lobbying for legislative change, and civil disobedience. NGOs range in size from small groups within a particular community to huge membership groups with a national or international scope.

Protected Area. A legally established land or water area under either public or private ownership that is regulated and managed to achieve specific conservation objectives.

Species. A group of organisms capable of interbreeding freely with each other but not with members of other species.

Sustainable development. Development that meets the needs and aspirations of the current generation without compromising the ability of future generations to meet their own needs and aspirations.

Variety. A variety is a sub-species, a work of evolution, and of interest in terms of biodiversity, evolution and classification.

Wetlands. Any ecosystem in which there is surface water or the substratum is waterlogged for at least part of the year. Freshwater wetlands include *open water* streams, watercourses, ponds, swamps, etc. and *semi-terrestrial wetlands* e.g. marshes, and *brackish saline wetlands* including, estuaries, and maritime salt marshes.

EXECUTIVE SUMMARY

ES 1.1 The Importance of Biodiversity

Biodiversity is the totality and variety of genes, species and ecosystems occurring in a region. The biodiversity in any such region is the result of hundreds of millions of years of evolutionary history. Biodiversity has also been shaped over time by human intervention through the domestication and breeding of local varieties of crops and livestock. The various components of biodiversity have enormous importance to all aspects of human life: food, medicines, industrial and agricultural products, and as the basis for recreation and tourism. Over time, the greatest value of biological diversity may be found in the opportunities that it provides humanity for adapting to local and global change.

The universal effort to conserve biodiversity is enshrined in the Convention on Biological Diversity (CBD), which was initially signed by 154 nations at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992. Since UNCED, additional nations have also signed the Convention. Ratification of the CBD commits Governments to correcting the imbalance between who benefits from biodiversity protection and who pays, i.e., finding equitable ways to share biodiversity's monetary and non-monetary values; spur technological cooperation; and establish mechanisms to finance investments in maintaining the diversity of life on Earth.

ES 1.2 Barbados' Commitment to the Convention on Biological Diversity

The Government of Barbados (GOB) ratified the CBD on December 10, 1993 and is therefore responsible for ensuring that the provisions of that Convention are met in accordance with the particular conditions within the country and with the available financial, technical and other resources.

The Environmental Unit of the Ministry of Physical Development and Environment (MPE) is responsible for the implementation of the obligations of the CBD. This unit also chairs a multi-sectoral Working Group of Biodiversity, which oversees this process. The MPE currently has in place a work programme for the conservation and sustainable use of biodiversity in Barbados. The objectives of the Ministry's biodiversity work programme are to:

- develop a more informed basis for decision making and policy formulation on the management of biodiversity in Barbados;
- develop a more comprehensive information data base for the management and utilization of biodiversity;
- enhance the regulation of domestic and international trade in endangered species and specimens of flora and fauna;

- promote the full appreciation of biodiversity as a national resource.

Among the specific biodiversity programme areas aimed at fulfilling the objectives of the work programme is the preparation of this National Biodiversity Strategy and Action Plan (NBSAP) for Barbados. This undertaking has been funded by the United Nations Environment Programme (UNEP) through a Global Environment Facility (GEF) project. The NBSAP is intended to define the current status of biodiversity, the threats leading to its degradation and the strategies and priority actions to ensure its conservation and sustainable use within the framework of the socio-economic development of the country.

ES 1.3 Objectives guiding the development of the National Biodiversity Strategy and Action Plan

Article 6 of the CBD, “*General Measures for Conservation and Sustainable Use*” calls for governments to:

- Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and
- Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

In this context, the specific objectives guiding the development of the NBSAP for Barbados are the:

- Identification of the current state of knowledge about biodiversity in Barbados;
- Identification of important gaps in the knowledge base and the assessment of further needs and associated costs;
- Identification of current pressures on biodiversity and future trends;
- Assessment of the present and future value to Barbadians of the country’s biodiversity;
- Assessment of the costs and benefits of conserving biodiversity in Barbados;
- Identification of the conservation priorities and strategies for conserving biodiversity;
- Identification of appropriate mechanisms or actions to carry out the identified conservation strategies;
- Identification of the institutional requirements to support the implementation of the strategies and actions.

ES 1.4 Contribution of the NBSAP to National Sustainable Development Planning

The NBSAP is one of several sectoral plans which have been prepared in the past few years with a view to achieving a comprehensive framework for the sustainable development of natural resources in Barbados. The existing plans for physical development and natural resources management in Barbados are:

- The *Physical Development Plan* (PDP), revised in 1998,
- The *Fisheries Management Plan* (FMP), first published in 1997 and revised in 2001,
- The *Environmental Management and Natural Resources Management Plan* (EMNRMP),
- Two area-specific plans to accompany the (EMNRMP): the *National Park Development Plan*, and the *Coastal Zone Management Plan*.

These plans make provisions for the sustainable management of the majority of the human activities that impact on the conservation of biodiversity in both the marine and terrestrial environment. In accordance with the CBD, the NBSAP integrates biodiversity management and conservation into these sectoral plans and serves to minimise overlap and increase the efficiency of use of human, financial and equipment resources. In order to achieve this successfully, there must be an improvement in inter-agency collaboration and coordination of environmental and natural resources planning and management activities.

ES 1.5 Legal Framework for the Conservation of Biodiversity

ES 1.5.1 International Agreements

International agreements have served as catalysts for much of the effort being expended in many countries of the world for conservation and protection of the environment and of natural resources. The CBD is now a key coordinating, catalysing and monitoring mechanism for international biodiversity conservation. However, there are several other international conventions, to which Barbados is party, which make provision for some elements of the conservation and protection of biological diversity. In accordance with the provisions of these conventions the island has obligations to implement rules for the preservation of biological resources. From a legal perspective, implementation is by way of the passage and enforcement of legislation and regulations. From an administrative perspective, new procedures and mechanisms would have to be employed to facilitate the implementation of biodiversity programmes. In respect of conventions signed by Barbados, but which have not yet entered into force, the island has the obligation to refrain from acts that would defeat the object and purpose of the treaty. The most relevant of these international agreements are outlined in the table below.

Table ES 1 Summary of Conventions Relevant to Biodiversity Conservation to which Barbados is a Party

Convention	Date Signed	Responsible Ministries & Executing agencies
<i>United Nations Convention on Biological Diversity.</i>	Barbados became a party 10 December 1993.	Ministry of Physical Development and Environment, Ministry of Finance, and the Ministry of Agriculture and Rural Development.
<i>The Convention on International Trade In Endangered Species</i>	Barbados became a party 9 December 1992	Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, and the Ministry of Foreign Affairs and Foreign Trade
<i>United Nations Framework Convention on Climate Change and Kyoto Protocol</i>	Barbados became a party 23 March 1994	Ministry of Physical Development and Environment.
<i>United Nations Convention on the Law of the Sea</i>	Barbados became a party 12 October 1993	Ministry of Physical Development and Environment, and the Ministries of Agriculture and Rural Development.
<i>The Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartegena), and the Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region, (OILSPILL Protocol)</i>	Barbados became a party to the Cartagena Convention and the OILSPILL Protocol 28 March 1985	Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, and the Ministry of Foreign Affairs and Foreign Trade.

Convention	Date Signed	Responsible Executing agencies
<i>Convention to Combat Desertification</i>	Barbados became a party on May 14, 1997.	Ministry of Physical Development and Environment, Barbados Water Authority, and the Ministry of Agriculture and Rural Development
<i>The Vienna Convention for the Protection of the Ozone Layer, and the Montreal Protocol on Substances that Deplete the Ozone Layer</i>	Barbados acceded to the Convention and Protocol on July 20 1994.	Ministry of Physical Development and Environment
<i>The UN Fish Stocks Agreement</i>	Barbados became a party on September 22, 2000	Ministry of Agriculture and Rural Development
<i>FAO Compliance Agreement</i>	Barbados became a party on October 26, 2000	Ministry of Agriculture and Rural Development
<i>International Commission for the Conservation of Atlantic Tunas</i>	Barbados became a party on December 13, 2000	Ministry of Agriculture and Rural Development

The Government of Barbados has also decided to sign the Protocol (to the 1983 Cartagena Convention) Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW).

ES 1.5.2 National Legislation

A review of Barbados' legislation identifies the need for a legal regime to be developed which would give a comprehensive response to the requirements for the protection of biodiversity. In developing this comprehensive legal response, environmental issues that should be considered include, among others, the following: -

- The local wildlife protection policies and strategies are antiquated and require complete revamping in order to promote the conservation and sustainable use of biodiversity in general, protect indigenous and endangered species and critical habitats, and give effect to Barbados' acceptance of the objectives of binding international conventions;
- General regulation of the release of pollutants into the environment that cause, among other things, contamination of biological resources, is required. In this regard, substantially new legislation is required for waste management, toxic substances, noise pollution, air pollution and climate change;
- EIA procedures need clear legislative authority;
- Planning legislation should be modified to attempt to ensure greater transparency and closer relationship between the granting of planning permission and the requirement of conformity with the National Physical Development Plan;
- General terrestrial protected areas legislation is required;
- Forestry legislation is required.

Existing local legislation is stated under Section 3.3.

ES 1.6 Institutional Capacity for Management and Conservation of Biodiversity

In Barbados, the responsibility for the management of biological resources is fragmented among several Government Ministries. There are also a number of non-government organisations (NGOs) and other entities involved in the conservation of biodiversity. The fragmentation of responsibilities has evolved into a situation whereby a myriad of institutions and agencies have their own legislative mandate, administrative procedures, resources, work programmes and priorities. There is often little communication between these organisations or coordination of their activities. Hence, there is frequent duplication of effort and blurred lines for the authorities with no clear jurisdiction in biodiversity management matters.

Despite these obstacles, personnel within these institutions and agencies are cognizant of the need for sustainable use and conservation of biodiversity. They also recognise the need for a coordinated and integrated approach to biodiversity management.

The various Government Ministries and NGOs with relevant responsibilities include:

- the *Ministry of Physical Development and Environment* which includes the *Environmental Unit*, the *Coastal Zone Management Unit*; the *Environmental Special Projects Unit*, *Environmental Engineering Division*, *National Conservation Commission*; and the *Town and Country Development Planning Department*;
- the *Ministry of Agriculture and Rural Development* which includes the *Fisheries Division*;
- the *Caribbean Agricultural Research and Development Institute*;
- the *West Indies Sugar Cane Breeding Station*;
- the *University of the West Indies*;
- the *Barbados National Trust*;
- the *Barbados Marine Trust*;
- the *Caribbean Conservation Association*; and
- the *Bellairs Research Institute*.

The GOB has also demonstrated its commitment to the sustainable development of natural resources by setting up a National Commission on Sustainable Development mandated to advise the GOB on national policy for sustainable development of national policy.

ES 1.7 Major Threats to Biodiversity in Barbados

The major threats to biodiversity in Barbados are habitat loss and fragmentation and a long history of alien species introduction. Habitat disturbance does not only precipitate loss of species, it also irrevocably alters natural habitats. Habitat loss is an on-going challenge to biodiversity conservation in Barbados. During colonial times, substantial vegetation was cleared for agricultural purposes, building materials and firewood. More recently vegetation loss has resulted primarily from land clearing to facilitate residential development, the largely ad-hoc urbanisation process and the construction of tourism sector developments, such as hotel and golf course facilities. Since Barbados' settlement in 1627, numerous species of plants and animals have been introduced both deliberately and accidentally. Some species are known to be invasive e.g. the mongoose (*Herpestes javanicus*), cane toad (*Bufo marinus*) and wild sage (*Lantana*). Introduced species have successfully preyed upon, competed against and altered habitats of indigenous species.

Other activities which impact upon biodiversity include resource extraction, monoculture sugarcane agriculture and tourism development. These activities are generally regarded as national economic necessities, and as such, need to be carefully planned and strictly controlled to ensure the minimisation of potential negative impacts, such as loss of species diversity, and degradation of habitats.

ES 1.8 Summary of the Biodiversity Strategy and Action Plan

The Biodiversity Strategy and Action Plan presents an overall goal with specific objectives and affiliated strategies and actions which should be applied to the various components of biodiversity described in the Biodiversity Country Study Technical Reports (Simmons & Associates, 1998), i.e. Natural Vegetation, Agriculture, Land Resources, Terrestrial Fauna, and Marine and Freshwater species. It is envisioned that the implementation of these recommendations will be undertaken by the various Ministries and NGOs responsible and will be overseen by a Biodiversity and Natural Heritage Unit established for that purpose.

The overall goal, specific objectives and strategies which form the foundation of the Strategy and Action Plan attempt to address the range of issues relevant to the management of biodiversity, from the development and implementation of a national biodiversity policy to research requirements for specific species.

The specific objectives of the Strategy and Action Plan are as follows:

1. To mobilize adequate financial resources for the management and conservation of Barbados' biodiversity.
2. To develop the human resource base and strengthen institutional capacity for biodiversity conservation and management
3. To conduct essential research to inform the development and implementation of management practices for the sustainable use of biodiversity

4. To use the results of the Research Programme to develop appropriate management techniques and mechanisms to ensure sustainable consumptive use and to preserve non-consumptive use values of biodiversity resources
5. To revise, consolidate and formulate policy and legislation to achieve the conservation and sustainable use of biodiversity
6. To promote biodiversity conservation and sustainable use through incentives
7. To incorporate conservation requirements into land-use planning
8. To improve public awareness and education
9. To establish effective in situ and ex situ biodiversity conservation measures
10. To ensure equitable biodiversity and traditional knowledge access and benefit sharing
11. To establish biosafety regulations in order to safeguard biodiversity
12. To promote the conservation and sustainable use of biodiversity in various sectors (agriculture, health, fisheries, tourism)

The strategies and actions that will be implemented to achieve the stated objectives are described in the Action Plan. The plan also identifies the priority of the proposed actions and the various institutions that will be potentially involved in the implementation of the strategy and action plan.

1. BASIC DATA ON BARBADOS

1.1 LOCATION AND LAND AREA

Barbados, the most easterly of the islands of the Caribbean, lies south of St Lucia, east of St Vincent, and north of Trinidad. The island is 34 kilometres long and 23 kilometres wide, giving it a total land area of approximately 432 square kilometres (166 square miles) and an Exclusive Economic Zone (EEZ) of 167,000 square kilometres.

1.2 CLIMATE

Barbados' climate may be described as mild subtropical. There is a dry season from January to May and a wet season from June to December when seasonal cooling north-east trade winds blow steadily. The wet season is humid and hot, but the climate is generally pleasant even then, as a result of sea-breezes. The island is on the southern edge of the West Indian hurricane zone. Apart from coastal damage experienced in 1998 due to ocean swells, it has not been affected by any major hurricane conditions since Hurricane Allen in 1980.

1.3 TOPOGRAPHY

Barbados is a comparatively flat island, rising in a series of terraced tablelands to Mount Hillaby at 336 m (1,104 ft). The north-east of the island is known as the Scotland District area (approximately 14% of the island) and is described as eroded and rocky. The rest of the island (approximately 86%) is coral limestone, crossed with deep river-bed gullies which accommodate the movement of water during heavy rain. There are no permanent rivers in Barbados. On the East coast of the island, much of the shoreline is rocky, pounded by strong surf. On the West and South coasts, natural coral reefs develop in calmer sea conditions and protect beaches of white sand, making these coasts highly valuable for tourism development.

1.4 GEOLOGIC STRUCTURE

Barbados is divided into two distinct geologic regions. The coral limestone area composed of a series of gently sloping, step-like terraces that cover the major part of the island, and the steep, broken slopes of sedimentary rocks that make up the Scotland District.

1.5 POPULATION

The population of Barbados in 1998 was recorded as 266,800, comprising 48.1% males and 51.9% females. Life expectancy at birth for males and females at this time in Barbados were 72.9 and 77.4 years, respectively. The Barbados Statistical Service Population and Housing Census for 2000 revealed that the population was 268,792, comprising 129,241 males or 48.1 % and 139,551 females or 51.9 %. The average life expectancy at birth is presently approximated at 74 years for males and 79 for females. The large net emigration to the United States of America, Canada and the United Kingdom during the 1950s, 1960s and 1970s, coupled with a very successful family planning programme, resulted in a low national average population growth rate. In fact, the average rate of growth during the 1970s, 1980s, and 1990s has been less than one (1) percent, and that trend is expected to continue up to the year 2020.

In the 1990s, there has been a change in the demographic profile in the population, with the proportion of elderly persons in the population increasing. According to the 1990 census, 31, 275 persons or 11.3 % of the population was aged 65 and over. This figure increased to 32, 373 or 12.3 % of the population by 2000, surpassing the projected figure of 31, 462. This increase may be attributed in part to the return of persons who emigrated to the United Kingdom, the United States of America, and Canada between the 1950s and 1970s. This trend is no doubt encouraged by the Government's programme to assist the return of Barbadian nationals who have been living overseas for extended periods.

Other population trends include a significant decline in the proportion of the population less than 15 years of age resulting from declining birth rates. This trend together with a decline in emigration is expected to continue as standard of living, quality and accessibility of health care, and level of educational attainment in the country continue to improve.

The crude death rate has remained relatively constant over the 1990s at about 9.1 per 1000 in the 1990s. Chronic non-communicable diseases are the leading broad group of diseases causing morbidity and mortality in Barbados. These include Hypertension, Diabetes, Heart Disease and various forms of Cancer. Besides being the cause of suffering, disability and loss of productivity, the cost of treatment of these diseases is very expensive. Despite the emergence of the Acquire Immune Deficiency Syndrome (AIDS) as a significant cause of mortality, communicable diseases have generally been on the decline.

1.6 SOCIO-ECONOMIC FACTORS

Education, particularly higher education, is believed to be the main vehicle of social mobility in Barbados. The enrolment ratio in primary and secondary education is 100 per cent. Tertiary education is not mandatory, but is free. Barbados boasts one of the highest levels of educational attainment among the Caribbean territories. The literacy rate in Barbados, which is estimated at 95%, is also believed to be one of the highest in the Caribbean.

A fundamental social indicator of level of development is that of public health care. Good health must be sufficient to enable people to lead socially and economically productive lives. The Government of Barbados has supported the principle of universal access to health care by “free delivery” of services to all sectors of the population. Several polyclinics have been established throughout the island providing free or subsidised medical, dental and ophthalmic care to the general population.

Barbados has an open economy with a very narrow range of exports, a heavy dependence on imported goods and a fragile and limited natural resource base. Although there has been an increase in the size of the offshore sector, the expansion of the tourism sector has been the primary engine of economic growth in Barbados during the 1990s and this trend is expected to continue into the 21st Century.

2. BACKGROUND TO THE BIODIVERSITY CONSERVATION PROCESS

2.1 THE IMPORTANCE OF BIODIVERSITY

Biodiversity is the totality and variety of genes, species and ecosystems occurring in a region. The biodiversity in any such region is the result of hundreds of millions of years of evolutionary history. Biodiversity has also been shaped over time by human intervention through the domestication and breeding of local varieties of crops and livestock. The various components of biodiversity have enormous importance to all aspects of human life especially food, medicines, industrial and agricultural products, and provide the basis for recreation and tourism. Biodiversity also provides ecological services such as prevention of soil erosion, removal of pollutants and maintenance of soil fertility that are essential to sustainable development. Over time, the greatest value of biodiversity may be found in the opportunities that it provides to humanity for adapting to local and global change.

Ironically, the destruction and degradation of genes, species and ecosystems has predominantly occurred as a result of the ways in which human beings have used and misused the environment in the course of development of their societies. For example, species-rich forests and wetlands have, over time, been converted to agricultural fields or have been removed to facilitate the development of residential and tourism facilities along the coastline.

Marine and coastal areas of a small island developing state often are affected by externalities caused by economic development initiatives and indiscriminate human activities. Coral reefs and sea grass beds, for example, have been destroyed by careless diving near shore, disposal of solid waste, indiscriminate alterations to coastal topography mainly for tourism development, destructive fishing practices, and the practice of anchoring boats over reefs. Since coral reefs and sea grass beds also act as nursery grounds for juvenile marine species on which fish feed, their destruction also leads to a reduction in the populations of fish and other commercially important marine species. As a result of the adverse effects of human activities, the once diverse and abundant populations of fish and other marine species have become impoverished.

This type of misuse and overuse of biological resources does not just impose a cost on society. Losing diversity also means the loss of genetic resources and direct values of species, declines in agricultural productivity, *inter alia*, all of which lead to adverse effects on human lives.

The situation that therefore exists in practically all countries of the world is that of a double-sided coin. On the one side, the conservation of biodiversity is increasingly recognised as an essential component of sustainable development. On the flip side, we are forced to adjust our patterns of living to find ways to make our societies sustainable so that biodiversity can be conserved. Biodiversity conservation is concerned not only with the protection of wild species but also with safeguarding the genetic diversity of cultivated and domesticated species on which we depend. Essentially, it involves the maintenance of the human life support system provided by nature and the living resources essential for development.

The present worldwide movement to conserve biodiversity is enshrined in the Convention on Biological Diversity (CBD), which was initially signed by 154 nations at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June, 1992. Since UNCED, additional nations have also signed the Convention. As the Convention is ratified, individual governments accept the responsibility to assess and protect the profusion of species, habitats, and ecosystems that make up the natural world. Governments also agree to foster development that promotes sustainable use of biological resources. In this regard, the Convention recognizes each nation's sovereignty over the biodiversity found in its territory and confers on each the responsibility to conserve that biodiversity.

Ratification of the CBD commits Governments to correcting the imbalance between who benefits from biodiversity protection and who pays, i.e. to finding equitable ways to share biodiversity's monetary and non-monetary values, to spur technological cooperation, and to establish mechanisms to finance investments in maintaining the diversity of life on Earth.

2.2 GOAL AND OBJECTIVES OF THE PROJECT

The Government of Barbados ratified the CBD on December 10, 1993 and is therefore responsible for ensuring that the provisions of the Convention are met in accordance with the particular conditions within the country and financial, technical and other resources available.

Article 6 of the CBD, "*General Measures for Conservation and Sustainable Use*" calls for governments to:

1. Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and
2. Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

The goal of this project, therefore, is to formulate a National Biodiversity Strategy and Action Plan (NBSAP) for the protection and sustainable use of Barbados' biodiversity within the framework of the CBD and to prepare a national report pursuant to Article 6 of the CBD and Decision 11/17 of the Conference of Parties (COP).

The NBSAP defines the current status of biodiversity, the threats leading to its degradation and the strategies and priority actions to ensure its conservation and sustainable use within the framework of the socio-economic development of the country.

In this context, the specific objectives guiding the development of the NBSAP were the:

1. Identification of the current state of knowledge about biodiversity in Barbados;
2. Identification of important gaps in the knowledge base and the assessment of further needs and associated costs;
3. Identification of current threats to biodiversity;
4. Assessment of the present and future value to Barbadians of the country's biodiversity;
5. Assessment of the costs and benefits of conserving biodiversity in Barbados;
6. Identification of the conservation priorities and strategies for conserving biodiversity and projection of future trends;
7. Identification of Conventions subscribed to;
8. Identification of relevant legislation;
9. Identification of gaps in legislation;
10. Identification of relevant institutions;
11. Assessment of resources;
12. Identification of appropriate mechanisms or actions to carry out the identified conservation strategies and
13. Identification of the institutional requirements to support the implementation of the strategies and actions.

2.3 BARBADOS' COMMITMENT TO FULFILLING THE PROVISIONS OF THE CONVENTION ON BIOLOGICAL DIVERSITY

The Ministry of Physical Development and Environment (MPE) is responsible for the implementation of the obligations of the CBD. The Ministry also chairs a multi-sectoral Working Group on Biodiversity, which oversees this process.

The MPE currently has in place a work programme for the conservation and sustainable use of biodiversity in Barbados. The objectives of the Ministry's biodiversity work programme are to:

1. develop a more informed basis for decision making and policy formulation on the management of biodiversity in Barbados;
2. develop a more comprehensive information data base for the management and utilization of biodiversity;
3. enhance the regulation of domestic and international trade in endangered species and specimens of flora and fauna;
4. promote the full appreciation of biodiversity as a national resource.

Among the specific biodiversity programme areas aimed at fulfilling the objectives of the work programme is the preparation of this NBSAP for Barbados. The United Nations Environment Programme (UNEP) through a Global Environment Facility (GEF) project has funded this undertaking. The NBSAP will serve as a basis for guiding the future activities of the biodiversity programme of the MPE through the development of policies, programmes and projects for the management and sustainable use of the island's biodiversity.

On a day-to-day basis, the Town and Country Development Planning Office (TCDPO) considers the provisions of the CBD during the review of applications for proposed developments. The TCDPO consults with the Environment Unit in an advisory capacity for clarification of issues relevant to the protection and management of biodiversity.

2.4 VISION FOR THE CONSERVATION OF BIODIVERSITY IN BARBADOS

The NBSAP is intended to provide the basis for guiding the conservation of biodiversity in Barbados. If the priorities and actions identified in the NBSAP are to realise their desired objectives, then biodiversity conservation will have to become an integral part of the development process in Barbados. The vision statements presented in the following paragraphs express specific goals for the role of biodiversity conservation in the development process in Barbados.

- **Sustainable Development**
Barbados will become a model of sustainable development for Small Island Developing States (SIDS). Integral to this is the development of sustainable ways of living and producing for all sectors of society that are founded on the sustainable use and management of biodiversity.
- **Environmental Preservation**
Barbados will be a nation that appreciates the intrinsic value of its natural assets, including ecosystems, landscapes and species. Respect for nature and responsibility for its protection will become an important part of the Barbadian consciousness.
- **Responsible Economic Decision-Making**
The Government and people of Barbados will recognise the critical role that biological resources play in the generation of economic benefits for the country and will endeavour to make environmental considerations, including biodiversity conservation, an integral part of all national economic decision-making.
- **Protection of National Biological Heritage**
Barbados will recognise its biodiversity as part of its national heritage and accord it a high conservation priority.

These goals should form part of the mandate of the MPE and of any entity set up within that Ministry specifically for the management of biodiversity. The time frame for development and implementation of specific programmes to achieve these goals is a maximum of five (5) years.

2.5 GUIDING PRINCIPLES FOR THE BIODIVERSITY CONSERVATION PLANNING PROCESS

In order to realise the vision for conservation and sustainable use of biodiversity, there are a number of guiding principles, which form the basis for research, monitoring and programme development:

Biodiversity is a national heritage, which must be sustainably managed and used for present development needs but also conserved for future generations of Barbadians to allow them to reach their development goals.

All Barbadians depend on biodiversity for their social and economic well-being and therefore have a responsibility to contribute to the conservation and sustainable use of biological resources.

Barbadians of all walks of life must become aware of the importance of biodiversity and should, as far as possible, be afforded the opportunity to participate in decision-making that affects the use of biodiversity.

The benefits from sustainable management of biodiversity should accrue, directly or indirectly, to all sectors of Barbadian society.

It is the responsibility of the Government of Barbados to formulate and implement the policy framework for sustainable management and use of biodiversity in close cooperation with scientists, the business community and the general public.

The interdependency of nations, particularly of Caribbean States, in the use of components of biodiversity must be recognized and taken into account in planning for biodiversity conservation efforts and to ensure fair and equitable sharing of biological resources.

An ecological approach to resource management is central to achieving biodiversity conservation and the sustainable use of biological resources.

Conservation of biodiversity should proceed on the basis of the best knowledge available, using approaches that can be refined as new information is gained.

Biodiversity conservation requires the cooperation of government and non-government organizations, resources users and the community in general.

Regional and international cooperative action and sharing of knowledge, cost, and benefits are essential to biodiversity conservation.

2.6 FACTORS INVOLVED IN THE IMPLEMENTATION OF THE STRATEGY

Pursuant to the guiding principles for conservation and sustainable use of biodiversity, there are certain necessary prerequisites that will facilitate the smooth and successful implementation of the NBSAP. These prerequisites primarily concern changes that must take place in the ways in which biodiversity is viewed by the public and private sector, including the general public, and in the nation's commitment to integrating biodiversity considerations into all aspects of our development process.

2.6.1 Establishment of a National Policy and Legislative Framework Supportive of Biodiversity Conservation

Biodiversity is ultimately conserved or lost at the local level. Government policies regarding agricultural production, urban development, industrial growth, natural resources management, tourism development and environmental protection, create the incentives that facilitate or constrain local action. If these policies do not place a high enough value on environmental resources, they will hasten the loss of the island's biodiversity. The biodiversity conservation planning process in Barbados must therefore include the reform of policies that promote damaging expansion of urbanisation, tourism and agriculture into natural habitats, over-exploitation of marine fisheries, excessive use of monoculture production or agrochemicals, degradation of terrestrial, freshwater, coastal and marine ecosystems and any other policies that catalyse the loss of biodiversity. New policies that promote conservation and sustainable, equitable use of biodiversity should be adopted instead, in conjunction with the strengthening of the legislative framework. The benefits of biodiversity conservation and sustainable use are phenomenal. Maintenance as well as quality of human life is dependent on the efficient management of natural resources. The livelihoods of future generations are less likely to be compromised, with the provision of access to equivalent natural resources as present or past generations. The capacity of institutions that develop policy relevant to biodiversity conservation must therefore be strengthened through improved training of staff and improved access to the financial resources required to carry out their functions.

2.6.2 Integration of Biodiversity Conservation with National Sustainable Development Planning Efforts

Biodiversity is fundamental to the country's development process. Though a separate biodiversity conservation planning process is valuable in identifying what exists and what conservation priorities for biological resources should be, it is important that the biodiversity conservation planning process be integrated with wider sustainable development initiatives in the country. The integration of biodiversity conservation as far as possible into other sector planning initiatives is in fact required under *Article 6 Section b* of the CBD. Ultimately, the aim would be to integrate biodiversity concerns into existing plans, strategies and programmes aimed at sustainable development and to make these more efficient by reducing overlap and redundancy between different institutions.

2.6.3 Making Public Awareness and Public Participation an Integral Part of the Process

An important aspect of achieving the desired level of biodiversity conservation is expanding people's awareness of the importance of biodiversity and appreciation of its significance. Conservation efforts will only be successful if persons in all sectors of society understand the values of biodiversity, how biodiversity affects their everyday lives and how to use it to meet their needs without causing its degradation.

The biodiversity conservation planning process should be as participatory as possible. All stakeholders in the process should be afforded the opportunity to share responsibility for developing the strategy and action plan and to jointly implement the plan. Stakeholder participants are those who have the responsibility for, and live within or otherwise care for, the variety of life and living resources. There is also a dependence on biodiversity by these stakeholders for an income. These persons should possess the knowledge, values and technologies required for successful implementation of biodiversity conservation actions. In addition, persons who participate in decision-making about what needs to be done and how, are more likely to understand the purpose of the actions and to be committed to following through with their implementation. Stakeholder participation has been an integral part of the process of identifying biodiversity conservation priorities, strategies and actions for Barbados.

2.6.4 Development of Human Resource Capacity to Manage and Conserve Biodiversity

Achieving the desired level of biodiversity conservation also necessitates the building of human capacity to manage and conserve biodiversity at all levels of society. For example, policy-makers, scientists, activists, resource managers, educators, school children, householders etc should be involved in the planning and implementation of biodiversity conservation and should therefore be armed with the knowledge of effective management techniques, and the related technology. Initial and on-going training for all levels of society are essential to maximizing the efficiency of implemented biodiversity management practices. Also, training specific to managing biodiversity issues experienced in small developing countries is essential because management models from developed countries do not have to take into consideration small island issues such as rapid unsustainable economic development. Regional training institutions such as The University of the West Indies and The University of Guyana are therefore important in the development of human resource capacity to manage and conserve biodiversity in the Caribbean and therefore in Barbados. To develop appropriate management strategies, however, constant research for current information must also be explicitly linked to national resource and development needs, and the research findings must, in turn, be accessible to all decision-makers, biodiversity managers and users. An ideal would be to empower every individual to have the capacity to manage and conserve biodiversity at the local or community level but this will have to incorporate a well-coordinated and comprehensive public awareness and training programme.

2.6.5 Development of a Supportive Macroeconomic Environment for Biodiversity Conservation

Macroeconomic policies strongly influence the way in which biological resources are used and the level of emphasis that is placed on their conservation. For example, macroeconomic policies that emphasise tourism investment encourage the acquisition of land in coastal areas for the construction of tourism facilities. This may result in the degradation of coastal ecosystems and the species that inhabit them. These policies may also indirectly encourage the conversion of agricultural lands in more rural areas to residential development because of higher land prices in the already more developed areas of the country. While biodiversity conservation does not mean an end to development, it does require changes in the macroeconomic environment to encourage the use of environmental economics as an analytical tool in determining the costs and benefits of certain types of development.

2.7 RELATIONSHIP TO NATIONAL SUSTAINABLE DEVELOPMENT PLANNING

Barbados has taken a lead among the other small islands of the Caribbean region in identifying itself with the principles of sustainable development. Within the last decade or so, a number of initiatives have been undertaken and plans developed to meet the needs of the present population in a way which will not adversely affect the ability of future generations of Barbadians to meet their needs.

The National Biodiversity Strategy and Action Plan should complement other plans relevant to national sustainable development planning which have already been prepared and implemented or which are in the process of being prepared. There are several plans in existence for elements of physical development and natural resources management in Barbados that should be considered:

- The Draft *National Physical Development Plan* (PDP), revised in 1998, provides policies for the use of land and the criteria and controls over the types of development that are allowable in different parts of the island.
- The *Fisheries Management Plan* (FMP), first published in 1997 and revised in 2001, contains the schemes for the management and development of fisheries in the territorial waters of Barbados as required by law under the Fisheries Act (1993). The 2001 FMP contains nine fishery-specific plans that are intended to ensure the sustainable use of the Barbados' fisheries resources for the benefit of the people of Barbados.
- The *Environmental Management and Natural Resources Management Plan*, prepared in 1998 as part of the Environmental Management and Land Use Planning for Sustainable Development Project (EMLUP), provides the framework and policies within which the government could protect, regulate the use, and monitor the health of the

island's environment and natural resources. The Government of Barbados has not yet adopted this Plan. .

- The *Environmental Management and Natural Resources Management Plan* is accompanied by area-specific plans, namely: the *National Park Development Plan*, and the *Coastal Zone Management Plan*. The latter however was not developed under the Environmental Management and Land Use Planning for Sustainable Development Project (EMLUP). These plans recognize the importance of the National Park Area (Scotland District and other significant natural heritage features) and the coastal area of Barbados, respectively, to the conservation and economic development of the island. The National Park Plan will be augmented by two local area plans currently under development for the Folkestone Marine Reserve at Holetown, St. James and for a proposed reserve in Carlisle Bay. The National Park Plan also provides direction for the preparation of management plans for the Natural Heritage Conservation Areas.

The existing plans and those in process provide a suitable framework for the sustainable management of the majority of the human activities that impact on the conservation of biodiversity in both the marine and terrestrial environments. A NBSAP that provides for the integration of biodiversity management and conservation into the implementation of these sector plans would serve to minimise overlap and increase efficiency of use of human, financial and equipment resources. In order to achieve this successfully, there must be an improvement in inter-agency collaboration and coordination of environmental and natural resources planning and management activities.

3. POLICY AND LEGAL FRAMEWORK FOR THE CONSERVATION OF BARBADOS' BIODIVERSITY

3.1 CONSERVATION POLICY

Barbados is a small island developing state with finite land space and limited natural resources. The island also has one of the highest population densities in the world, coupled with a rapidly improving standard of living that manifests itself in a growing demand for the provision of goods and services. These increasing demands in turn place ever-increasing pressures on natural habitats, freshwater resources and energy supplies giving rise to such problems as groundwater reserve depletion, destruction of natural vegetation and coastal ecosystems along with problems of solid waste disposal. Negative impacts on the natural environment as a result of development activities have far-reaching social and economic implications. Thus, the island requires a very strong policy on conservation that emphasises the protection of remaining natural resources, habitats and species.

There is currently no comprehensive national policy on the management of biodiversity in Barbados. However, measures to overcome this deficiency are outlined in various sectoral plans that are in existence. These are described in Section 2.7. Among the measures being considered is the setting up of a number of special units within the Ministry of Physical Development and Environment as outlined in the Environmental Management and Natural Resources Management Plan (1998).

The Coastal Zone Management Unit armed with the Coastal Zone Management Act is a government agency that provides for more effective management of the coastal resources and for the conservation and enhancement of these resources. Important proposed new units relevant to biodiversity conservation are the *Policy and Coordination Unit* and the *Natural Heritage Unit*. The *Policy and Coordination Unit* would provide a strong focus for the development and implementation of national and international environmental policies. Its mandate would be to provide the Ministry with a well-coordinated approach to dealing with environmental policy issues and to advise on and articulate such policy. The *Natural Heritage Unit* would manage policy implementation related to conservation of natural heritage resources, including the production of operational guidelines and the compilation of a database on biodiversity inclusive of a survey of local flora and fauna and the development of species management plans.

The following issues should be considered for guidance in policy formulation for the conservation and sustainable use of biodiversity:

- Major natural heritage areas and habitats (especially land based) for conservation and legal status;
- Past, current and future impacts on these sites;
- Preferred management options;

- Mechanisms for implementing management options;
- Incentives for biodiversity conservation and sustainable;
- Introduction of alien species, both invasive and non-invasive;
- Mitigation of land based sources of coastal and marine pollution;
- Tourism development and the implications for biodiversity management;
- Food security and sustainable agricultural development.

3.2 INTERNATIONAL AGREEMENTS

International agreements have served as catalysts for much of the effort being expended in many countries of the world for conservation and protection of the environment and of natural resources. The CBD is now the key coordinating, catalysing and monitoring mechanism for international biodiversity conservation. However, there are several other international conventions, to which Barbados is party, which make provision for some elements of the conservation and protection of biological diversity. In accordance with the provisions of these conventions the island has obligations to implement rules for the preservation of biological resources. From a legal perspective, implementation is by way of the passage and enforcement of legislation and regulations. From an administrative perspective, new procedures and mechanisms would have to be employed to facilitate the implementation of biodiversity programmes. In respect of conventions signed by Barbados, but which have not yet entered into force, the island has the obligation to refrain from acts that would defeat the object and purpose of the treaty. The most relevant of these international agreements are outlined in the following paragraphs.

The *United Nations Convention on Biological Diversity* was adopted on June 5, 1992, in Rio de Janeiro, at the end of the United Nations Conference on the Human Environment. The CBD entered into force on December 29, 1993 and Barbados became a party to the Convention on December 10, 1993. A number of ministries are responsible for matters falling under this Convention, they include:

- The Ministry of Physical Development and Environment; and
- The Ministry of Agriculture and Rural Development.

There is no legislation that comprehensively implements the CBD. However, the GOB has commissioned the preparation of a “Draft Environmental Management and Conservation Act for Barbados” which would seek to address local environmental management issues in general, and

would therefore speak to biodiversity and its management. The Environmental and Natural Resources Management and Land Use Planning for Sustainable Development Report (1997/98), (EMLUPSD Report 97/98), which was submitted to the Ministry of Physical Development and Environment, makes recommendations for the drafting of this all encompassing environmental legislation.

The *Convention on Trade In Endangered Species of Fauna and Flora* (CITES) was concluded on March 3, 1973 in Washington and entered into force on July 1, 1975. Barbados became a party to this convention on December 9, 1992. Barbados makes annual reports to the CITES Secretariat regarding measures taken to implement the Convention. Responsibility for the enforcement of this convention rests with various Ministries and Departments, including:

- The Ministry of Physical Development and Environment;
- The Ministry of Agriculture and Rural Development; and
- The Ministry of Foreign Affairs and Foreign Trade.

Legislative provisions that may assist Barbados in controlling international trade are scattered throughout a number of statutes including: the *Fisheries Act 1993 (6/1993)*, which protects such species as marine turtles and whales; the *Wild Birds Protection Act (cap. 398)*; the *National Conservation Commission Act 1982 (cap. 393)* and the *Coastal Zone Management Act* which together offer protection for some species of plant life. Administrative measures taken include the training of Customs Officers and relevant private sector personnel (e.g., pet shop owners), and the operationalization of an import/export permit system. Both initiatives took place in February 1998.

The *Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region* (Cartagena Convention), and the *Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region, (OILSPILL Protocol)*, were concluded in Cartagena de Indias on March 24, 1983. They entered into force on October 11, 1986.

Barbados became a party to the Convention and OILSPILL Protocol on March 28, 1985. Executing agencies in Barbados are the Ministry of Physical Development and Environment, the Ministry of Agriculture and Rural Development, and the Ministry of Tourism and International Transport. The GOB participates in the biennial meetings of the Contracting Parties that act as a forum for the communication and exchange of information regarding measures taken to implement the Agreements.

Although there is no legislation specifically geared towards the implementation of these legal instruments, a contingency plan exists to deal with oil spill emergencies, and the GOB has promoted the identification and development of the capability to respond to an oil- spill incident and the designation of an authority responsible for the implementation of the protocol.

The GOB is presently examining the Environmental Management and Land Use Planning for Sustainable Development (EMLUPSD) 97/98 proposal for the development of national parks legislation. This would offer greater protection to the preservation of rare or fragile ecosystems, as well as the habit of depleted, threatened or endangered species. This initiative is in accordance with the SPAW Protocol which the GOB has decided to sign. The protocol, which covers matters also represented in the CBD, was adopted in Kingston, Jamaica, on January 18, 1990.

The *United Nations Convention on the Law of the Sea* (UNCLOS), signed on December 10, 1982, at Montego Bay, entered into force on November 16, 1994. The Convention is relevant to biodiversity because it prescribes jurisdictional rules for the protection of resources found in the marine environment.

Barbados became a party to this Convention on October 12, 1993. There are no regular meetings of parties to review implementation of the environmental regime. Responsibility for the implementation of this Agreement is shared by:

- the Ministry of Foreign Affairs and Foreign Trade;
- the Ministry of Agriculture and Rural Development; and
- the Ministry of Physical Development and Environment.

Barbados has taken action to implement the UNCLOS regime on jurisdiction, competence and sovereignty and sovereign rights, over such zones as the internal waters, territorial sea and the exclusive economic zone. Relevant legislation includes: the *Barbados Territorial Waters Act 1977 (cap. 386)* and the *Marine Boundaries and Jurisdiction Act 1979 (cap. 387)*, and the *Shipping (Oil Pollution) Act 1994 (1994-16)*.

The GOB enacted the *Marine Pollution Control Act* in December of 1999. This is a broad marine pollution statute, which is crafted to protect various elements of biological diversity in the maritime zones of the Island.

3.3 EXISTING LEGISLATION

Barbados has no legislation designed specifically to deal with the protection of biodiversity enacted in response to the country's ratification of the 1992 Convention on Biological Diversity. Environment-related legislation currently in force in Barbados is dispersed over several statutes charging various government bodies with the management of the environment, including biological resources.

There is also currently no comprehensive legislation in Barbados governing terrestrial protected areas. Marine protected areas were described under the Marine Areas (Preservation and

Enhancement) Act (Cap 392) but this legislative document has been repealed since the more all-encompassing Coastal Zone Management Act was enforced. Preservation and conservation of ecologically important areas is undertaken in a piecemeal fashion. The most prominent pieces of legislation providing statutory protection of the environment are described in the following section.

3.3.1 Land Use

The *Town and Country Planning Act (cap.240)* makes provision for the orderly and progressive development of land. The Act provides for the preparation of a Physical Development Plan by the Chief Town Planner (CTP) which may make provision for: (i) allocation of lands as open spaces, communal parks, bird and other sanctuaries, protection of marine life; (ii) preservation of sites of artistic, architectural, archaeological or historical interest; (iii) preservation or protection of forests, woods, trees, shrubs, plants and flowers; (iv) regulation and control of the deposition of waste materials, refuse, sewage and the pollution of rivers, lakes, ponds, gullies and the seashore.

The *Land Acquisition Act (cap. 228)* makes provision for the acquisition of land for public purposes, such as the development of parks or caves.

The Constitution (Section 16) provides for the protection from deprivation of private property. The establishment of protected areas or the imposition of planning restrictions that deprives the land of its value could attract legitimate claims for compensation. S.16 allows for the confiscation of property in circumstances where the environment is threatened.

3.3.2 Protected Areas/Habitats

The Soil Conservation (Scotland District) Act (cap.396) restricts the use to which land can be put in the Conservation Area known as the Scotland District. The Scotland District comprises both the hinterland and the coastal zones in the parishes of St. Peter, St. Andrews, St. Joseph and St. John.

The National Conservation Commission Act (cap.393) establishes the National Conservation Commission (NCC) which has, as one of its main functions to conserve the natural beauty of Barbados; control and develop public parks; public gardens, beaches and caves; advise on the removal of coral from the ocean bed; and regulate commercial activities in public parks, gardens, caves, and on beaches.

The Trees (Preservation) Act (cap.397) provides that the killing of any tree one metre or more in circumference is an offence unless a permit has been obtained from the CTP. The Act also empowers the CTP to require the owner of vacant land or land adjoining or near a public road to plant or replant trees and to clear land of weeds or overgrown grass.

The Cultivation of Trees Act (cap.390) promotes the cultivation of certain species of trees through the financial incentive of receiving a tax contribution payment equivalent to the amount of taxes payable in respect of the land so cultivated, the payment of a fruit tree subsidy or subsidy payment. Species currently approved for the incentive scheme are mahogany, casuarina, teak, tamarind and coconut. This piece of legislation only stresses however non-native species and efforts should be made to promote incentives for the cultivation of species, which are indigenous to Barbados.

3.3.3 Agriculture/Livestock

The Town and Country Planning Act (cap.240) contains some provision relevant to agriculture and livestock. These include the use of any land for the purposes of agriculture or forestry, including forestation and the use of any agricultural purpose, other than dairy farming and the breeding and keeping of livestock, including any creature kept for the production of food, wool, skin or for the purpose of its use in farming the land.

The Barbados Agricultural Development and Marketing Corporation Act (BADMCA) (12/1993) establishes the BADMC with responsibility for the stimulation and development of agriculture. The Corporation is mandated to develop and manage, on a commercial basis, such plantations and other agricultural land that may be vested in it and to stimulate and encourage the private sector.

3.3.4 Marine Resources

The Barbados Territorial Waters Act 1977 (1977-26) which defines the territorial waters of Barbados as existing within 12 nautical miles around the island. Section 3 (2) provides that these waters, including the underlying seabed and subsoil, form part of the territory of Barbados and are, therefore, subject to full territorial sovereignty. Foreign vessels have a right of innocent passage through the territorial waters but not if the captain or other person in charge of the ship engages in any calculated act of pollution or acts likely to cause harm to Barbados' resources or its marine environment.

The Marine Boundaries and Jurisdiction Act 1979 (cap. 387) establishes a 200 mile EEZ in which sovereign rights are vested in the Government of Barbados in respect of the exploration, exploitation, conservation, protection or management of the natural living and non-living resources of the sea-bed, subsoil and superjacent waters; and the preservation and protection of the marine environment and the prevention and control of marine pollution. Barbados has all other rights in and jurisdiction over, the EEZ recognized in international law.

The Fisheries Act 1993 (cap. 391) addresses the provision for the management and development of fisheries (including protection of endangered and critically endangered sea turtles from exploitation) in Barbados.

The Fisheries Management Regulations (1998) address closed areas and seasons, fishing methods and equipment to be adopted, and protective measures for lobsters, turtles, sea eggs and tuna.

The Marine Pollution Control Act (1998) focuses on the quality of the marine waters on the south and west coasts of the island. The legislation has been approved to help combat the steadily deteriorating coastal water quality in some locations that has resulted due to the increased physical development occurring along the coastline over the last three (3) decades. As in all coastal island states dependant on marine resources, poor water quality poses a serious threat to human, fisheries and marine ecosystem health. Overall, the legislation seeks to prevent, reduce and control pollution from its various sources. It recognizes that much of the marine pollution affecting coastal waters originates from land based sources and activities

The Coastal Zone Management Act (1998-39) provides a comprehensive statutory basis for coastal management and planning in Barbados. It seeks to coordinate and update the existing fragmented statutes relevant to coastal management and makes provision for critical areas of concern not covered by current legislation. The Act provides the legal basis for the preparation of a Coastal Management Plan, which establishes and clearly sets out Government's coastal management policy and technical guidelines for the use and allocation of coastal resources. The Act specifically deals with protection of marine resources, for example destruction of corals and fouling of the foreshore. It also encompasses the designation of Marine Protected Areas and Marine Parks. This Act repealed the *Marine Areas (Preservation and Enhancement) Act (cap.392)*.

3.3.5 Protection of Wild Flora and Fauna

Barbados has no legislation for the general protection of wild fauna and flora. Some species of wild plants are worthy of protection in respect of which no legislation obtains. Similarly, there is no broad regulation of the international trade in endangered species as required in international conventions such as CITES. Legislation protecting special areas and wildlife is in evidence, however there is need for comprehensive regulation which incorporates suitable provisions for management plans and protection of intellectual property rights.

The *National Conservation Commission Act 1982 (cap. 393)* addresses the protection of flora and fauna found in caves.

The *Wild Birds Protection Act 1907 (cap. 398) (WBPA)* provides for the protection of some forty-six (46) species of wild birds specified in the schedule. Any person who knowingly kills or wounds or attempts such an act is liable to a fine, one-half of which is payable to the informant. Possession or export of the skin or features of any wild bird is also an offence, which is punishable by a fine. The only exception is the killing of wild birds for the purpose of obtaining specimens for natural history provided a licence has been obtained by the Minister (not defined) to do so.

The *Protection of New Plant Varieties Act (2000-17)* was formulated because of legal obligations imposed by the World Trade Organisation. It basically addresses, amongst other issues, the qualification of rights of plant breeders, their entitlement to protection, licenses and criminal liability in respect of variety denomination. This act seeks to protect property rights with respect to flora, and therefore can be used as a tool to regulate and control biodiversity access.

3.3.6 Legislation Requirements

A review of existing legislation relevant to the management and conservation of biodiversity identifies the need for a legal regime to be developed which would give a comprehensive response to the requirements for the protection of biological diversity. The concept of the protected area, as developed in international instruments to which Barbados is a party, including the CBD, requires articulation in statute, as does the basic tool of the management plan designed to achieve specified conservation objectives. These measures must find expression in a comprehensive environmental enactment that would include existing natural resources legislation.

In developing this comprehensive legal response the following environmental issues should be considered:

- Legislation to protect wild flora and fauna are antiquated and require complete revamping in order to protect indigenous species.
- General regulation of the release of pollutants into the environment that causes, amongst other things, contamination of biological resources, is required. In this regard, substantially new legislation is required for waste management, toxic substances, noise, air pollutants, climate change, and dumping.

- EIA procedures need clear legislative authority.
- Planning legislation should be modified to attempt to ensure greater transparency and closer relationship between the grant of planning permission and the requirement of conformity with the Physical Development Plan.
- National parks legislation is required.
- Protected areas legislation is required.
- Forestry legislation is required.

The GOB has reviewed the EMLUP Report 1997/98. This Report has suggested enactment of several environmental statutes most of which will be critical to effective protection of biodiversity.

The “Draft Environmental Management and Conservation Act for Barbados” contains provisions for the implementation of the CBD and the SPAW Protocol. It makes provision for designation of specially protected areas, including the Scotland District and coastal planning areas. Line items of the proposed legislation include the following relevant concepts:

- implementation of biodiversity conventions
- integrated environmental management
- conservation of natural heritage resources, flora and fauna
- protection of cultural knowledge
- prohibition and regulation of discharges into the environment
- enforcement procedures
- regulation of waste management and waste disposal operations
- provision for environmental impact assessment
- establishment of regime for the protection of forestry and arboriculture
- wildlife protection
- pollution control
- regulation of toxic substances and pesticides

The proposed “Revised Town and Country Planning Act” makes extensive revisions to the existing planning legislation. These revisions will address the aspects of the legislation, discussed above, which inhibit its effective protection of biodiversity.

The proposed “Barbados National Parks Act” builds upon existing fragmentary legislation. The proposed Act includes the following:

- the description of the area to be included in the National Park;
- the creation of the post for a Director of the Barbados National Park;
- the constitution of a National Park Advisory Board;
- the creation of a Barbados National Park Plan; and
- a number of procedures for notification and consultation with other relevant agencies.

3.4 ECONOMIC ASPECTS OF BIODIVERSITY CONSERVATION

3.4.1 Economic Valuation of Biodiversity

In the process of economic growth and development, trade-offs invariably will have to be made between development goals and the conservation of the environment. Economics attempts to facilitate such decisions by providing a yardstick to compare different types of costs and benefits of natural resources and the environment. This yardstick is the dollar value of costs and benefits. The concept of “value” of natural resource and environmental goods and services is relatively new, and based on the neoclassical concept of utility. Application of a utility based valuation system, which is exclusively anthropocentric, to value a complex commodity like biodiversity has attracted criticism from some environmental groups. Their protests are often based on the argument that the intrinsic value of life on earth and the right of species to exist on their own is not captured in this valuation system, not that ecological services provided by biodiversity are adequately valued.

Despite these caveats, economic values provide a powerful tool for guiding public policy decisions as well as in allocation of public funds to various sectors of the economy. For a long time, environmental causes have generally received little consideration in the decision-making process because it has been difficult to quantify the qualitatively identifiable benefits and costs. Economic valuation methods now place the environment on the same footing as the other traditional sectors of the economy such as health, education, transportation, agriculture and industry. In addition, it is possible to include the value of natural capital in national accounting systems. This is known as the “greening of national accounts.” Several developed and developing countries have used economic valuation methods to value important environmental resources, such as forestry, fisheries, mines, for national accounting purposes. Valuation of biodiversity is the next logical step in this process, where values are placed on the physical inventory of different categories of biodiversity.

An important component of this project has been to value the natural wealth of the island which is categorized as agricultural biodiversity, terrestrial flora and fauna and marine resources. Appendix 2 provides details of these valuations which use only available data and information. Where data and information were not available, suitable valuation is recommended.

3.4.2 Economic Incentives

In order to develop a meaningful and workable policy for the conservation of biodiversity, it is important not only to have descriptive information on the causes of biodiversity loss, but it is also important to have an understanding of the underlying economic forces which are causing the problems. There are three major, interrelated economic forces driving biodiversity loss and which must be addressed through a broad range of policy mechanisms:

Unsustainable patterns of consumption and production are a major cause of biodiversity loss. Barbados' much-improved standard of living over the past few decades has led to a corresponding increase in per capita consumption of energy and natural resources. It is crucial to remove economic incentives that encourage unsustainable production, in addition to increasing education about the impacts of excessive consumption. Eco-labelling and certification e.g. for manufactured goods and for the tourism industry, develop consumers' understanding about the impacts of unsustainable consumption and encourage producers to use sustainable production processes;

Population growth and distribution are major factors in determining how the country's land resources and biological resources are used. Although population growth in Barbados has been relatively stable in the decade of the 1990s, the island's population density is one of the highest in the world. This high population density, in combination with improving socio-economic conditions leads to increasing pressure on land and marine resources for food production, roads, housing and commercial developments. The high density of tourism related development along the coastline makes coastal, and marine biodiversity extremely vulnerable to degradation; and

Market failure means that the interplay of market forces does not ensure the economically correct balance of habitat conversion and conservation. This is because those who convert the land do not have to compensate those who suffer the consequences of that conversion, locally or globally, e.g. the loss of biodiversity values. As a result, the private cost of engaging in activities that adversely impact on biodiversity is artificially low. The cost of losing habitat and wildlife is shifted to society rather than being internalised by the private actor. This pattern encourages the overuse of components of biodiversity (OECD, 1996).

In summary, biodiversity decision-making and policy development will be improved if information on the state of biodiversity is introduced into the economic accounts and economic decision-making. In addition, the introduction of economic incentives as complements to regulatory provisions will aid in the achievement of biodiversity conservation objectives.

4. EXISTING CAPACITY FOR THE CONSERVATION OF BIODIVERSITY IN BARBADOS

4.1 INSTITUTIONAL CAPACITY

In Barbados, the responsibility for the management of biological resources is fragmented among several Government Ministries. There are also a number of non-government organisations and entities involved in the conservation of biodiversity. The fragmentation of biodiversity responsibilities has evolved into a situation whereby a myriad of institutions and agencies have their own legislative mandate, administrative procedures, resources, work programmes and priorities. Despite some inadequacies caused by fragmentation such as lack of real time communication, these aforementioned institutions and agencies have cooperated in the form of steering committees and working groups, and therefore are cognizant of the need for a coordinated and integrated approach to sustainable development and biodiversity management. The Government of Barbados has also demonstrated its commitment to the sustainable development of natural resources by setting up a National Commission on Sustainable Development mandated to advise the Government, *inter alia*, on national policy for sustainable development of natural resources.

4.1.1 Ministry of Physical Development and Environment

The Ministry of Physical Development and Environment, through its various Divisions, is responsible for all matters pertaining to physical planning and development, and environmental conservation and protection. The mission of the environment sector of MPE is to “promote and facilitate the sustainable use of our resources encouraging the involvement of all citizens and the integration of environmental consideration into all aspects of national development planning”. The environment sector of the Ministry is the main policy-coordinating government department with regard to environmental policy at the national, regional and international levels. The environmental units are also responsible for the management of the island’s energy and natural resources. The environment sector of the MPE includes the Coastal Zone Management Unit, the National Conservation Commission, the Environment Unit, the Energy Division, and the Environment Engineering Division. The MPE also possesses an Environmental Special Projects

Unit (ESPU) that consists of an Executive Officer, a Director, an Architect, an Environmental Engineer and three Administrative staff.

The current responsibilities of the environment sector of the Ministry include:

- advising the Minister on national environmental policy and legislation, including environmental impact assessment;
- developing and executing environmental education and public awareness programs;
- advising the Minister on a range of environmental management concerns including the development of protected areas, research and technical assistance needs;
- facilitating the integration of the environmental dimension into the development planning process;
- advising on the adoption of global environmental initiatives to the local context and otherwise articulating local concerns for the international context;
- serving as the technical focal point for a wider range of regional and international environmental programs and institutions.

Some of the institutional constraints that the environment sector of the Ministry faces in carrying out its responsibilities were identified under EMLUP and include the following:

- Inadequate staffing;
- A deficiency in appropriate training, e.g. in communication/media skills;
- Unavailability of vital technical support from the Government Information Services (GIS) at most times for environmental programmes;
- A lack of a structured information database or library for technical material; and
- Lack of direct financial support.

Responsibilities of the existing divisions of the MPE relevant to the conservation and sustainable use of biodiversity are described in the following sections.

National Conservation Commission

The National Conservation Commission (NCC) is mandated to conserve the natural beauty of Barbados, control and develop public parks, public gardens, beaches, caves and marine underwater parks and regulate commercial activities in public parks, gardens, caves, and on beaches.

The NCC is also involved in cleaning and maintaining these above-mentioned public amenities, and employs 125 Park Rangers and Wardens in order to administer activities in the national parks and beaches. There are also some small-scale re-vegetation programs undertaken by the NCC periodically. The NCC plays an important role in the preservation of biodiversity through regulation of human activities in ecologically sensitive areas. The National Conservation Commission may establish restricted areas and the Commission may, with the approval of the Minister responsible for land issues, make Regulations for the protection of these areas.

Coastal Zone Management Unit

The Coastal Zone Management Unit (CZMU) is a scientific government agency specializing in the environmental management of the coastal zone. It carries out routine monitoring and analyses of oceanographic conditions around the island, hydrographic surveys, GIS data management, and coral reef and water quality monitoring. The CZMU also assists in the evaluation of all coastal related development planning applications submitted to the Town and Country Development Planning Office. This agency can be said to play a vital role in the preservation of marine and near shore biological assets.

Environmental Unit

The Environmental Unit (EU) is a technical agency specializing in conducting public awareness and education programmes, measuring and monitoring sustainable development, protecting and managing local biodiversity, assisting the adaptation to and prevention of atmospheric changes, and policy coordination and planning. The latter speciality involves merging international laws and conventions with national environmental policy.

Environmental Engineering Division

The Environmental Engineering Division (EED) is a technical monitoring agency involved in marine pollution control, air quality monitoring and control, water quality monitoring and control, hazardous material management, development control, and noise pollution control. The EED also contributes to the management of gullies through its Derelict Vehicle Programme, which focuses on monitoring, and removal of debris.

Environmental Special Projects Unit

The Environmental Special Projects Unit (ESPU) conceptualises and implements practical environmental projects. The unit is committed to marrying the natural and built environment by analysing past initiatives and ideas, and therefore designing workable projects. Included in its portfolio is the redevelopment of Harrison's Cave, the development of the National Botanical Gardens, and beautifying Barbados' major Highways.

Town and Country Development Planning Office

The Town & Country Development Planning Office, under the Ministry of Physical Development and Environment, is the primary agency responsible for planning the use of land resources in Barbados. The TCDPO essentially facilitates the “orderly and progressive” development of land based on an approved National Physical Development Plan. The National Physical Development Plan is prepared by the Chief Town Planner and approved by the Minister.

The Development Plan refers to provision for a number of matters that include amenities such as: (a) allocation of lands as open spaces; (b) allocation of lands for communal parks, bird and other sanctuaries and protection of marine life; (c) preservation of sites of artistic, architectural, archaeological or historical interest; (d) the preservation or protection of forests, woods, trees, shrubs, plants and flowers; and (e) prohibiting, regulating and controlling the deposit of waste, materials and refuse, the disposal of sewage and the pollution of rivers, lakes, ponds, gullies and the seashore. The Plan also makes provision for facilitating the establishment and operation of public services in relation to, for example, power, water supply, sewerage, drainage, sewage disposal and refuse disposal.

Findings of the EMLUP study have indicated that the TCDPO has generally been unable to effectively monitor and regulate development activities, which may be in conflict with the Town and Country Planning Act (TCPA). The TCPA was also found to be inadequate in some respects as a regulatory instrument e.g. the regulation of sand mining and quarrying activities. It was also observed that there was a lack of adequate personnel to properly regulate such development or resource extraction activities.

4.1.2 The Ministry of Agriculture and Rural Development

The Ministry of Agriculture and Rural Development has overall responsibility for agricultural development in Barbados. Its function is carried out through two divisions, Livestock and Crop, as well as through several specialized sections, such as the Agricultural Planning Unit, Plant Pathology Unit, Central Agronomic Research Station, Entomology, Land and Water Use Unit, Animal Nutrition Unit, Agricultural Stations, Soil Conservation Unit, and Veterinary Services.

The Fisheries Division

The Fisheries Division falls under the Ministry of Agriculture and Rural Development. This agency engages in fisheries planning and management.

The Administration and Services Section provides administrative support within the fisheries division, and services the fishing industry as required by fishery laws. The principal duties of this section include:

- Office property and human resource management
- Incentives, accounting and other administration
- Boat or fisher registration, inspection and licensing
- Boat haul-out service.

The Infrastructure and Development Section assists in providing infrastructure and implements measures to develop the resources available to the fishing industry in keeping with fisheries plans and includes:

- Landing site facilities
- Training and extension
- Research, technology and development.

The Fisheries Resource Management Section provides scientific information for planning and implementing measures for fishery management and development, and includes:

- Catch and effort statistics
- Biological, social and economic information
- Fisheries management measures
- Computer management
- Aquaculture and mariculture
- Library service.

4.1.3 Other Agencies with Relevant Responsibilities

The *Barbados Agricultural Management Company Ltd* (BAMC) was set up by the government of Barbados and given a 12-year lease to manage sugarcane farms and factories, which had become indebted to the banks. The BAMC manages 40% of all lands under sugarcane, is the largest producer of cotton in Barbados, and cultivates some root crops and hot peppers for export. The BAMC also operates the Agronomy Research and Variety Testing Unit (ARVTU), which is geared towards the improvement of sugarcane cultivars and sugar yields and the reduction of production costs.

The *West Indies Central Sugar Cane Breeding Station* (CBS) located at Groves in St George, is operated by the Sugar Association of the Caribbean and is responsible for the production of seeds each year for distribution to participating variety testing stations such as the ARVTU. The CBS maintains on 16 ha of land, a working collection of over 1000 commercial clones and 900 species and early-generation inter-specific hybrids.

The *Caribbean Agricultural Development Institute* (CARDI) sub-regional office located on the Cave Hill Campus of the University of the West Indies conducts research on animal production

and development, and crop production and development. CARDI also provides technical assistance to farmers and government agencies.

The University of the West Indies, Cave Hill Campus assists in the management and monitoring of biodiversity in Barbados. Academics, mainly from the Department of Biological and Chemical Sciences and the Centre for Resource Management and Environmental Studies (CERMES), advise Government and the private sector on biodiversity issues, and also conceptualise and develop sustainable environmental projects. The university also offers environmental science and management degrees at the undergraduate and postgraduate levels.

The *Bellairs Research Institute* was established as a marine research facility in Barbados in 1954. It is owned by McGill University in the city of Montreal, Canada. Bellairs goal is to provide scientists with high quality tropical laboratory and field facilities in the Caribbean.

The office of the *Director of Public Prosecutions (DPP)* is responsible for the enforcement of environmental regulations and legislation and the prosecution of violators of these laws. The DPP office was found in the EMLUP Report to possess inadequate resources, and so lacks the strength to prosecute violators of environmental conservation regulations. Increased staffing is required to overcome most of the difficulties presently being experienced by the DPP.

5. ASSESSMENT OF BIODIVERSITY RESOURCES

5.1 NATURAL VEGETATION

The first European settlers arrived in Barbados in 1627 and found most of the island covered with forests, however, within 30 years about 80% of the forested area was cleared for agriculture (Watt, 1966). Over the past 300 years sugarcane was and continues to be the primary crop planted on the island, however, there has been a steady decline in the area under sugarcane cultivation and an increase in the area under natural vegetation. Gooding (1974) noted that, in the early 1970's, some 25,000 ha out of about 31,000 ha of arable land were planted in sugarcane. In 1989 arable lands accounted for about 17,000 ha (Ministry of Agriculture, Food and Fisheries, 1992), with sugarcane occupying about 11,000 ha. By 1996 sugarcane cultivation was further reduced to just less than 9,000 ha. Abandoned sugarcane lands, particularly in the Scotland District now have some secondary forest and regenerating natural vegetation. It is not known with certainty what area of these abandoned lands have been converted to other uses such as housing and tourism development.

The vegetation of Barbados has been described in many studies by several researchers particularly within the last 50 years. The following paragraphs provide a description of the various classes of natural vegetation existing on the island.

5.1.1 Natural Plant Communities

Beaches, Sand Dunes and Sandy Bushlands

The beaches on the eastern (windward) side of the island differ markedly from those on the more sheltered west (leeward) coast, but in both areas they are characterised by predominantly xerophytic and halophytic vegetation. The former are usually wider, often backed by sand dunes, a strip bare of vegetation up to about 10m from the high tide mark and impacted by saltwater spray. The beaches on the windward coast are located from Cattlewash to Morgan Lewis, Foul Bay, Crane Beach and Long Bay (St Phillip), Chancery Lane and Silver Sands (Christ Church). On the seaward side of the dunes, isolated creeping plants are common. On the windward coast, the sandy bush-lands, sometimes referred to as dry thorn scrub communities with cacti and other prickly shrubs, often appear to be a further development of the *Coccoloba* association of the dunes, extending inland with increased number of species.

The leeward beaches are relatively narrow and, where they have not been cleared for coastal development, are backed by trees and shrubby undergrowth. Examples of this are the small area of dry woodland, which persists at Batts Rock, St James and Cluffs, St Lucy. Coastal development up to the high tide mark in many cases is a dominant feature of the west coast.

Sea Cliffs and Sea Rocks

The windward sea cliffs extend from just west of North point in St Lucy to Cove Bay; from Consett Point to Chancery Lane; and then near Inchmarlow and South Point. On the vertical walls of the sea cliffs plant life is sparse and restricted to halophytes which occur in the crevices. Two rare cliff species are *Heliotropium microphyllum* (lesser Antillean endemic) found only at River Bay, St Lucy, and *Strumpfia maritima* (Caribbean-wide sp), which is found only near Gemswick to Foul Bay. At the tops of these cliffs, grasses and shrubs are usually abundant. Further inland from the edge of the cliffs more species appear with increased soil cover.

Rocky Land and Inland Cliffs

The rocky land has evolved from historical soil loss over the past three centuries and is characterised by protruding rock with a few pockets of shallow soil and can be found at areas like Kitridge Point in St Phillip, Mount Brevitor in St Peter, and in St Andrew and the Boscobel area. These pockets support dry scrubby vegetation and many have been planted for grazing animals.

The vertical walls of inland cliffs usually support sparse vegetation, clinging to cracks in the rock or in pockets of soil on ledges where stunted plants are common. The slopes of some cliffs that have more loose boulders and pockets of soil may have additional species.

Gullies

The gullies are steep clefts in the coral cap of Barbados that provide a sheltered environment with more moisture than the other habitats so far described. The major gullies can be found in the Parishes of St Peter, St James and St Thomas, however, the ravines in the Scotland District (St Andrew), which have a different geological history, are less steep sided and tend not to have the same vegetation characteristics of the gullies in the coralline areas. Historically, gullies have been used as a source of firewood and some of them provided more suitable areas for the planting of fruit trees. Today, these gullies tend to have a large and mature collection of native ferns, climbers, shrubs and trees in Barbados.

Forests

Carrington (1991b) estimated the total tree cover of Barbados to be about 2% of the area of the island or about 800 ha which included the gullies, coastal woodlands, undercliff woods and other planted wooded areas. Remnants of the xerophytic coastal forest can be found at Cluffs, Bath and Batts Rock.

The undercliff woods lie mainly on talus slopes at the base of the coralline cliff from Sealy Hall in St John, around the rim of the Scotland District, to Boscobel in St Peter. The best development of the woods is behind Codrington College in St John, then from Edgecliff passing below Hackleton's Cliff in St Joseph to near Horse Hill (comprising Forster Hall wood and Joe's River wood), and then in clumps between Horse Hill and Boscobel Hill, near Bleak House, Farley Hill and at Cherry Tree Hill. Turner's Hall wood (about 21 ha), in the Scotland District is perhaps the least disturbed wooded habitat in Barbados and is the best local example of a Tropical Mesophytic (semi-deciduous) forest. It is considered to be the most species rich site on the island with respect to plant life. This forest has two discernable tree layers, occasionally a third layer consisting mainly of palms, a moderately developed evergreen shrub layer, a poorly developed herbaceous layer, poorly developed climbers and few epiphytes.



Plate: 1 Sea Rock on the East Coast, Bathsheba (National Park Area), (photo: ESPU)

Coastal Wetlands

Remnants of natural wetlands or wetland vegetation, primarily mangroves, can be found at Graeme Hall, Chancery Lane, Holetown, near Brighton, near Gibbes and at Lakes/Long Pond. Graeme Hall Swamp is the largest mangrove area (30 ha) in Barbados and it comprises natural and man-made water bodies. With respect to coastal wetland plant life, Carrington (1991b) reported that *Conocarpus erectus* is now limited to Chancery Lane. The mangrove at Holetown is essentially a fringe of *Laguncularia racemosa*, less than 1 ha in area along the bank of the creek adjacent to the Discovery Bay Hotel. Further, severely degraded mangrove sites with only a few trees of *Laguncularia racemosa* persist in seasonally wet areas near Brighton on either side of the Spring Garden Highway, as well as near Gibbes (St Peter).



Plate: 2 The Graeme Hall Swamp (photo: Dr Horrocks, UWI)



Plate: 3 The Graeme Hall Swamp white mangrove forest (photo: Dr Carrington, UWI)

5.1.2 Man-made Habitats

Plantation Forest

Plantation forests consist of *Swietenia mahagoni* (small-leaf mahogany) many of which were planted before 1900 on small-holdings, usually not larger than 2 has scattered across the country (Ramnarine, 1991). Since 1963, about 39 ha at Joe's River was replanted with Honduras mahogany and other exotic timber species. Joe's River Forest has been an experimental plantation rather than a production forest.

Due to the extensive deforestation in previous centuries and the dominance of agriculture, forests are nonexistent in Barbados. However, the planting of trees was encouraged through the designation of Arbor Day from 1905, when the colonial government advertised and provided plants for free distribution to be planted on a designated day. At least 70 exotic species of plants were widely distributed between 1907 and 1930, and in some years, as many as 13,000 trees and shrubs were given out (Chandler, pers.comm.) for planting around homes, roadsides, open spaces and other property. Arbor Day became dormant after 1950 but was reactivated by the Government of Barbados in September 1997.

Sugarcane Plantations

Sugarcane plantations are distributed throughout the island, however, plantations greater than 300 ha in size are found only in the parishes of Christ Church, St George, St Phillip, St John, St Peter, and St Lucy (Ministry of Agriculture, Food and Fisheries, 1992). Eleven varieties of sugarcane account for the majority of land currently under sugar production and a variety of chemicals are applied for the control of invasive weeds in these plantations. These weeds are more dominant during the period of land preparation and planting of the sugarcanes, during early growth of the sugarcanes, and after harvesting of the crop when the land is fallow or until the ratoons have grown sufficiently to shade out most of the weeds. These weeds can also be found in and around vegetable gardens where manual or chemical weed control is not practised.

Pastures

Land, where the soil was too shallow or too poor for other crops, was often planted for pastures and was either cut at intervals for fodder or direct grazing by animals were permitted. Some pastures have been created on more favourable soils, primarily in the Scotland District.

Cane-field Roads

Cane-field roads are numerous, traversing all sugarcane plantations, and varying from well made and well kept roads of crushed stone bound with marl, free of all plant growth, to tracts of compacted earth with or without crushed stones, often bordered on either side with earthen banks. Many of the weeds found in the sugarcane plantations will be found along cane-field roads.

Roadsides

Most of the roads are asphalted with some bordered by cane-fields and relatively deep soil banks or shallow gutters and trenches. Others are cut through the coral cliffs creating steep rocky walls at the roadside. Paved shoulders usually with no roadside vegetation border roads passing through towns. Wayside gutters and trenches may contain some residual moisture and may have more luxuriant growth herbs and shrubs. However, these are often cutback or clean weeded by roadside maintenance crews.

Ponds and Streams

There are virtually no natural ponds in Barbados and only three watercourses (at Joe's River, Farmer's Gully and the Three Houses stream) have water all year round. Man, however, has

extensively modified these watercourses. At the margins of ponds, weed control has reduced the extent and diversity of the natural plant associations, and few species are prominent.

Miscellaneous Waste Sites

Any land such as disused quarries, disused building sites, and abandoned agricultural lands soon become colonised by a range of herbs, shrubs and trees provided there is no intervention by grazing livestock

5.1.3 Endemic, Rare and Endangered Plants

There are about 700 species of flowering plants in Barbados with only two endemic species identified so far, neither of which are rare or endangered: *Phyllanthus andersonii* - a gully shrub, and *Metastelma barbadense* - a slender climber (Carrington, 1993). A recent study by Rogers (1999) indicates that the species *Agave barbadensis* - the maypole, commonly thought, until recently, to be endemic to Barbados, is synonymous with *Agave karatto*, found throughout the Lesser Antilles.

Carrington (1991) indicated that there were 23 plants in Barbados that require protection, although all are found elsewhere in the Lesser Antilles. Fifteen of these species are known from only one site and eight species were considered rare or endangered in Barbados.

Some of the Bryophytes and Pteridophytes in Barbados have been inventoried but not much research has been conducted on these groups when compared to the flowering plants. Coulter (1968) lists 37 species of ferns and fern allies for the country with only one endemic, *Adiantum tenerum* var. *farleyense*, commonly known as the Barbados Farley Fern. Pearce (1963), and Welch and Crum (1969) have collectively identified 22 species of mosses, four species of leafy liverwort and one hornwort. Carrington (1991) lists the following lower plants as rare or endangered: *Psilotum nudum* - a fern ally, *Adiantum tenerum* var. *farleyense*, and *Cyathea arborea* - a tree fern. A study by Rogers (1998) overturns earlier evidence on the Barbados Farley fern. The Rogers study indicates that the Farley fern is neither a wild plant nor a variety; it is a cultivar. According to Rogers, the Farley Fern has no wild representation and probably never did. Further, being widespread in cultivation, it is not rare or endangered.

Much work needs to be done on Caribbean lower plant groups such as algae and Bryophytes, those of Barbados being no exception. Most of the published collection and identification of Barbadian seaweeds, for example, was carried out about a century ago (Dickie, 1875; Vickers, 1905, 1908) with some 222 algal species documented (Howe, 1928). There is no reference collection of algae in the Barbados Herbarium (BAR) at the UWI. Likewise there is no collection of Barbadian lichens or macrofungi.



Plate: 4 A rare sea cliff species (*Strumpfia maritime*) (Photo: Dr Carrington, UWI)

5.1.4 Major Impacts on Vegetation Biodiversity

The potential major impacts on current vegetation biodiversity are from tourism development and uncontrolled grazing of livestock. The construction of hotels and marinas, particularly along the west coast, for example, Port St Charles in St Peter, and also along the south coast have caused the destruction of native plant communities and introduction of exotic species in areas not under concrete and asphalt. Several proposals for the creation of golf courses were submitted by investors to the government for approval. The areas targeted for these facilities are likely to be abandoned agricultural lands, which are being recolonised with natural vegetation. The provision of housing and settlements expansion are also likely to utilise marginal abandoned agricultural lands.

The beaches, dunes and sandy bush-lands on the east coast, gullies and under-cliff woods do not seem to be under threat for conversion into tourism infrastructure. Plans to modify the privately owned western side of the Graeme Hall Swamp are underway and will include modification of the wetland to accommodate wading ponds, aviaries, a restaurant and other visitor facilities (The Broad Street Journal, November 26, 1997: page 4).

Free range grazing by cattle, sheep and goats, has been a historic practice in rural Barbados. No data were readily available which evaluated the extent and effects of this practice on selected natural plant communities in the island. Gooding (1974), however, suggested that grazing suppressed the development of shrubs and trees in some gullies; this would allow grasses and other herbaceous plants to become dominant.

While there have been no definitive local studies on alien invasive species in Barbados, there is anecdotal evidence (Carrington, pers. comm.) that some exotic plant species may be displacing local species in certain key habitats. In some forested areas, the cultivated Macarthur Palm (*Ptychosperma macarthurii*) seems to be displacing the indigenous Macaw Palm (*Aiphanes minima*) as the dominant understorey species. In certain forested gullies, the characteristic shrub layer has been replaced by solid stands of Sweet Lime (*Triphasia trifolia*) or Mother-in-law's tongue (*Savsevieria hyacinthoides*), both garden escapes. While Casuarina has been deemed serious alien invasive species in Florida and elsewhere, it seems in Barbados to be invasive solely in the Scotland District.

5.2 AGRICULTURAL BIODIVERSITY

Agricultural production was the primary occupation of early settlers to Barbados, not just for local consumption but also for export to England and for trade with other colonial territories. The first European settlers arrived in Barbados in 1627 and found much of the island covered with forests. By 1700, most of this forest was eradicated and replaced with agricultural crops (Watts, 1966). Much of the landscape therefore was transformed from natural ecosystems into

agricultural ecosystems comprised of large mono-specific plantations such as sugar cane, small-scale vegetable, root crop and fruit tree cultivations, and pastures with livestock.

The land area under agricultural production in Barbados has continued to decline over the past two (2) decades, primarily through the demand for land for settlements and tourism development, particularly, hotels and golf courses. Sugarcane has long been considered the major agricultural crop, accounting for about 75% of the arable land, but has continued to decline because of reduced sugar prices, high production costs and labour shortages.

Certain local cultivars of vegetables and root crops, which were traditionally cultivated, have disappeared being replaced by higher yielding exotic varieties.

5.2.1 Agricultural Holdings

The 1989 Agricultural Census recorded 17,178 agricultural holdings with a total area of 21,560 hectares, distributed among the 11 parishes in the country (Ministry of Agriculture, Food and Fisheries, 1992) (Table 5.1 and 5.2). These holdings were categorized as producing, either sugar, vegetables, root crops, fruits, livestock, poultry, mixed or other agricultural uses.

The land occupied by agriculture in Barbados is about 50% of the total area of the island. Arable land is considered as land capable of being cultivated and having some form of production. These lands contain a wide variety of crops, fruit trees and other foliage that adds to the diversity of the agricultural resources.

Table 5.1 Agricultural Holdings in Barbados Distributed by Parish and Principal Agricultural Category.

Parish	No. of Holdings	Size of Holdings (ha)	Principal category (ha)						
			Sugar	Vegetables	Root crops	Fruits	Livestock/Poultry	Mixed	Other
St Michael	2950	837	116	33	2	93	183	401	2
Christ Church	2753	2536	815	47	7	154	46	1262	204
St George	1764	2295	350	27	2	59	39	1814	2
St Phillip	2091	3711	810	82	4	79	125	2498	113
St John	1277	2516	320	144	2	42	45	1963	0
St James	1315	1008	90	6	1	81	56	772	2
St Thomas	1122	2664	174	9	0	34	29	2411	6
St Joseph	928	1129	238	15	-	117	191	564	3
St Andrew	876	744	149	6	1	23	73	489	1
St Peter	991	2612	496	3	1	17	34	2059	1
St Lucy	1075	1507	362	48	3	221	113	760	0
TOTAL	17178	21560	3920	419	23	921	933	14996	334

As reported in the Census of 1989 (Ministry of Agriculture, Food and Fisheries, 1992).

Table 5.2 Areas of Holdings in Barbados by Parish and Land Use

Parish	Total Area (ha)	Arable Land					Permanent Pasture		Wood and Forest	Other Land	
		Temporary Crops	Temporary Meadows	Temporary Fallow	All other	Permanent Crops	Cultivated	Natural		Potential Production	Roads / Buildings
St Michael	871	320	39	61	44	94	116	92	1	9	95
Christ Church	2541	1742	45	185	104	74	10	109	6	11	255
St George	2259	1501	40	195	116	59	15	127	51	20	136
St Phillip	3772	2120	33	568	424	63	56	262	1	1	244
St John	2511	1933	28	143	62	51	14	116	32	3	128
St James	807	402	12	66	64	31	18	111	19	13	71
St Thomas	2248	1226	29	300	169	41	111	187	6	3	177
St Joseph	1180	425	76	120	169	48	16	195	10	100	120
St. Andrew	747	251	48	149	112	26	6	88	11	5	50
St Peter	2350	1479	25	444	131	19	5	113	1	0	135
St Lucy	1304	746	24	172	110	20	7	154	1	1	69
TOTAL	20590	12144	399	2404	1506	525	374	1554	138	67	1476

As reported in the Census of 1989 (Ministry of Agriculture, Food and Fisheries, 1992).

5.2.2 Agricultural Products

Crops

Agriview, the agricultural report of the Ministry of Agriculture and Rural Development for 1995, records some statistics for the following crops: sugarcane, cotton, root crops, corn, onions, other vegetables, bananas/plantains/figs, other fruits and cut-flowers and foliage. Production surveys done by the Ministry of Agriculture and Rural Development show an increase in the area under vegetable production and a decrease in sugar production over the past few years.

Fruit Trees

During the last decade mainly private growers have planted fruit trees on over 200 ha of land for local consumption. The productivity of these orchard crops has been varied due to the limitations of soil moisture and fertility, and the lack of understanding of the requirements of fruit trees (Skeete, 1995). The Soil Conservation Unit of the Ministry of Agriculture and Rural Development (MARD) produce seed and planting materials for a variety of orchard crops from its 4.2 ha nursery. The government also has about 3.3 ha under fruit crops at the Codrington Agricultural Station. Citrus, mango and avocado are in greater demand by growers.

Cut flowers and Foliage

An estimated 25.1 ha were under cut flower and foliage production in 1995 as compared to 24.2 ha in 1994 (Agriview 1995). Cut flowers are sold mainly to hotels and florists during the tourist season.

Livestock

Livestock production consists mainly of chickens, turkeys, cattle, sheep, goats, and pigs. Large-scale poultry production is done by private farmers with a stocking density of about 1 ft² per bird, however, backyard or domestic rearing of chickens and ducks is common in rural areas. Free range and semi-intensive system is practiced for ruminants, so stocking density varies according to access to grazing land and number of animals. Estimated production of livestock products is generally increasing, however importation is still required to satisfy local demand.

5.2.3 Germplasm Conservation

Sugarcane

The West Indies Central Sugar Cane Breeding Station (CBS), located in Groves, St George, is funded by Caribbean sugarcane growers and is responsible for producing disease resistant, high yielding commercial varieties of sugarcane. Its Genetic Base Broadening programme runs concurrently with its Commercial Crossing programme, utilising *Saccharum officinarum* and *S. spontaneum* as the main donor species, and to a lesser extent, *S. robustum* and *Erianthus arundinaceus*. About 30,000 varieties have been bred and are being tested for commercial application by the Agronomy Research and Variety Testing Unit of the Barbados Agricultural Management Company Limited. Over the past 21 years sugarcane breeding has produced about 20 million genotypes which are kept in cold storage. About 2600 accessions are kept in field plots, of which 12 varieties have found commercial application in Barbados over the past decade

Other crops

There is no national programme for conserving plant genetic resources in Barbados (Wickham, 1995), however, other than the activities at the CBS, sweet potato conservation is done by both the Ministry of Agriculture and Rural Development and the Caribbean Agricultural Research and Development Institute (CARDI). Cassava, yam, pineapple, onion, pigeon peas, and maize germplasm are also conserved by CARDI. The Ministry of Agriculture and Rural Development has a conservation plan for fruits and cut flowers. With respect to fruits, the Ministry has an informal system for propagation, which uses several varieties of mango, avocado and citrus on private and government lands. These fruit tree varieties, which are grown at Haggats, St Andrew and Codrington, St John, are used in the Ministry's grafting programme. With respect to germplasm, the Andromeda Botanic Garden was formerly designated a repository by the Heliconia Society International however some local flower farmers probably have more important germplasm collections.

Livestock

Stock for many of the breeds of commercially important animals have been imported, however, for cattle and goats much of the local stock are considered as "creole", which resulted from uncontrolled cross breeding and having no easily determined major pedigree.

The black belly sheep is one such commercially important animal and it is being aggressively marketed locally and internationally for its good quality meat. It is known for its prolificacy and demonstrates the ability to live under Barbadian conditions of climate, and the food availability. Improving the genetics of the black belly sheep is emphasized locally, and a high growth rate is encouraged to maximise the potential of commercial rearing. This initiative forms the basis of the Government's Barbados Black Belly Sheep Improvement Program. Within this programme,

the genetic base of the breed is improved by selecting female and male lambs based on their performance during a 120-day observation period starting directly after birth. The only Government owned farm rearing the black belly sheep is the Greenland Agricultural Livestock Research Station in Greenland, St. Andrew, which is under the MAR. However there are many private farms and privately owned sheep scattered throughout Barbados. Presently the MAR is in the process of patenting the DNA profile of the Barbados black belly sheep.



Plate: 5 Barbados black belly sheep (photo: MAR)

5.2.4 Major Impacts of Agriculture on Biodiversity

Agricultural plantations over the last 300 years have reduced the extent of natural terrestrial ecosystems to relatively small isolated patches and created several monospecific, agroecosystems, the most persistent of which has been sugarcane. This long history of intensive agriculture has contributed to erosion of topsoil, decrease in soil fertility, and subsequent large inputs of agrochemicals, particularly pesticides and chemical fertilizers, as a means of maintaining productivity. Due to the coralline nature of most of the soils in Barbados, percolation of water and subsequent discharge into subsurface water bodies as well as overland runoff, eventually reaches the sea in a relatively short timeframe. Agrochemical contamination of underground water supplies, nearshore waters and biota is not well documented for Barbados but presents a serious risk to human and animal health.

5.3 TERRESTRIAL FAUNA BIODIVERSITY

The assessment of Terrestrial Fauna Biodiversity of Barbados has been restricted to mammals, birds, reptiles, amphibians and terrestrial invertebrates of social or economic importance, namely insects and allied arthropods for the purpose of this study. For each group, the species composition is described, and information on the abundance and distribution of populations, their habitats, the threats to populations and habitats, the current and future value of populations and existing monitoring and management infrastructure is presented.

5.3.1 Class Mammalia

The only remaining extant indigenous mammals of Barbados are six species of bats, about which very little is known (Horrocks 1997). Instead, the mammalian fauna of Barbados is dominated by mammals introduced since the island was colonized e.g. rats, green monkeys and mongooses. None of Barbados' mammals are endangered, with the exception of the raccoon (*Procyon glomeralleni*) should it be proved still extant. However, the hare (*Lepus capensis*) is rare. There is no protective legislation for mammals in Barbados, either for the species themselves or their habitats. Indeed, the Ministry of Agriculture and Rural Development has offered a bounty on monkey tails since 1975. Barbados is probably one of only a few countries in the world that offers a bounty for a primate species (J. Horrocks, pers.comm.).

Order Chiroptera

Bats

Jones and Phillips (1970) list six species of bats as being present in Barbados. One of the six *Monophyllus plethodon plethodon* is an endemic sub-species, and another is an undescribed and likely endemic subspecies of *Myotis nigricans*. There is no available information on the distribution and abundance of bats in Barbados, except that the house bat *Molossus molossus molossus* is apparently common.

A general lack of knowledge about the ecology of the bats of Barbados makes it difficult to assess additional threats to populations or habitats. One or possibly two of the bats of Barbados are endemic sub-species. They are therefore unique to Barbados and of significant scientific, educational and intrinsic value.



Plate: 6 A bat found in the Jack in the Box Gully, St Thomas (photo: ESPU)

Order Carnivora

The Raccoon

The Barbadian raccoon, *Procyon gloveralleni*, is presumed to be an early human-assisted introduction to Barbados (Lazell 1972). According to Lazell, it is distinguishable from the closely related North American species, *Procyon lotor*, on the basis of its teeth. However, the specimen in the Barbados Museum is reported to not closely resemble either the North American raccoon or the South and Central American raccoon, *Procyon cancrivorous* (J. Baulu, Barbados Wildlife Reserve, pers. comm).

The last published report of a raccoon sighting was an animal killed on a road near Bathsheba, St. Joseph in 1964 (Lazell 1972). There is no published information on the habitat use of the Barbados raccoon. In the unlikely event that a viable population of raccoons still exists in Barbados, their rarity would make them extremely valuable for their scientific, educational and intrinsic values, and for their direct economic value if they were exploited as an eco-tourism attraction. There are however no efforts underway to confirm whether a viable population of Barbados raccoons remains.

The Mongoose

The mongoose, *Herpestes javanicus*, was introduced to Barbados from Jamaica between 1877 and 1879 to control rats that had become serious sugar cane pests. Mongooses are omnivorous generalists and include rats, mice, domestic fowl, lizards, frogs, cane toads (may only eat the legs to avoid toxic parts), lizards, snakes, crabs, eggs (including turtle, and perhaps tortoise, eggs), centipedes, spiders, insects, and fruit in their diets. They are considered to be amongst the most serious of invasive species globally. They have the potential to be crop pests if animal material is not readily available (Horrocks 1997b). The mongoose is likely to thrive in many types of habitats, even those that are heavily human-disturbed.

The absence of predators of the mongoose in Barbados, and its omnivorous diet, resulted in mongooses becoming numerous soon after introduction. Horrocks (1997b) reports an observation that the mongoose is less common in the areas where snakes are still found, than in other parts of the island. However, more quantitative information on the distribution and abundance of mongooses in Barbados is unavailable.

Order Lagomorpha

The Wild Hare

By 1870, hares *Lepus capensis* were common enough in Barbados that one man was reported to have shot between 200-300 hares annually (Feilden 1890). The mongoose was introduced to Barbados in the late 1870s. By 1890, the numbers of hares had declined, presumably partly in response to the growing mongoose population and partly because people had greater access to firearms. However, by the 1940s, the hare population had recovered and they were reported to be quite common. Explanations for the most recent recovery evident in the hare population include the suggestions that more of the hares' favoured crops that were being grown, that more grassland that was formerly under sugar cane is now available, and that less poisonous herbicides are being used in the fields than in former years (Horrocks 1997b).

Anecdotal reports suggest that hares are patchily distributed on an island-wide scale, primarily occurring in the higher, central area of the island (Horrocks 1997a,b). They are also patchily distributed on a smaller spatial scale, being most often observed in open grassy areas adjacent to cane fields (Marsh 1981) (see Figure 2).

There have been no efforts to monitor the hare's population or habitat requirements quantitatively. A study of the hare's biology, abundance, distribution and ecological requirements would be a necessary prerequisite to guide appropriate wildlife protective legislation. Consideration should be given to protecting hares from hunting by establishing a closed season that encompasses the primary breeding season, or by prohibiting shooting within a designated protected area(s). Consideration should also be given to the possibility of maintaining a small hare population in captivity. Efforts are currently underway to determine if the Barbados hare has diverged genetically from its European ancestors (Horrocks pers. comm.).

Order Primates

The Green Monkey

The Green monkey *Cercopithecus aethiops sabaesus* was introduced to Barbados from West Africa soon after the island was settled in 1627. Green monkeys live in troops, with an average size of 15 individuals. The typical age-sex composition is 1-2 adult males, 4-5 adult females and their offspring (Horrocks 1986). Green monkeys have been described as an extremely adaptable, semi-terrestrial, territorial species that has flourished in the human-disturbed Barbados environment. They have no predators except humans and dogs.

The first assessment of the size of the monkey population in Barbados was in 1980, at the onset of trapping by the Monkey Crop Damage Control Programme. A total of 14,200 monkeys was estimated from that survey (CARDI 1981, Boulton et al 1996). The population was assessed again in 1994 and was estimated at 14,792 (Boulton et al 1996).

Their distributional preference for wooded areas supports the evidence to suggest that the population size of green monkeys in Barbados may be limited more by the availability of woodland cover, which they use for refuge and food, than by predation (Boulton et al. 1996; Horrocks 1985).

The Barbados green monkey has been successfully marketed by the Barbados Primate Research Centre & Wildlife Reserve as a valuable natural resource for biomedical research, especially for the production and testing of vaccines and as a tourist attraction. Barbadian green monkeys are currently responsible for 75% of the world's polio vaccine production.



Plate: 7 The green monkey (*Cercopithecus aethiops sabaesus*) (photo: Dr Horrocks, UWI)

5.3.2 Class Aves

Birds

The bird fauna of Barbados is much more diverse than the island's mammalian fauna. However, much of the diversity is attributable to seasonal migrants passing through the island on their way to the South American continent towards the end of the year. The resident bird species are relatively few by comparison, the numbers of species having declined primarily due to habitat loss following the island's colonization in the 1600s and through predation by introduced mammals such as the mongoose and the green monkey.

Resident avifauna

Watson (1993) reports at least 36 species of birds as resident and confirmed as nesting in the wild in Barbados, including the first record of breeding by the little egret (*Egretta garzetta*) in the Western Hemisphere. The thirty-six species include at least sixteen exotics, eight of which occur naturally due to expanded range (although some may have been unintentionally human-assisted), and eight of which have been deliberately introduced. Most of the resident species adapt well to human-altered habitats, and are considered to be common (Watson, 1996). A few species with more specialized habitat requirements e.g. Audubon's shearwater and the yellow warbler are rare. The cattle egret (*Bubulcus ibis*) expanded its range to Barbados in 1957, but is likely to have received assistance from shipping in its original range expansion from Africa to the Western Hemisphere. It is now well established in Barbados, with at least four breeding colonies and a population size of over 14,000 recorded in 1997 (J. Horrocks, pers.comm.). The increase in the number of cattle egrets has caused concerns for aviation safety and amongst sectors of the farming community.

Parrots and parakeets nest in holes in trees and in abandoned buildings, mainly in the Greater Bridgetown area. There are about 10 pairs of parrots, mainly orange-winged (*Amazona amazonica*), nesting in the hollow palms in Belleville (in the vicinity of 7th-10th Avenue). Illaro Court, Government House, the Military cemetery, and the deserted Paradise hotel complex also provide nesting habitat for parrots (Horrocks 1997b).

Wetland and forest habitat has been severely reduced by human activity in Barbados. The Graeme Hall swamp is the only significant mangrove ecosystem remaining on the island, and includes the largest body of fresh/brackish water on the island. It has the highest avian biodiversity in Barbados. There are some concerns surrounding the recent development of part of the swamp as a nature reserve primarily for waterbirds.

Many of the island's resident avian species are protected under the Wild Birds Protection Act cap 398 (1985). This list needs updating to include missing resident species and to add visiting species in need of protection. Private citizens and institutions have also reintroduced species that formerly bred in Barbados.

Migratory birds

Over 150 species of migratory birds have been recorded in Barbados, including seabirds (e.g. gulls and terns) and shorebirds (e.g. plovers and sandpipers). Barbados lies on a major migratory flyway for the eastern North American populations of many species of shorebirds heading for South America over-winter. Thirty-five, representing the more common shorebird species, pass through Barbados between July and December. Bad weather causes migratory birds to fly low over Barbados, and the presence of suitable aquatic habitat attracts the birds to land.

The privately owned western portion of Graeme Hall swamp is being restored to attract migratory shorebirds by creating shallow foraging habitat, similar to the trays used to attract birds when the site was maintained as a shooting swamp in former years. Apart from Graeme Hall swamp, there are three other natural areas with critical habitat for migratory birds - Chancery Lane swamp, Green Pond and Long Pond. Chancery Lane swamp is located behind a well-developed coralline sand dune system on the south east coast of the island. It is seasonally filled with water and is important for both resident and migratory birds. Both Green Pond and Long Pond on the north east coast also provide important habitats for migratory birds. Green Pond is the estuary of the Greenland River. Long Pond, to the south of Green Pond, is a permanent water body fed by two small rivers. In addition to these areas of natural habitat, there are twelve artificially maintained shooting swamps where birds alight and feed. An artificial swamp called Cole's swamp, one mile to the south east of Ragged Point, is currently maintained as a private bird sanctuary. Although providing preferred habitat for species such as gallinules and gaulins, the manmade freshwater swamps are not the preferred habitat of most migratory species, which generally prefer shore or tidal marsh areas.

Winter residents

A substantial number of bird species are regular winter visitors to Barbados, e.g. osprey (*Pandion haliaetus*), purple gallinule (*Porphyryla martinica*), great blue heron (*Ardea herodias*) and little blue heron (*Florida caerula*). Graeme Hall swamp, Chancery Lane swamp, Long Pond and Green Pond provide important foraging and refuge habitat for these over-wintering species. The American redstart, *Setophaga ruticilla*, can be seen in Turner's Hall woods and in small numbers in east coast woodlands e.g. at Farley Hill, between October and April.

The winter residents have habitat needs overlapping with those of resident and migratory birds. Critical habitats include Turner's Hall woods, woodlands in the upper reaches of less accessible gullies, and the wetland areas of Graeme Hall swamp, Long Pond, Green Pond and Chancery Lane, as well as remnant swamps along the west coast of the island. There is no monitoring of winter residents aside from the information recorded by local naturalists and bird-watchers, and no management infrastructure is in place.

5.3.3 Class Reptilia

The class Reptilia in Barbados is represented by terrestrial lizards, geckos, snakes and tortoises, as well as marine turtles.

Order Squamata

Snakes

There is at least one species of colubrid snake in Barbados. The snake that many people had assumed was the endemic grass snake, *Liophis perfuscus*, for the past few decades, was identified from an incomplete specimen as *Mastigodryas bruesi* in 1997 (Underwood *et. al* 1999). This species is likely to have been accidentally introduced from St. Vincent thirty years ago. A confirmed sighting of *Liophis perfuscus* has not been made since 1961 (Emsley 1963). There is also a worm snake, *Leptotyphlops bilineata*. This snake grows to about 9cm and is dark brown with two yellowish stripes down the sides. The status of the worm snake is unknown.

The habitats in the area of the island where snakes are most commonly sighted seem cooler and damper than many other parts of the island (Horrocks, pers. comm.), although it has been suggested by a local resident that the mongoose may be rarer in the area where snakes are found. Horse Hill, an area where snake sightings are relatively frequent, straddles the wooded areas of the northern end of Hackleton's Cliff and that of Joe's River. Relatively inaccessible woodland areas in the vicinity of Joe's River and Hackleton's Cliff may be functioning as last refuges for one or both snake species.

Both colubrid snake species are likely to have been affected by human, rat and mongoose predation, but *Mastigodryas* may have fared better because of its more arboreal habit. Habitat disruption or loss may have also played a significant role. Joe's River became an experimental area for growing tree crops in the 1960s, and it is possible that the land clearance and pesticide use associated with this type of agriculture may have contributed to *Liophis*' disappearance (Horrocks 1997a). Periodic fires in cane fields that spread to adjacent gullies and sour grass pastures may also be a significant mortality factor. If it is not already extinct, *Liophis* is certainly one of the world's rarest species, and there is therefore an urgent need to assess its status and initiate a conservation programme.

Lizards and Geckos

Confirmed endemic lizards in Barbados are the tree lizard (*Anolis extremus*) and the leaf-toed gecko (*Phyllodactylus pulcher*). *A. extremus* is the only anole on Barbados, is common, and is found throughout the island. *Phyllodactylus*, the Barbadian leaf-toed gecko, is reported from Ragged Point, St. Philip, but its range has not been systematically investigated.

The other extant reptiles of Barbados include the large teiid ground lizard *Kentropyx borkiana*, which Corke (1992) considered to be rare in Barbados. This species is primarily distributed in the central parishes of the island, particularly St. Thomas and St. George, where it can be locally quite common, and has also been reported from St. Michael and St. James in recent years (Horrocks 1997a). Feilden (1889) stated that the species was once common in Chancery Lane, but there have been no reports in recent times. *Kentropyx* is more ground dwelling than *Anolis*,

and is likely to have been more seriously affected by domestic cat and mongoose predation. The other terrestrial reptiles in Barbados are a small, bronze and black burrowing ground lizard *Gymnophthalmus underwoodi*, a bronze coloured skink *Mabuya mabouya* (possibly extinct), and a gecko *Hemidactylus mabouia*. *Hemidactylus*, the wood slave, is thought to be an introduced species (Corke 1992) although its introduction to this hemisphere may have been far earlier than originally thought and is commonly seen in houses. Although the species discussed in this paragraph are known not threatened, there is a need to conduct quantitative surveys to assess their abundance.

There is insufficient knowledge of the abundance of lizards and geckos and of their habitat requirements to know what factors may be threatening them. However, lizards and geckos are often sprayed with insecticides if seen inside houses. Lizards are consumed both by exotic predators (e.g. mongoose and cattle egrets, see Horrocks 1993) and domesticated predators (i.e. cats).

Order Chelonia

This order includes all tortoises and turtles. There is one species of tortoise in Barbados, the red-footed tortoise, *Geochelone carbonaria*¹. It is unlikely that these reptiles have a viable breeding population in the wild, since individuals encountered outside of captive environments have always proven to escape from those environments. There are two species of marine turtles nesting in Barbados (*Eretmochelys imbricata* and *Dermochelys coriacea*) and another species that only feeds in the nearshore waters of the island, *Chelonia mydas*.

Tortoises

Ray (1964) reported a giant tortoise, *Geochelone* sp. now extinct, from fossilised remains found at Spring Bay, St. Philip. For much of this century there has been a captive population of *Geochelone carbonaria* in Barbados. Captive tortoises (often marked for identification) frequently escape into the wild, but it is not known whether there are sufficient numbers of wild animals to form a breeding population, or whether the vulnerable hatchlings could survive predation pressure, particularly from the mongoose. Given no remains of *Geochelone carbonaria* either fossilised or associated with prehistoric settlements, and no mention of tortoises by early writers of Barbados' natural history, it seems most likely that the red-footed tortoise was introduced to Barbados subsequent to Schomburgk's 1848 Natural History of Barbados (Horrocks 1997a, see also Censky (1988) and Corke (1992).

1

The latest herpetological data available (TFH Atlas of Reptiles and Amphibians) reclassifies the new world tortoise under the genus *Chelouridis*.

There is a substantial breeding group of *G. carbonaria* held in captivity by the Barbados Wildlife Reserve. There was previously another large breeding group held at the Oughterson Zoo Park, but this Park is no longer in existence. A breeding colony of 25 adults, which have consistently produced about 100 hatchlings per annum, is held by Exotic Tropical Import Export and is probably the second largest breeding group of *G. carbonaria* in Barbados. There are also believed to be several breeding groups held at private residences.

Given the amount of gully woodland remaining on the island, there is probably not a shortage of suitable habitat. However, mongoose and rat predation on hatchlings is likely to be high.

Turtles

There are two species of marine turtle nesting in Barbados. They are the Critically Endangered (IUCN, 1996) hawksbill turtle, *Eretmochelys imbricata*, and the Endangered (IUCN, 1996) leatherback turtle, *Dermochelys coriacea*. The hawksbill is valued for its meat, eggs and shell, and current estimates suggest that 100 – 120 hawksbills nest in Barbados each year (Horrocks, pers. comm.). Since there are 2-3 year gaps for an individual female between nesting seasons, this gives a total population of about 250 adult females nesting in Barbados. About ten leatherback females are estimated to nest in Barbados each year. The numbers nesting in Barbados may always have been relatively small compared to some other Caribbean islands.

Marine turtles generally show high levels of nest site fidelity, returning repeatedly to the same beach or beach stretch to nest. The hawksbill primarily nests on the west and south west coasts (Horrocks and Scott 1991, Vermeer 1994), and on the east coast at the wave-sheltered Bath beach. Less frequent nesting occurs on north east coast beaches (e.g. Abbotts Bay), along the East Coast Road and on south east coast beaches (e.g. Peat Bay, BelAir, Long Beach). The most important hawksbill nesting site on the island is between the Hilton and Coconut Court hotels on the south west tip of the island e.g., over 150 nesting activities were recorded during the 1997 nesting season (Poponi et al. 1998). The leatherback nests primarily between Morgan Lewis and Cattlewash. Other sites where leatherbacks have been recorded nesting occasionally is on Brandons, Southern Palms and Miami Beach.

The spongivorous hawksbill forages primarily on the bank reef along the west coast and on south coast patch reefs, and the Endangered (IUCN, 1996) green turtle, *Chelonia mydas*, is reported to forage on algae and sea grass at ten main nearshore sites (North Point Resort, Barclays Park, Congor Bay, Consett Bay, Foul Bay, Long Bay, Casuarina, Hilton (Castle Bank), and Carlisle Bay; see Horrocks 1997b). The leatherback leaves Barbados to forage in more temperate waters immediately after finishing its nesting season.

Critical hawksbill nesting beaches are found particularly along the west and south coasts. Horrocks (1992) provides a detailed account of the stresses facing nesting turtles in Barbados. Apart from predation by man, three problems are particularly severe for hawksbills nesting on the south and west coasts. These are buildings or enclosures that are constructed too close to the

high water mark, thereby preventing turtles from finding a suitable area of dry beach on which to lay their eggs, beach armouring that similarly prevents females from nesting, and beach lighting that disorients adult females and hatchlings.

The three primary problems, apart from predation, facing nesting hawksbills and leatherback turtles on the east coast are sand mining, vehicular use of beaches, and oil/solid waste pollution of beaches. Sand mining, particularly in the Green Pond/ area, has the potential to destroy nesting habitat for leatherback turtles. Use of 4-wheel drive vehicles on the beach damages beach vegetation and crushes turtle nests, and tyre ruts prevent hatchlings from reaching the sea. Solid waste on beaches can impede the access of females to nesting sites and, once buried, can prevent hatchlings from emerging from nests. Chronic tar pollution may contaminate beaches and interfere with incubation (Horrocks 1997a). Coral reefs and seagrass beds are negatively affected by components of land run off such as high sediment load and sewage pollution, as well as poor boat anchoring practices and over-fishing.



Plate: 8 A green turtle (*Chelonia mydas*) being fed by a diver (Photo: ESPU)



Plate: 9 A hawksbill turtle (*Eretmochelys imbricata*) being observed by a diver (photo: ESPU)

5.3.4 Class Amphibia

Order Anura

Frogs and Toads

The Order Anura includes frogs and toads. There are only two species of amphibians in Barbados, the cane toad, *Bufo marinus*, and the whistling frog, *Eleutherodactylus johnstonei*. Both species are thought to have been introduced, and the cane toad is considered to be amongst the worst of invasive species.

The Cane Toad

Schomburgk (1848) reported that the cane toad was introduced in the 1830s to control insect pests of sugar cane. The toads are now abundant and widespread across the island, particularly in rural areas.

Cane toads have a broad diet and consume small vertebrates as well as invertebrates, which would presumably include the eggs and nestlings of ground nesting birds. The toxic dorsal skin of the toads protects them from most predators, although they do fall prey to some e.g. the mongoose, which attacks their unprotected legs. The toads are known to lay their eggs in large puddles, streams and ponds.

There has been no survey of cane toads to assess their population, but there is no reason to believe that numbers are threatened, and no reason to be concerned if they are, given their invasive impacts on native fauna. Mongooses do successfully attack toads, but they are unlikely to be a preferred food. Toads are particularly susceptible to being run over by vehicles on roads at night during and following heavy rain, and being amphibians they are generally particularly vulnerable to habitat alteration because they require both terrestrial and aquatic habitats to complete their life cycles. The potential impacts of pesticides/herbicides on adults or eggs have not been investigated.

The Whistling frog

Whether the whistling frog *Eleutherodactylus johnstonei* is indigenous to Barbados is controversial. Marsh (1983) points out that Ligon (1657) described a noise in the woods like that of whistling frogs, without knowing what kind of animal he was hearing. Feilden (1889) claims that whistling frogs were not known in Barbados in 1869, but were found island wide twenty years later. Schwartz (1967) considers them to have been introduced to Barbados in about 1879 (see Horrocks 1997b).

A primary predator on whistling frogs is the cattle egret (*Bubulcus ibis*). Stomach content analysis revealed that egrets nesting at a former colony located at Frizers, St. Andrew consumed an average of 3.63 frogs/bird every one to two days (Horrocks 1993). However, given the densities of frogs recorded by Ovaska (1991), at present population sizes, egrets are unlikely to be negatively affecting the frog population. Agricultural and household pesticides may be having an effect on adult and egg mortality. One pest exterminating company reported that they were regularly asked to spray houses, particularly rented properties on the west coast, to remove whistling frogs.

The sound of whistling frogs at night is an intrinsic part of the nocturnal background noise in Barbados, which would probably be missed should the species decline or disappear. However, *Eleutherodactylus johnstonei* is considered to be an invasive species in some Caribbean islands (Horrocks, pers. comm.).

5.3.5 Class Insecta and Allied Arthropods

Insects

Aside from investigations of pests of economic importance, their natural enemies and other associates, there have been few efforts to systematically collect any taxonomic groups of insects in Barbados. The most up to date list of insects and allied species of arthropods is that of Bennett and Alam (1985). Bennett and Alam's list includes approximately 1,320 species, which is three times the length of the list provided by Tucker (1952).

There is no quantitative information on the distribution and abundance of insects and allied species on a species by species basis in Barbados except for significant crop pests such as the diamond-back moth *Plutella xylostella* (Jones 1985, Gibbs 1993), or significant livestock parasites e.g. the tropical bont tick (*Amblyomma variegatum*). The library at the Caribbean Agricultural Research and Development Institute, Cave Hill Campus has an extensive collection of insects, and literature on pest insects and allied species.

Insects cause damage to crops and disease to livestock and animals (e.g. tropical bont ticks carry the causative rickettsia or heartwater fever in cattle and mosquitos cause dengue fever in humans). However many insects are also beneficial to agriculture and natural plant communities. Apart from being predators or parasites of insect pests, they are also pollinators of crop plants and important in maintaining soil fertility. Conservation of Barbados' insect and allied arthropod fauna provides options for future biological control of pests.

5.4 BIODIVERSITY OF MARINE AND FRESHWATER HABITATS

The marine and freshwater habitats of Barbados support a diverse collection of living organisms. Brief descriptions of each habitat in terms of its location, description (main features), status and biodiversity are presented in the following sections.

5.4.1 Wetlands

The Graeme Hall Swamp is the largest body of inland water in Barbados with the largest remaining area of red mangroves (*Rhizophora mangle*) and white mangroves (*Laguncularia racemosa*). It provides a watering hole for many migratory birds and a permanent home for several resident birds including the locally rare and endangered red seal coot (*Gallinula chloropus barbadensis*) and the yellow warbler (*Dendroica petechia*). The Graeme Hall Swamp also serves as a sanctuary for juveniles of marine fish. Biodiversity for Graeme Hall Swamp includes several species of fish, crustaceans, insects, amphibians and wetland plants.

There are also smaller wetlands at Chancery Lane, Christ Church and at Long Pond, St. Andrew. The Chancery Lane wetland is only site where the *Conocarpus erectus* can be found. There is also a number of permanent surface catchments, the major ones being the Careenage, Bridgetown; Holetown Hole, St. James; Salt Pond, St. Peter; Maycocks, St. Lucy; Bawdens, Green Pond, Hillaby, St. Andrew; Joe's River, St. Joseph; Bathsheba, Codrington and Consett, St. John; Culpepper and Three Houses, St. Philip.

5.4.2 Water Catchments

The permanent surface freshwater catchments for which biodiversity has been reported are Bawdens, Long Pond, Green Pond, Hillaby, Bathsheba, Conset, Codrington, Three Houses and Culpepper. Known biodiversity in permanent and temporary freshwater catchments include several species of shrimp. Other than Turnbull (1979) who studied the water quality and benthic communities in the Careenage, there have been no other published studies of the biodiversity in the fresh and brackish water catchments. Biodiversity reported for the Careenage includes several species of Foraminiferans, Sipunculids, Mollusks, Annelids, Crustaceans and Echinoderms.

5.4.3 Rocky Intertidal Areas

The intertidal area is that area that straddles the marine and terrestrial habitats where the shore is washed by the sea at low or high tides. Organisms inhabiting the intertidal areas are exposed to harsh and highly variable conditions such as heavy wave action, periodic desiccation and high temperatures. The intertidal area in Barbados may be categorized as sandy or rocky. Rocky shores predominate along the north and southeast of the island, while the rest of the coast is dominated by sandy shores, interrupted occasionally by rocky areas. In some rocky areas there are limestone platforms that retain water at low tide to form tidepools. Both the rocky areas and the tidepools provide habitats for a diverse collection of living organisms. Lewis (1960) reported three categories of rocky intertidal areas:- local rocky cliffs, pebble beaches and low-lying platforms.

Rocky Cliffs

Lewis (1960) described the local intertidal rocky cliffs at River Bay, Bathsheba, Consett Bay, Silver Sands, Oistins and Payne's Bay. Other investigations revealed that the rare plant species *Heliotropium microphyllum* and *Strumpfia maritima* are located on some of the rocky cliffs of Barbados. There is a need to assess the present status of cliff biodiversity and factors impacting on the biodiversity, and to recommend measures required to conserve the biodiversity and the habitat within which it exists.

Pebble Beaches

The pebble beach is characterized by having pebbles, boulders and outcrops of limestone along the outer edge of the beach, and a reef flat extending from the beach seaward for several metres. Lewis (1960) described the pebble beaches located at Tent Bay, St. Joseph. Since that study, there has been no update of information on the biodiversity of pebble beaches at Tent Bay.

Low-Lying Platform

This type of rocky shore is characterized by a low-lying platform that slopes gently upward from the sea towards the land. The following four zones are visible on low-lying platforms: surf zone; Fissurella zone; boulder zone and a Neritina-Ulva zone. Low-lying platforms are located at Six Men's Bay, Stroud's Bay and Sam Lord's Castle.

Tidepools

Tidepools are found mainly along the north, east and southeast coasts of Barbados. Tidepools play an important role as nursery habitat (Mahon and Mahon, 1994) and a significant role in recruitment (Halcrow et al, 1998) for some reef fish. An assessment of the role of tidepools in recruitment of juveniles to commercial fisheries is required.

The plateau at Martin's Bay on the east coast is protected from the full force of the wave action by headlands and an offshore reef. The plateau measures about 50m at the widest point in the onshore-offshore direction and about 200m in the long-shore direction. Shoreward, the plateau is bounded by the beach. The seaward edge, where the plateau drops off, is honeycombed with burrows of the sea urchin, *Echinometra lucunter*. The surface of the plateau is covered with a mat of algae and dotted with depressions, which become pools at low tide. The sides of the pools are usually vertical with holes and undercuts. The substrate may consist of bare-sand, sand with turtle grass (*Thalassia testudinum*), rock covered with algae or limestone rubble.



Plate: 10 A tidepool site at Bathsheba, East Coast (photo: ESPU)

5.4.4 Seagrass Beds

Seagrasses are marine flowering plants with extensive root and rhizome systems, dense leaf development and high growth rates, (Vermeer, 1997). Four species of seagrasses have been reported for Barbados (Delcan 1994, Vermeer 1997). They are *Thalassia testudinum* (turtle grass), *Syringodium filiforme* (manatee grass), *Halodule wrightii* (shoal grass), *Halophila* sp.. Seagrass areas, like coral reefs, are highly productive areas. They play an important role:

- as primary producers in the food chain of the reef community;
- in fixing nitrogen;
- in providing habitats – feeding, breeding, recruitment sites and nursery grounds - for juveniles and adults of reef organisms including the major commercial species;
- in reducing sediment movement in nearshore waters and removing sediments from the water column;
- in decreasing turbidity of the water; and
- in stabilizing the coastline.

Seagrass areas, commonly known as seagrass beds or meadows, are distributed along the coast in shallow water where sunlight penetration is adequate to facilitate photosynthesis. Delcan (1994b), reported seagrass beds along the west coast at Shermans, Six Men’s Bay, Speightstown and Brighton; along the southwest coast at Bridgetown, Hastings, Rockley, Worthing, St.

Lawrence, Dover, Maxwell, Welches, Oistins, Enterprise and Atlantic Shores of Barbados; and along the east coast at Bath and Conset Bay.

There is evidence that the quality of the local coastal marine water is deteriorating due to increased sedimentation, eutrophication and sewage pathogens, localised increases in temperature, decreases in salinity, and perhaps increases in toxins (Delcan, 1994a). There is also evidence to suggest that grazing by fish and sea urchins is an important mechanism for recycling nutrients within the beds. Heavy fishing pressure that results in the removal of these animals can therefore also negatively affect the vibrancy seagrass beds. Physical damage in coupled with poor water quality will negatively impact on the vibrancy of seagrass beds. It is therefore probable that the local seagrasses are being impacted negatively by many coastal activities and land based sources of pollution and urgent attention must be given to ways of minimizing these impacts.

5.4.5 Coral Reefs

The coral reef communities are of immense ecological and socio-economic importance to Barbados. Ecologically, the coral reefs contribute significantly to the national biodiversity by providing shelter, feeding and breeding grounds, recruitment sites and nursery grounds for a diverse collection of adult and juvenile marine organisms. In addition the coral reefs contribute to food supplies by supporting several commercial fisheries. Many medicinal properties of coral reefs are also presently being discovered and this phenomenon will have important ramifications for Barbados. Socio-economically, the coral reef communities with their diverse marine life and associated white sand are of tremendous aesthetic, recreational and educational value to both visitors and locals. Coral reefs also contribute to employment and foreign exchange earnings. In addition they are important for coastline protection from erosion and for providing sand as the source of beach nourishment.

Barbados is for the most part surrounded by a narrow shelf, with the 200 m isobath lying approximately 2 - 3 km offshore. The coastline can be divided into five sections, west, southwest, southeast, east and north, each with its own characteristics. The total area covered by the bank reefs is estimated at 4.9 km², while the fringing reefs cover 1.4 km². The fringing reefs generally have three (3) distinct zones - back reef, reef flat, and the spur and groove zone, while the bank reefs are characterised by a narrow crest and steep landward and seaward slopes.



Plate: 11 Sponge on a Barbadian reef (photo: ESPU)

5.4.5.1 West Coast

The west coast is relatively calm with little or no surf and is characterised by a sloping shelf on which fringing reefs grow. These reefs generally extend 300 m out from the beach and to a depth of 10m. Extending from these reefs are the patch reefs, which terminate at 30m and seaward of the patch reefs are two ridges which run approximately parallel to the shore. The inner reef is found 700 -900 m offshore and the outer reef between 1300m and 1 km. These are the bank-barrier reefs.

5.4.5.2 South-west Coast

The southwest coast is periodically exposed to Atlantic swells, with moderate surf. There are generally relic, fringing reefs, then a gently sloping sandy shelf and in depths of 6 - 15m

extensive patch reefs. At approximately 1000m from shore, the bank reef runs parallel to shore and is continuous with the west coast bank reef.

5.4.5.3 South-east Coast

The southeast coast is fully exposed to the Atlantic swells and there is heavy surf. There are no actively growing fringing reefs in this area. There is however a flat, shallow bank reef, 400-800m from shore running roughly parallel to it.

5.4.5.4 East Coast

The east coast is fully exposed to Atlantic swells. Limestone pavements dominate the southern areas, a generally gently sloping featureless ramp extending from the beach out to 40-60m. Off the Scotland District and further north (off Pico Tenerife), the bottom type changes abruptly as a result of a submarine canyon. To the north of the canyon the shelf is terraced and carbonate rich, while to the south there is more siliclastic material and a gentler slope.

5.4.5.5 North Coast

The north coast has a rock terrace which extends seaward from the base of the cliffs (90 - 100m high) out to 40 - 60m. At the end of this is a ridge, which runs parallel to shore, and further seaward is another terrace and isolated ridges and mounds. The north west coast in particular is well sheltered and supports the most extensive and diverse hard coral reefs on the island.

5.4.5.6 Status of Coral Reefs

The Bellairs Research Institute has carried out quantitative coral reef surveys on Barbadian coral reefs for the Coastal Zone Management Unit, since 1982. The initial surveys were concentrated on the west coast, with the south coast surveys being included in 1987. These surveys are carried out at 5-year intervals. The east, northeast and southeast coasts were included in 1997 as part of the Coastal Conservation Project, Phase 1. In general, health status was indicated by live coral cover and coral species diversity. Commencing April 2002, the Unit will carry out quarterly video monitoring of specific coral reefs.

5.4.5.7 Coral Health

Studies conducted have revealed that generally, there has been significant deterioration in the health of the coral reefs, with slight increases in coral abundance being found on the west coast fringing and south coast patch reefs during the last monitoring event in 1997. The bank reefs are generally in relatively good condition, although some deterioration and signs of disease have been observed. From the initial surveys carried out on the Atlantic coast, it appears that the reefs are relatively healthy and support a rich and diverse community of marine fauna in particular.

On the west and south coast bank reefs, hard coral abundance decreased from an average of 42.1% in 1987 to 30.69% in 1997. Macroalgae abundance increased during the same time period. Hard coral abundance increased on the west coast fringing reefs from an average of 8.89% in 1987 to 12.86 in 1997, and on the south coast patch reefs from 8.7% in 1987 to 19.9% in 1997. On the south coast macroalgal abundance decreased while on the west it increased in abundance. The primary cause of reef deterioration appears to be eutrophication, and on the west coast in particular, coupled with the decimation of *Diadema antillarum*, the black sea urchin. In 1983 mortality of *Diadema antillarum* occurred at Barbados with the epidemic reaching its peak in early September. This phenomenon had a great impact on Caribbean reefs, as these animals were some of the primary grazers on coral reefs. With their demise, there was a corresponding increase in algal abundance on coral reefs.

5.4.5.8 Anthropogenic Threats To Coral Reef Biodiversity

Eutrophication

This is thought to be the primary cause of coral reef degradation in Barbados, resulting from a combination of sewage, fertilizer and pesticide use. The Government has embarked on a sewage treatment project for the south and west coasts of the Island largely as a result of the identification of this problem. In addition, the Marine Pollution and Control Act was passed in 1998 in order to control land-based sources of pollution.

Diver/Anchor Damage

As in all dive destinations, divers here have impacted on the reef systems by both intentional and unintentional practices. PADI is the main diver certification body on the Island and as part of their course, simple aspects of coral safety and marine ecology are taught in order to educate divers about the importance of these ecosystems and ways in which they can minimise damage to them. In addition, a series of permanent moorings have been installed in a joint public and private sector activity, in order to eliminate the threat of anchor damage. Draft dive legislation in which anchor damage is an offence has been accepted by Parliament. The destruction of corals by any means is also an offence under the Coastal Zone Management Act and the Fisheries Regulations.

Over Fishing

Over fishing is evident in the decreases in fish numbers as well as decreases in the average sizes of especially the reef fish caught. Fish counts taken during the coral reef monitoring surveys have indicated that decreases in the number of grazers coupled with the *Diadema* die off in the 1980's resulted in significant overgrowth of corals by algae. This situation, however appears to be improving. The Fisheries Division of the Ministry of Agriculture and Rural Development has

also initiated the implementation of their Fisheries Management Plan, which is aimed at producing a sustainable fishery as well as providing protection to the coral reefs.

Poor Construction Practices

Coastal construction usually results in sedimentation, which has a deleterious effect on corals. It is stipulated that turbidity coastal measures must be utilised during these activities.

Harvesting

The harvesting of corals is carried out on a limited scale, primarily for sale to tourists. This practice however has become an illegal activity under the Coastal Zone Management Act, passed by Parliament in 1998.

5.4.6 Fisheries Resources

The local fishery may be divided into four groups, based on the area in which the fish are found. These are *nearshore shallow shelf resources*, *offshore deep slope resources*, *coastal pelagic resources* and *offshore pelagic resources*.



Plate: 12 A school of striped grunts (*Haemulon striatum*) (photo: ESPU)

5.4.6.1 Nearshore Shallow shelf Resources

Nearshore coral reefs and associated habitats (seagrass, rubble) provide habitat for many of the species that are harvested by fishers. The main fishery resources are coral reef fishes, sea urchins, and lobsters. Small quantities of conch and octopus (sea cat) are also harvested.

Shallow-shelf reef (trap or pot) fishery

The main nearshore fishery resources inhabit the fringing reef and seagrass beds all around Barbados, however, the fishery is concentrated on the more protected south and west coasts because of the difficulty of setting fishing gear in east coast sea conditions. The shallow-shelf reef fishes are harvested mainly by wire-meshed, wooden framed Antillean traps, and to a lesser extent handlines, seine nets and spear guns. At least 60 species have commercial importance. Small, open boats with outboard engines (moses) are the most commonly used vessels for harvesting shallow-shelf reef fishes. Dynamite, poison and noxious substances, though prohibited under the Fisheries Act (1993-6) are rarely used in harvesting. The potential yield is unknown due to lack of accurate time-series of biological or catch and effort data.

Sea Urchin Fishery

The main fishing areas for the sea urchin or sea egg *Tripneustes ventricosus* are located on the east and southeast coasts and to a lesser extent on the northwest coast. Both sexes are harvested for their gonads, which are considered to be a delicacy. Sea urchins are harvested close to shore by divers using masks, snorkels and fins or SCUBA. It should be noted that in 1998 Government banned the use of SCUBA for the harvesting of sea eggs. Between the mid-1980's and 2000 the size of the local sea urchin stock had declined to a level that was too low to support a viable fishery. However, following very successful recruitment in 2000, stock size increased dramatically making the 2001 fishing season the most successful harvest recorded in decades. The sustainability of the stock and the fishery in the future relies heavily on prudent management of the fishery.

Spiny Lobster

Adult lobsters are commonly found in coral reefs from 4 – 40 metres and also in deep-slope habitats (rocks and coral rubble) at depths down to 200 metres. Juveniles inhabit shallow coastal habitats such as seagrass, coral rubble, benthic sargassum and coastal defence structures. As the juveniles grow older and larger they gradually move into deeper water, coral reefs and deep slope habitats. Lobsters are taken along with reef fish in the shallow shelf trap fishery as well as with snappers in the deep slope trap fishery. The lobster fishery is a minor fishery. There is also a relatively minor lobster-specific fishery with lobsters being captured mainly along the east coast by skin or SCUBA divers using spears. The potential yield of the local lobster fishery is

unknown. The Fisheries Division does not collect biological or catch and effort data on lobsters. However, anecdotal information suggests a possible increase in abundance in recent years.



Plate: 13 The Caribbean spiny lobster (*Panulirus argus*) at the Cornwallis site in Carlisle Bay (photo: ESPU)

Sea Turtles

The hawksbill (*Eretmochelys imbricata*) and the leatherback (*Dermochelys coriacea*) nest on local beaches, while the green turtle (*Chelonia mydas*) forages in nearshore waters. The loggerhead turtle (*Caretta caretta*) is occasionally caught by fishermen in open waters. The turtle fishery was a minor fishery of little economic importance. Internationally, stocks are severely overexploited and, in some cases, threatened with extinction. All turtles found in Barbados are on the list of endangered species included under the Convention on International trade in Endangered Species of Wild Fauna and Flora (CITES) to which Barbados is signatory. In response to the threatened status of these animals, in 1998 Government imposed an indefinite ban on the harvesting of turtles, disturbing of their nests and the sale of turtle products.

Conch

Small quantities of two species of conch are harvested in Barbados. The queen conch (*Strombus gigas*) is harvested mainly along the south coast. The helmet conch (*Cassis madagascariensis*) is harvested along the northwest coast. Both species are harvested for the shells, which are sold as curios. The flesh is also consumed but usually not sold on the open market. There is no accurate information on the local status of these species of conch. However, the queen conch population is believed to be small compared to other islands in the Caribbean and restricted to deep water, while that of the helmet conch is restricted to the northwest coast in relatively shallow waters. The queen conch is listed in CITES Appendix II. Management plans for the conch fishery have been included in the 2001-2003 Fisheries Management Plan.

5.4.6.2 Offshore Deep Slope Resources

Snapper Fishery

The snapper fishery targets snappers on the deep-slope and outer bank reefs, especially, on the south and west coasts. Handlines are used to fish queen snappers (*Etelis oculatus*) and vermilion snappers (*Rhomboplites aurorubens*), while traps set on the slopes and banks are used to target silk (*Lutjanus vivanus*), and vermilion snappers. The annual estimated catches for the period 1986-95 ranged between 30 to 60 MT (Fisheries Division, 1997). The fishery is practised year round by a few fishers and seasonally (during summer months) by others. These resources are considered as under-exploited. The total potential yield from the slopes of Barbados is estimated at around 18 to 80 tonnes/year (FAO, 1990). Snappers are a highly priced and high demand species.

5.4.6.3 Coastal Pelagic Resources

This fishery targets the small, schooling pelagic fish resources within 2 km from shore. Seine nets are used mainly to target carangids (commonly known as jacks and cavalli). A variety of trolling and hand-lines from “moses” or launches are used to capture a number of species including small tunas (locally known collectively as blowgoats), Spanish mackerels and small kingfish. Castnets are used to capture small schooling pelagics such as herrings and silversides, which are used mainly as bait. The status of most of the coastal pelagic resources is unknown. Annual estimated catches of jacks and small tunas from 1986-95 ranged from about 8 to 40 MT, with no clear trends.

5.4.6.4 Offshore Pelagic Resources

Large Pelagic Fishery

The large pelagic fishery is an offshore fishery which targets a number of different species. The most important large epipelagic (surface) species are dolphin fish (*Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*), although many other species of tuna, shark and billfish are also taken. The most important sub-surface pelagic species are yellow fin tuna (*Thunnus albacares*) and swordfish (*Xiphias gladius*), although several species of shark and other billfish (blue marlin, white marlin and saltfish) are commonly taken. The large pelagics are believed to be of two groups: Caribbean stocks that migrate within the area of the Lesser Antilles e.g. dolphin fish; and Western Atlantic stocks or oceanic stocks (e.g. yellow fin tuna, swordfish, wahoo) whose range extends throughout at least the Western Atlantic. The fishing methods include the traditional trolling and lurk-lining for surface species, and the more recently introduced longlining for sub-surface pelagics. The International Commission for the Conservation of Atlantic Tunas (ICCAT) reports that many of the large tuna species and all of the billfish species, in the Atlantic in general, are either fully exploited or overexploited. The status of most other tuna and tuna-like species in the Western Atlantic and Caribbean is uncertain.

Flyingfish Fishery

The flyingfish fishery is the “mainstay” of the local fishing industry. Flyingfish accounts for over 50% of total landings in most years. Annual estimated catches of flyingfish between 1986 and 1995 ranged from about 1200 to 2800 MT. The effort directed at flyingfish increased since the 1980's by expansion of the number and the capacity of flyingfish vessels. The four-winged flyingfish *Hirundichthys affinis* comprise over 90% of the total flyingfish catch. Other fish species taken in this fishery include margined flyingfish, known locally as guineaman, (*Cypselurus cyanopterus*) and turpits (*Canthidermis* sp.).

5.4.7 Marine Mammals

Current information on marine whales is based on unpublished data collected by Dr. Julia Horrocks of the University of the West Indies. Barbados does not have a resident population of whales, however several species are known to migrate through Barbadian waters. A local whale fishery existed up until the early years of the 20th century, targeting the humpback whale.

However, all the species recorded in Barbados (Horrocks, unpub. info.) are considered to be depleted. Consequently, all are listed under the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) and some under the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Animals.

5.4.8 Conclusion

The local marine and freshwater ecosystems support many habitats where a diverse collection of aquatic organisms interact with each other, feed, grow, reproduce and find shelter. The diversity and survival of these organisms depends on the water quality of the ecosystems. The information reviewed for this assessment indicates that 990 genera and 1548 species of organisms have been identified in the marine and freshwater ecosystems of Barbados. However, there are several organisms that have not yet been identified to the species level.

There are indications that the marine and possibly the freshwater ecosystems are under stress. The nearshore benthic marine communities has been degraded primarily by deteriorating water quality, arising mainly from increased sedimentation, eutrophication and sewage pathogens, localised increases in temperature, decreases in salinity and perhaps increases in toxins, overfishing, physical damage (Delcan, 1994a) and use of destructive fishing methods, such as dynamite.

Delcan (1994a) identified surface water runoff and groundwater discharge as main mechanisms by which terrestrial pollutants (nutrients, suspended solid material and sewage pathogens) enter the marine environment. By extrapolation, it is likely that similar pollutants are also entering the surface water catchments, since the catchments also receive water from surface water runoff and groundwater discharge.

5.5 LAND RESOURCES

Land is one of the most important natural resources in Barbados due to its scarcity in this developing small island state. Barbados has a total land area of 430 km² and an EEZ of 167,000 km², which is approximately 388 times larger than its land area. Approximately 43,000 ha of available land existed in 1989, of which 21,000 ha were classified as arable at that time, (The Environmental Unit, Consumer Affairs & the Environment, 1992).

Barbados has a well-developed physical and social infrastructure including transportation networks. The island also has one of the highest population densities in the world. These factors over time have led to the rapid expansion of development throughout the country, and resulted in the existence of very few areas that can be considered remote. Consequently, the island's terrestrial biological diversity is limited and restricted in range, and the existing natural habitats are constantly under threat from the encroachment of human activity.

The above-mentioned anthropogenic pressures on land use and by extension the biodiversity assets of Barbados, have been inadequately addressed in the past. Developments, including golf courses and other tourism developments, scattered residential and commercial development occurring outside of the "Urban Corridor", rural subdivisions, and intensive mono-culture agriculture, are among the contemporary issues with the potential to impact negatively on the island's biodiversity. These issues, coupled with the island's relatively scarce land resource

endowment, create an even greater need for specific strategies to conserve biodiversity in Barbados.

5.5.1 The Evolution of Current Land Use Patterns

Barbados' early economic wealth was based primarily on the production of sugar. The large-scale clearing and cultivation of land has therefore greatly influenced the patterns of land use that have developed on the island. Agricultural production was the primary occupation of early settlers to Barbados, both for export to England and for trade with other colonial territories. As early as the 17th century, large sugar estates dominated the island. Much of the landscape therefore was transformed from natural ecosystems into agricultural ecosystems comprised of large mono-specific plantations such as tobacco and sugar cane, small-scale vegetable, root crop and fruit tree cultivation, and pastures with livestock.

The activities associated with operating the large sugar estates influenced the establishment of the early transportation routes. A network of 'cart roads' developed on the island to service the industry, primarily linking the estates to the port of Bridgetown for shipping sugar, rum and molasses overseas. Bridgetown, and on a smaller scale, Speightstown and Oistins, also served as commercial centres for supplies and materials, as well as meeting places.

The emergence of tourism as a viable industry began in the 1950s, and with it the 'urbanization' of the south and west coasts of the island. The land on these coasts, with very accessible coral sand beaches, made these areas particularly attractive for tourism and up-market residential developments. This trend has continued well into the 1990's and was certainly sustained going into the 21st century. Tourism related-service industries emerged, mainly in and around Bridgetown as the south and west coasts developed for the tourism sector, which became the dominant economic sector. With the expansion of business and increased opportunities for work, the demand for housing also grew. As a result, the development of Bridgetown and the greater Bridgetown area grew unplanned and unchecked for decades.

In 1963, five classes of water protection zones were established. Development and waste disposal practises are regulated to various degrees in these zones. Also these zones have played a major part in influencing the land use patterns on the island.

Physical planning as a government function is based on the Town and Country Planning Act, 1965. The first Physical Development Plan for Barbados was published in 1970 and came into full operation in 1976. The Chief Town Planner carries out a survey of the island every five years and in addition to any alterations or additions to the plan submits an updated NPDP to the Minister.

The most current development plan is the February, 1998 Draft National Physical Development Plan (NPDP)²; this draft was prepared as part of The Environmental Management & Land Use Planning for Sustainable Development Project (EMLUP). In this NPDP an attempt was made to address some related biodiversity conservation concerns. The relevant studies include The Environmental and Natural Resources Management Plan, The National Park Plan, GIS Data Custody & Implementation Strategy, Environmental Impact Assessment Guidelines and Procedures for Barbados, and the report on Institutional Strengthening of the Planning System.

5.5.2 Major Land Use Issues Affecting Biodiversity in Barbados

Habitat Loss & Fragmentation

The major contributing factors to the loss of biodiversity in Barbados are habitat loss and fragmentation. Habitat disturbance precipitates loss of species, and is an on-going threat to biodiversity in Barbados. During colonial times substantial vegetation was cleared to make way for agriculture and to provide building materials and firewood. More recently vegetation loss has resulted primarily from clearing to facilitate residential development, and the construction of tourism sector developments such as hotel and golf course facilities.

Natural Resource Extraction

Resource extraction is generally regarded as a national economic necessity in the context of the island's relatively scarce natural resource stock. In this regard, these operations need to be strictly controlled to ensure minimization of the potential negative impacts, such as soil erosion, flooding in coastal areas and the degradation of terrestrial and marine habitats.

Natural resource reserves include sand and clay reserves, which are mainly found within the boundaries defined for the National Park, and oil and gas reserves occurring predominantly in the St George Valley and the Woodborne area of St. Philip. There are five active quarry and sand mining operations within the National Park boundaries, in addition to numerous limestone quarries scattered throughout the island. The quarries characteristically range from very low impact resource extraction (such as that associated with pottery operations), to high impact mining of sand from the beach and sea berm at Walkers Savannah, or some of the limestone quarries where operations involve blasting.

² The Draft National Physical Development Plan (NPDP), 1998, was compiled by the Environmental Management & Land Use Planning for Sustainable Development (EMLUP) Project Team. The Draft NPDP Document has been submitted to the Cabinet of the Government of Barbados and is currently pending approval. The reference to the EMLUP Research documents, serves strictly as an indicator of current government policy trends, and to provide the most current baseline research, which reflects the socio-economic and demographic status of the country, including infrastructural development and land use resource allocation trends, occurring in the island of Barbados.

Intensive Monoculture Agriculture

The cumulative effects of the intensive sugarcane monoculture agricultural system on Barbados' biodiversity has not been studied in detail to date. However, the significant effects of reductions of crop and livestock varieties due to selective breeding, decreases in the size of natural habitats over time, increased erosion and the eutrophication of marine habitats, in addition to pollution of marine environments by agro-chemicals are factors which have, no doubt, adversely effected the island's biological resources. (WRI, IUCN, and UNEP 1992).

Growth Management

Barbados has been characterized by a relatively low rate of population growth over the past twenty years. Recent projections indicate that this trend will continue, with population increasing from 266,990 in 1997 to 274,200 by the year 2010. It is estimated that approximately 9,000 additional housing units will be required during the 1997 to 2010 period. It is estimated that some 1,400 hectares of additional residential land will be required to accommodate this growth during this period.

In recent years, Barbados' economy has experienced expansion in the tourism sector, accompanied with a decline in the agriculture sector, particularly with respect to sugar production. In this regard, concerns have arisen as agricultural lands are lost to higher value uses such as residential and golf course developments. If this trend continues, in the absence of a strategy for managing the impacts on biodiversity, one likely result will be the loss of unique plant and animal species which are now important for agricultural production.

Key growth areas include the areas around Warrens, Wildey, coastal areas in St.Philip, and the escarpments along the northern edge of St. Georges Valley. Housing is a serious consideration for a small island with limited land resources. However, in the Barbados context, a switch to higher density housing and the development of the existing subdivisions within the urban corridor will greatly reduce the pressures for outward expansion of urban/residential land in the coming years.

The NPDP identifies four growth management areas for Barbados (see Figure 4). These are classified as follows:

i. The Urban Corridor

This area includes a full range of residential, commercial, industrial and institutional land uses. The urban corridor is thought to contain sufficient lands to accommodate projected urban growth over the next thirty years. The majority of growth during the projected life of NPDP is to be directed to the urban corridor.

ii. The Rural Villages

Limited residential, commercial and institutional development will be permitted within the rural and national park villages, which are communities that lie within areas designated or proposed to be designated as national parks.

iii. Agricultural Areas

Within areas delineated as “agricultural,” predominantly agricultural and related land use activities and passive recreation uses will be permitted. Limited subdivision of lands to provide opportunities for small farming may also be permitted.

iv. The National Park Area

Within the National Park Area only activities related to agriculture, conservation, forestry, passive recreation and facilities related to the National Park will be permitted. The NPDP details a set of policies to guide land use in this area.



Plate: 14 A section of the National Park Area with East Coast in the background (photo: ESPU)

The urban corridor contains the largest population density concentrations on the island, and consequently presents the greatest challenges for preserving biodiversity. The ongoing outward expansion of this area also exacerbates the encroachment of development into biologically rich areas.

5.5.3 The Proposed NPDP System of Parks and Open Spaces

The revised NPDP recommends the establishment of a nation-wide system of parks and open spaces. This system aims to ensure the protection and conservation of national and cultural assets, while supporting the social and economic development of existing communities within the park boundaries. The national open space system comprises six open space categories:

OS1: *The Barbados National Park.* This designation applies to the entire area of the National Park. This park encompasses various land use activities including conservation, forestry, tourism, resource extraction, and rural village settlements.

OS2: *Natural Heritage Conservation Areas.* These include features and locations that are important to the natural and physical heritage of the island. This designation encompasses both terrestrial and marine environments, which are deemed to require protection from urban and recreational development pressures.

OS3: *Coastal Landscape Zones.* This designation refers to two coastal areas outside of the national park, which are said to exhibit natural character and possess unique physical or cultural attributes.

OS4: *Public Parks and Open Spaces.* These include publicly owned sites in both urban and rural settings that have been designed specifically to serve as recreation areas.

OS5: *National Attractions.* This designation refers to attractions used for public enjoyment and as part of the tourism plant.

OS6: *Barbados National Forest Candidate Sites.* These are crown-owned sites, which are predominately covered in mature or emerging forests.

The *OS1, OS2, OS3 and OS6* areas possess immense value in terms of their potential *in situ* conservation of Barbados's biological diversity. These proposed designated parks and open spaces contain many natural features supportive of natural habitats. It is envisioned that the official designations of parks and open spaces as natural reserves, would result in greater regulation of human activities, which may adversely impact on existing biodiversity in these marine and terrestrial areas. The following section 5.5.4 outlines some of the significant and rich biodiversity areas, which are contained throughout the above mentioned areas.

The National Park Development Plan

The goals and objectives outlined in the draft National Park Development Plan include the following:

- To conserve and enhance the character and quality of the landscape and marine resources of the park, including all features of natural and cultural heritage.
- To define and protect a functionally connected natural heritage system based on an ecosystem approach.
- To foster an awareness of the value of the National Park to the daily lives of residents of Barbados.
- To ensure that the use and management of the land and marine resources of the park is of a sustainable nature and is supportive of social and economic development of local communities.
- To establish a strong presumption against activities which conflict with or are detrimental to the landscape, seascape and environmental qualities that led to the national park designation.
- To provide opportunities for informal recreation and to promote understanding and enjoyment of the special qualities of the park.
- To conserve and enhance the biodiversity of the area including terrestrial and marine ecosystems, habitats and species. (NPDP, 1998)

The plan identifies the following Natural Heritage Conservation Areas and National Forest Candidate Sites to be part of an ecosystem approach towards the management of the Barbados National Park.

Natural Heritage Conservation Areas:

- Walkers Savannah, St Andrew
- Graeme Hall Swamp, Christ Church
- Chancery Lane Wetland, Christ Church
- Folkstone Marine Reserve, St James
- Carlisle Bay, St. Michael
- Harrison's Cave, St. Thomas

National Forest Candidate Sites:

- Hackleton's Cliff Woods, St. Joseph
- Joes River Forest, St. Joseph
- Turners Hall Woods, St. Andrew
- Bruce Vale, St. Andrew
- Pico Teneriffe, St. Peter
- Forest Linkages

5.5.4 Significant Biodiversity Resource Areas

The EMLUP report on Environmental and Natural Resource Management identified the following “*spatially limited and unique habitats*”: The Graeme Hall Swamp, Turners Hall/Hackletons Cliff, Walkers Sand Dune, Long Pond Estuary, the Chancery Lane Wetland and Sand Dune features, and the islands extensive Gully network. The further identification of significant and unique biodiversity supporting habitats should be an ongoing activity for researchers working in this area. In this regard, Needham’s Point in St. Michael is also considered to be a significant biodiversity resource area.

The following areas contain a number of natural features and habitat areas that are described as “*ecologically diverse and environmentally sensitive*”, and require special measures be put in place for their protection. A brief discussion of these areas is described in the following sections.

- ***Coastal Land Resource Areas***

The coastal zone areas of Barbados provide unique landscapes and areas for public access to the sea and walking areas. The coastal zone area is generally defined as the interface where the land meets the ocean, and encompasses shoreline environments as well as the adjacent coastal waters. Its components includes:

- coastal plains
- wetlands
- beaches
- sand dunes
- reefs
- mangroves and other coastal features.

These dynamic and biologically diverse ecosystems provide crucial nursery habitats for many marine species. The coastal zone areas in Barbados in recent decades have attracted many human settlements due to the increased demands for tourism development and increased demand for beachfront residential properties.

- ***Sand Dunes***

Sand dune areas occur primarily in the Scotland District and specifically along Walkers Beach and Walkers Savannah. The most remarkable sand dunes occur at Morgan Lewis Beach, Salt Cave Point, Chancery Lane and Long Pond. The island’s sand dunes are highly significant in terms of their support of various terrestrial plant communities, and provide habitats and nesting grounds for various species of crabs and sea turtles among other species. These sand dunes also provide a relatively high aesthetic value to the coasts of Barbados.

These dunes also offer protection against salt water flooding into low lying areas, and, in conjunction with coastal vegetation, effectively slows the process of beach erosion by wave action, and blow outs caused by wind. Coastal erosion is most active along the coastline in St Lucy, the eastern and southeastern coasts of St Philip and along all of the island's beaches. These sand dunes are described in the NPDP as being under serious pressure from sand mining activities. In this regard, sand mining activities must be carefully managed to minimize negative impacts on this sensitive resource. An attempt at efficient management of these sand dunes is fulfilled under the Coastal Zone Management Unit which addresses sand mining activities and the protection of sand dunes.

- ***Turtle Nesting Sites***

Turtles such as the hawksbill turtle are known to frequent the waters and shores of Barbados. Turtle nesting sites are scattered throughout the south, west and east coasts. The hawksbill, which is Barbados' only indigenous Critically Endangered (c.f. IUCN) species, has a significant nesting site at the Needham's Point area, which stretches from the site of the Hilton Hotel, Needhams Point, St. Michael to Coconut Court, Hastings, Christ Church. Over 25% of all hawksbills on the island nest on this 1.5 km stretch of beach. Special protection and efficient management of this critical habitat is vital to sustain a viable population.

The Integrated Coastal Management Plan (ICMP) and the Coastal Zone Management Act (CZMA) provides support through several statutory and policy mechanisms, for the management of turtle nesting sites on the island which occur scattered throughout the south, west and east coasts. These mechanisms include elements of beach management in relation to sand mining, setbacks, vehicular beach access, enclosures and fences, in addition to replanting and protection of littoral vegetation.

As part of the development control process, the CZMU carefully reviews any application which proposes lighting for upper beach areas, and recommends appropriate adjustments in lighting arrangements to prevent adverse impacts on sensitive nesting and hatching turtles to lighting and the disorienting impacts of lighting on turtle hatchlings.

- ***Coastal Wetlands***

Remnants of natural wetlands or wetland vegetation are found along the south and west coasts. Mangroves can be found at Graeme Hall, Chancery Lane, St. Lawrence, Brighton, Holetown, Heywoods, and Lakes/Long Pond. These sites have been under threat from large scale encroachment by residential/commercial development by various degrees over time.

The importance of mangroves as a biodiversity resource lies in their high level of organic productivity, which enables them to sustain fish and wildlife populations. Mangroves

serve as a nursery and breeding grounds for reef fish and crustaceans. In addition the root system acts as a sediment trap, thus reducing the amount of sediment particles that may enter the open sea and impact on the reefs. There is therefore a strong interdependence between mangroves and coral reefs.

- ***The Graeme Hall Swamp***

The largest and most significant mangrove swamp is the Graeme Hall Swamp with a total area of 30 ha. The swamp is colonized by red mangrove and white mangrove, which form the dominant species in the wooded parts of the swamp. The man-made drainage canals contain a variety of plants including water lilies, water lettuce and filamentous algae while sedges, grasses and other wetland plants grow on the banks. This swamp provides a watering hole for many migratory birds, as well as a permanent home for several resident birds including the locally rare red seal coot and the yellow warbler. It also serves as a sanctuary for many juvenile marine fish and provides a recreational site for bird watching, fishing, and model boat racing.

- ***The Chancery Lane NPDP Special Study Area***

An area in Chancery Lane, situated at the extreme south west of the island, has been designated as a Special Study Area in the revised NPDP. The area is of national environmental significance because of its coastal wetlands, which are rare in terms of ecosystems in Barbados. Also significant, is the area's importance as a bird and sea turtle nesting area and as an archaeological site. The Chancery Lane beach and the surroundings are also a popular recreation area for local residents and tourists who stay in the hotels and small guesthouses nearby.

The Chancery Lane Special Study Area includes the escarpment, a swamp, an extensive beach and sand dune ecosystem system, which together contain a wide range of natural habitats, along with open water, wet meadows, marshes, and inland coral stone cliffs covered by trees and shrubs. Unfortunately, a large portion of the land in the Chancery Lane Special Study Area has already been approved for development activities, which potentially could cause severe damage to the landscape value and result in the destruction of the habitats.

Special attention will be given by the TCDPO, in consultation with the director of the Natural Heritage Unit, to site planning issues such as regulation of appropriate development densities, lighting, separation distances and setbacks between developments and natural features, treatment and disposal of storm water runoff and preservation and enhancement of natural vegetation.

- ***The Folkestone Marine Reserve***

The Folkestone Marine Reserve is located on the west coast of Barbados, stretching from Sandy Lane Hotel in the south to Colony Club Hotel in the north, and extending seaward for 660 to 950 metres. This Reserve consists of four zones: a Scientific Zone; a Northern Water-sports Zone; a Recreational Zone; and Southern Water-sports Zone. The Reserve contains an offshore bank reef and a series of near shore fringing reefs that are separated by sand. Within the reserve there is an underwater trail that highlights the corals and fish of interest in the Reserve.

Rakitin (1994), noted that the Reserve was located in an area subjected to rapid coastal development for tourism and recreational activities and hence is continuously exposed to a variety of environmental stresses. These include damage to off shore reefs from diving and illegal fishing activities, and the disturbance of turtle nesting areas from tourism related and other human activity on the beaches.

The Holetown Hole is also a major source of pollutants, which breaks through the sand barrier and discharges large amounts of fine silt, agro-chemicals and domestic waste into the Reserve when major rainfall occurs.

- ***Inland Escarpments***

A series of escarpments, paralleling the south and west coasts of Barbados are described by the NPDP as environmentally sensitive. These rocky land features have evolved from historical soil loss over the past three centuries and is characterized by protruding rock with a few pockets of shallow soil and can be found at areas like Kitridge Point in St Phillip, Mount Brevitor in St Peter, and in St Andrew and the Boscobel area. These pockets support dry scrub or woodlands, and many have been planted for grazing animals.

The vertical walls of inland cliffs usually support sparse vegetation, clinging to cracks in the rock or in pockets of soil on ledges and stunted plants are common. The slopes of some cliffs, which have more loose boulders and pockets of soil, may have additional species.

The islands limestone cliffs typically possess numerous caverns, which provide habitats particularly for various species of bats and nesting birds. These cliff tops are rapidly becoming more attractive for residential development due to the pristine views afforded by these higher elevations. Issues associated with development adjacent to these escarpments include loss of stability and erosion at the edge of these escarpments, rock falls at the bottom of the escarpments, and deforestation at the top of the escarpments that can increase the rate of erosion and reduce the visual quality of the escarpment.

- ***Forested Areas***

Forests are important in the preservation and enhancement of terrestrial ecosystems, soil stabilization, water recharge into aquifers and flood control. In this regard, the NPDP stressed the importance of preserving the remaining forest cover and allowing natural regeneration to continue. Requirements for encouraging tree planting in residential subdivisions and replacement planting plans are being incorporated in the development of the Integrated Coastal Zone Management Areas. Almost all of the remaining forested areas are in the National Park and can be described under four main categories.

- i ***Barbados National Candidate Forest Sites*** are located on publicly owned lands and represent a variety of forest communities of contrasting “environmental quality” and potential to develop as National Forests;
- ii ***Existing Forests*** are typically mature forested areas characterized by a diverse range of vegetation, species, ages and habitats;
- iii ***Emerging Forests*** are mid-successional forests, and are younger than the existing forests. Although these forests are in the earlier stages of natural regeneration, they provide a wide range of vegetation and species habitats; and
- iv ***Forested Linkages*** are areas undergoing very early stages of natural regeneration. Mainly scrub vegetation and some young trees characterize these forested areas. However, it is estimated that these early successional areas can possibly evolve into mature forests in about twenty years if left in an undisturbed state.

- ***Gullies***

Gullies are important from an ecological perspective as sanctuaries for plant and animal species. Gullies typically provide relatively sheltered habitats due to the characteristic steep inclines and thick foliage, and provide favourable moist conditions for mature and diverse collections of native flora. In this regard, it is important that public access and development activities in close proximity to these areas be carefully controlled.

Presently the MPE is managing the Gully Ecosystem Management Study and this initiative has two objectives.

- To prepare a comprehensive integrated management strategy and programme for the national gully systems which recognizes:
 - The preservation and enhancement of biodiversity resources;

- The maintenance of storm water flow patterns, including the protection of critical groundwater catchment areas and abstraction zones; and
 - Identification of sustainable socio-economic uses of selected gully systems.
- The development and implementation of an appropriate public awareness and education programme which is complementary to the aforementioned objective.



Plate: 15 Members of a tour group appreciating the natural features in the Jack in the Box gully (photo: ESPU)

- ***Freshwater Springs and Water Catchments***

The majority of the freshwater spring systems drain into east coast drainage basins and watercourses with the notable exception of Porey Spring, which originates in St Thomas and drains into a west coast catchment. The rest of these springs include Three Houses in St Philip, Pot House, Bath, Codrington College, and New Castle located in St John, the

two Whitehill spring systems, and the spring systems which feed Green Pond, Long Pond, and Joes River water courses in St Andrew.

The permanent surface water catchments, which support significant aquatic biodiversity, include Bawdens, Long Pond, Green Pond, Hillaby, Bathsheba, Consett, Codrington, Three Houses and Culpepper. Freshwater species, which occur in these surface water bodies, consist mainly of species of freshwater fish, crustaceans, and some species of aquatic flora, insects and amphibians (Felix, 1991). The major surface water catchments, which retain water year round, need to be studied in detail in order to ascertain their significance in terms of their support of freshwater aquatic species.

In light of the paucity of permanent surface water bodies in Barbados the few existing natural water catchments can be regarded as being an extremely valuable natural resource, both in terms of their potential as an alternative water source, and in their role in supplying terrestrial aquatic habitats with fresh water.

Water sampling and testing programmes carried out mainly by the Environmental Engineering Division, and the Coastal Zone Management Unit, on these fresh water springs in Barbados have indicated relatively high levels of water pollution in recent times, noted by exceedingly high levels of pathogens. There is a need to preserve these terrestrial water sources from the adverse impacts, and modifications of watercourses as a result of unsustainable development, and human activities in proximity to these sensitive land resource areas.

- ***Natural Corridors and Linkages***

Natural corridors and linkages exist where there are spatial associations between land resource features such as the gully systems, escarpments, coastal zone areas, non-arable lands undergoing regeneration, and other contiguous vegetation or open space units that may support various ecosystems, and also define the range of particular terrestrial or aquatic species habitats.

There is a need to evaluate all proposed development activity which may occur within close proximity to identified areas of significant open space vegetation and assess the potential of these activities to encroach upon or fragment existing habitats, and negatively impact upon associated ecosystems.

5.5.5 Conclusion

Land use conflicts in Barbados are exacerbated by the relative scarcity of land resources characteristic of small island countries, coupled with the strong developmental pressures which exist in the Barbadian economy at this time. Some mapping of the island's land resources has been carried out under various unrelated projects, and by various government departments over

the years, the most recent to date being the EMLUP study in 1998. Significant gaps however still remain in available large scale and detailed spatial data with respect to the vegetation classification, and the distribution of ecosystem supporting habitats in Barbados at a national level. The relevant researchers must address these gaps in information in order to facilitate more comprehensive assessments of development activities and their potential to negatively impact on existing biological resources. Presently, the Gully Ecosystem Management Study is in its initial stage and it is expected from its outputs that geographical information on presence and abundance of flora and fauna within the gullies will be ascertained.

Areas of regenerating vegetation and open space linkages generally tend to be natural features such as gullies, escarpments, uncultivated open lands and other areas of contiguous or associated vegetation. These areas have been traditionally undervalued in terms of importance in supporting biodiversity, and this is generally due to the lack of awareness, and information supporting the relative importance of these open lands. The fact that these open spaces are usually the first areas earmarked for development should no doubt warrant further research in order to re-evaluate some of these lands in terms of ecological value.

5.6 SOCIO-CULTURAL ENVIRONMENT

Most threats to the preservation of biodiversity are the direct or indirect results of human activities, therefore, developing an effective management plan for biodiversity conservation requires not only a scientific assessment of existing biological resources and their value but also an examination of the social context in which those resources are used. This section of the report assesses existing socio-cultural and socio-economic conditions in Barbados as a basis for evaluating the patterns of use of biological resources (e.g. agricultural plant and animal species, fisheries resources, natural vegetation) on the island. The assessment is also useful for determining the degree of threat and the time frame for addressing problem areas.

5.6.1 Human Diversity

In 1996, the human diversity of Barbados was ninety per cent (90%) of African descent; 4% of European descent, the remaining 6% being partly of Asian descent and partly of mixed (European and African) descent (Commonwealth Yearbook, 1998). This population composition can clearly be traced to three major periods in the island's history: (i) the period of colonisation by Britain; (ii) the slavery period which saw the forcible migration of large numbers of Africans to the island to work on the sugar plantations and unions between planters and slaves during this period also resulted in the emergence of a noticeable sector of the population of mixed race; (iii) the post slavery period when indentured servants were brought in to do the work on the plantations that had previously been performed by the African slaves. These labourers were mainly from Asia and China but there was also a significant number of white labourers from northern England, Ireland and Scotland.

5.6.2 Historical Factors Influencing the Culture of Barbados

Archaeological evidence suggests that prehistoric Barbados was inhabited by cave dwellers of the Ciboney culture, from Florida. Later, the Arawaks, who were agriculturalists, weavers and potters, arrived from South America. The early English settlers were primarily agriculturalists, producing tobacco, cotton and indigo. The introduction of sugar by the Dutch in the 1650s led to the development of large plantations and to the importation of vast numbers of African slaves to work on them. By the end of the 18th Century, Barbados had 745 plantations worked by over 80,000 African and African descended slaves. After slavery was abolished between 1833 and 1834 throughout the British Empire, indentured labourers were brought to Barbados to work on the sugar estates. The use of indentured labour allowed plantation owners to continue to dominate the country even into the 20th Century (Commonwealth Yearbook, 1998).

An important feature of Barbadian heritage is the legacy of the extended period of British colonisation. This legacy is very evident in the governmental, organisational and educational systems, which exist on the island today. Barbados has a history of governmental stability, which persists today. Unlike other islands in the English speaking Caribbean, Barbados did not experience the numerous changes in colonial rule, and the change over to from British colonial rule to self-government was virtually unchallenged. This factor has contributed to the progressive economic and social development, which is characteristic of the island and must be considered as part of its culture.

5.6.3 Population

The population density of Barbados, at approximately 615 persons per square km, continues to be one of the highest in the world. In order to be able to use biological resources sustainably, pressures from population growth and/or movement must not exceed the ability of species to replenish themselves or to adapt to changing environmental conditions. The statistics show that although the population size in relation to the land area of the country is rather large, the actual rate of growth of the population is comparatively low. This can be attributed to a number of factors such as the availability of a high standard of health care and educational opportunities to all sectors of the population, a high standard of living and positive economic growth resulting in low unemployment levels. This implies that population growth factors do not pose any serious threats to the conservation of biodiversity in Barbados.

5.6.4 The Economy

The 1995 UN Development Programme's Human Development Index ranked Barbados twentieth in the world. This gives the country the highest "quality of life" rating of any developing country, higher than several Western European countries. The economy, formerly a sugar monoculture, has been carefully developed over three decades to achieve greater diversity.

The three main sectors in decreasing order are currently tourism, light industry and sugar production.

By the end of 1996, the Barbadian economy had expanded significantly, with real output increasing by 5.2 per cent. The value of real Gross Domestic Product (GDP) for 1996 was estimated at \$903.6 million, an increase of \$44.7 million over 1995. Per capita GDP for 1996 was \$12,800 (US \$6,400) representing an increase of \$900 or 7.6 percent. This significant growth in per capita income is indicative of the recovery of the economy (Barbados Economic Report, 1996).

5.6.5 Employment

One major feature in the performance of the Barbadian economy in 1996 was the reduction in the rate of unemployment from 19.7 percent in 1995 to 15.6 percent. This continued the pattern of a falling unemployment rate observed since 1993 when the rate was 24.7 percent. In 1996, some 114 300 persons were employed compared to 109 900 thousand in the previous year.

5.6.6 Poverty

Poverty may be considered as the inability of an individual or household to satisfy the basic needs (food, clothing and shelter) required for survival due to a lack of adequate financial resources. Poverty can have profound impacts on the preservation of biodiversity. If conditions of poverty persist over the long term, biological resources may be exploited to the point that they become irreversibly depleted.

Barbadians enjoy a relatively high standard of living in comparison to other developing countries and some European countries. Poverty is present in some vulnerable sectors of the population, such as the elderly, the undereducated and teenage mothers, but it is not a widespread situation. Barbados has a relatively sophisticated social services sector, which is funded in large measure by taxpayer contributions. The objective of the social services sector is therefore to provide a support system which fills the gap in meeting the basic needs of those members of the population who, for whatever reason, are unable to find means to satisfy these needs themselves.

5.6.7 Health Care

The effectiveness and sustainability of the health care system is essential to maintaining the health status of the population at such a level that the productivity of the work force and hence the economic viability of the country is not compromised. The GOB continues to view health care as a fundamental right of all Barbadians and its goal is to provide comprehensive health care to all Barbadians at a price which the country can afford. To achieve the health care policy goals, emphasis has been placed on a community approach to Primary Health Care and making

effective use of government and non-governmental organisations in all aspects of health care. In addition, the GOB is continuing to strengthen the institutional capacity at the secondary and tertiary levels of care.

The chronic non-communicable diseases, particularly hypertension, diabetes and all forms of cancer; and the spread of HIV infection have the capacity to bring about a health crisis if not aggressively managed and controlled. Such a crisis would inevitably undermine the productivity of the work force and the country at large. In recognition of the potential for such a situation to occur, the GOB has taken a very pro-active approach towards the prevention of further growth in incidences of these diseases. Aggressive public education campaigns, particularly in the case of HIV, are a key component of this approach. A national AIDS Programme was established in 1988 with the Ministry of Health and the Environment as executing agency, to implement projects, which would serve to reduce the transmission of HIV and give care and support to people infected with or affected by HIV. There is also a strong and committed national Advisory Committee on AIDS, and an AIDS management team at the QEH, which provide assistance and support to the Programme.

5.6.8 Transport Infrastructure

The island's road network was developed, in part, to serve the sugar cane industry transporting goods from the various plantations to the capital, Bridgetown. With the emerging dominance of Bridgetown, this trend led to the development of a strong radial network. The seven main highways (Highways 1 to 7) radiate from central Bridgetown. In recent times, there have been four major additions to the highway network.

The current development pattern characterised in transport terms exhibits a concentration of demand along the west and south coasts in a band from Speightstown through Bridgetown to Oistins. In this west-south development axis, the Bridgetown Port and the international airport are also located. The existing transport infrastructure pattern is being reinforced through proposals to expand the port and the airport and to extend the ABC Highway artery along route 2A.

To the extent that a dominant transport infrastructure pattern has evolved along the South and West Coasts and around Greater Bridgetown, and that recent investment in the sector will tend to reinforce this pattern, it is difficult to identify any significant different and realistic alternative land use/transport strategies that could emerge in the future. Transport related environmental problems are more likely to be identified from intensification in traffic levels and congestion, impacts of vehicular emissions, mortality of fauna caused by collisions with vehicles, and on-line improvements to existing highways rather than from provision of major new infrastructure.

5.6.9 Cultural Heritage

Cultural heritage can be defined as the present manifestation of the human past. It refers to sites, structures and remains of archaeological, historical, religious, cultural or aesthetic value and is a record of humanity's relationship to the world, past achievements and discoveries. Much of this heritage is under threat, particularly in developing countries as a result of modernization and development. If archaeological and historical sites and structures are allowed to disappear, important testaments to a society's creativity and the knowledge base for shaping the future will be lost.

Architecture

Barbados has a diversity of architectural styles unique to the island. These include chattel houses, parish churches, plantation houses, army barracks, sugar factories and much more. These buildings are critical aspects of the island's cultural heritage and should be preserved. One organisation that has been instrumental in this area is the Barbados National Trust. The Trust was founded in 1961 by an Act of Parliament to preserve the unique heritage of Barbados, whether it is historic buildings, places of natural beauty or the island's flora and fauna. The Trust works to ensure that the public has access to as many of them as possible, and it actively promotes restoration and preservation. It also places plaques, with the permission of the owners, on buildings of historical and architectural interest. There are presently eight (8) properties administered by the Barbados National Trust.

Archaeological Sites

An extensive survey of the coastline of Barbados to locate pre-historic sites was undertaken during of 1985/86 by archaeologists from the Institute of Archaeology, University College of London in conjunction with the Barbados Museum and Historical Society. This survey supplemented findings of known sites derived from the literature, museum collections and information provided by members of the Barbados Museum and Historical society. Sites discovered since 1986 have been added to this list. The 1985/86 survey reinforces the earlier research and confirmed the predisposition towards coastal sites in early settlements. Following the extensive field survey, four coastal sites were selected for detailed study. These were Heywoods on the west coast, Highcrest on the east coast and two south coast sites at Chancery Lane and Silver Sands.

Traditional Knowledge

There is a need to identify indigenous communities and peoples, and if this proves to be difficult ascertain their traditional knowledge base for future reference. Traditional knowledge

constitutes the cultural and spiritual values of biological diversity, and is developed by indigenous people to be transmitted to future generations as the basis of their continued existence as a people.

Traditional knowledge regarding sustainable use of biodiversity has not been adequately studied or publicised in Barbados despite its importance. Activities such as herbal medical practices, waste management, and environmentally friendly agricultural practices have cultural and spiritual influences, and therefore traditional knowledge can assist in their planning and management.

The foundations for Barbados' folk healing tradition, for example, were established during the period of slavery and African medical traditions played a crucial role in contributing to this foundation. In general, historical sources refer to many medicinal plants, however the information on traditional knowledge with respect to their use by different races is unclear.

The names, stories, and folklore about flora and fauna present in Barbados are part of the local culture and need documenting as much as the scientific aspects. For example, in Barbados one species of the land crabs are called "swampee", and marine crabs are called "shaggers" and these names can be considered important when implementing an environmental management plan for traditional communities. Therefore for cultural, spiritual, as well as scientific reasons, it would be instructive to carry out a survey of the persons in Barbados knowledgeable in the use of biological diversity for herbal medicine or for other cultural or spiritual uses, document their claims and undertake systematic and detailed study of these plants and animals.

5.6.10 Conclusion

It is well recognised that prevailing socio-cultural and socio-economic conditions in a country affect the patterns of use of biological and cultural resources. A country, such as Barbados, with a stable political environment, relatively high per capita income and stable or declining population growth rate would be in a position to allocate financial and technical resources for ensuring the sustainable use of biological and cultural resources.

Barbados has a rich cultural heritage which is evidenced in the number of sites and structures of archaeological, historical, religious, cultural and aesthetic significance along with a rich tradition of festivals, music, art, dance and folklore. There has been a considerable amount of work undertaken by both governmental and non-governmental organisations such as the National Cultural Foundation, the Barbados National Trust, the Barbados Museum and Historical Society, the Caribbean Conservation Association and interested individuals for the preservation of cultural heritage of the island.

6. THE BIODIVERSITY STRATEGY AND ACTION PLAN

The Strategy and Action Plan presented in this section comprises goals, strategies and actions which seek to guide the development and application of management approaches for the conservation and sustainable use of biodiversity across the entire range of economic, social and cultural sectors identified in the Country Study Technical Reports (Simmons & Associates, 1998).

The magnitude and range of actions proposed require the involvement of several ministries, agencies and many individuals spanning both governmental and non-governmental institutions, as well as the application of multi-disciplinary approaches, which are sometimes non-existent or insufficiently developed. This shortcoming will present major challenges for the proposed Natural Heritage Unit, which is for the purpose of managing the implementation of biodiversity conservation initiatives proposed

Costs for implementing these recommended actions are also expected to present added challenges, particularly when the exigencies of other development parameters are considered. However, the contents of the NBSAP clearly illustrate the importance of biodiversity for its sustainable development, reinforcing the importance of finding adequate funding for the implementation of this Action Plan.

The overall goal of the NBSAP is to promote the conservation and sustainable utilization of the island's terrestrial, marine and freshwater biodiversity. To achieve this, a number of major objectives have been identified. For each objective, the strategy and the actions required are described. All actions are considered to be important to achieve the overall goal of the NBSAP, but within each section, those actions of highest priority have the identifier [H] attached.

Objective 1: To mobilize adequate financial resources for the management and conservation of Barbados' biodiversity

Strategy: Develop mechanisms for funding the conservation and management of biodiversity, ensuring that the costs of protection are equitably shared.

Actions

1. Define and implement a specific mandate for negotiating with financial and technical assistance agencies in the regional and international arenas to fund NBSAP project priorities. This initiative will entail creating and filling the positions of Fund Raising Specialist and Assistant in the Ministry responsible for the environment. The responsibilities would include the submission of suitable projects to the Global Environment Facility. [H]
2. Allocate additional Government funds for biodiversity conservation and management.
3. Establish appropriate user fees for biodiversity resource users (for example, hoteliers, fisherfolk, SCUBA operators, tour operators).

Implementing Institutions and Agencies

Ministry of Physical Development and Environment

Objective 2: To develop the human resource base and strengthen institutional capacity for biodiversity conservation and management

Strategy: Strengthen the institutional and technical capacity of environmental government agencies to effectively manage the components of biodiversity and promote their sustainable use.

Actions

1. Endorse and encourage the recommendation arising out of EMLUP to establish a Natural Heritage Unit with the purpose of managing the sustainable use and conservation of biodiversity within the Ministry responsible for the environment. Full time, trained staff within this proposed Environment Division would be employed to coordinate the Government's biodiversity activities. This Unit will interface with other relevant agencies. [H]
2. Define specific mandates for the relevant governmental institutions with respect to the conservation of biodiversity.
3. Acquire and/or train key personnel within Government in biodiversity conservation and management.
4. Establish and/or strengthen links with Governmental and Non-governmental agencies (local and international) with responsibilities related to the conservation and sustainable use of biological resources.
5. Encourage cooperation between local Governmental and Non-governmental agencies to reduce duplication of activities, and encourage more efficient information sharing. [H]

6. Enhance the capacity of a selected institution(s) to scientifically describe, classify and store collected specimens. [H]

Implementation Institutions and Agencies

Ministry of Physical Development and Environment, The University of the West Indies

Objective 3: To conduct essential research to inform the development and implementation of management practices for the sustainable use of biodiversity

Strategy: Establish a national Research Programme to document the status of, threats to and value of, biodiversity.

Actions

1. Prepare and implement a prioritized programme on biodiversity research, incorporating appropriate governmental and non-governmental agencies, students and staff of UWI, polytechnics and colleges, schools, communities and user groups in appropriate elements of the programme.

The programme will include the following research and monitoring elements:

- a) Development of a full reference collection of work already conducted on Barbadian species and habitats by local and overseas researchers. [H]
- b) Assessment of existing data on presence/absence, abundance and distribution of terrestrial, marine and freshwater biodiversity. [H]
- c) Research on species and communities that are indigenous, rare or threatened, particularly those that require urgent protective measures, and development of a GIS compatible database. [H]
- d) Research on the presence, distribution and abundance of alien and genetically modified species and the development of a GIS compatible database.
- e) Development/support of monitoring projects designed to assess impacts of exploitation, habitat loss, pollutants and alien species on the distribution and abundance of terrestrial, marine and freshwater biodiversity, alien, indigenous and rare species.
- f) Adoption of the biodiversity indicators under the National Indicators programme as well as the identification of additional potential indicators that can be used to highlight biodiversity degradation.
- g) Documentation of research on indigenous knowledge, innovations and practices with respect to utilization of biodiversity (for example, medicinal plants).
- h) Assessment of past, current and future patterns of consumptive use of biodiversity.
- i) Assessment of the economic value of consumptive use of biodiversity resources.
- j) Preliminary assessment of non-consumptive value of biodiversity e.g. in biological control, prevention of soil loss, ecotourism.

- k) Assessment of the role of education in biodiversity conservation and management.
 - l) Assessment of the effects of climate change on biodiversity conservation and management.
2. Convert the Herbarium of the University of the West Indies, Cave Hill Campus, to a National Herbarium (using the Government-funded and staffed UWI-based herbarium in Trinidad as a model). [H]
 3. Develop a National Clearing House Mechanism (internet web site) to provide a forum for national/regional biodiversity researchers. [H]

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, The University of the West Indies, Caribbean Agricultural Research and Development Institute, Barbados Museum, Barbados National Trust, Caribbean Conservation Association

Objective 4: To use the results of the Research Programme to develop appropriate management techniques and mechanisms to ensure sustainable consumptive use, and to preserve non-consumptive use values of biodiversity resources

Strategy 1: Develop management approaches for the sustainable consumptive use of flora and fauna.

Actions

1. Identify ecological factors affecting the population status of exploited species e.g. predation rates, habitat loss, and disease.
2. Identify management measures needed to prevent over-exploitation of biodiversity resources by users, including measures to control negative biotic interactions that are simultaneously impacting on exploited biodiversity, e.g. control of invasive species that compete with or prey on the biodiversity resource, and measures to protect critical refuge, foraging or breeding habitats. [H]
2. Develop taxon-specific management plans for the consumptive use of key biodiversity resources e.g. green monkeys, migratory birds, rock balsam, *inter alia*, taking into account non-consumptive use values where appropriate (see Goal 5). The Fisheries Management Plan 2001 consists of taxon-specific plans for conch, sea eggs and pot fish, and therefore should be reviewed and revised if necessary. [H]

Strategy 2: Develop management approaches for conservation of species and ecosystems that have significant non-consumptive use value, for example, for tourism or for ecological services provided.

Actions:

1. Identify key biodiversity resources with high non-consumptive use value e.g. coral reefs, gullies, green monkeys, and sea turtles. [H]
2. Develop taxon-specific management plans to protect species of significant non-consumptive use value e.g. insectivorous and frugivorous bats, snakes, reef fish, sea turtles *inter alia*. [H]
3. Ensure that appropriate elements are incorporated into management plans to protect biodiversity that is of simultaneously high consumptive and non-consumptive use value e.g. coral reefs, green monkeys. [H]
4. Develop management approaches to control alien species where studies have shown demonstrable negative impacts on indigenous biodiversity. These may include mongoose, cane toads, cattle egrets, *Casuarina*, water hyacinth, *inter alia*. Ensure adequate legal protection for critical habitats of key species and important ecosystems.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, The University of the West Indies, Caribbean Agricultural Research and Development Institute, Caribbean Conservation Association

Objective 5: To revise, consolidate and formulate policy and legislation to achieve the conservation and sustainable use of biodiversity

Strategy: Implement existing national legislation and revise or develop new legislation to incorporate biodiversity management policies that are not currently adequately addressed

Actions:

1. Endorse and encourage the creation of a position of Environmental legal officer which was recommended under EMLUP. This officer would be the manager of the proposed Policy and Coordination Unit for the Ministry. [H]
2. Develop regulations to fully implement the revised environmental legislation for Barbados under the Environmental Management and Land Use Planning for Sustainable Development Project. [H]
3. Ensure the incorporation of biodiversity concerns in all Environmental Impact Assessments (EIA).
3. Review present incentives and disincentives for conservation and sustainable use of biodiversity, and make necessary amendments with the intention of incorporation into a national incentives policy.

4. Develop regulations under the Coastal Zone Management Act to minimize impacts of coastal constructions on the beach and near shore marine environment, for example, lighting and beach cleaning regulations to protect sea turtles nesting habitat, regulation of discharges to protect coral reefs, for example, chlorinated and grey water, and regulation of coral rubble and sea grass removal *inter alia*. [H]
5. Strengthen the enforcement of the Marine Pollution and Control Act to reduce marine and freshwater pollution and biodiversity kills due to land based sources of pollution, and the Coastal Zone Management Act to protect important feeding and breeding grounds in the coastal zone. Formulate national legislation relating to biodiversity access and benefit sharing.
6. Finalize the Draft National Physical Development Plan and make it legally binding.
7. Formulate national legislation to address biosafety and biotechnology concerns.
8. Formulate national legislation to address biodiversity access and benefit sharing.
9. Facilitate community and user-group involvement in the drafting process of any revisions to existing legislation, development of new legislation and in the enforcement of legislation.
10. Strengthen the mechanisms for the enforcement of all biodiversity protection and management legislation.
11. Conduct biodiversity legislation and enforcement workshops for communities and user groups, the Judiciary, the Royal Barbados Police Force, the Barbados Defense Force and the Coast Guard.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Attorney General's Chambers

Objective 6: To promote biodiversity conservation and sustainable use through incentives

Strategy: Develop practical incentive measures so that persons are encouraged to conserve biological diversity

Actions:

1. Develop innovative mechanisms for funding incentive packages. [H]
2. Adopt suitable economic valuation methods to value the biodiversity so that it can be included in the national accounting system. [H]
3. Identify sustainable economic alternatives to activities that threaten biodiversity.
4. Promote the participation of non-governmental organizations in funding incentive packages. [H]

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Finance, Ministry of Economic Development, Attorney General's Chambers

Objective 7: To incorporate biodiversity conservation requirements into land-use planning

Strategy: Rationalize land use designation and encourage sectoral planning for environmentally friendly development.

Actions:

1. Adopt the finalized and legally binding National Physical Development Plan as a blue print for land use planning. **[H]**
2. Ensure that biodiversity conservation and sustainable use become limiting factors within all land use planning decisions and processes. **[H]**
3. Establish strong and transparent linkages for land use planning among sectors.
4. Introduce legally binding environmental regulations into the land use planning processes which take into account ecological stability, carrying capacity, vulnerability of ecosystems, and impacts on species. These should incorporate EIAs for all hotels and condominium developments adjacent to the beach or on clifftops, and all golf courses and hotel construction inland. **[H]**

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Housing and Lands

Objective 8: To improve public awareness and education

Strategy: Develop public awareness through educational and training activities to ensure broad based support and involvement in biodiversity conservation.

Actions

1. Incorporate the Ministry responsible for education into the planning and execution of the proposed educational activities.
2. Disseminate information on biodiversity issues to primary and secondary schools through the development of age-appropriate educational materials (posters, books, videos), essay and poster competitions, *inter alia*. **[H]**
3. Train teachers to teach courses on the topics of biodiversity conservation and sustainable use.
4. Incorporate studies on the environment and biodiversity into the school curricula.
5. Provide scholarships for tertiary level studies in fields related to biodiversity management e.g. taxonomy, ecology, and biotechnology. **[H]**
6. Create a web page on biodiversity issues, concerns and action plans for Barbados. The site should also contain pictures and descriptions of fauna, flora and habitats. **[H]**
6. Encourage tree-planting schemes along roads, in new housing developments and around playing fields.
7. Conduct community workshops on biodiversity conservation and sustainable use.

8. Conduct workshops at hotels to increase the awareness of hoteliers and visitors of the special challenges of tourism on small island environments, and of the part that they can play in ensuring that the country's biodiversity is conserved.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Education, Youth Affairs and Sports, Government Information Service, Caribbean Conservation Association

Objective 9: To establish effective *In situ* and *Ex situ* biodiversity conservation measures

Strategy 1: Establish an effective and sustainable system of protected areas

Actions

1. Establish Natural Heritage Conservation Areas and identify National Forest Candidate sites under the revised National Physical Development Plan as measures to prevent habitat fragmentation, and to protect critical habitats of rare and endangered species in terrestrial, coastal, marine and freshwater environments. [H]
2. Establish a Park Service within the National Conservation Commission with wardens to manage the National Heritage Conservation Areas, National Forest Candidate sites and to enforce park regulations. This activity will involve institutional strengthening of the National Conservation Commission and a shift in emphasis from landscape beautification to habitat protection. [H]
3. Provide for adequate buffer zones and plan for environmentally sound developments in areas bordering the protected areas.
3. Identify degraded ecosystems for rehabilitation and restoration.
4. Develop and implement ecosystem rehabilitation activities and recovery plans such as the removal of alien species and replacement with indigenous species.
5. Encourage adjacent communities to assist in habitat protection and enforcement of regulations.

Strategy 2: Establish effective and sustainable ex situ facilities for biodiversity conservation

Actions:

1. Identify species of fauna and flora requiring *ex situ* conservation measures. [H]
2. Establish or support captive breeding facilities/plant nurseries/arboreta or support existing facilities (Governmental or non-governmental) for appropriate threatened species.

3. Manage and control the collection of biological resources from natural habitats for *ex situ* conservation.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, The University of the West Indies, Ministry of Housing and Lands

Objective 10: To ensure equitable biodiversity access and benefit sharing

Strategy: Promote necessary actions to facilitate equitable biodiversity access and benefit sharing

Actions

1. Designate authority(ies) responsible for biodiversity and traditional knowledge access. **[H]**
2. Identify entities that are involved in granting access to biodiversity and traditional knowledge and create a database to store this information.
3. Debate considerations for biodiversity access, such as expectations of all parties, impacts on stakeholders, resources required, legal framework required, negotiating training, certificates of origin, protocols for field collection and laboratory work, patents, method of prior informed consent from local/indigenous communities involved, economic benefits (up-front payments, milestone payments, royalties), and duration and termination of access. **[H]**
4. Debate considerations for traditional knowledge access, such as definitions of traditional knowledge, regional harmonization, on going international efforts, list of informal innovations to be protected, negotiating training, and certificates of origin.
5. Create an inventory of local/traditional innovations and technologies.
6. Creation of conditions to facilitate access to genetic resources for environmentally sound uses only.
7. Review by the Government of Barbados whether it is a sufficient beneficiary in bilateral agreements made between local Non-Governmental institutions, companies inter alia, and overseas companies that involve the sale of biodiversity.
8. Creation of conditions and policies to facilitate equitable benefit sharing for access. **[H]**
9. Establish equitable and environmentally friendly, bilateral agreements between local institutions and international pharmaceutical companies.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, The University of the West Indies, Barbados Primate Research Center and Wildlife Reserve

Objective 11: To establish biosafety regulations in order to safeguard biodiversity

Strategy: Encourage activities which will safeguard the environment from risks caused by genetically modified organisms and other forms of biotechnology.

Actions:

1. Designate authority(ies) responsible for biosafety control, including the establishment of an early warning system. **[H]**
2. Develop regulations to reduce the release of, and to control the use of, genetically modified organisms in the environment.
3. Introduce basic standards for testing, labeling, importing, exporting and commercial use of genetically modified organisms. **[H]**
4. Elaborate detailed procedures and measures for risk assessment concerning the release of genetically modified organisms. **[H]**
5. Develop appropriate administrative regulations to promote access to the results of biotechnologies.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Barbados National Standards Institution, The University of the West Indies

Objective 12: To promote the conservation and sustainable use of biodiversity in various sectors (agriculture, health, fisheries, and tourism)

Strategy 1 (Agriculture): Encourage agricultural biodiversity conservation and sustainable use by revising approaches towards agricultural management.

Actions:

1. Develop an official mechanism for collaboration with the Ministry of Agriculture and Rural Development with respect to the conservation and sustainable use of agrobiodiversity.
2. Promote knowledge in the farming sector of the economic value of biologically diverse farms arising from improved yields, prevention of soil erosion, biological pest control, use of organic fertilizers collected from rearing livestock, and reduction in use of agrochemicals. **[H]**
3. Collect and disseminate indigenous knowledge and innovations about environmentally sound and biologically diverse farming practices.
4. Develop local organic farming standards and train persons to certify organic farms.
5. Establish an organic Farm Management Programme, which promotes and supports biologically diverse organic businesses.
6. Establish a pilot project, which converts an abandoned cane field into an organic food forest. This initiative would include the rearing of livestock for food and organic fertilizer.

7. Establish a National Integrated Pest Management Programme.
8. Establish an effective National Plant and Animal Quarantine Programme.
9. Educate farmers about the impacts of agro-chemicals on the environment, including effects on human health, and the benefits resulting from the use of organic fertilizers from livestock. **[H]**
10. Promote the cultivation of crops that require less water and less agrochemicals to produce good yields.
11. Encourage a market system, which will ensure sales for persons involved in diverse organic farming.
12. Promote diverse organic house gardens, including tree crops.
13. Develop a national planting material programme to include awareness, certification and standards for seed exchange.
14. Regulate and restrict use of herbicides and pesticides, which result in biodiversity loss. This can be done in conjunction with a fully staffed and equipped Pesticide Control Board. **[H]**
15. Establish a national programme to preserve germplasm from the Barbados black belly sheep (either by storing the frozen semen or storing the fertilized eggs).

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, Caribbean Agricultural Research and Development Institute, Inter American Institute for Cooperation on Agriculture, Government Information Service

Strategy 2 (Health): Incorporate biodiversity conservation issues into disease control and waste management practices

Actions:

1. Review existing management strategies for mosquito and rodent control in relation to harmful impacts on non-target species and sensitive ecosystems e.g. Graeme Hall swamp.
2. Ensure that pesticides in use and timing of application conform to international standards in order to minimize negative environmental impacts on biodiversity.
3. Promote natural biological control of disease vectors where appropriate. **[H]**
3. Endorse and support the revision and enforcement of existing legislation by the Solid and Sewerage Waste Project Unit to impose significant monetary penalties for illegal dumping and littering.
4. Design and implement a national programme to increase awareness of the value of natural habitats for wildlife to deter wide scale de-bushing, and to inform the public of the impacts of illegal dumping on terrestrial wildlife and on the marine environment, e.g. deterioration of water quality and impacts on sensitive nearshore ecosystems, entanglement of fish, sea turtles, and sea birds in plastic garbage *inter alia*. **[H]**
5. Ensure that appropriate techniques and equipment are used to clean up illegal dump-sites to ensure minimum disturbance to natural habitats.
6. Actively support recycling schemes through subsidies and incentives to reduce costs associated with landfill maintenance. **[H]**

7. Ensure that solid waste and hazardous waste disposal sites are adequately distanced and buffered from sensitive ecosystems and critical habitats of endangered species.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Health

Strategy 3 (Fisheries): Encourage fisheries conservation and sustainable use by revising approaches towards fisheries management

Actions:

1. Ensure that important breeding grounds are protected within Natural Heritage Conservation Areas.
2. Provide mechanisms to facilitate consultations between the Fisheries Division, the Coastal Zone Management Unit, the proposed Marine Management Agency, fisherfolk and other marine and freshwater resource users, including neighboring community members.
3. Ensure that the regulatory systems in place maintain populations of exploited species at levels that ensure ecosystem integrity and function. [H]
4. Regulate fishing apparatus and methods to reduce adverse effects on marine biodiversity, for example, damage to corals and incidental catch of non-target species.
5. Reduce at-sea dumping of garbage and discarded fishing gear.
6. Maintain comprehensive catch per effort statistics to provide quantitative estimates of population sizes of targeted species, and thus provide more accurate information on the impacts of exploitation on marine species. [H]
7. Sensitize fisherfolk to the importance of sustainable fishing practices and the need for marine protected areas or reserves to protect critical habitats. [H]
8. Train fisherfolk to allow for self-enforcement of regulatory measures.
9. Research and encourage alternative income generation for fisherfolk, and ensure that there is a definite market for their catch at all times.
10. Improve monitoring and enforcement capabilities at sea by strengthening the Coast Guard, including the purchase of a helicopter.
11. Develop and implement a consistent monitoring and surveillance program, to scrutinize and document information on the influence that climate change has on the life-cycles of the local fish stocks.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Agriculture and Rural Development, Barbados National Union of Fisherfolk Organization

Strategy 4 (Tourism): Encourage measures to reduce threats to biodiversity resulting from improperly planned and managed tourism development

Actions:

1. Conduct research to determine the extent to which tourism facilities and their associated activities directly and/or indirectly contribute to the loss of biodiversity. **[H]**
2. Conduct workshops to sensitize the hotel sector to the negative impacts of tourism on the environment, e.g. the negative impacts of beachfront lighting on sea turtle nesting beaches, groyne and gabion basket placement on beaches, coral rubble clearance.
3. Encourage the application of sound environmental management techniques at existing tourism facilities e.g. encourage the pursuit of Green Globe accreditation by hotels. **[H]**
4. Encourage programmes aimed at educating tourism personnel of the importance of the relationship between tourism and biodiversity conservation.
5. Promote regulatory measures (seasonal restrictions, entrance fees) to keep the number of visitors in balance with the carrying capacity of sensitive habitats.
6. Restrict further development of large tourism centers, particularly in or adjacent to, protected areas and conduct cost-benefit analyses to determine whether further development should proceed.
7. Prevent high impact tourism development in currently undeveloped areas of significant biodiversity importance e.g. Morgan Lewis, Walkers, East Coast Road, St. Lucy coast. **[H]**
8. Promote only small-scale, fully trained guided tourism in important biodiversity areas.
9. Consider the need for an additional head tax for all arrivals (including cruise ship passengers) specifically to assist in mitigating environment impacts.

Implementing Institutions and Agencies

Ministry of Physical Development and Environment, Ministry of Tourism and International Transport, Barbados Hotel and Tourism Association, Barbados Tourism Association, Tourism Development Cooperation

7. THE IMPLEMENTATION OF THE BARBADOS NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN

The implementation of the Barbados National Biodiversity Strategy and Action Plan is ultimately dependent on the interest and will of all Barbadians. At the national level, the political directorate will need to confirm that it has indeed recognised and fully accepted the importance of biodiversity as an integral part of a sustainable development plan for Barbados. Decision makers will therefore be required to lend their full support to the development of a policy, which articulates this principle while ensuring that necessary legislative and regulatory mechanisms are developed to support the enforcement of this policy.

At the technical level, there needs to be an increase in the cadre of professionals who can provide accurate information and advice to the decision making process. At the macro level this information will allow policies and major development decisions to be made with concern for biodiversity issues. At the micro level, where the day-to-day lifestyle decisions of the average citizens can negatively impact on biodiversity, it is critical that this information be simplified and made available through accessible channels.

At the local and community levels, the NGOs, CBOs and private agencies, including developers, banks etc., must become committed to increasing their knowledge of how their work impacts on the environment. They must begin to operate in ways, which will enhance the environment and lead their colleagues by example.

Finally, at the individual level, every citizen must be committed to a healthy and safe Barbados, and to becoming stewards of the environment. Public awareness programmes must be developed and implemented to ensure that Barbadians recognise that the “bush” at the side of the road has as much value as the ornamentals which they plant in their gardens; and that insects and reptiles have not been created solely for the purpose of extermination. Such education will assist in overcoming morbid fears of certain animals and instil the respect and awe required for a truly sustainable conservation effort.

8. REFERENCES

Sections 1 to 3

OECD, 1996. *Saving Biological Diversity: Economic Incentives*. OECD Publications Service.

Simmons & Associates Inc, 1998. *Country Study Technical Reports - Assessment of Land Resources, Biodiversity of Terrestrial Flora and Agricultural Biodiversity; Assessment of the Biodiversity of the Terrestrial Fauna of Barbados; Assessment of Marine and Freshwater Diversity; Assessment of Socio-Cultural Conditions; A Biodiversity Data Management System for Barbados*.

United Nations Environment Programme. 1993. *Guidelines for the Preparation of Country Studies on Biological Diversity*.

World Resources Institute in Cooperation with the United Nations Environment Programme and the World Conservation Union (IUCN). 1995. *National Biodiversity Planning: Guidelines Based on Early Experiences Around the World*. WRI Publications, Baltimore.

World Resources Institute (WRI), World Conservation Union (IUCN), United Nations Environment Programme (UNEP) in consultation with the Food and Agriculture Organisation of the United Nations (FAO) and the United Nations Education, Scientific and Cultural Organisation (UNESCO), 1992. *Global Biodiversity Strategy*.

Section 4

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *Environmental Impact Assessment Guidelines & Procedures for Barbados*, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *Institutional Strengthening of the Planning System, Volume 2 Planning legislation*, Ministry of Health and the Environment, Government of Barbados

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *Institutional Strengthening of the Environmental Unit and other Institutions*, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *The Natural Database, Biophysical, Cultural and other Planning Related Information*, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *General Specifications: Future Data Collection, Data Custody & Implementation Strategy*, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *Environmental Impact Assessment Guidelines & Procedures for Barbados*, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. *Environmental and Natural Resources Management Plan*, Ministry of Health and the Environment, Government of Barbados.

Section 5

Natural Vegetation Biodiversity

- Agronomy Research and Variety Testing Unit. 1994. Weed control manual for sugarcane fields. Barbados Agricultural Management Company.
- Allan, J.A. 1957. The grasses of Barbados. HMSO, London.
- Andromeda Botanic Gardens. 1997. Beachcomber's guide to Barbados seashore grasses. Barbados National Trust/ University of the West Indies.
- Box, H.E., and Philipson, W.R. 1951. An undescribed species of *Mastichodendron* (Sapotaceae) from Barbados and Antigua. *Bulletin of the British Museum (Natural History) Botanical Series* 1, 21-23.
- Carrington, S. 1993. Wild plants of Barbados. Macmillan Caribbean.
- Carrington, C.M.S. 1991a. Tropical Forestry Action Plan Barbados: Report on biological diversity, herbaria and conservation of tropical forest ecosystems. CARICOM/FAO/Ministry of Agriculture Food and Fisheries.
- Carrington, C.M.S. 1991b. New collections for the Flora of Barbados II. *Journal of the Barbados Museum and Historical Society* 39, 60-71.
- Coulter, D. 1968. Ferns of Barbados. *Journal of the Barbados Museum and Historical Society* 32, 150-154.
- Dickie, G. 1875. On the marine algae of Barbados. *Journal of the Linnean Society (Botany)* 14: 146-152.
- Gooding, E.G.B. 1991. New collections for the Flora of Barbados I. *Journal of the Barbados Museum and Historical Society* 39, 52-56.
- Gooding, E.G.B. 1974. The plant communities of Barbados. Ministry of Education, Barbados.
- Gooding, E.G.B. 1970. Historic relics in the flora of Barbados. *Journal of the Barbados Museum and Historical Society* 23, 101-110.
- Gooding, E.G.B. 1947. Observations on the sand dunes of Barbados, British West Indies. *Journal of Ecology* 34, 111-125.
- Gooding, E.G.B. 1944. Turner's Hall Wood, Barbados. *Caribbean Forester* 5, 153-170.
- Gooding, E.G.B. 1939-1942. Facts and beliefs about Barbadian plants. *Journal of the Barbados Museum and Historical Society* 7, 170-174; 8, 32-35, 103-106, 194-197; 9, 17-19, 84-88, 126-129, 192-194; 10, 3-6.
- Gooding, E.G.B., Loveless, AR., and Proctor, GR. 1965. Flora of Barbados. HMSO, London.
- Howard, R.A. 1979. Early botanical records from the West Indies, particularly Barbados: Ligon (1657) to Lord Seaforth (1806). *Botanical journal of the Linnean Society* 79, 65-96.
- Howe, M.A. 1928. Notes on some marine algae from Brazil and Barbados. *J. Washington Academy of Sciences* 18: 186-194.

- Huges, G. 1750. The natural history of Barbados. London 1972 reprint, Arno Press, New York.
- Hutt, M.B. 1981. The Barbados national park. Report of an investigation into the physical and ecological aspects of the proposed national park. Barbados National Trust.
- Light, M.H.S. 1976. Non-flowering plants of Barbados. Ministry of Education, Barbados.
- Maycock, J.D. 1830. Flora Barbadosensis. James Ridgeway, London.
- Pearce, E.J. 1963. A note on the mosses of Barbados. Journal of the Barbados Museum and Historical Society 30, 59-60.
- Ramnarine, S. 1991. Tropical Forestry Action Plan Barbados: Report on silviculture. CARICOM /FAO/Ministry of Agriculture Food and Fisheries.
- Randall, R.E. 1970. Vegetation and environment on the Barbados coast. Journal of Ecology 58, 155.
- Rogers, G. and Holder, A. 1998. Barbados grasses and sedges of conservation interest. Typescript.
- Vickers, A. 1905. Liste des algues marines de la Barbade. Annales des Sciences Naturelles (ser. 9) 1: 45-66, 215-222.
- Vickers, A. 1908. Phycologia barbadensis; Iconographie des algues marines recoltees a l'Ile Barbade (Antilles), Librairie Des Sciences Naturelles Paul Klincksieck, Paris.
- Watts, D. 1966. Man's influence on the vegetation of Barbados: 1627 to 1800. University of Hull Publications, Hull.
- Welch, W.H. and Crum, H.A. 1969. Recent cryptogamic collections in Barbados. Journal of the Barbados Museum and Historical Society 33, 85-87.

Agricultural Biodiversity

- CARDI. 1996. Annual Technical Report 1994/95, Barbados Unit, Cave Hill. CARDI.
- Ministry of Agriculture, Food and Fisheries. 1992. Barbados 1989 agricultural census. Government of Barbados.
- Ministry of Finance and Economic Affairs. 1996. Medium term macro-economic strategy 1996- 1999. Government of Barbados.
- Ministry of Agriculture and Rural Development. 1996. Agriview 1995. Government of Barbados.
- Ministry of Finance and Economic Affairs. 1997. Economic report 1996. Government of Barbados.

Rao, P. Seshagiri and Gardiner, John. 1997? Varietal change and diversity in the sugar association of the Caribbean member countries. Typescript.

Skeete, Stevenson. 1995. The phenological behaviour of fruit crops in Barbados. Typescript.

Watts, David. 1966. Man's influence on the vegetation of Barbados. University of Hull.

Wickham, Orville. 1995. Barbados report on plant genetic resources. Typescript.

Terrestrial Fauna Biodiversity

Adamson, A.M. 1948. Notes on the termite fauna of the Lesser Antilles. *Tropical Agriculture* 25: 53-55.

Allen, G.M. 1911. Mammals of the West Indies. *Bull. Mus. Comp. Zool. Harvard Coll.* 54:175-263.

Ballou, H.A. 1937. Notes on the insects mentioned in Schomburgk's history. *J. Bar. Mus. Hist. Soc.*

Barbour, T. 1930. Some faunistic changes in the Lesser Antilles. *Proc. New Eng. Zool. Club* 11: 73-85.

Baulu, J. 1992. The Barbados Primate Research Centre and Wildlife Reserve. Paper presented at Eco '92, Earth Summit, United Nations Conference on Environment and Development, Rio, Brazil.

Bennett, F.D. and Alam, M.M. 1985. An annotated checklist of the insects and allied terrestrial arthropods of Barbados. Caribbean Agricultural Research and Development Institute, Barbados

Boulton, A. M., Horrocks, J.A. and Baulu, J. 1996. The Barbados vervet monkey (*Cercopithecus aethiops sabaues*): changes in population size and crop damage, 1980-1994. *Int. J. Primatol.* 17: 831-844.

Burgess, B. 1993. The status of *Oreochromis* sp. (*Tilapia*) in the surface waters of Barbados. Undergraduate Research Project Report, Dept. Biology, University of the West Indies, Cave Hill.

Caribbean Agricultural Research and Development Institute. 1981. Monkey Crop Damage Control in Barbados . Report to the Caribbean Development Bank, Bridgetown, Barbados.

Censky, E.J. 1988. *Geochelone carbonaria* (Reptilia:Testudines) in the West Indies. *Biological Sciences* 2: 108-114.

Chace, F.A. and Hobbs, H.H. 1969. The freshwater and terrestrial decapod crustaceans of the West Indies, with special reference to Dominica. *Bull. Smithsonian Inst. No. 292.* US National Museum, Washington, DC.

Christens, E. And Blokpoel, H. 1991. Operational spraying of white mineral oil to prevent hatching of gull eggs. *Wild. Soc. Bull.* 19: 423-430.

Corke, D. 1992. The status and conservation needs of the terrestrial herpetofauna of the Windward Islands (West Indies). *Biological Conservation* 62: 47-58.

- Corn, J.L. 1992. The role of wildlife in the population dynamics of the tropical Bont tick in Guadeloupe, French West Indies. Final Report to Agricultural Research Service, United States Department of Agriculture, Washington, D.C. 20p.
- Emsley, M.G. 1963. The rediscovery of Cope's *Liophis perfuscus* in Barbados. *Copeia* 3:577-579.
- Feilden, H.W. 1889. Notes on the reptiles of Barbados. *The Zoologist* 13: 295-298.
- Feilden, H.W. 1890. Notes on the terrestrial mammals of Barbados. *Zoologist* 14: 52-55.
- Gibbs, I.H. 1993. Investigations of cabbage production in Barbados and insecticide resistance in diamondback moth [*Plutella xylostella* (L.)(Lepidoptera:Plutellidae)] and a larval parasitoid [*Cotesia plutellae* (Kurdj.) (Hymenoptera: Braconidae)]. M.Phil. Thesis. University of the West Indies, Cave Hill, Barbados. 215p.
- Gowdy, John M 1997. The Value of Biodiversity: Markets, Society and Ecosystems *Land Economics*. 73(1):25-41.
- Govindarajulu, P, Hunte, W., Vermeer, L. and Horrocks, J. 1993. The ontogeny of social play in a feral troop of vervet monkeys (*Cercopithecus aethiops sabaeus*): the function of early play. *International Journal of Primatology* 14:701-719.
- Horrocks, J.A. 1985. Aspects of the behavioural ecology of *Cercopithecus aethiops sabaeus* in Barbados, West Indies. Ph.D. thesis. Department of Biology, University of the West Indies. 283pp.
- Horrocks, J.A. 1986. Life history characteristics of a feral population of vervets (*Cercopithecus aethiops sabaeus*) in Barbados. *International Journal of Primatology* 7: 31-47.
- Horrocks, J.A. 1992. WIDECASST Sea Turtle Recovery Action Plan for Barbados. (K.L. Eckert, Editor). CEP Technical Report 12. UNEP Caribbean Environment Programme, Kingston, Jamaica. 61 pp.
- Horrocks, J.A. 1993. An investigation of the role of cattle egrets (*Bubulcus ibis*) in the intra-island transmission of tropical Bont ticks (*Amblyomma variegatum*) and in the consumption of agriculturally beneficial/detrimental fauna. Unpubl. Report to Ministry of Agriculture, Food and Fisheries.
- Horrocks, J. 1997a. Terrestrial ecology - Fauna. Barbados Coastal Conservation Programme- Phase 1. Sir William Halcrow and Partners Ltd, London/Ministry of Health and the Environment, Government of Barbados. 45pp.
- Horrocks, J. 1997b. The wildlife of Barbados: Distribution, abundance and conservation status of selected faunal components. Environmental Management and Land Use Planning for Sustainable Development Project. Bird and Hale Ltd., Toronto/Ministry of Health and the Environment, Government of Barbados. 51pp.
- Horrocks, J.A. and Baulu, J. 1988. Effects of trapping on the vervet (*Cercopithecus aethiops sabaeus*) population in Barbados. *American Journal of Primatology* 15:223-234.
- Horrocks, J. A. and Baulu, J. 1994. Food competition between vervets *Cercopithecus aethiops sabaeus* and farmers in Barbados: implications for management. *Revue D'Ecologie* 49: 281-294.

- Horrocks, J.A. and Hunte, W. 1983a. Maternal rank and offspring rank in vervets: an appraisal of the mechanisms of rank acquisition. *Animal Behaviour* 31:772-782.
- Horrocks, J.A. and Hunte, W. 1983b. Rank reversal in vervet sisters: a critique of the role of reproductive value. *American Naturalist* 122:417-421.
- Horrocks, J. A. and Hunte, W. 1986. Sentinel behaviour in vervet monkeys: who sees whom first? *Animal Behaviour* 34:1566-1568.
- Horrocks, J.A. and Hunte, W. 1992. Interactions between juvenile and adult male vervets: implications for adult male turnover. In: *Juvenile Primates* (Ed. by M. Pereira and L. Fairbanks), Oxford University Press, pp.228-239.
- Horrocks, J.A. and Scott, N.M. 1991. Nest site location and nest success in the hawksbill turtle *Eretmochelys imbricata* in Barbados, West Indies. *Marine Ecology Progress Series* 69:1-8.
- Hunte, W. and Horrocks, J.A. 1987. Kin and non-kin interventions in the aggressive disputes of vervet monkeys. *Behavioural Ecology & Sociobiology* 20: 257-263.
- Hughes, G. 1750. *The natural history of Barbados*. London.
- Hutt, M.B. 1978. Save the hare-rabbit from extinction. *Barbados Advocate* (issue unknown).
- IUCN 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.
- James, C. 1991. Report on wildlife and national parks. *Tropical Forestry Action Plan for Barbados*. CARICOM/ODA/FAO, Bridgetown, Barbados. 42p.
- Jones, J.E. 1985. Aspects of the population interaction of *Plutella xylostella* (L.) Lepidoptera: Plutellidae and *Apanteles plutellae* (Kurdj.) Hymenoptera: Braconidae. Ph.D. thesis, University of the West Indies, Cave Hill. 268p.
- Jones, J.K. Jr. and C.J. Phillips. 1970. Comments on systematics and zoogeography of bats in the Lesser Antilles. *Stud. Fauna Curacao & Carib. Islands* XXXII: 131-145.
- Krebs, E.A., Riven-Ramsey, D. and Hunte, W. 1994. The colonisation of Barbados by cattle egrets (*Bubulcus ibis*) 1956-1990. *Colonial Waterbirds* 17: 86-90.
- Lazell, J.D. 1972. Raccoon relatives. *Man and Nature* 11-15.
- Ligon, R. 1657. *A true and exact history of the island of Barbados*. London.
- Marsh, R.E. 1981. Comments on the current status of the European hare in Barbados. *Lagomorph Newsletter* 2: 5-6.
- Marsh, R.E. 1983. Unquestionable evidence that the whistling frog of Barbados is indigenous. *J. Bar. Mus. Hist. Soc.* XXXVII: 68-71.
- Nellis, D.W. and C.O.R. Everard. 1983. The biology of the mongoose in the Caribbean. *Stud. Fauna Curacao & Carib. Islands* LXIV: 1-162 .

- Ovaska, K. 1991. Reproductive phenology, population structure, and habitat use of the frog *Eleutherodactylus johnstonei* in Barbados, West Indies. *J. Herpetology* 25: 424-430.
- Ovaska, K. and Hunte, W. 1992. Male mating behaviour in the tree frog, *Eleutherodactylus johnstonei*, in Barbados, West Indies. *Herpetologica* 48: 40-49.
- Pearce, E.J. Rev. 1969. An attempted reappraisal of the butterflies of Barbados, with reference to certain weather phenomena. *J. Bar. Mus. Hist. Soc.* 33: 76-84.
- Peck, S.B. 1981. Community composition and zoogeography of the invertebrate cave fauna of Barbados. *Fla. Entomologist* 64: 519-527.
- Poponi, A., Vermeer, L. Horrocks, J.A. and McConney. 1998. The Barbados Sea Turtle Project. In Proc. Eighteenth Ann. Symp. on Sea Turtle Biology and Conservation.
- Ray, C.E. 1964. A small assemblage of fossils from Spring Bay, Barbados. *J. Bar. Mus. Hist. Soc.* 31: 11-22.
- Richardson, K.S. 1988. Space use by vervet monkeys (*Cercopithecus aethiops*) and its consequences for the genetic structure of the Barbados population. M.Sc. Thesis, McGill University, Canada.
- Schwartz, A. 1967. Frogs of the genus *Eleutherodactylus* in the Lesser Antilles. *Stud. Fauna Curacao & Carib. Islands* XXIV: 1-62.
- Schomburgk, R.H. 1848. The history of Barbados. London.
- Snyder, T.E. 1956. Termites of the West Indies, the Bahamas, and Bermuda. *J. Agr. Univ. Puerto Rico* 14:189-202.
- Tucker, R.W.E. 1952. The insects of Barbados. *J. Agr. Univ. Puerto Rico* 30: 330-363.
- Underwood, G., Horrocks, J.A. and Daltry, J. 1999. A new snake from Barbados. *J.BMHS.* XLV: 67-75.
- Vermeer, L.A. 1993. The stability of matrilineal dominance hierarchies in vervet monkeys (*Cercopithecus aethiops sabaeus*). M.Sc. Thesis, McGill University, Canada. 123p.
- Vermeer, L.A. 1994. Seasonal, lunar and tidal variation in reproduction of the endangered hawksbill turtle (*Eretmochelys imbricata*) in Barbados. M.Sc. Thesis. University of the West Indies, Barbados.
- Watson, K. 1993. The resident birds of Barbados: a historian's perspective. *J. Bar. Mus. & Hist. Soc.* XLI 165-174.
- Watson, K. 1996. The birds of Barbados. Unpublished presentation to Barbados Museum Summer Programme, August 28, 1996
- Watts, D. 1987. The West Indies. Patterns of development, culture and environmental change since 1492. Cambridge University Press, UK. 609 pp.
- Wood, C.A. 1923. The glossy cowbird (*Molothrus atronitens*) in Barbados. *The Auk* XL: 128-129.

Marine and Freshwater Diversity

Acker, K.L. 1987. The carbonate-siliclastic facies transition in the modern sediments off the northeast coast of Barbados, W.I. M.Sc. thesis, McGill University, Montreal, Canada.

Allard P. 1993. Changes in the Coral Community Structure in Barbados: effects of eutrophication and reduced grazing pressure. M.Sc. thesis, McGill University, Montreal, Quebec, Canada.

Bellairs Research Institute 1984. Marine studies component of the south and west coast sewage project. Technical Report 13, Barbados, West Indies

Bellairs Research Institute 1988. Monitoring the environmental impact of the Bridgetown sewage plant outfall: 1983-1987. A Technical Report for the Coastal Conservation Project Unit, Ministry of Employment Labour Relations and Community Development, Barbados, West Indies

Bellairs Research Institute 1989. Community descriptors 1987 for nearshore and offshore reefs on the south and west coasts of Barbados. A Technical Report for the Coastal Conservation Project Unit, Ministry of Employment Labour Relations and Community Development, Barbados, West Indies

Cattaneo, A. Kramer, D. Kramer, V. and Peters, R. 1988. A Limnological and Ichthyological Reconnaissance of Graeme Hall Swamp. A report for the Ministry of Employment, Labour Relations and Community, Development Government of Barbados.

Caribbean Conservation Association.(CCA) 1995. Graeme Hall Swamp Management Study Part 1. Synthesis of Resources and Potentials (mimeo).

Cotter, P.J. 1984. A comparative study of three reef fish populations and their relationship to fringing reef structures on the west coast of Barbados, West Indies. M.Sc. thesis, McGill University, Montreal, Canada.

Delcan International Corp. Ltd. 1994a. Terrestrial Water Quality Report. Report for the Government of Barbados and American Development Bank..

Delcan International Corp. Ltd. 1994b. Nearshore Benthic Communities of the West and Southwest Coasts of Barbados: Importance, Impacts, Present Status and Management Status. Report for the Government of Barbados and American Development Bank.

Duarte, C. M. 1992. Submerged Aquatic vegetation in Relation to Different Nutrient Regimes. *Ophelia* 41:87 - 112.

Fisheries Division 1997. Barbados Fisheries Management Plan: schemes for the management and development of fisheries in the waters of Barbados. A report for the Government of Barbados, Ministry of Finance and Economic Affairs, Barbados, West Indies.

Felix, C. 1991 Freshwater shrimps of Barbados: some aspects of their biology, ecology and culture. PhD. thesis University of the West Indies, Barbados, West Indies.

- Famum, P.A.L. 1979. A preliminary study of the present conditions of the beaches, the coral reef structures, and the inshore fisheries and the general marine life around the south and east coasts of Barbados and of the effects of oil and other pollutants on the same. Unpubl. MS. Barbados, West Indies.
- Fortes, M.D. 1988. Seagrass-Mangrove Ecosystems Management: a key to marine coastal conservation in the Asean region. *Marine Pollution Bulletin* 23:93-103.
- Frydl, P. 1977. The geological effects of grazing by parrotfish (Scadidae) on a Barbados coral reef. M.Sc. thesis, McGill University, Montreal, Canada.
- Halcrow, W. and Partners. 1998. Barbados Coastal Conservation Programme - Phase 1: Marine Ecology - Draft Report.
- Hunte, W. Allard, P. 1997. Temporal Changes in the Coral Reef Communities on the West and South Coasts of Barbados; 1982-1992. A Technical Report prepared on behalf of the Bellairs Research Institute for the Coastal Conservation Project Unit of the Government of Barbados.
- James, N.P., Steam, C.W. and Harrison, R.S. 1977. Field guide book to modern and Pleistocene reef carbonates, Barbados, W.I. Proc. 3d Int. Coral Reef Symposium., Miami, Florida.
- James, N.P. and Whittaker, S. 1990. Field guide book to modern and Pleistocene reef carbonates, Barbados, W.I. (updated and modified version). The Atlantic Reef Committee, University of Miami, Florida.
- Johannes, R.E 1975. Pollution and degradation of Coral Reef Communities. In: Ferguson Wood, E.J and Johannes, R.E (eds) *Tropical Marine Pollution*. Elsevier, Amsterdam pp. 13-51.
- Lewis, J.B. 1960. The fauna of rocky shores of Barbados, West Indies. *Canadian Journal of Zoology*,. Vol. 38, 391-435.
- Lewis, J.B. 1965. A preliminary description of some marine benthic communities from Barbados, West Indies. *Canadian Journal of Zoology*,. Vol. 43, 1049-1074.
- Lewis, J. Oxenford, H. 1996. Field Guide to the Coral Reef of Barbados. Biology Department of McGill University, Montreal, Canada.
- Liddell, W.D. 1979. Shallow-water comatulid ctenoids (Echinodermata) from Barbados, West Indies. *Canadian Journal of Zoology*, Vol. 57, 2413-2420.
- Luckhurst, B. 1978. Reef fish populations on small coral heads with special reference to the territoriality of *Eupomacentrus fuscus*. M.Sc. thesis, McGill University, Montreal, Canada.
- MacGeachy, J.K. 1975. Boring by macro-organisms in the coral *Montastrea annularis* on Barbados reefs. M.Sc. thesis, McGill University, Montreal, Canada.
- MacGeachy, J.K. 1978. Geological significance of boring sponges on Barbados reefs. Ph.D. thesis, McGill University, Montreal, Canada.

- MacIntyre, I.G. 1967a. Recent sediments off the west coast of Barbados, W.I. Ph.D. thesis, McGill University, Montreal, Canada.
- MacIntyre, I.G. 1967b. Submerged coral reefs, west coast of Barbados, West Indies. *Canadian Journal of Earth Science*, Vol. 4, 461-474.
- Mahon, R. and Mahon S. 1994. Structure and Resilience of a Tidepool Fish Assemblage at Barbados, *Environmental Biology of Fishes*.
- Mahon, R. and Mahon S. 1997. Overnight Die-Off of Fish in Graeme Hall Swamp. Unpublished.
- Martindale, W. 1976. Calcareous encrusting organisms of the recent and Pleistocene reefs of Barbados, West Indies. Ph.D. thesis, University of Edinburgh, Edinburgh, Scotland.
- Miller, J. 1975. The fish fauna of an inshore reef flat at Barbados, with special reference to the grazing activity of Acanthuhdae and Pomacentdae. M.Sc. thesis, McGill University, Montreal, Canada.
- Parker C. and Oxenford H. 1994. Characterisation of the Barbados CARICOMP site. Unpublished
- Patriquin, D.G. 1971. The origin of nitrogen and phosphorous for growth of the marine angiosperm *Thalassia testudinum* Konig. Ph.D. thesis, McGill University, Montreal, Canada.
- Proctor & Redfem Int. Ltd., David Lashley & Partners, Hunter & Assoc. 1984a. Nearshore ecological zonation and reef degradation. Coastal Conservation Project Unit, Diagnostic Survey ,Technical Report Vol. 4 (12), Government of Barbados, Ministry of Housing and Lands and Inter-American Development Bank.
- Pulich, W. M. and White, W.A. 1991. Decline of Submerged Vegetation in the Galveston bay System: Chronology and Relationships to Physical Processes. *Journal of Coastal Resources*, Vol. 7: 1125-1138.
- Ott, B.S. 1975a. Quantitative analysis of community pattern and structure on a coral reef bank in Barbados, West Indies. Ph.D. thesis, McGill University, Montreal, Canada. .
- Reed, J. 1989. Cruise Report: Eastern Caribbean Expedition R/V Seward Johnson and Johnson-Sea-Link II Submersible. Harbor Branch, Oceanographic Institute Inc.
- Riven-Ramsey D. 1988. Foraging and breeding behaviour of the cattle Egret (*Bulbulcus ibis*) in Barbados. M Phil. Thesis, University of the West Indies, Barbados.
- Riven Ramsey D. 1993. Terms of Reference and supporting material for the feasibility study of the Development of Graeme Hall Swamp as a nature reserve. A Report to Government of Barbados and Inter-American Development Bank.
- Rakitin, A. 1994. The Effect of a Marine Reserve of the Abundance and Size of Coral Reef Fishes in Barbados, West Indies
- Seakem Oceanography Ltd. 1989. Marine studies. Barbados south and west coast sewerage project. A Technical Report for Reid Crowther Inc., Barbados, West Indies

Snelgrove, P.V.R. 1986. Pollution detection models and habitat preference of the cryptofauna associated with the coral *Madracis mirabilis*. M.Sc. thesis, McGill University, Montreal, Canada.

Steam, C.W., Scoffin, T.P. and Marfindale, W. (1977). Calcium carbonate budget of a fringing reef on the west coast of Barbados. Part 1: Zonation and productivity. *Bulletin of Marine Science*, 27, 479-510.

Tomascik, T. (1986). The effects of eutrophication on the growth rates, reproductive potential and community structure of the inshore reef-building corals in Barbados, West Indies. Ph.D. thesis, McGill University, Montreal, Canada.

Taylor, J. L. and Saloman, C.H. (1968). Some Effects of Hydraulic Dredging and Coastal Development in Boca Ciega Bay, Florida. *Fisheries Bulletin* 67:213-241.

Thorhaug, A. and Marcus, J. H. 1987a. Oil Spill Clean-up: The effects of three dispersants on three tropical/subtropical seagrasses. *Marine Pollution Bulletin* 18:124-126.

Tomascik, T. and Sander, F. 1987. Effects of eutrophication on reef-building corals. Structure of scleractinian coral communities on fringing reefs, Barbados, West Indies. *Marine Biology* 94, 53-75.

Turnbull, D. 1979. The water quality characteristics and distribution of benthic invertebrates in a polluted harbour, Barbados, West Indies. M.Sc. thesis, McGill University, Montreal, Canada.

Vermeer, L.A 1997. Present Status and Tropical Trends in Seagrass Communities Near Graeme Hall Swamp. A report prepared for ARA Consulting Group Inc., Ottawa, Canada

Wilson 1983. A Report of the Trap Fishing Industry of Barbados, prepared for the Ministry of Agriculture, Food and Consumer Affairs, Government of Barbados.

Land Resources

Felix, C. 1991. Freshwater shrimps of Barbados: some aspects of their biology, ecology and culture. PHD. Thesis University of the West Indies, Barbados.

Town and Country Planning Office (Barbados), 1988. Barbados Physical Development Plan.

Land Use Planning for Sustainable Development Project; National Physical Development Plan Draft, 1998.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. Environmental Impact Assessment Guidelines & Procedures for Barbados, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. Environmental and Natural Resources Management Plan, Ministry of Health and the Environment, Government of Barbados.

Environmental Management & Land Use Planning for Sustainable Development (EMLUP), 1998. The National Park Development Plan (Draft), Ministry of Health and the Environment, Government of Barbados.

Assessment of Socio-cultural Conditions

United Nations Commission on Sustainable Development 1997. Barbados Country Profile. Implementation of Agenda 21: Review of Progress Made since the United Nations Conference on Environment and Development.

Barbados Statistical Service 1990. Population and Housing Census.

Bayley, I., 1949. The Bush Teas of Barbados, *Journal of the Barbados Museum and Historical Society*. Volume 16, No. 3, pp. 103-112.

Commonwealth Yearbook, 1998. The Commonwealth Member Countries Part IV - Barbados. Hanson Cooke Ltd.

Drewitt, P. 1991. Settlement Pattern and Morphology, Prehistoric Barbados. Institute of Archeology, University College of London. Barbados Museum and Historical Society.

Handler, J. and Jacoby, J. 1994. Slave Medicine and Plant Use, *Journal of the Barbados Museum and Historical Society*, Vol. XLI 1993, pp. 74-98.

Dr. Elizabeth Ferdinand, Acting Chief Medical Officer, speech delivered November, 1997. Health Situation in Barbados - Overview of Health Policies and Strategies.

Ministry of Education, Youth Affairs and Culture, 1997. Curriculum Modules on Citizenship Education for the 12 to 14 Age Group in Secondary School in Barbados - Module: The Environment.

Ministry of Finance and Economic Affairs. September 1997. Barbados Economic Report. 1996, Central Bank of Barbados

Travers Morgan International, Islands Engineering Group and Environmental Planning Group. 1996 National Transport Plan Study

The World Bank, Environment Department. .September 1994. Environmental Assessment Sourcebook Update. Vol 8.

APPENDIX 1

ECONOMIC VALUATION OF BIODIVERSITY IN BARBADOS

1. Introduction

In the process of economic growth and development, trade-offs invariably will have to be made between environmental preservation and development activities as well as among different types of environmental goods and services. Economics attempts to facilitate such decision-making by providing a common yardstick to compare different types of environmental costs and benefits. This yardstick is the dollar value of costs and benefits.

The concept of “value” of resource and environmental goods and services is relatively new and is based on the neoclassical concept of utility. Application of a utility based valuation system, which is exclusively anthropocentric, to value a complex commodity like biodiversity, has attracted criticism from some environmental groups. Their protests are often based on the argument that the intrinsic value of life on earth and the right of species to exist on their own is not captured in this valuation system. Also, more technical issues such as cognition, the incongruity problem, indivisibilities and complementarities of ecosystem functions and pure time preference are identified as potential problems (Gowdy, 1997).

Despite these caveats, economic values provide a powerful tool in guiding public policy decisions as well as in allocation of public funds to various sectors of the economy. For a long time, environmental causes have generally been under-emphasised because of the difficulty in quantifying the qualitatively identifiable benefits and costs. When economic values are given to environmental attributes, environmental concerns can be more easily weighed against traditional sectors of the economy such as health, education, transportation, agriculture and industry. In addition, it now becomes possible to include the value of natural capital in national accounts systems. This is known as “greening of national accounts.” Several developed and developing countries have valued important resources, such as forestry, fisheries, mines, for national accounting purposes. Valuation of biodiversity is obviously the next step in this process, where values are placed on the physical inventory of different categories of biodiversity.

In this section, valuations are presented for agricultural biodiversity, natural flora and fauna and marine resources in Barbados. Valuations presented herein use only available data and information.

2. Agriculture and Livestock Biodiversity

According to the United Nations Guidelines for Country Studies on Biological Diversity, an indicator of the socio-economic benefits of agricultural biodiversity is the value of production. The suggested method of valuation is the market price of output. For outputs to be valued at market prices, the demand for the product should be perfectly elastic. That is, the market price (supply) should be equal to the marginal revenue and the marginal cost of production (and also average cost of production) for all levels of output. In general, this criterion is satisfied for agricultural commodities because, even though as a group the demand for agricultural products may be inelastic, the demand for an individual agricultural commodity is perfectly elastic due to the substitutability. Further, in the context of Barbados, agricultural production comes from many farmers (especially for vegetables, root crops and fruits) and sold to many consumers. Therefore, each producer and consumer is a price taker and satisfy conditions of a perfectly competitive market.

Commercial Crops

Most of the value of agricultural biodiversity in Barbados is from commercial crops. The two major commercial crops in the island are sugar cane and cotton. Sugarcane is by far the more important crop. However, the area under cotton increased by nearly 87% in 1995 over 1994. Both, cotton seed and cotton lint yields also showed significant increases.

Due to agreements and a guaranteed pricing system, sugar prices still remain attractive. However, inefficient production technology, unfavourable weather conditions and other factors have resulted in the cost of production exceeding the export price during the last four years. In 1997, total export earnings were 73 million dollars from 57.8 thousand tonnes. In comparison, the cost of production of this amount of sugar was nearly 81 million dollars.

Although in terms of production cotton has fared better than sugar, marketing of the crop has been a problem. In 1996, the area under cotton decreased by nearly 77% due to the uncertainty in market conditions. Without any clear prospects for marketing, it is highly unlikely that any agricultural land will be reverted to cotton in the future. Therefore the value of cotton as a component of agricultural biodiversity will probably remain insignificant.

Several vegetable crops have shown significant upward trends. Notable are beans, cabbage, cucumber, okra, hot pepper, sweet pepper, sweet potato, pumpkin and tomato. The increase in acreage of these crops can be attributed to the fact that these items have become important components in Barbadian diet as well as being in high demand from hotels and restaurants. This trend is likely to continue unless significant changes occur in the international markets of commercial crops. Besides the main crops, varieties of other vegetables are grown in Barbados. Some notable ones are lettuce, eggplant, butternut squash, christophene and cauliflower.

Although, the total value of these vegetables is relatively insignificant, individual vegetables, particularly cauliflower, are highly priced.

Although a variety of fruits are available in the island, bananas, figs and plantains are the major fruits produced. Yet compared to vegetables and root crops, the land area under fruit cultivation remains relatively minor. Production and price data are scant for fruits in general. Production of bananas, plantains and figs was 1797, 800 and 72 tonnes, respectively in 1995. Estimated at retail prices, value of these three items is about 6.48 million dollars.

No production data exists on local cut-flower and foliage production. Cut-flowers and foliage are primarily sold to hotels and florists. From import data available, cut-flowers and foliage appear to be highly priced items. In 1995, 29,490 kg of cut-flowers were imported which had a total value of \$440,792, which is nearly \$15/kg. Foliage import was 25,454 kg. with the average value of 3.60/kg.

Livestock

The major livestock products in Barbados are pork, beef, chicken, fresh milk, eggs and mutton. Local livestock, especially cattle and goats have been cross-bred and no major pedigree can be determined. Most of the commercial breeds are imported. Therefore, besides the value of products, it is unlikely that livestock biodiversity in Barbados are valuable in an intellectual property rights capacity. The total value of livestock products in their primary form amounts to nearly 138 million dollars. Most livestock products are also used to produce secondary products with significant value added. For example, chicken is used extensively in the fast food industry while beef is used to make hamburgers, sausages and such products. Ham and bacon are two popular secondary products of pork. Milk is also used for yoghurt and cheese production. Therefore, the value presented here should be only considered as a lower bound.

Other Values of Agricultural Biodiversity

Besides commercial consumption value, agricultural biodiversity could generate other values, such as germplasm; soil erosion prevention and landscape value. These values are relatively difficult to quantify as these are not products traded in the market. Nevertheless, under certain circumstances, the value generated due to these uses could be quite substantial.

Germplasm conservation allows for the production of disease resistant, high yielding varieties through cross-breeding. The ultimate value of germplasm conservation is commercial value. Whether a high yielding variety or a disease resistant variety, the ultimate benefits would be higher value from the same area of land. The most organized germplasm conservation program in Barbados is for sugar cane. The Sugar Cane Breeding Station, Agronomy Research and Variety Testing Unit works to breed and field test better varieties of sugar cane. Out of this research and testing about 12 varieties have been commercially introduced in Barbados over the

past decade. This is evidence that agricultural biodiversity could produce indirect value through the conservation of germplasm conservation.

Some agricultural crops are known to prevent soil erosion as well as produce other benefits such as nitrogen fixation and weed control. Sugar cane cultivation, for example, is known to produce soil erosion control and weed control. Considering that sugar cane still remains the primary agricultural crop in the country, it is likely that the benefits of soil erosion control and weed control through sugar cane cultivation could be substantial.

The scenic value generated by cultivated agricultural land could be an important external economy of agricultural biodiversity in Barbados. However, landscape value generated by agricultural biodiversity is a public good. Therefore, traditional market based methods cannot be applied to obtain landscape value of agricultural diversity in the island. To estimate the landscape value therefore, survey based methods such as the contingent valuation method could be used.

Costs of Agricultural Biodiversity

The costs of agricultural biodiversity can be categorized as direct or indirect. Direct costs are (a) costs involved in the production of crops and livestock; and (b) costs of maintaining the institutional capacity to implement and administer the programs specifically intended for agriculture. Input costs in the production of crops and livestock, such as labour, fertilizer, pesticides, land preparation, harvesting, loan payments are all part of the market price of products. However, the opportunity cost of land, that is, the value of land for best alternative uses to agriculture, is not taken into account. Indirect costs of agricultural biodiversity are generated through the production process as external dis-economies. Probably the two most important externalities of agricultural production in any country is soil erosion and contamination of groundwater and coastal waters through agro-chemicals.

There is no comprehensive database to adequately evaluate the cost of externalities of agricultural production. It is expected that costing of externalities of agricultural production will be considered as part of the implementation of the government's Sustainable Development Action. It would be imperative that proper evaluation of externalities of agricultural production is done not only to determine the cost of agricultural biodiversity in Barbados, but also to determine the efficient use of resources in the agriculture sector.

3. Vegetation and Forestry Biodiversity

Forestry in Barbados is not a major land use component. Much of the original forests were cleared for agriculture, primarily, sugar cane so that only a fraction of the virgin forest which covered the island over 350 years ago remains intact today. However, with the gradual abandonment of sugar cultivation in recent years, some land has reverted to secondary forests.

There are also isolated patches of other natural plant communities. Typical economic values of vegetation and forestry diversity are identified in the following sections.

Logging and Timber Value

There is no commercial scale logging industry in Barbados primarily due to the paucity of natural forest cover. There is only limited use of local timber for furniture production, handicrafts and utility goods. The value of products, which are produced using local timber, is therefore not expected to be significant.

Recreational Value

Although forest based recreation may not be as significant in Barbados as in other countries with abundant forest cover, the remaining forested areas are important for the tourist industry. The Welchman Hall Gully and the Granade Hall Forest Reserve are two popular locations with visitors to the island. There are other forested locations, which have become popular tourist sites. These include Jack-in-the-Box gully and Joe's River Forest, which are also popular tourist sites.

Market Value of Forest Products

The local population does not depend heavily on forest products for sustenance or income generation. If anything is collected from natural forests or vegetation for edible purposes it is mostly informal and insignificant. It is highly unlikely that these products generate a significant income for sellers.

Value of Ecological Functions

Most of the value of ecological functions for forests and natural vegetation is accrued through watershed protection, soil erosion prevention and carbon sequestration. Before any attempts can be made at quantification of the benefits of these ecological functions, the connection between forests and natural vegetation and the benefits they generate should be established.

Although the importance of forested gullies to recharge groundwater aquifers is well known, no research has been done to quantify this relationship. If it could be done, then the amount of water recharged into the aquifers could be valued at the social cost of water, that is, the market value and the scarcity value of water.

Value of Plants for Medicinal and other Purposes

Some wild plants are used by locals to treat minor illnesses. However, no data is available to determine to what extent they are being used. Also, the effectiveness of these indigenous treatments is not documented. Some wild plants are also used to produce handicrafts such as

baskets, fresh and dry flower arrangements. Although done at a limited scale, it is likely that these uses generate a very high value added as they are sold primarily to tourists. Market value of these products could be used to approximate the value for these purposes.

Nonuse Values

Nonuse values are values of forest and vegetation diversity irrespective of their present anthropogenic uses. Economic theory suggests that as the availability of a good or a service become progressively less, the value of a marginal unit increases. Since the remaining forest area and land under natural vegetation is severely limited in Barbados, the potential value for these uses could be quite substantial.

Research and Educational Value

The existing forests and natural vegetation in the island are extensively studied by the staff and students of the University of the West Indies (UWI) as well as staff and students of foreign universities. However, it is not easy to determine the contribution that forests and natural vegetation make in this aspect. One way to determine the minimum value for research and educational purposes is to estimate the cost necessary to replicate the benefits derived by local plant diversity by other means. This would be similar to the replacement cost method which estimates the cost of replacing or replicating the service of an environmental good for a particular use.

Grazing and Fodder Value

Small farmers and backyard livestock enterprises would be the primary beneficiaries from the use of natural vegetation. However, there is no data to determine the amount of milk and meat produced from animals which are fed exclusively on natural vegetation. The replacement cost method can be used to value natural vegetation for this use. By estimating the cost of animal feed which is necessary to provide the same nutrition, a value can be placed on the contribution of natural vegetation for livestock production.

Cost of Forestry and Vegetation Diversity

The only significant cost is the opportunity cost of land which is under forest and natural vegetation cover. However, except for the biological diverse areas such as gullies, other natural vegetation sites exist primarily on land which is unsuitable for residential or other development or on land that is marginal for agriculture. Therefore, it is highly unlikely that existence of natural vegetation in Barbados imparts a significant social cost. In the case of protected areas which could be used for other productive uses, it would be quite straightforward to determine the opportunity cost of best possible alternative use.

It is clear that the most important values of forestry and natural vegetation in the island will be indirect use values such as ecological functions and nonuse values. There appears to be no major use values of natural vegetation, except probably for grazing of livestock. Therefore, it is important that nonuse values are properly quantified. Before such an exercise can be undertaken, it is imperative that research is done on the ecological functions of natural areas. Also, to place meaningful nonuse values, it is important that the individuals in the society have complete knowledge of the importance of functions of the natural environment.

There is no existing program dedicated to the estimation of indirect use and nonuse values of forests and natural vegetation in the island. The internationally funded Global Environmental Facility (GEF) project has initiated a program known as Caribbean Planning for Adaptation to Global Climatic Change (CPACC). One aspect of this program is to take a physical inventory of all natural resources in the island and use economic tools to elicit their value. This is obviously an important baseline study. As a component of a biodiversity strategy action plan it would be necessary to repeat this exercise periodically to understand the depreciation/appreciation of the total economic value of the forestry and natural vegetation diversity.

4. Marine and Freshwater Diversity

4.1 Benefits of Wetlands and Water Catchments

The most important wetland area in the island is the Graeme Hall Swamp. The Swamp has a number of important ecological and biological functions.

Fish Sanctuary Benefits

The Graeme Hall Swamp provides a sanctuary for juvenile marine fish. Although fish sanctuary and fish nursery functions are identified for the Graeme Hall Swamp, the biological link between the wetland area and fish production is not easily established. Due to the complications of association of wetland areas to fish production, several methods have been used to estimate the fishery benefits of wetlands (Barton, 1994). These are the Biological Growth Model, the impact of fishing effort on carrying capacity and catch, the relationship between area and stock carrying capacity, and the Wetland Production Function.

Recreational Value

Since the Graeme Hall Swamp is a well known bird sanctuary in the island, there would be a significant recreational value for bird watching. This could be particularly important for tourism as bird watching could provide a type of recreational experience that is different to the traditional sun, sea and sand tourism, which has made the island popular as a tourist destination.

Research and Educational Value

The Graeme Hall Swamp is an extensively studied area in Barbados. The Marine Resource and Environmental Management Programme (MAREMP) of the University of the West Indies routinely uses this location for educational purposes for graduate students. Also, staff and students from foreign universities also study the swamp. Caribbean Coastal Marine Productivity Programme (CARICOMP) has a monitoring site along the eastern shore of the lake. As stated earlier, research and educational uses have very high private and social values.

4.2 Benefits of Seagrass Beds

Sea grass beds are highly productive marine ecosystems. Some of the major functions of sea grass beds are:

- Primary producers in the food chain of the reef community
- Nitrogen fixation
- Feeding grounds for juveniles and adult reef fish
- Removal of sediments from the water column

It is clear that the primary importance of sea grass beds is their contribution to the reef fish yield. However, as in the case of wetlands, the link between fish catch and sea grass bed area should be first established to value their economic contribution. Currently there is no quantitative time series data for sea grass communities in Barbadian coastal waters. Once solid data is available and the link between sea grass bed areas and the fish production (catch) can be established, methods described for wetland production functions could be used to put economic value on these important marine ecosystems.

4.3 Benefits of Coral Reefs

Beach Protection and Nourishment

It is generally accepted that without coral reefs most of the beaches on the west and south coast of the island would disappear. However, the quantitative relationship between beach protection and coral reef area cannot be determined. Therefore, the value generated by beaches could be directly attributed to the coral reefs. Value of beaches is primarily for recreational purposes of tourists and local residents. Methods that could be used to value beaches for recreational purposes include net monetary benefits of tourism; consumer surplus to visitors; consumer surplus for local beach users; and the Travel Cost Method.

Recreational Diving

Recreational diving among coral reefs is a popular activity among tourists and locals alike. Yet, no studies have been conducted to estimate the economic value of recreational diving. Some potential methods, which could be used to quantify the economic value of recreational diving activities, include the Total Expenditure Method and willingness to pay for diving.

4.4 Benefits of Fishery Resources

The most valued components of marine biodiversity are fishery resources. Although the contribution of fisheries to the national income remains insignificant, fisheries still is considered as a basic industry and important in providing subsistence employment. Besides fishermen, fisheries resources provide employment for fish vendors and persons skilled in boat manufacturing and repair.

Other than commercial fisheries, recreational fishing could be an important use which could impart a very high value on fisheries resources without having a major detrimental impact on fish stocks. Although, there is an active recreational fishing sector in Barbados, no studies have been done to determine the value of recreational fishing. Several methods such as the total expenditure method, travel cost method could be used to value recreational fishing activities. More sophisticated models, such as random utility model, probit and logit models have been used to determine site selection and valuation of recreational fishing, particularly in the USA.

4.5 Cost of Marine and Freshwater Biodiversity

There is no significant direct value of freshwater diversity as freshwater catchment areas are natural locations which could not be used for other purposes without incurring significant expenditure. However, some catchment areas, particularly the Graeme Hall Swamp are known to breed mosquitos which have recently become a major health threat with the spread of dengue fever. Mosquito breeding areas of the swamp are regularly fogged to control the mosquito population and growth. Assuming that fogging is 100% effective, then the cost of fogging (both the chemicals and labour) should be considered as an indirect cost. There are no indirect costs of marine diversity. Cost of fishing is captured in market prices of fish. The other direct costs are the budget of the Fisheries Division and other related local institutions dedicated totally or partially to the management of fisheries resources.

5. Terrestrial Fauna

Economic valuation of fauna is a somewhat controversial issue as economic valuation is exclusively conducted in an anthropocentric framework. Intrinsic value may be captured to

some extent in the existence value which is defined as the value individuals place on environmental goods and services irrespective of use. Yet, existence value is exclusively defined for endangered species when individuals feel that a species may cease to exist. Since a major objective of valuation of the environment (including animal species) is to make decisions on efficient resource use, for human welfare, it is highly unlikely that economic valuation would ever capture the intrinsic value or the “right to live” value of species of animals.

5.1 Benefits of Mammalian Diversity

The Green monkey was introduced to the island in 1627 and is probably the only mammal that has shown a considerable economic value. The current uses of green monkey are described below.

Biomedical Research

Currently 75% of the world’s polio vaccine is produced from the kidneys of green monkeys. Annually approximately 800 monkeys are sold at an average price of about US\$500 each. Therefore, the direct economic value is close to 1 million Barbados dollars. However, this represents only a lower bound as the benefits from prevention of polio could be much higher worldwide. Therefore, the maximum willingness to pay for a monkey could be significantly higher.

Recreational Value

The major non-consumptive use of monkey is the viewing value for tourists. The Barbados Wildlife Reserve, which is primarily a monkey reserve, is estimated to collect Bds\$750,000 to \$1 million annually from visitors. Again, this amount should be considered only as a minimum value as the consumer surplus visitors derive from viewing monkeys would not be captured in the current entrance fee. The willingness to pay by visitors to view the monkey could be estimated by the Contingent Valuation Method. Alternatively, the Travel Cost Method could be used to estimate the total surplus of a visit and it would be possible to determine the value of monkeys by including viewing the monkeys as a quality variable in the model.

Hunting

It is reported that some hunting of monkeys is done for meat. There is no data on the scale at which this is done. It is unlikely that monkey meat is substituted for other types of meat purchased at the market.

To minimize agricultural loss and damage caused by monkeys invading local farms, the MAR has implemented a system where monkey tail tips can be exchanged for monetary rewards. This

activity, which encourages hunting, was initiated to control the size of the monkey population and therefore reduce loss to farmers.

5.2 Cost of Mammalian Diversity

The major cost identified due to the existence of green monkey is the cost of crop damage. If the loss is at the harvesting stage of the crop, then most of the production costs are already incurred, and the loss to the society can be valued by multiplying the estimated quantity lost by the prevailing market prices, provided that the loss is “small” and hence would not induce a non-marginal change in market prices. The costs associated with invasive mammalian species introduced to Barbados, like the green monkey, should be a definite concern and one of the foci of future valuation research.

5.3 Benefits of Avian Diversity

Apart from the viewing value, no significant uses are identified for resident bird species. Even the viewing value is not formalized as bird watching does not constitute a significant recreational activity in Barbados. Further, no local species are endangered and therefore may not have a significant existence value. Migratory birds have the same potential as local species for bird watching. Besides the potential recreational use, the other major current use is hunting. The benefits to hunters would be the consumer surplus they derive from hunting. This surplus can be estimated by modelling the number of hunting days as a function of cost of hunting, including the time cost. Due to easy access and relatively low expenditure, consumer surplus per hunter could be quite large. However, since only a small number of hunters are involved, the aggregate benefits may not be large.

5.4 Cost of Avian Diversity

No significant cost has been identified except for the suspected threat of tropical bont tick (from migratory birds).

5.5 Benefits of Reptilian Diversity

The two major marine reptiles in Barbados are the critically endangered hawksbill turtle and the endangered leatherback turtle. Endangered species may have tremendous non-consumptive use values (viewing value), option and nonuse (particularly, existence) values. There is already evidence that viewing value could be quite significant as some hotels near the turtle nesting beaches have cooperated with the Barbados Sea Turtle Project, and have their visitors also

involved in project activities. In addition, hand-feeding of turtles, glass bottom boat tours, viewing turtles out in the sea and swimming among them, have also become popular activities.

There has been no research done to quantify whether these activities are significant factors to visit Barbados, or whether the length of stay of some visitors is increased due to these activities. Suggested methods for estimating the value of turtles for tourism are effect on repeat visits, effect on the length of stay, the willingness to pay by visitors to engage in turtle related activities.

Nonuse Values

Since turtles are endangered, it is expected that they would have highly significant nonuse values. Especially the existence value and the user's nonuse value could be significant components. The CVM methods could be used to estimate these nonuse values.

Direct Revenue

The net income of divers, glass-bottom boat operators and other individuals who are engaged in turtle viewing related activities for visitors can also be considered as a financial benefit of turtles.

5.6 Cost of Reptilian Diversity

No significant direct or indirect costs have been identified for any of the reptiles in Barbados. However, due to the endangered status of sea turtles, it is necessary that measures be taken to ensure that their population does not experience a further decline. The economic term for maintaining such a standard is known as the Safe Minimum Standard.

5.7 Benefits of Amphibian and Insect Diversity

Apart from conventional uses such as pollination of plants and as predators /parasites of insect pests, insect diversity in Barbados is not identified for any other specific uses. Insects could be used effectively in an integrated pest management programme. Integrated pest management programmes worldwide has shown to reap substantial benefits through savings in insecticide expenditure. Also, the social cost of externalities such as ground water pollution and coastal pollution (due to agricultural runoff) could be greatly reduced. The extent to which insects are being used in this capacity in the agricultural sector in Barbados is not evident.

5.8 Cost of Amphibian and Insect Diversity

No significant direct or indirect costs can be identified due to amphibian diversity. However, there are substantial costs due to insect diversity. One of the major costs can be attributed to mosquitos. The recent outbreak of dengue fever shows that this cost is much more than just the inconvenience of being stung by mosquitos. Since dengue fever can cause both morbidity and mortality, the private and social cost could be substantial. It is possible to use the methods described earlier, such as the loss of value of statistical life and cost treatment (both doctor visits and medicine) to estimate the cost due to mosquitos. Further, the Ministry of Health has a mosquito eradication program which involves fogging of infested areas. The cost of this program; labour costs, cost of insecticides, and other variable costs should be also considered as a cost component of the insect diversity.

Besides these costs, general public incur expenditure on insecticides and insect repellents. Expenditure on these items reflects the willingness to pay by individuals to eliminate or reduce inconveniences and perceived threats to their health due to insects (primarily mosquitos and cockroaches). This expenditure is also a component of the total cost of insect diversity in Barbados.

6. Conclusion

Marine biodiversity is probably the most important source in terms of value to the local economy and social welfare. Although, fisheries resources account for only about 1% of the Gross Domestic Product (GDP), its potential contribution could be much higher. Despite the high level of research on the biological aspects of the management of marine resources, research on the economic aspects of management has not kept pace.

Access to marine resources is for the most part free. This will invariably erode any economic rent and lower the net benefits to the society. Further, alternative uses of marine resources, other than commercial exploitation is virtually absent. For example, the sports fishing industry could be vastly expanded. Sports fishing is a low consumptive but a high valued use of fisheries resources. Barbados is ideally suited for expansion of this industry because of its proximity to the United States. The island is also served by an excellent air travel system from other developed countries such as the UK. Demand for sports fishing could be a priority area in valuation of marine biodiversity. Other non-consumptive uses of marine resources such as diving, snorkelling and viewing endangered sea turtles could be important values and income generators as well. Currently, these activities are done on an informal basis, primarily through private enterprise. However, since these resources are held in public trust, resource rent should be collected as part of public revenue. The demand for non-consumptive and recreational uses of marine can also be identified as a priority area of research on marine biodiversity.

Agricultural biodiversity appears to be the next most important category of resources in terms of value to the economy and society. Despite the declining area of agricultural production, the total value of agricultural production has shown an increasing trend. However, the importance of traditional commercial crops, primarily sugar, has declined over the years and has been replaced by vegetable crops. This trend is likely to continue unless major changes are made in the sugar industry to improve productivity and profitability. It should be noted though that the high value of agricultural biodiversity is due to the level of protection agricultural sector enjoys from current economic policies. If agricultural trade were to be made more liberal, the value of agricultural diversity is bound to be much lower.

In terms of natural flora, there appears to be no significant value using the available data information available. However, ecological functions such as watershed protection, wind protection, soil erosion control, carbon dioxide consumption, nitrogen fixation, are all potential benefits of natural vegetation. All these “standard” benefits need to be first accurately and comprehensively quantified in physical terms before economic values can be placed on them. Such ecological research is still in a state of infancy in Barbados. The medicinal value of some indigenous plants could also be important.

The most prominent aspect of natural fauna in Barbados is the green monkey. Although an introduced species, green monkeys have had a significant impact on the local economy in terms of costs and benefits. Costs of the green monkey population arise mainly from damage to agricultural crops, whereas benefits are accrued through sale of monkeys for biomedical research as well as a tourist attraction at the Barbados Wildlife Reserve. A recent study by Horrocks et.al revealed that the benefits of maintaining a stable population at the current level would exceed the costs.

Besides monkeys, diversity of bird and fish population at some wetlands could be important sources of economic value. Barbados still depends mainly on traditional sea, sand and sun tourism. With the global trend tending towards ecotourism, the need for diversification of the tourism product has been given a high priority by the government. Within this context, wetlands could be developed as locations for bird watching, freshwater fishing and nature tours. Demand for these activities by tourists is pivotal to obtain maximum benefits to the economy and significantly enhance the value of faunal diversity.

To manage the biodiversity of Barbados, economic tools could provide valuable assistance. Although preferences of the society could be expressed through the political process, transforming those preferences to actions requires adequate funding. Economic values could be used to guide allocation of limited public resources among competing needs. Calculation of economic values could also be used as a basis for recovery of biodiversity conservation benefits from the beneficiaries. Such funds could be crucial in the cost recovery of public sector investment projects in the island.

7. Summary

DIRECT EXTRACTIVE USES OF BIOLOGICAL RESOURCES IN BARBADOS

List of Direct Extractive Uses	Indicators of Socio-economic Benefits	Potential Valuation Methods
COMMERCIAL		
a) Agricultural Production		
Export crops: sugar, cotton	Value of production	Market price of output
Vegetables and root crops: beans, cabbage, cucumber, okra, hot pepper, sweet pepper, sweet potato, pumpkin, tomato	Value of production	Market price of output
Other field crops: lettuce, eggplant, butternut, squash, christophene, cauliflower	Value of production	Market price of output
Fruits: bananas, figs, plantains, paw paw, mango, citrus	Value of production	Market price of output
Livestock: pork, beef, chicken, mutton, eggs, milk	Value of products	Market price
b) Forest/ Natural Vegetation		
Timber: local mahogany used for furniture	Value of products	Total value minus cost of collection
Edible products: cherries, golden apple, guava, ackees, etc.	Value of livestock products	Replacement cost method - amount of animal feed required to provide the same nutrition
Grazing and fodder	Value of total fish landings	Market price

Barbados National Biodiversity Strategy and Action Plan

List of Direct Extractive Uses	Indicators of Socio-economic Benefits	Potential Valuation Methods
c) Fisheries Resources		
BIO-MEDICAL RESEARCH a) Kidneys of green monkeys used to make polio vaccine		Benefits from prevention of polio
SCIENTIFIC a) Germplasm conservation	Commercial value of high yielding or disease resistant varieties	Requires information on success of field trials; adoption of varieties for commercial production; increase in yield over existing varieties.
RECREATIONAL a) Sport fishing	Total willingness to pay based on sportsmen's expenditure	Total expenditure; Travel cost method
SUBSISTENCE a) Handicrafts (e.g. baskets, flower arrangements) made from forest products and sold on a small scale	Value of products	Price

DIRECT NON-EXTRACTIVE USES OF BIOLOGICAL RESOURCES IN BARBADOS

List of Direct Non-extractive Uses	Indicators of Socio-economic Benefits	Potential Valuation Methods
<p>RECREATIONAL</p> <p>Bird watching in Graeme Hall Swamp</p> <p>Exploration/viewing in forested areas, e.g. Welchman Hall gully, Jack-in-the-box gully, Joe's River Forest</p> <p>Diving among coral reefs</p> <p>Landscape/scenic value, e.g. rural areas</p> <p>Hawksbill turtles: viewing, hand feeding</p>	<p>Total willingness to pay</p> <p>Total willingness to pay for use of the area based on expenditure; consumer surplus</p> <p>Total willingness to pay based on gross revenue of those involved in providing goods and services to divers</p> <p>Total willingness to pay</p> <p>Expenditure of tourists</p>	<p>(i) Contingent valuation method; (ii) Hedonic method</p> <p>Access value based on user fees for entering locations with established entrance fees; Contingent valuation method to elicit value for locations with free access</p> <p>Total expenditure method</p> <p>Contingent valuation method</p> <p>Effect on repeat visits, effect on length of stay, willingness to pay</p>
<p>RESEARCH/EDUCATION</p> <p>Existing forested areas and natural vegetation</p>	<p>Value of the services</p>	<p>Cost of replicating the benefits derived from local plant diversity by other methods</p>

INDIRECT USES OF BIOLOGICAL RESOURCES IN BARBADOS

List of Indirect Uses	Indicators of Socio-economic Benefits	Potential Valuation Methods
Agricultural crops, e.g. sugar cane: soil erosion prevention, nitrogen fixation, weed control	Proxy value for the services provided	Change in productivity method; Universal soil loss equation
Forested gullies: recharge of groundwater aquifers	Proxy value for services provided	Market value and scarcity value of water
Wetlands: Fish sanctuary and nursery function	Proxy value for services provided	Biological Growth Model; Impact of Fishing Effort on Carrying Capacity and Catch ; Relationship between Area and Stock Carrying Capacity; Wetland Production Function
Seagrass Beds: Primary producers in food chain of reef community; nitrogen fixation; feeding grounds for juvenile and adult reef fish; removal of sediments from the water column	Proxy value for service provided	Requires data to establish the link between seagrass bed areas and fish catch.
Coral reefs: beach nourishment and protection	Value generated by beaches	Net monetary benefits of tourism; replacement cost; consumer surplus to visitors; consumer surplus for local beach users

APPENDIX 2a

A BIODIVERSITY DATABASE FOR BARBADOS

1. Introduction

In keeping with the UNEP Guidelines, the issues related to the creation of a Biodiversity Database were identified and evaluated. The role of a Biodiversity Database is to manage and maintain the biodiversity-related data that exists presently or may exist in the future; in a digital database with the attendant data usage and update procedures defined; responsibilities assigned for data collection and update; all encompassed within a coordinated technical and institutional environment; where the maximum value may be made of the data through structured professional analyses.

The main parameter guiding the creation of a Biodiversity Database - the digital data environment - was however, largely absent from the study due primarily to institutional restrictions on access to information on the status of the digital Biodiversity data - the datatypes, extents of coverage, data formats, accuracies and currency - were also largely unavailable. In light of this situation, it was agreed that the remainder of the UNEP Guidelines should be fulfilled as closely as possible and that the conceptual outline for the future creation of a Biodiversity Data Management System be developed.

One of the major objectives of the study as identified by the client and arising from the UNEP Guidelines, states that the data that exists should be identified and evaluated and that gaps in the data should be identified but not filled. This was seen to be an appropriate starting point for the exercise and guides for the creation of the Biodiversity Database were formulated around this objective.

Arising from an evaluation of the suggested data requirements within the UNEP Guidelines, the Potentials and Design Considerations for a Biodiversity Database were identified.

2. Biodiversity Data for Barbados

From the information made available, it is apparent that substantial biodiversity-related data exists for Barbados in digital and non-digital form for many different datatypes for Barbados. However, the value of the data collected is severely diminished due to deficiencies in scope and completeness of data coverage, the difficulty in relating the data spatially as well as institutional restrictions on access to the data.

2.1 Deficiencies in Scope and Completeness of Data Coverage

Due to the fact that data collection efforts of a biological/ecological nature have been largely disjointed, organizational priorities have determined the nature and scope of the data collection activities. Thus, for example, fairly extensive data exists on identification of marine species in the national waters and fish-catch statistics whereas data on terrestrial fauna species and location is sporadic and lacking.

A national initiative to determine the critical biodiversity-related data collection activities is necessary.

2.2 Difficulties in Spatially Relating Data

In order for active analyses to be undertaken using multiple biodiversity datatypes, some relationship must exist that at least provides a spatial comparison of the area for which the data is collected. If data is collected at a national level then it may only be accurately compared or analysed against other data collected at a national level. If any other disaggregation of spatial areas is desired, assumptions and estimations must be made and the inherent error needs to be identified. It is most ideal to maintain data collection at the smallest available spatial entity, aggregating to larger spatial entities as required or desired. Cost and management (both data and organisational management) considerations, of course, play a much larger part in such an ideal scenario.

Biodiversity data exists presently in two types, Tabular or Statistical and Mapped or Spatial.

2.3 Tabular and Statistical

A large number of studies in all fields related to the natural environment have been undertaken. From these studies, a substantial amount of data is available in a descriptive format by lists and tables. Primarily, this entails an identification of the presence or absence of particular species. This is evidenced in the other component sub-reports of this Technical Report.

While such data holds value for knowledge of species existence and statistics related to the same, much of the existing data cannot be accurately spatially referenced. The majority of data on the natural environment that is collected is not locationally referenced to great detail. On the most part, data is referenced to the island on the whole, a particular Parish or to a specific area - either known by a common community name or identified by a particular physical, topographical and/or natural feature

2.4 Mapped or Spatial

A more limited selection of Biodiversity data is actually mapped. Most mapping of this nature is of a species identification nature - identifying the approximate location and extent of species sightings, for fauna, or species sites existing, for flora. More extensive and wider-ranging mapping actually exists for the marine environment (through the CZMU projects) than for the terrestrial environment, evidence of Barbados' environmental emphasis.

The author is unsure whether any one base mapping may be common throughout the mapping of all of these datatypes. It is unlikely as they originated from different sources over a period of time. Even though common base mapping should be a definite requirement, the vague and broken boundaries of flora and fauna (including marine) sites and ranges allows some flexibility for cross-relating biodiversity data based on different base mapping. This exercise should, however, be overseen by the professionals engaged in the original collection of the data.

3. GENERAL CONSIDERATIONS FOR A BIODIVERSITY DATABASE

Some general guidelines can be defined for consideration in the creation of the national Biodiversity Database.

3.1 Technical Design Considerations

Some important Technical Design considerations that must form part of the design of a Biodiversity Database include:

- Distributive database structure.
- Considerations given to the physical data transfer (telecommunications) networks that exist to evaluate their adequacy.
- Use of Relational Database Management Systems (RDBMS) with Structured Query Language (SQL) capabilities.
- Use of Geographic Information System (GIS) software to input, manage and analyze spatial and attribute data.
- Compliance with Open Systems and Open Database Connectivity (ODBC) to foster easy data formats compatibility and transfer.
- Attention should be given to the Interoperability of GIS and RDBMS systems proposed. Interoperability between themselves and competing systems and also across operating systems and platforms.
- As far as possible, attempts should be made to allocate spatial values at the most localized level to data.
- Security and access restrictions designed into the system.
- Knowledgeable systems management and database management personnel for

maintenance of the system.

3.2 Institutional Design Considerations

Some important Institutional Design considerations that must form part of the design of a Biodiversity Database include:

- Organizational agreements on data transfer.
- Data costing and copyright issues.
- Allocation of responsibilities to organizations, for data collection, maintenance and update. Leave responsibilities to those most knowledgeable of the particular data.
- Distributive database structure rather than centralized database allows greater opportunity for timely data update.
- Some degree of agreement to abide by coordinated frameworks for data management and acquisition of appropriate hardware, software and trained personnel. Agreement on Activity Timing to fulfill national biodiversity objectives.
- Agreements on security and access limitations for various datatypes and users.

4. CONCLUSIONS

The establishment of a national biodiversity database is essential to enhancing our understanding and our appreciation of the biological diversity of Barbados. There are substantial gaps in the current knowledge of biodiversity with respect to flora and fauna species classification, location and extent, pattern of distribution, and quantity. The appropriately trained biologists and ecologists working in these fields must fill these gaps. Data collection must be undertaken by these respective experts, in order for the information output of the compilation process to be of relevance to the various stake holders. In addition a more liberated policy environment for data transfer is required for the true value of the information to be realized.

The utilization of mapping sciences such as Remote Sensing and Photogrammetry employs techniques such as satellite imagery and air photo interpretation, which can be used to assess vegetation cover. These techniques can be used in conjunction with baseline data collected from studies done on species identification and habitat delineation. These discreet data-types can then be examined with respect to encroaching development over a particular time series, and the likely impacts on wildlife and their respective habitats.

A national Natural Resources Geographical Information System has been established under EMLUP (GIS Data Custody and Implementation Strategy, November 1998). The EMLUP consultants recommended that a GIS unit be established within the Ministry responsible for

environmental matters. This GIS unit would serve as a repository of environmental data to all other units and agencies.

The articulation of a National Policy on Biodiversity will be dependent upon our ability to effectively quantify and value the stock of biological diversity in Barbados. The compilation of a comprehensive database management system exclusively for biodiversity resources will no doubt contribute immensely towards our accomplishment of this goal.

APPENDIX 2b

INFORMATION REQUIREMENTS FOR THE BIOLOGICAL ENVIRONMENT

Categories	Required Data Collection	Explanation & Standards	Status of Existing Data	Maintenance Requirements	Responsible Agencies & Assigned Priority
Vegetation/ Communities	Structure, location, extent, configuration, arrangement, proximity and fragmentation with respect to other units of the same community, type with respect to other types, dominant species and diversity, use history and level of disturbance, fragility/sensitivity, significance.	Vegetation cover classified according to type e.g. grasslands, vegetation, wetlands, woodlands, regenerating areas, pioneer areas, information collected on each type and relationship among types and across island assessed.	Requires work.	Every 5-10 years and after major natural disasters (fire, hurricane, slippage, etc.)	NHU: Priority 1 Policy coordinating Unit: Priority 4
Vegetation Species	Inventory, distribution, habitat requirements, origin (endemic, indigenous, exotic), frequency (common, vulnerable, threatened, endangered).	Requires systematic inventory of the islands species communities, and location within the natural communities. Requires the establishment of a data management system and conventions for categorization of communities, existing data	Requires work.	Periodically in specific areas of interest.	NHU: Priority 3 Policy coordinating Unit: Priority 4

Barbados National Biodiversity Strategy and Action Plan

Categories	Required Data Collection	Explanation & Standards	Status of Existing Data	Maintenance Requirements	Responsible Agencies & Assigned Priority
		needs to be consolidated systematically.			
Wildlife Habitat, Marine Aquatic, Terrestrial	Location, distribution, users e.g. (birds, coral, benthos for aquatic birds), mammals, hierarchy of biomass, water quality, and/or physical characteristics, categorization by use (spawning, nesting/breeding/nursery/rearing, food source, loafing areas, travel routes, use history and level of disturbance, fragility/sensitivity, significance.	NA	Freshwater: None existing Marine: need work Terrestrial: None existing	Periodical update	NHU, CZMU, MARD, Fisheries Unit: Priority 1
Species - marine and terrestrial	Location, distribution, users e.g. (birds, coral, benthos for aquatic birds), mammals, hierarchy of biomass, water quality, and/or physical characteristics categorization by use (spawning,	NA	Freshwater: none existing Marine: need work Terrestrial: none existing	Periodical update	NHU, CZMU, MARD, Fisheries Unit, Policy coordinating Unit: Priority 1

Barbados National Biodiversity Strategy and Action Plan

Categories	Required Data Collection	Explanation & Standards	Status of Existing Data	Maintenance Requirements	Responsible Agencies & Assigned Priority
	nesting/breeding/nursery/rearing, food source, loafing areas, travel routes, use history and level of disturbance, fragility/sensitivity, significance.				

Source: The Natural Database, Biophysical, Cultural and other Planning-Related Information (Feb. 1998)

APPENDIX 2c

INFORMATION REQUIREMENTS FOR HABITATS AND ECOSYSTEMS

Categories	Required Data Collection	Explanations & Standards	Status of Existing Data	Maintenance Requirements	Responsible Agencies & Assigned Priority
Landscape Analysis	Systematic classification and assessment of landscape units.	Based on principals of biogeography, considering function, sensitivity/fragility and significance.	None existing	Periodical update	NHU, TCPO: Priority 2.
Natural Corridors and Linkages	Identify types and locations of corridors. Functions of specific corridors and corridor types	Example: Gully systems escarpments, coastline, non-arable lands, contiguous vegetation units. Consider non contiguous functions (e.g. visual connections for arian species, aquatic, and non aquatic)	None existing	Periodical update	NHU: Priority 2.
Species Categorization	Establish and maintain a sightings recording system (data management system), establish conventions for categorization of communities (vulnerable, threatened endangered etc.)	Required for each class of plant and animal species, existing data needs to be consolidated systematically.	None existing	Ongoing	Policy & coordinating Unit, NHU: Priority 2

Source: The Natural Database, Biophysical, Cultural and other Planning-Related Information (Feb. 1998)

APPENDIX 3

RECOMMENDATIONS FOR INSTITUTIONAL STRENGTHENING

INTRODUCTION

A number of institutions have been mandated by the GOB to manage the environmental and natural resources of Barbados, which include the island's biological resources. The responsibility for environmental management is generally fragmented between these various institutions whose responsibilities has been described in section 4 of this document. There is evident duplication and, in many instances, a lack of clear jurisdiction in terms of biodiversity management concerns. The sharing and integration of information, as well as the reduction of duplication of effort, in the acquisition of biodiversity and other related environmental information among the various agencies should be a fundamental goal of the GOB.

The overall aim of this section is to provide recommendations which would improve the overall efficiency in the biodiversity management and conservation efforts of the GOB, thereby ensuring the successful implementation of the Biodiversity Strategy and Action Plan. These recommendations are based on identified needs for biodiversity management and conservation as well as the assessment of the current institutional capacity

Institutional strengthening for biodiversity management can be achieved through:

- establishment of a unit or committee responsible for coordinating biodiversity management and protection efforts;
- a concerted effort to define distinct mandates for the relevant institutions with respect to the conservation of biodiversity;
- a logical appropriation of suitably trained human resources among these institutions;
- improvement of communication between the various institutions involved on biodiversity conservation issues and activities;
- more efficient dissemination of biodiversity related information by relevant government agencies to increase the level of awareness of the general public of biodiversity conservation, and also to strengthen the political will of the GOB to protect biodiversity.

PRIORITY AREAS FOR IMPROVED BIODIVERSITY MANAGEMENT

The NBSAP Country Study and the Public Consultation process identified the following areas, which would greatly enhance the GOB's capacity to undertake effective conservation and management of the island's biodiversity:

1. Improved Protected Area Management and Conservation;
2. Revision and updating of legislation and regulations for the protection of habitats and species;
3. On-going research and compilation of biodiversity information into a central repository, including the collation and maintenance of a comprehensive GIS database;
4. Expansion of the capacity to provide biodiversity and related environmental education and public awareness to the citizens of Barbados;
5. Enhancement of the capacity to effectively prosecute violators of existing regulations put in place to ensure the protection of biodiversity.

TARGET AGENCIES FOR INSTITUTIONAL STRENGTHENING

Ministry of Physical Development and Environment

The Environmental Unit (EU) of the MPE needs to expand its role and function as a "lead agency" in biodiversity management. Sub-committees should be further established under the EU which coordinate National Park and Protected Areas Management, and seek to involve all required organizations and stakeholders into the process of biodiversity conservation.

Recommendations coming out of EMLUP include the setting up of an expanded Education and Information Unit with library functions. This proposed unit would greatly enhance the capacity of the MPE to effectively document and disseminate biodiversity resource information that is currently not readily accessible to all relevant organizations and agencies.

The capability to assess the potential impacts of human activity on the island's biodiversity to allow for prudent planning and decision-making is highly dependent upon complete, accurate and current available data on the status and location of existing biodiversity at a national level. The effective dissemination of this type of spatially related information to all developers, relevant organizations and decision makers is also essential for facilitating the decision making process.

The EMLUP project document General Specifications: Future Data Collection, Data Custody & Implementation Strategy (1998), addresses and outlines the mechanisms and steps necessary to facilitate the integration of environmentally related GIS data. This document also outlines some of the gaps in existing biodiversity data, and the priority assigned to various types of data collection among the various agencies. It is strongly recommended that these proposed steps, in conjunction with the gaps in knowledge and data identified in the NBSAP Country Study Technical reports, be utilized as a guide for directing all future biodiversity research and data acquisition for Barbados. A summary of the spatial data requirements and guidelines for data collection and management for Barbados are presented in Appendix 3.

The EMLUP study also recommended the appointment of an environmental legal officer within the MPE. The rationale for maintaining in-house legal services in the Environmental Unit would be enhanced to supplement the limited services currently provided by the Attorney General and the Director Public Prosecutions (DPP) office, thereby clearing up the backlog of environmental legislation, and so enabling the Ministry to effectively enforce environmental standards imposed by legislation.

The in-house legal services would include, among other things:

- consult with environmental specialists to identify measures necessary to regularize their operations and make them more effective;
 - assist the Attorney Generals Office in preparing legislation on identified environmental issues;
 - prepare and process draft legislation for submission to parliament;
 - advise other environmental enforcement agencies as required;
 - assist in enforcement prosecutions on environmental matters as required.
- (EMLUP, 1998)

Other benefits which could be realized from this in-house legal capacity would include, the avoidance of inordinate delays in securing legal responses and opinions on biodiversity protection issues, as well as assistance in assuring that Barbados ratifies, and adheres to, or complies with obligations contained in international conventions of which Barbados is a signatory.

The Town & Country Development Planning Office

The lack of a legally binding National Physical Development Plan (NPDP) was found by the EMLUP study to reduce the capacity of the GOB to achieve effective habitat and species protection. This deficiency also curtails the GOB's ability to address other wider environmental degradation concerns through the planning process. As a result of these findings, two recommendations were made with respect to enhancing the legal status of the development plan:

1. establishing the NPDP as Development Control Regulations, or

2. implementing the NPDP as a first Screen for Development Applications. Barbados would derive many advantages from enhancing the legal status of the NPDP, including:
 - enhancement of the credibility of the TCDPO and the Minister in their dealing with development applications;
 - official recognition of the status of the NPDP as standing policy of the GOB;
 - provision through the planning process of a mechanism for the protection of species, habitats, and landscape features;
 - enabling of the Chief Town Planner (CTP) to negotiate with developers from a “strong and principled position” where biodiversity protection issues are a concern;
 - ensuring that applications for development that do not conform to the NPDP requirements will automatically undergo an EIA that adheres to guidelines and procedures which adequately incorporate all biodiversity and habitat conservation concerns;

The EMLUP Reports made a number of recommendations aimed at improving the level of transparency and public participation in the planning process. These recommendations in the NPDP address the issue of the granting of development permits and are currently pending the approval of the cabinet.

The current Town and Country Development Planning Advisory Committee consists of nine appointed members including a chairman. This Committee represents a mixture of public servants and private sector interests, which act to advise the Minister. It is recommended that the role of this committee be formally revised so that it would act in an advisory capacity to the Chief Town Planner who would in turn advise the Minister. This panel should comprise technical experts from various agencies such as the National Conservation Commission (NCC), Coastal Zone Management Unit (CZMU), Ministry of Housing and Lands, MAR, and other public and private sector organizations with appropriate expertise with regard to biodiversity and habitat conservation, among other wider environmental management concerns.

Coastal Zone Management Unit

The CZMU is responsible for the management and development of the coastal areas of Barbados in the specialized areas of Coastal Engineering, Coastal Planning, and Marine Biology. This division is involved in environmental monitoring and the development of environmental standards on an ad-hoc basis. The CZMU currently lacks the resources to implement systematic monitoring and impact assessment projects. The division employs 21 field officers and six office/clerical staff.

The capacity for the CZMU to conduct systematical monitoring on all coastal development activities in order to assess potential impacts on marine ecosystems needs to be upgraded, since it is the principal organization charged with this responsibility. The capacity for this unit to collect coastal resource data should be enhanced where possible due to their expertise in this area.

National Conservation Commission

The National Conservation Commission (NCC) can potentially play a major role in the monitoring and maintaining of biological resource habitats. According to the EMLUP report on Institutional Strengthening of the Environmental Unit and other Institutions (1998), many of the functions previously assigned to the NCC by the Marine Reserves legislation have been allocated to or assumed by other agencies, some of which were created to perform other specific functions. These agencies include the CZMU, the Barbados National Trust, the TCDPO, the Soil Conservation Unit, and the Ministry of Tourism and International Transport.

Though the NCC is responsible for maintaining public parks, public gardens, beaches and caves and other areas such as the Harrison's Cave, and the Folkestone Marine Reserve, the role and powers of this organization in policing human recreational and other activities within ecologically sensitive areas needs to be greatly enhanced.

The feasibility of establishing a National Park Administrative Sub-Committee should be examined to address biodiversity conservation within National Park areas and other protected areas. The establishment of such a committee under the NCC may enhance the GOB capacity to effectively monitor and manage biodiversity habitats throughout the island. The functions and role of this proposed joint agency sub-committee would have to be further defined.

The NCC technical staff will need to be expanded in order to provide national park management expertise once the proposed National Park designations are officially approved and established by the GOB. Previous studies which looked into the designation and establishment of a National Park in Barbados include: N. C. Pennington, Barbados National Park, (1983), and EMLUP National Park Plan (1998).

Close cooperation is required between governmental and non-governmental organizations which have relevant technical expertise, with regard to the national park and protected area administration activities.

Organizations, which should be represented on the national parks administrative sub-committee, include the following:

- Environmental Unit (lead agency for biodiversity conservation);
- National Conservation Commission (technical administration);
- Environmental Special Projects Unit;

- Town & Country Development Planning Office;
- Coastal Zone Management Unit;
- Soil Conservation Unit;
- Barbados National Trust;
- Caribbean Conservation Association;
- Bellairs Research Institute;
- The University of the West Indies; and
- The Ministry of Tourism and International Transport.

The full integration of the Environmental Unit's biodiversity management programme initiatives, and the National Park and other protected habitat management concerns, will be highly advantageous to the Government and people of Barbados in the long run. The NCC is perhaps the most logical agency for the provision of technical administration to these significant biodiversity habitats.

The Ministry of Agriculture & Rural Development

The Ministry of Agriculture and Rural Development (MAR) can be described as having no explicitly stated involvement in environmental management. MAR's capacity as an observer and advisor on agricultural practices can, however, greatly enhance the GOB efforts in the regulation of practices in the agricultural sector, which have the potential to degrade the environment. Due to the prominence of agricultural activity throughout the island, this function of MAR can potentially be a significant contributor to the conservation and management of biodiversity.

One such activity with the potential for harmful environmental effects is the use of fertilizers and pesticides. MAR does not currently have a legal mandate to regulate fertilizer or pesticide application and does not conduct research into the impacts of these chemicals on the environment. The Pesticide and Control Board (PCB) is however, responsible for the regulation of pesticides. The EMLUP study however, noted that the PCB does not have the resources or a clear mandate to monitor or regulate the environmental effects of pesticide application. Under the coordination of the MPE, the PCB, if fully staffed and equipped, could become a key agency in carrying out research testing on non-point sources of agricultural pollution and its impacts on the marine and terrestrial biological resources.

MAR could also play an instrumental role in facilitating and coordinating biodiversity related research with input and coordination from the MPE, along with agencies such as BAMC, CARDI, Bellairs Research Institute, CZMU, the Fisheries Unit and UWI. Research areas, which need to be addressed in this respect, include:

- germplasm and biological pest control;
- the implications of introduced agricultural species;

- the environmental impact of pesticides; and
- the implications of aquaculture, among other issues facing agricultural sector.

The Fisheries Division

The Fisheries Division of MAR develops plans for the management and development of fisheries in Barbadian waters. Environmental concerns are not explicitly mentioned in the Fisheries Act legislation. However, the Minister is charged with protecting endangered species of marine organisms. The Fisheries Division was initially established as a technical and scientific unit in 1944, but has since evolved into a service provider and safety organization for the industry. The Division is now in the process of rehabilitating its scientific and technical functions and also increasing its participation in environmental management. It is also actively seeking to improve its communications with the CZMU and the other units under the MPE. However, the involvement of the Fisheries Division in environmental management activities, results in a severe stretch of the resources of the agency.

Some specific environmental issues of concern to the protection of marine biodiversity are:

- pesticide impacts on the marine environment - the agency does not maintain frequent communication with the PCB in this regard.
- the impacts of sewage pollution - the agency relies on research conducted by the CZMU and Bellairs Institute.
- ecological changes, e.g. *Diadema* die off and changes in reef ecology in addition to information from Bellairs and CZMU. (EMLUP, 1998)

The Fisheries Division provides scientific information and statistics on catches, biological, social and economic information, in addition to fisheries management measures. The Division presently relies heavily on anecdotal observations made by fishermen. The compilation of more comprehensive catch per effort statistics needs to be undertaken by the Division to provide more accurate estimates of species population size, and thus provide more accurate inferences on the impacts of the fishing activities on marine species.

There is an expressed concern by the Fisheries Division about the potential for conflict between its interests, and the creation of marine protected areas or reserves. Further evaluation of how this division can best provide assistance in the regulation and protection of the islands marine biodiversity needs to be undertaken in light of this fact.

CONCLUSION

The conservation of biodiversity in Barbados relies heavily on the effectiveness of the GOB to streamline the operations of the various Ministries and agencies, which are involved in environmental management. The formulation and delegation of clear biodiversity protection mandates among these institutions, enhanced levels of communication and documentation of biodiversity related information, in addition to the optimal utilization of resources at hand is essential if they are to effectively carry out their functions. The Environmental Unit of the MPE needs to fully embrace its role as the lead agency for biodiversity, and protected area management and also seek to establish committees in order to effectively administer National Park and other protected habitats which impact upon the livelihood of the nations biodiversity. With the implementation of these initiatives the GOB can no doubt vastly improve upon its goals of sustainable environmental management and biodiversity conservation.