PROTECTING NATIVE PTERIDOPHYTES IN ANTIGUA, BARBUDA AND REDONDA:

A CONSERVATION PERSPECTIVE

April 10, 2012

PROTECTING NATIVE PTERIDOPHYTES IN ANTIGUA, BARBUDA AND REDONDA:

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By

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FINAL

Cover photograph of native fern *Blechnum occidentale*, *Thelypteris* species and native vines, shrubs and other plants at Christian Valley along ghaut, Antigua, June 2011.

Photo: Kevel C. Lindsay, 2011

TABLE OF CONTENTS

ABOUT THIS PUBLICATION

This publication was produced by the Environmental Awareness Group (EAG) of Antigua and Barbuda, with funding support from ***The Rufford Small Grants for Conservation***, UK, and ***The Mohammed Bin Zayed Species Conservation Fund***, United Arab Emirates. With this effort, the EAG hopes to focus attention on the country's pteridophyte flora, to encourage national support for the protection of native species and habitats, to stimulate science and research into the local biodiversity, and to help increase the awareness about the importance and value of the islands' native fern flora.

1.0 INTRODUCTION

The pteridophytes of Antigua, Barbuda and Redonda are one of the islands' least studied and understood group of plants. Unfortunately, many are quite rare. In the past four years, and particularly in the past year, several species have been newly added to the country plant record. The current national list stands at over 80 species. Most are found in the volcanic southwest, with some narrowly restricted to moist sheltered valleys. Some species are rarely seen, and a few have not been observed for more than 30 years.

Since April 2011, the Environmental Awareness Group (EAG) has embarked on a study to survey the nation's pteridophytes, looking at their distribution, habitats, threats and their conservation needs. It is with this in mind that the organisation has produced this document ***Protecting Native Pteridophytes in Antigua, Barbuda and Redonda: A Conservation Perspective***. This document forms part if a larger effort: *The Conservation of the Ferns of Antigua and Barbuda and their Forest Habitats*, which focuses on the regional range-restricted pteridophytes—species of which are only known from one small population or from areas less than a few hundred square meters in extent. The project highlights the plight of these ferns and their ecosystems, and in addition to the Conservation Perspective, it has published a Regional Red List of the islands' ferns and fern allies, and by 2013, will produce an atlas and guide to the pteridophytes of these islands. The project aims to strengthen national biodiversity conservation by highlighting the enormous challenges that the species face, and use them as a vehicle to promote forest protection, and management.

The main objectives of the fern project include:

I. *To survey and determine the status of the ferns of the country and highlight species of critical concern;*

II. *To survey and determine the taxonomy and conservation status of the West Indian range-restricted endemic ferns and other rare species, including: Adiantum pyramidale, Adiantum cf. melanoleucum, Pityrogramma chrysophylla and possibly Asplenium cf. ocoense, Adiantum fragile, Ophioglossum harrisii, Marsilea nashii, Asplenium barbadense, Thelypteris patens, Thelypteris hispidula var. inconstans and Pteridium caudatum;*
III. *To increase the awareness of the value of native ferns and in cooperation with local stakeholders, develop effective guidelines and measures for the conservation and protection of their habitats;*
IV. *To develop a national conservation perspective for the recovery of the range-restricted fern species;*
V. *To develop a much better understanding of the distribution of ferns and their conservation status GIS and GPS mapping of this data; and*
VI. *To produce a National Red List of ferns.*

Protecting Native Pteridophytes in Antigua, Barbuda and Redonda: A Conservation Perspective was developed with funding support from ***The Rufford Small Grant for Nature Conservation***, of The Rufford Small Grants Foundation, UK, and ***The Mohammed Bin Zayed Species Conservation Fund***, United Arab Emirates.

Though pteridophytes are recognised for their horticultural value, imparting great joy and wonder to gardeners and others, their role in the natural environment is less obvious or understood. They, like other plants, are important in their own right, and are a significant part of the country's biodiversity heritage. In some Antigua's forest ecosystems for example, ferns often make up the bulk of the ground cover on the forest floor, and therefore, are a significant part of the forest biomass, contributing significantly to the nutrient and water cycles of the upper layers of the soil.

It is critical that the islands' native pteridophyte flora be protected. The loss of the ferns and their allies would not only be a blow to the psyche and culture of Antigua and Barbuda (because the country loses yet again a part of native natural heritage, and it has already lost so much), but it would also cause tremendous damage to the islands' ecological framework. Pteridophytes are great environmental indicators, and because many species are habitat-specific, they can provide important clues as to changes that may occur, including the quality of the habitat, the effects of deforestation and fragmentation on the long-

term ecological processes and stability of an area, and even on the potential impacts of global Climate Change on the forests.

By focusing on ferns, this project is supporting a long-term integrated conservation approach in order to address both acute and broad conservation issues, including the plight of regional (West Indian) plant and bird endemics, and critical ecosystems. This project forms part of an ongoing plant conservation programme being led by the EAG in Antigua, and supports the organisation's long-term goal to conserve and protect the country's native biodiversity; developing a pteridophyte Red List and the Conservation Perspective are two significant parts of achieving this.

The purpose of this the Conservation Perspective is:

- To bring together paleontological, historical, geological, ecological and other key information on the islands ferns together to create a unique local perspective on the islands' pteridophyte flora ;
- To be a basis for input to new environmental protection legislation in Antigua & Barbuda;
- To encourage, promote and instill greater research into the pteridophyte and other flora of these islands;
- To increase the conservation and protection of native pteridophytes and their habitats;
- To be one of the focal points for native plant and habitat protection in Antigua and Barbuda; and
- To increase the awareness and understanding of the pteridophyte flora.

Two questions that the reader may ask (and rightly so) is why a conservation perspective? Why not produce a conservation plan? The simple truth is that a conservation plan is an enormous undertaking and well beyond the scope and resources of this project. Additionally, and an equally important reason, is that the country faces enormous challenges with regard to all of its biodiversity, and there are a number of species and issues that also require significant attention. By first tackling these issues on a holistic basis, and by setting the groundwork for more focused efforts, it can then dedicate more time and commitments to specific groups such as the pteridophytes. In the meantime, organisations such as the EAG will do whatever it can to help conserve and protect the country's ferns and their allies.

Because our knowledge of the local pteridophytes is growing and will undoubtedly improve over time, this Conservation Perspective is meant to be

updated as a result of future work, and as our understanding and knowledge of the taxonomy of the species and the on-the-ground situations. In due course it is

hoped that this publication, along with the project's other outputs, will facilitate future protected area legislation and in situ conservation programmes on Antigua and on Barbuda, and secure the long-term protection of the island of Redonda as a nature reserve.

2.0 BACKGROUND

2.1 The Evolution of this Project

As pointed out in the section above, many of the country's plants, animals and ecosystems are under threat. Then why focus on the pteridophytes of Antigua, Barbuda and Redonda? What about the other groups of plant of these islands? For this document's author, all native plants are very important and he has devoted his life to their discovery and understanding, but the truth is that the pteridophytes has always fascinated and inspired Mr. Lindsay, even as a child. When you are 10 and something fascinating seems to take a special hold of you it may have a profound and lasting impression on your life, and help guide your future interests and creative spirit. This life-long curiosity has sparked a quest to learn and understand the species and their ecologies and to help others appreciate just why they are so fascinating.

Having graduated college and returned to Antigua to work in the Ministry of Agriculture in 1990, Kevel Mr. Lindsay began to study the islands' native flora. Ferns loomed large in his interest. He poured over books, spoke to people and developed his own ideas about their habits, ecologies and taxonomies. It was during these years that he became convinced that Antigua and Barbuda had far more species than had been previously listed. At the time, only about 38 species were recorded for these three islands.

In 1999, Kevel departed for studies in New York, but kept his strong ties with Antigua. In 2006, he began to collaborate with Chris Pratt, who similarly shared with Kevel a natural interest in the flora of the islands. In 2007, through the persistent efforts of Chris, the EAG received funding to undertake its Antigua and Barbuda Plant Conservation Project (ABPCP), and began work on the survey of the islands' native and naturalised plants. It was during these two years of study, assessment and fieldwork that Kevel became even more convinced that more work was needed to focus attention on the ferns and fern allies of the islands. By the completion of field study for the ABPCP, the list of pteridophytes of the islands increased to nearly 50.

The ABPCP work culminated in publication of the book: *The Wild Plants of Antigua and Barbuda: An Illustrated Guide to the Vascular Native and Naturalised Plants* (EAG, 2009). Though the book highlighted the islands' native

pteridophytes, only 21 of species were profiled, due in large part to the rarity of many of them.

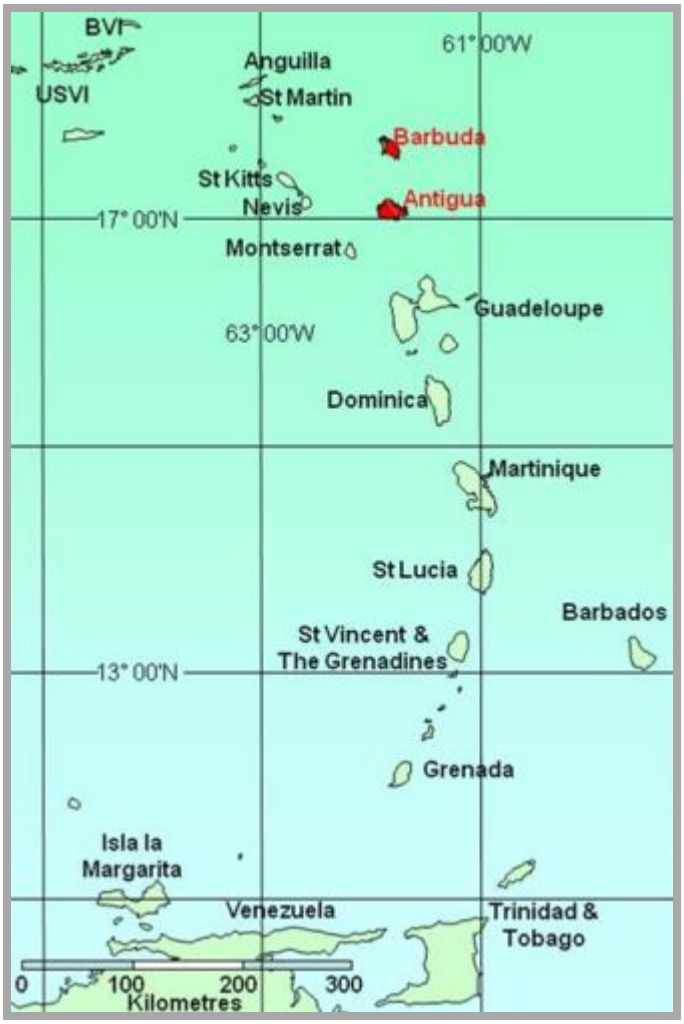
In 2010, Kevel was awarded a small grant from the Rufford Small Grants for Conservation, UK, to study the pteridophytes of these islands and to aid in their conservation. Kevel and the EAG have come together on this effort, and to help promote its Plant Conservation Project even further ahead. This support has helped to make a life-long dream become realised and has provided encouragement to the EAG to work to ensure that native pteridophytes and their habitats are conserved and protected.

2.2 The Setting

To understand the landscape, geology and biodiversity of Antigua, Barbuda and Redonda, is to understand the intricate and complex nature of the islands' pteridophytes and other plants.

2.2.1 Geography and Landscape

The country of Antigua, Barbuda and Redonda is a tripartite state, consisting of three islands. It is located 402 km (250 miles) southeast of the United States territory of Puerto Rico (see map 1.0 below). The state is part of the Lesser Antillean grouping commonly referred to as the Leeward Islands. The capital of the country is St. John's, located on the largest island of Antigua, it being 280 km^2 (108 $mile^2$). Antigua has a total population of approximately over 100,000 (2010 estimate). It has an average population density of more than 357 people/km^2 (357 people/0.4 $mile^2$). The island is 23 km (14 miles) long by 18 km (11 miles) wide. The northern third of the island is geologically referred to as the Limestone Region, while the middle Central Plain and the southern third the Volcanic Region. There are three permanent streams: Body Ponds-Big Creek system (the largest), Ayers Creek on the east of the island and Fitches Creek on the northeast. The highest point on the island is Mt. Obama (formerly Boggy Peak) at 402 metres (1,319 ft.), situated on the western end of what is called the Shekerley Mountains.



Map 1.0. Map showing general location of Antigua and Barbuda in the Lesser Antilles (Redonda, not shown, lies between the islands of Nevis and Montserrat).

Barbuda, the second largest island, is about 100 km^2 (62 miles^2), is located about 48 km (30 Miles) slightly northeast of Antigua. It has only one settlement, Codrington, located on the easternmost shore of a large natural lagoon of the same name. The island is 24 km (15 miles) long by 14 km (9 miles) wide. It has a population of 1,400 to 1,800 people. The highest point of the island is located in the Highlands at 42 m (138 ft.). The island has a population density of about to 14 to 18 people/km^2.

Redonda, the smallest of the islands, is located 56 km (35 Miles) southwest of Antigua. It is 2.6 km^2 (1 $mile^2$) and reaches an elevation of 305 m (1,000 ft.). It is uninhabited.

Map 2.0 shows the general outline of Antigua. Map 3.0 shows Barbuda.

2.2.2 Geology, Drainage and Soils

Antigua: The initial geological landscape of Antigua was created when volcanoes burst through the ocean floor some 40 million years ago. Eruptions continued sporadically for the next 10 million years, to build at least 5 clusters of volcanic cones, craters, domes and lava flows in a triangle between what is now deep bay, Shirley heights and Johnson's point. The following million years of weathering, landslides, mudflows, erosion and sedimentation has contributed to the landscape we see to date.

The island is divided in three distinct regions. These include the volcanic region in the south, which consist of weathered igneous rocks on the uplands and sedimentary materials in the valleys. The primary rocks types are andesitic with some dacite scattered in easternmost areas.

The central plain consists of agglomerates, tufts and conglomerates and small deposits of limestone materials and petrified formations.

The limestone region is the youngest of the most recent, and is a mixture of limestone deposits and marls.

Barbuda: Geologically, Barbuda differs considerably from Antigua. Located to the northeast of the active volcanic line, Barbuda has remained a low-lying island which first appeared when a broad ridge of oceanic crust had buckled upwards close enough to the sea surface for coral reef to grow on top of it. Based on fossil records, it is estimated that Barbuda first emerged some 15 to 20 million years ago.

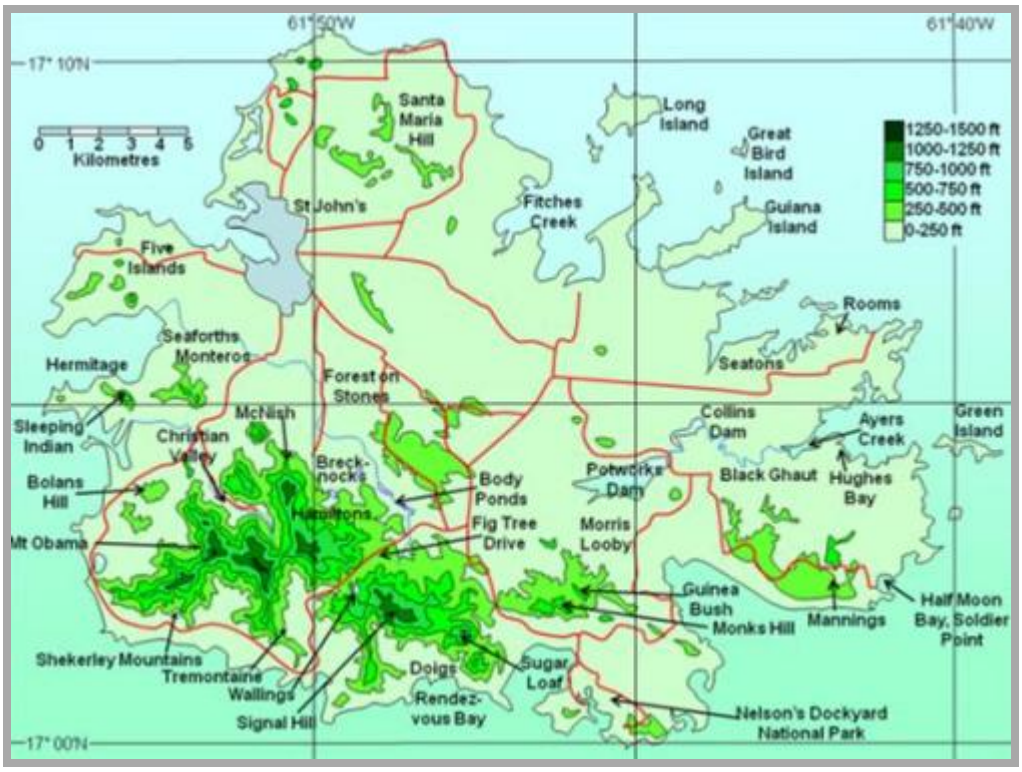
Barbuda is a limestone island with the presence of dunes that make up large sand fields. The coastline has no marked indentation. Barbuda's topography is rather low in elevation. Some variations in height do exist, for example, at the

Highlands, located in the east, reach elevations above 30 m (98 ft.); it has an abrupt escarpment on the north and west, a gentle slope on the south, and sea cliffs on the east. Although the rest of the island is only a couple of meters above sea level, two topographic levels can be distinguished, each containing numerous smaller depressions.

Barbuda can be distinguished in three geological regions:

1. The Highland limestone area, mostly of hard limestone which contain sink holes and caverns;
2. The Codrington Limestone region which contains sandy and fossiliferous sediments less crystalline than the Highland limestone;
3. The Palmetto Point area, which overlies the part of the Highlands and Codrington formations in coastal areas especially between Palmetto Point and Sandy Ground and is composed of beach sands and ridges, with shelly strata.

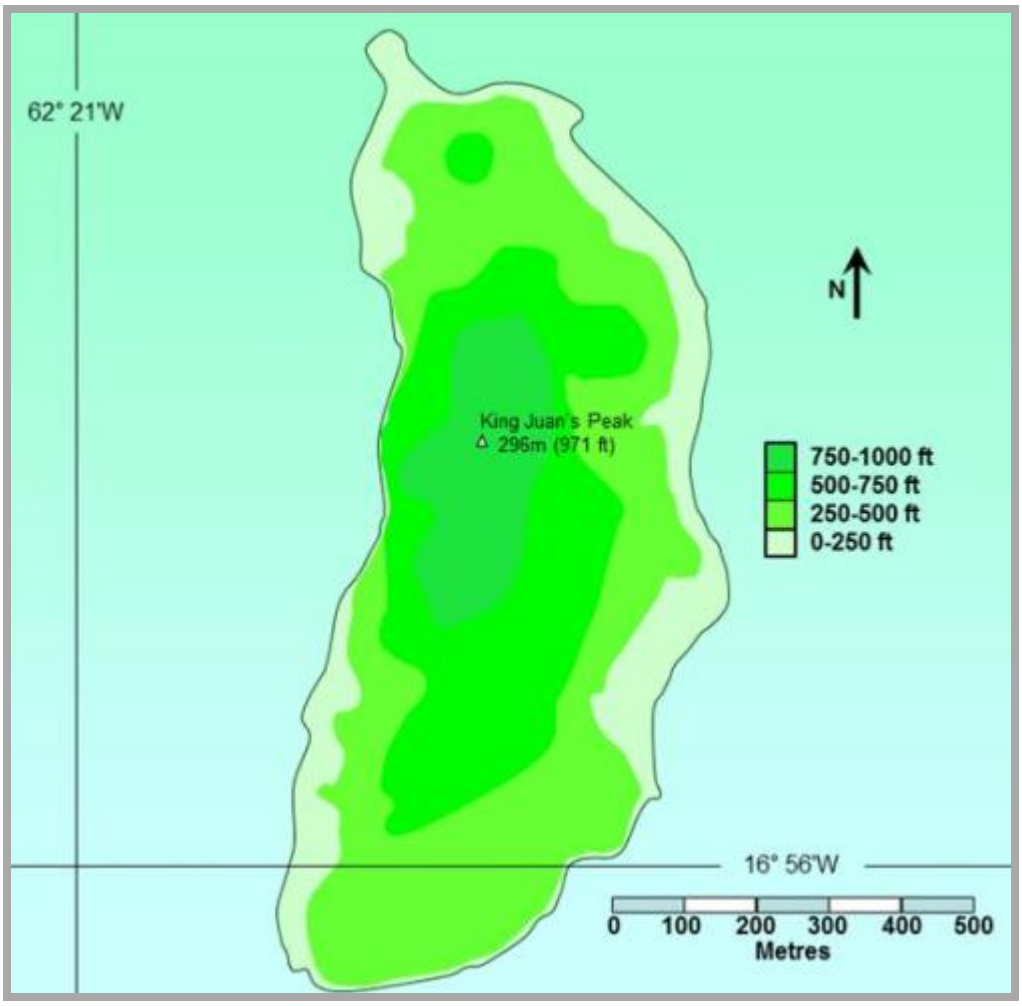
Redonda: Redonda is situated about 56 km (34.8 miles) southwest of Antigua, but it is actually closer to the island of Montserrat lying to its west at about 25.5 km (14 miles). It resembles a large sugar loaf floating effortlessly and alone on the open ocean. The present structure is the core remnant of a small volcano that arose sometime in the early tertiary some 65 years ago. It is the smallest of the three major islands, being about 1.6 km^2 (0.6 sq. miles), though because of its sheer cliffs, some estimates put it at 2.6 km^2 (1.0 sq. miles). There is very little natural soil, and the upper slopes are littered with large boulders, much of it a result of phosphate and guano mining that occurred in the mid-1800s up until the 1920s. Map 4.0 shows the island of Redonda.



Map 2.0. Map showing general outline of Antigua.

Barbuda's landscape combined with very arid condition is the reason that no discernible drainage pattern can be found on the island. The flat nature of the topography and permeable nature of soils make surface runoff minimal and surface catchment impractical. Rainfall rapidly seeps through the limestone and collects in natural sink holes. Much of the water drains from the Highlands to the lower plains forming extensive flooded areas during the rainy season and during the passage of tropical storms.

Map 3.0. The island of Barbuda.



Map 4.0. The island of Redonda.

2.2.3 Climate

Antigua: As with most islands in Lesser Antilles, Antigua is strongly affected by the Northeast Trade winds, which means winds approach with great constancy from directions between east-northeast and southeast. The average wind direction varies throughout the year according to the following pattern:

- December to February: winds blow from east-northeast (known locally as
- "Christmas Winds"),
- March to May: winds blow from easterly directions,
- June to August: winds blow from east to east-southeast directions,

- September to November: winds blow mainly from the east to southeast.

Normally, except for the occasional hurricane, highest wind speeds are experienced from December to February and again in June and July. Average wind speeds for the months of June – July are around 9m/sec (20 mph), while for October average wind speeds drop to 6m/sec (13.5 mph).

During the winter months, October to April, the island is occasionally influenced by frontal systems moving in an eastward direction across the southern part of the United States. The trailing edge of these fronts sometimes affects Antigua and results in winds blowing from between northwest and northeast for short periods of time – usually no more than to two days. The area also lies within the hurricane belt. These intense storms occur between June and November, with September being the month when most tropical storms or hurricanes occur.

Temperature varies little throughout the year, with daytime temperatures that fall within the range 25°-29° C and usually drop 6° C at night. Temperatures average an annual 81° F (21.6° C), with the winter lows averaging 76° F (24° C), and the summer high reaching the mid to upper 80s. The temperature and climate are moderated by near constant on-shore breezes. Due to year-round high temperatures and nearly constant winds, the evapo-transpiration rate is generally high.

Heavy rainfall sometimes occurs during the passage of the easterly tropical waves, which are spawned off the West African coast from June to November of each year. Occasionally, these waves intensify into tropical depressions, tropical storms, or hurricanes.

Barbuda: Barbuda lies to the west of the northeast trade wind system and within the latitudes of tropical storms. The island is one of the driest islands in the West Indies, with a mean monthly rainfall of about 8.2 mm (0.3 inches). February and March are the driest months while the wet season occurs between August and November.

Temperature varies little throughout the year, with daytime temperatures that fall within the range 25°-29° C (77° to 84.2° F), and usually drop 6° C (42.8° F) at night. Temperatures average an annual 21.6° C (81° F), with the winter lows averaging 24° C (76° F), and the summer high reaching the mid to upper 80s. The temperature and climate are moderated by near constant on-shore breezes.

Due to year-round high temperatures and nearly constant winds, the evapo-transpiration rate is generally high.

The area also lies within the hurricane belt. These intense storms occur between June and November, with September being the month when most tropical storms or hurricanes occur. Within recent years, several hurricanes passed sufficiently close to the island, to cause significant damages, the most recent being Hurricane Omar this past October 2008.

Heavy rainfall sometimes occurs during the passage of the easterly tropical waves, which are spurned off the West African coast from June to November of each year. Occasionally, these waves intensify into tropical depressions, tropical storms, or hurricanes.

Barbuda, by being rather low-lying nature, the solar intensity reaching the land surface is relatively high. This, combined with the prevailing Trade Winds, leads to quick and excessive drying of the soils and plants. As a result, periods of intense dry periods and droughts are therefore common.

Redonda: Redonda is the smallest of the three islands. The island is currently uninhabited, but from the 1860s to the First World War, there occurred a phosphate mining operation. At its peak, about 125 people lived there.

The island is steep, and there is no permanent water. The soils are thin and rocky and support little vegetation.

2.2.4 Vegetation

For nearly a century, the vegetation of Antigua has been described and defined to various extents and under a number of classification systems. Most of the early attempts by such people as Harold E. Box (the early 1900s), were based on a loosely circumscribed set of principles with the notion of tropical rainforests as the premiere and superior form of vegetation in these islands. Any vegetation type that has not yet achieved this level or has since diverged is of less significance. What resulted was a somewhat distorted and often limited view of the vegetation of Antigua, since it did not possess the rainforest types of its more elevated neighbours such as Guadeloupe and St. Kitts.

For most of the 19th and 20th Centuries, this idea of the existence of a natural ecological superiority—a strong hierarchy structure in the development of forms

of vegetation communities—dominated vegetation and plant community classification systems used to define these islands. The most prominent and significant system, developed by J.S. Beard (1949) in *The Natural Vegetation of the Windward and Leeward Islands*, is also guilty of this. Beard was a forester, which in those days meant that his primary interest was in forest management for timber, managed fruit plantations and for water extraction, among other lesser forest uses, and his views were very clearly expressed in his monumental work. He even referred to rainforest as “optimal formation.”

Beard often seemed to dismiss plant species that may have been considered of less significance, especially if it did not seem to define the vegetation community in any meaningful way. Very often in his analysis, one may find statements about species of plants or groups of plants but no scientific or common name with which to determine their identities.

Needless to say, later attempts tried to reconcile these early ideas and conflicts by using more ecological concepts and by including on the ground realities, including human settlements and other forms of little known landscape features.

In 1997, Lindsay and Horwith developed the country’s most up-to-date vegetation classification system, which is still in use to today. However, the difficulty of mapping this classification system becomes obvious when attempts are made to spatially plot and represent them. Many systems are sub-divided into alliances; one may differ from another by the mere presence of one or more other species, associations of species, age groups, height, and so on. This then becomes difficult to map.

It is for this reason that the most recent mapping effort to spatially represent the vegetation of two of the major islands (excluding Redonda), done in 2010, tried to simply this classification by using broad categories (it assimilated and amalgamated similar groups). These categories include:

Development and Settlement Areas: On the map below, much of these areas are in red and are defined by human settlements, including towns, villages, commercial areas, industrial infrastructure, and aggregates of residences.

Tourism: Physical infrastructure, facilities, sites and attractions that are dedicated to the tourism industry.

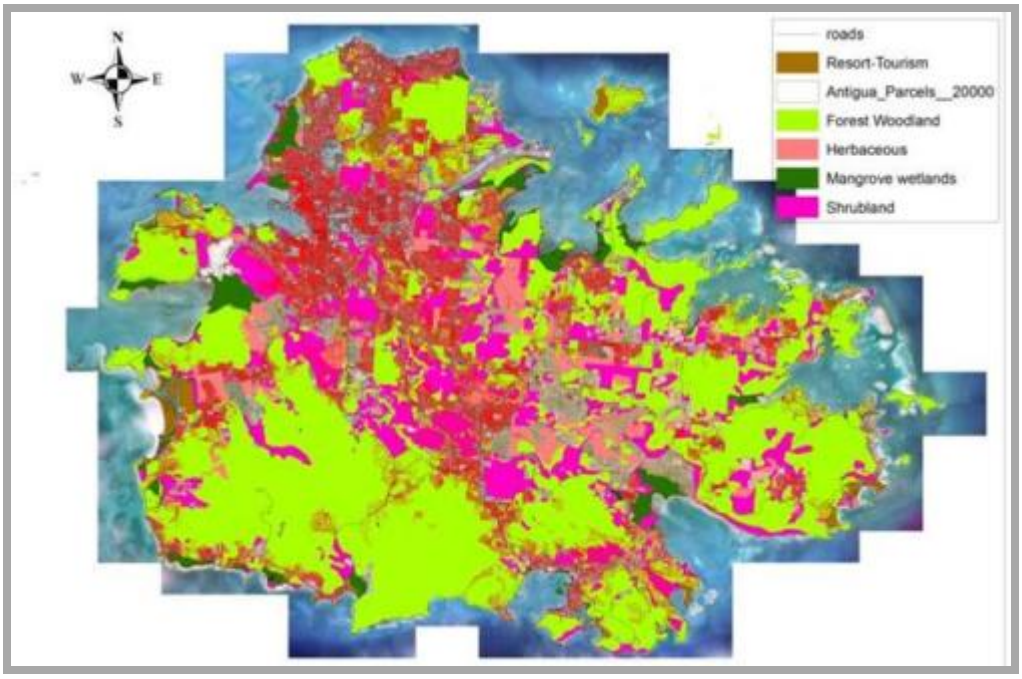
Mangrove wetlands: These are primarily coastal wetland communities, though in Barbuda, there are some inland mangrove systems; these wetlands are

defined by the presence of the five mangrove species (*Rhizophora mangle, Avicennia germinans, Avicennia schaueriana, Laguncularia racemosa* and *Conocarpus erectus*). There are some areas with few mangroves, both species types and numbers, such as salt ponds and salt flats, and lakes, which are also included here. So are many smaller and less common systems.

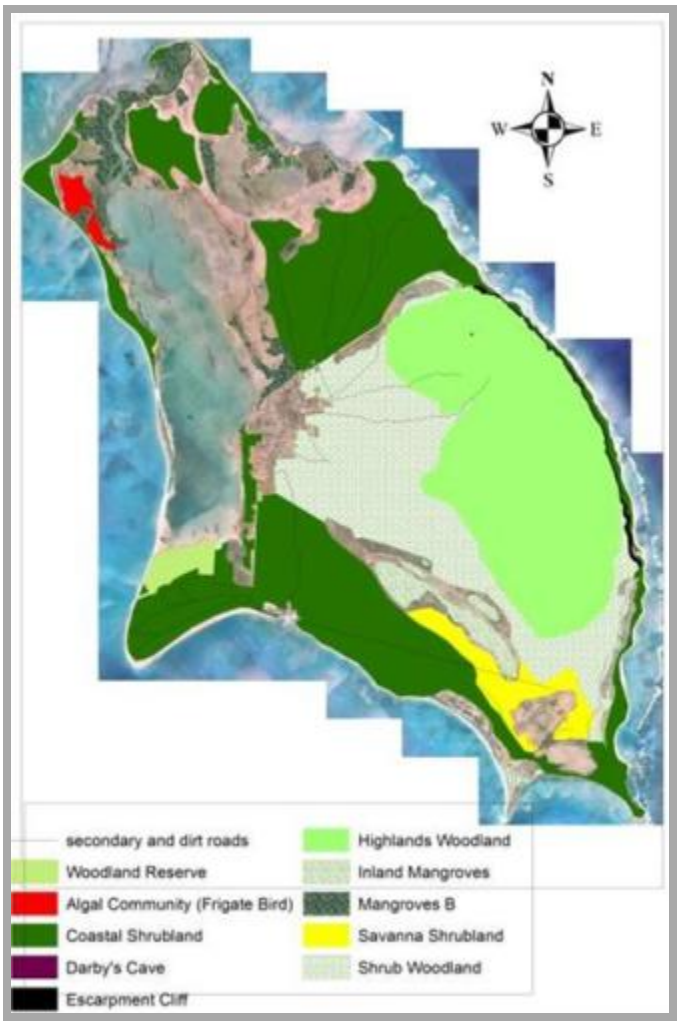
Herbaceous: Plant communities dominated by grasses and other low-growing species. These may be abandoned agricultural lands or pasture for livestock grazing. These areas have some small percentage of successional shrubs but are primarily grasslands. In some cases they can be misinterpreted for low impact agriculture or be mixed uses but provide similar low structure habitat suitable for specific wildlife and plant species.

Shrubland: Generally successional communities to both abandoned agriculture and herbaceous pasture, though some areas are dominated by shrubs due to ecological and climatic factors. Shrublands are dominated by shrubs of multiple species, and form a more complex habitat structure with height and floristic diversity. As these shrublands mature, they will overtop and exclude ground level grasses and such for the most part forming an almost closed canopy. Forest and woodland species will germinate in their shade and eventually overtop and exclude the shrubs. No distinction has been made to map the dwarf shrubland communities found on Antigua as these can only be inaccurately mapped by aerial interpretation.

Forest woodland: Forest communities are dominated by closed-tree canopy vegetation. Many areas are an open mix of successional shrubland; shrubs maturing to low growth forest, and were mapped according to dominance of the structural plant material.



Map 5.0. Simplified Map of the vegetation of Antigua.



Map 6.0. Simplified map of the vegetation of Barbuda.

Woodland Reserve: Close-canopy woods on old dunes found on the northern areas of Palmetto Point. Much of Palmetto has been mined for the large deposits of marine sand that have accumulated over thousands of years, and which have created extensive natural dunes. It is hoped that this reserve will help to protect the remainder of this community.

Algal Community: This is a small patch of floating algal mats that are found around the frigate bird nesting colony. It is likely as a result of the mineral and organic matter derived from the droppings and dead bodies of the nesting birds.

Coastal Shrubland: Low shrubs, some areas intermixed with grasslands and herbaceous communities. This is found on flat plains on Goat and Kid Islands, the areas northwest of the Highlands, areas on the southeastern peninsulas and east coast, and at Palmetto Point eastward.

Darby's Cave: This is found at Darby Cave, a large sinkhole in the Highlands with tall dense growth of forests, including palms and trees over 50m (50 feet).

Escarpment Cliff: Found on the eastern areas of the Highlands bordering the ocean. These are ancient limestone cliffs riddled with small solution holes and caves. On these raised rocky cliffs are small stunted plants, some of them spaced widely apart.

Highlands Woodland: Limited to the Highlands area, which is a raised limestone escarpment, and the vegetation is somewhat larger that on the flat plains below; some areas patches of vegetation consist of thickets of shrubs and taller trees.

Shrub Woodland: This area surrounds the southeast, south and southwest of the Highlands, and receives the limited runoff from this area. The land imperceptibly slopes from the highlands and then creates seasonal flashes during the rainy season.

Inland Mangroves: Found on the southeast corner of the Highlands. This area is dominated by small lakes, flashes and marshes. Four species of mangroves are found here, though R. mangle dominates the immediate perimeter of the lakes.

Mangroves B: These are found around the Codrington Lagoon and other small lagoons around Goat and Kid Islands, and connecting flashes.

Savanna Shrubland: Areas of open shrubland, which are intermixed with natural grasslands. These are found south and southeast of the inland mangroves.

Despite the remarkable achievement and value of having the country's vegetation mapped, this effort is limiting for most conservation and focused management of the flora, fauna, habitats, landscapes and issues.

For example, the extensive Lemon Grass or Citronella (*Cymbopogon citratus*) grasslands that dominate and are rapidly spreading in many areas of the south of Antigua, and which are prone to severe wildfires during the annual dry season, are not explicitly represented on the Antigua map. Nor is there a sense for the advancement, decline or stability of these grasslands over periods of time. This would help us understand trends and for us to construct scenarios that may help devise methods of control of this invasive species, and also reduce the annual fires.

Another example of limits of this map and the classification is the inclusion of the vegetation types of the volcanic south, with those of the central plains and the limestone north. Most of the species of ferns are found in the south, and this in many ways is linked to rainfall, higher levels of humidity and the much taller and larger trees found here.

In Barbuda, a similar factor limits the use of this map and classification for conservation, science and management. For example, many of Barbuda's grasslands are more widely scattered throughout the island, and consist of small patches or glades between clumps of shrubs and trees.

The inland mangroves are in fact a complex of grasslands, flood plains, flooded savannas, marshes and temporary lakes. The mangroves are only one component of this system. These areas are also important for the aquatic ferns *M. nashii*.

Not represented on the Barbuda map are the extensive seasonal flash pools and depressions that occur throughout the lowlands of the island. These areas are often populated by many species of aquatic plants and are also used by many birds and other wildlife.

Future mapping need to focus on explicitly representing these and many issues if the maps are to be used in science and research, conservation, management

and for forecasting trends and issues, including the potential impacts of Climate Change and Sea-level Rise.

2.2.5 Flora and Fauna

The Flora and fauna of Antigua, Barbuda and Redonda are summerised in table 1.0 below.

Table 1.0. Total number of species of plants and animals known to occur on Antigua, Barbuda and Redonda.

GROUP	TOTAL NUMBER OF SPECIES
Plants (native & naturalised)	Over 1,200 species.
Fungi	No complete species and habitat inventories undertaken.
Lichens, Mosses & Liverworts	No complete species and habitat inventories undertaken.
Algae	No complete species and habitat inventories undertaken.
Mammals	12 species (4 introduced).
Birds	Over 300 species.
Reptiles	About 27.
Amphibians	4 species (two introduced).
Aquatic Fish	No complete species and habitat inventories undertaken, but includes a number of introduced taxa.
Marine Fish	Species inventory information not available.
Invertebrates (terrestrial)	Species inventory information not available.
Invertebrates (marine)	Species inventory information not available.

Many of the plant and animal taxa remain largely understudied and the numbers in the table reflect the current inventory of knowledge and understanding of the species. While specimens and records for many species may be housed in museums and with institutions throughout the world, there have been no systematic inventory and updating of this information, which could be made widely available for use on the islands. Further to this, the marine environment remains little understood and surveyed, and hence, much of the information in the table reflects the more widely studied terrestrial environments.

3.0 ABOUT PTERIDOPHYTES

Pteridophytes, the Vascular Cryptogams, or more commonly, ferns and fern allies, are vascular plants that do not produce flowers or seeds (non-flowering), but reproduce through the production of spores (reproductive structures that disperse widely and are able to survive desiccation and extreme heat for considerable lengths of time; they do

not store food like the seeds of flowering plants). The pteridophytes are generally divided into two groups:

- The Lycopodiophyta (club mosses, spike mosses and quillworts); and
- The Ferns:
    - Marattioid ferns
    - Equisetophyta (horsetails); *no species of this group are present in the West indies*
    - Psilotophyta (whisk ferns) and Ophioglossophyta (adder's tongue and grape ferns)
    - Leptosporangiate ferns (the largest group with about 97% of the species)

There are about 11,000 species of pteridophytes today, making this group the most diverse after flowering plants.

The Lycopodiophyta is the oldest group of pteridophytes that is still present with us today. Photo 1.0 shows a member of the Lycopodiophyta, a clubmoss, the Staghorn Clubmoss (*Lycopodiella cernua*) from the nearby island of St. Kitts. These are not really mosses at all and are not directly related to them, but are given this common name because of their vague resemblance to that group of plants.

To date, there are no members of the Lycopodiophyta that has been recorded for Antigua, Barbuda or Redonda. Members of this group are more common on more mountainous volcanic islands with higher rainfall, though Antigua does have the habitat for a number of the region's representatives so it is a puzzle why no species is found here.

The Lycopodiophyta typically have spirally arranged leaves, often scale-like in appearance, somewhat reminiscent of conifers (though they are not related), or what we would commonly call pine trees, with their overlapping leaves and cone-

like reproductive structure called a strobilus from which many spores are released.
In the photo with the Clubmoss are also other pteridophytes, members of the true ferns (dissected leaves) and a sedge (grass-like plant).

There are two common groups found in the Lesser Antilles—members of the Lycopods and *Selaginella*.

Members of Lycopodiophyta often form colonies through the spreading of their root-like rhizomes that allow new shoots to pop up, sometimes creating large areas of these plants.

Photo 1.0. *L. cernua*, a clubmoss, found growing at D'os Don Pond, an extinct crater lake on the nearby island of St. Kitts.

Photo 2.0 below shows *Asplenium cristatum*, a modern fern, and member of the true ferns. This group is fairly well represented on Antigua, though not so on Barbuda and on Redonda.

It has finely dissected compound leaves, which gives the appearance of a delicate lacey plant. True ferns produce spores in sporangia, most often on the underside of the frond (the leaf). Immediately on its right is another fen species, with the blade-like leaves, *Campyloneurum phyllitidis*. It is another member of the modern fern group.

This species was photographed near Mount Obama in Antigua in 2007.

Photo 2.0. *Asplenium cristatum*, a terrestrial fern growing near the summit of Mount Obama in Antigua

3.1 The Evolution of the Pteridophytes

The first pteridophytes appeared on earth nearly 400 million years ago, but reached their height of dominance during the Carboniferous period of the Paleozoic Era; it was the age of the ferns, when during a wet global climate, the group attained its greatest diversity. These primitive pteridophytes and their

relatives formed extensive forests in the coastal woodlands and swampy areas of that period, and many became giants, growing like trees do today.

Giant species related to *L. cernua*, in photo 2.0, grew to over 40 meters in height (over 131 feet). Other species such as relatives of horsetails also grew to be giants, while species resembling modern tree ferns were far more impressive than their modern cousins of today.

By about 290 million years ago, most of the ancient pteridophytes disappeared as their home, the large super-continent of Pangaea began to split apart, and resulting climate

change created drier environments and the swamps dried up. This gave rise to the conifers and later to the true flowering plants, descendants of which dominate the earth today.

3.2 Pteridophyte Life Cycle and Ecology

The life cycle of a fern is complex, but for the purpose of this report, the process is briefly summerised; however, this is not to diminish the intricacies that it takes to produce a typical fern. Many online sources provide extensive information on the life cycle and reproductive stages of pteridophytes in great detail.

Most groups of plants reproduce through a process commonly called ***alteration of generations***, which generally means that they pass through two stages during their reproductive life cycle. In the initial stage of this process, a typical fern first reproduces through asexual means (without the means of male or female gametes), and then in the other stage, it reproduces sexually (with the means of male and female gametophytes (a gamete is a sperm or egg)). But unlike flowering plants (such as the mango tree for instance), which reproduce by using flowers and seeds, pteridophytes employ a very different approach. In the reproductive cycle of ferns and fern allies, the alteration of generations results in the production of two very distinct plant bodies—each stage behaving almost as if they are two very different organisms from very different plants.

The process first begins in what is termed the gametophyte stage. When pteridophytes are mature enough and they produce clusters of sporangia (small structures often produced on the underside of the leaves or within the cones that contain what may resemble tiny seeds) on fertile fronds. Fertile fronds are those leaves that are capable of producing reproductive structures. Not all leaves on a pteridophyte are fertile, and some species may take many years before they are

mature enough to produce fertile leaves or fronds. In the sporangia are the spores—these are the basic reproductive means that they use for carrying on the next generation. The spores are very small, and can easily be carried on the wind or fall to the ground below. If the spore finds a suitable place, the process of cell division begins. Since chromosomes are fundamental to passing on genetic materials in organisms, all spores possess these, but only one set (or half) divides—that means only half of what the plant will eventually need to function, but they are separated into discrete types. Inside the spore, the cells divide and produce a slimy green structure that vaguely resembles a very small plant or leaflet, a process which produces the gametophyte.

This leaf-like structure contains both sperm and eggs needed for sexual reproduction (so it now has two sets of chromosomes needed for a fully functioning plant). When fertilisation occurs, uniting the male and female genes (the sperm swims to the egg), a

young or baby fern may be produced, which is called a zygote, and which has both copies of the male and female chromosomes. After fertilisation, this zygote may then grow to be what you may see as a typical fern. This last stage when fertilization occurs is called the sporophyte stage.

For the process of reproduction to begin, a pteridophyte must be able to successfully grow from a spore, mature and produce spores of its own. For most species, the most suitable environment is moist, and this allows it to have the moisture it needs to survive and for the gametophyte to be able to develop. These often do so in shaded damp areas, especially on rocks, tree trunks, rocky soil and earthen banks, places which won't be disturbed by heavy rains, wind, floods and other forces in short time. The gametophyte must be able to develop in an environment that is relatively stable.

But stable for people may mean long years without incident. For ferns, a stable environment may mean a few months of relative peace so that it can go through its entire life cycle—from spore to mature spore-bearing plant—in that period.

Photo 3.0. *A. tenerum* and *A. fragile* var. *fragile* growing on an exposed stream bank at Tremontania, Antigua.

Many pteridophytes are pioneer species (species that first colonise fresh earth), and these environments are suitable for them because they have little competition from other plants. Some groups have a large number of their species that inhabit in disturbed ground, while others are only found in old growth forest habitats. In Antigua, many of the species of *Thelypteris* or *Adiantum* are typically pioneer species, while *Vittaria* often occur in higher elevations where conditions are wetter and more stable over longer periods of time. Photo 3.0 shows two often pioneer species of *Adiantum* (*A. tenerum* and *A. fragile*) on earthen bank at Tremontania, Antigua.

Nevertheless, this does not mean that all pteridophytes require a hot and humid environment in which to survive, though the spores require a moist environment to germinate. Many species grow in deserts and dry high altitudes areas where moisture is scare. Keep in mind that this group of plants once dominated the earth's landscapes forming vast forests, with species reaching more than 40 meters in height (more than 131 feet). Though most of the species of this period were found in wet swampy areas, their overall diversity and range would have

included species from various habitats, including dry scrub landscapes. This is why pteridophytes are around today—many adapted to the varied conditions of the Carboniferous period and diversified and evolved to include the many forms we now see today.

They have evolved to remarkably resilient. Their spores travel on the wind far and wide, and may even travel across seas, especially during storms. This may be how they colonise many of the islands of the Lesser Antilles.

Ferns are some of the first plants to appear on fresh ground such as new islands created by volcanoes. These were some of the first plants to arrive on Krakatau or Krakatoa Island (near Java in the Sunda Strait) after it erupted in 1883 when animals and plants there were obliterated in the volcanic nightmare that permeated the slopes soon after.

In Antigua, the Silver-back Fern (*P. calomelanos*) is one of the first to colonise fresh ground. This species is often used by some residents to stamp temporary leaf tattoos on the skin on account of the silver and white deposits on the back of the leaves.

For some species of pteridophytes, the spores can persist in the environment for hundreds of years, and remain viable in soils, under rocks and on the barks of old trees. When these spores arrive at a favorable environment they then germinate and start their life cycle all over again. This may explain why Antigua has now recorded several new fern species records since the time of Box (1935). As the forests return and mature, and as favourable ecological conditions stabilise, the spores find their way from the trapped soils and are then “free” to live once again in their island home.

Sadly, it may also mean that many species are now extinct on Antigua—the prolonged bleak and harsh landscapes after deforestation were too much to overcome. Though viable spores may persist in the soil for many generations, on the barks and in the dead wood of trees, most will likely have perished after a few dozen years. In Antigua, many of the large old growth trees were harvested for the timber, for fuel and to clear land for agriculture and for settlements. When these trees were removed, this created a systematic collapse of stable ecological frameworks where the unique local micro-climate and habitat (habitats include environments on the stems and branches of trees and other plants, as well as the animals and ecological structure, processes, weather and climate), that existed on and with these giants disappeared.

Epiphytic communities form a very significant feature of tropical and subtropical forests and woodlands. These arboreal or “hanging” plant communities, sometimes suspended over 30 meters (98.4 ft.) in the air, are specialised habitats that maintain their own cycles and processes somewhat apart, but also connected to the wider and more

dominant plant formations. For example, the typical bromeliad or “wild pine” as Antiguans locally call *Tillandsia reticulata*, can often be seen growing on rocks and trees and sometimes on the ground. Among the rosette of leaves is a “pond” of water collected from precipitation, and in which invertebrates may survive, organic matter accumulates and other plants may grow. The wild pine extracts nutrients from the pond it creates amongst it leaves. Other species may find this attractive because around the plants, a specific microclimate develops (a microclimate is localised atmospheric environment, which differs from the surround and more dominant climate).

Photo 4.0. An example of an epiphytic community, where *Campyloneurum* and *Pleopeltis* ferns are growing amongst *Peperomia* sp., and the orchid *Epidendrum anceps* on the trunk of a *Guazuma ulmifolia* tree in seasonal forest at Christian Valley.

In some of these epiphytic communities, mosses, fungi and lichens form clusters on the branches, trunks, stems and roots of plants, and very often, as lithophytes on rocks. These usually occur in humid moist conditions where water is fairly regularly available throughout the year (there is some seasonal fluctuation). But when an area is deforested, and when the large old trees are cut, the forest loses its stability, and the

unique conditions found on individual trees and on rocks quickly disappear as the exposure to desiccating winds and solar radiations kills of the plants.

For more than 200 years, most of Antigua's and Barbuda's large epiphytic trees have been selectively removed for timber, fuel, and as the forest were cleared to make way for cultivation of crops. This most likely caused many specialised species of pteridophytes, bromeliads and orchids, as well as flowering epiphytes to disappear, some possibly going extinct locally.

While this scenario of the extinction of some of Antigua's and Barbuda's pteridophytes flora is speculative, it is for the most part based on the study and observations of epiphyte communities of nearby Lesser Antillean islands, and on field experience in Antigua and Barbuda. The species of local ferns and fern allies fall more into the terrestrial group than they do in the epiphytic category. Only a handful of native species are strictly epiphytes, growing on trees primarily or on rocks, as opposed to those growing on soil.

This last issue is further discussed in the section ***The Pteridophytes of Antigua, Barbuda and Redonda***.

Photo 4.0 above shows a typical fern epiphyte community in Antigua where members of the fern family Polypodiaceae grow on the trunks of trees along with other plants, including orchids and vines. Many of these ferns are not strict epiphytes, but can also grow on rocks, boulders and on cliffs. This example was found growing in seasonal forests, a somewhat dry vegetation community at Christian Valley.

4.0 THE PTERIDOPHYTES OF ANTIGUA, BARBUDA AND REDONDA

4.1 The Lesser Antillean Context

To date, there are more than 323 species of pteridophytes recorded from the islands of the Lesser Antilles (the Lesser Antilles is regarded a singular biogeographic region, starting from Sombrero in the North to Grenada in the South).

It may be tempting to imagine or to consider Antigua, Barbuda and Redonda as separate and isolated entities, each existing in their own time, space and realities without connections to each other or to the other islands of the region. This scenario is not unrealistic if one focuses solely on the relative distances of open sea between these territories. In fact, the human imagination cannot often contemplate anything beyond birds being able to move between these islands. How could it be possible that entities as small as spores move up and down the islands? What forces may come to bear to transport them across vast distances and overcome these insurmountable barriers? But like we humans use planes, boats and gliders to cross such distances and boundaries, plants use “vehicles” to cross vast distances. In fact, they have had millions of years of practice to perfect their abilities. Consider that these islands are like stepping stones along a long timeline, stretching from South America in the south to the Greater Antilles in the north, with some islands having disappeared many ions ago.

Antigua and Barbuda, once forming one large island during the Quaternary Glacial Intervals (about 3 million years ago), and was about 110 km long by 55 km (68.4 miles by 34.2 miles) at its widest point. It is part of the outer old Volcanic Arc of the Lesser Antilles. Antigua and Barbuda arose from the ocean floor some 34 to 54 million years ago. Islands such as Montserrat are more recent, and are a part of the Inner Volcanic Arc and formed about 22 million years ago.

Antigua and Barbuda precede Montserrat by about 12 to 24 million years. The Lesser Antillean islands are formed by the Caribbean Plate colliding with the Atlantic Plate, creating volcanoes. Antigua at one point would have resembled Montserrat, with the violent eruptions and cataclysms that we see there today. The process would have taken many millions of years, but as the earth’s surface moved, Antigua would have aged, cooled and eroded to what we now see.

The prehistoric Antigua of millions of years past would have had high peaks with elfin woodlands (cloud forests), fern savannas, montane forests, tree ferns, and mountain

swamps. There would have been steep wet valleys, rivers and coastal freshwater wetlands similar to what we now see in nearby Guadeloupe.

On the more volcanic islands of the Lesser Antilles, the steep montane peaks possess extensive pteridophyte savannas, swamps and glades. There are many species found growing on trees, rocks, cliffs, riversides, at the edges of lakes and in bogs and on logs. This is somewhat reminiscent of the Carboniferous era when ferns and their allies dominated the earth's landscape. In fact, some places in the Lesser Antilles resemble those most prehistoric eras before flowering plants dominated. Photo 5.0 shows the prehistoric D'os Don Pond (an ancient volcanic lake) on nearby St. Kitts where pteridophytes and other plants form a bizarre and spooky landscape that seems out of this world.

Photo 5.0. The marshy and boggy landscape of D'os Dan Pond on St. Kitts.

But over time, as the climate and erosion took their toll on the ancient Antigua landscape, the mountains eroded away, and many of the lush tropical forests disappeared as did many species of plants and animals, some maybe even going

extinct forever. And as sea levels rose at the end of the last Ice Age some 20,000 to 25,000 years ago, Antigua and Barbuda then slowly split into two separate islands.

Each of these islands is connected through time and space, and the destruction of habitats on one island ultimately affects the biodiversity and ecology of the others despite their modern geo-political realities.

Today, only Antigua retains some of that old volcanism on its surface. That of Barbuda is hidden below vast limestone deposits. Antigua is wetter, hillier and larger than Barbuda. That island is dry, low and swampy in nature. And yet, Antigua has far more species of pteridophytes.

Many species of plants now absent from Antigua and Barbuda would have been here millions of years ago when the mountains of these islands reached hundreds of meters into the sky. Antigua and Barbuda would have been a base from which many plants colonised more recent volcanic emergent islands such as St. Kitts, Nevis and Montserrat. So what we see now is by no means true for thousands and millions of years past.

Redonda, geologically, is unique in that is was always separated from any of the surrounding islands. Though it is part of the new Volcanic Arc, Its formation likely preceded Montserrat by hundreds of thousands to a few million years, but overall, it is considered as a relative contemporary with that island. The waters around Redonda are deep, reaching more than 1,000 meters in depth (over 3,000 feet). While Antigua and Barbuda are true sister islands, Redonda is a unique and singular entity of its own.

The present day pteridophyte flora of Antigua, Barbuda and Redonda is as much of an evolutionary and geologic realisation, as much as it is a result of human intervention. What we now see is as a result of a torrid and violent geologic, climate, ecological and human history. Today, we strive to understand this past, and to conserve the mechanisms that allow nature to continue to allow the species, the habitats and the ecology to thrive and produce a viable and sustainable pteridophyte heritage on these islands.

It is for this reason that the study and the future conservation of pteridophytes proves to be quite a challenge. We have to understand this past to know what to look for today and to appreciate what possibilities that the future may hold. Added to this is the fact that many species in the world, including Antigua, Barbuda, Redonda and many of the Lesser Antilles are threatened with extinction because

of us humans. Though many of the species were able to survive over hundreds of millions of years by adapting to those unique and often harsh environments millions of years ago, many are now rare and endangered due to the adverse impacts of human habits and activities.

4.2 History, Discovery and Research

There is no early comprehensive report that includes the pteridophyte flora for the three major islands of Antigua, Barbuda and Redonda. Early in this instance would mean 1800 and before.

The first formal record of any pteridophyte from Antigua and Barbuda was by A.H.R. Grisebach in *Flora of the British West Indian Islands*, published in 1864. This was perhaps the first most serious work on the flora of Antigua and Barbuda, and yet, only a handful of plants were mentioned for these islands, and only one species of fern was mentioned and this was *Pteris biaurita*. Photo 6.0 below shows *P. biaurita* on the west slopes of Mount Obama (formerly Boggy Peak) in Antigua.

In 1916, L.R. Wheeler published a short description of the vegetation and plants of Antigua in *The Botany of Antigua*. Wheeler's list of the island's plants is remarkably short, and he does not mention a single species of fern. But it represents the most interesting early picture of the conditions and the type of vegetation that existed in the southern volcanic hills around the turn of the 20th Century. From what he reports, it seems that the hills were more or less denuded of any forest and that cacti, shrubs and succulents—species that one would expect in very dry conditions—dominated the area. Wheeler's description is of course very biased, and it is likely that there were small tracts of early secondary seasonal forests protected in steep gullies, ghauts and valleys, but because they were never extensive, he might have regarded them as unworthy. Nevertheless, the picture he paints is in stark contrast to what is described by Alston and Box, and by Beard's assessment. If Wheeler were in Antigua's southern hills today, he probably would not recognise the place.

In 1926, William R. Maxon mentions 13 species of ferns for Antigua in the *Scientific Survey of Porto Rico and the Virgin Islands*. His list is presumed to be based on collections made by several American botanists and private collectors of the time. However, this publication focused on the species of Puerto and the

Virgin Islands and many Lesser Antillean species were not a part of his publication.

The work of A.H.G Alston and H.E. Box (1935) represents the foremost effort of its kind undertaken on the ferns of Antigua since the arrival of the English, until Proctor's 1977 publication. No similar work exists for Barbuda. Box also visited Redonda and produced a list of plants, which also includes a short list of ferns.

Alston and Box's publication, *Pteridophyta of Antigua*, is remarkable because it was the first comprehensive list ever produced for the island, and because it provided a very detailed overview of the landscape of the island at the time, as well as the ecological

conditions that may have existed then and what brought about the conditions that they observed.

Alston and Box also commented on previous botanical works that highlighted the pteridophyte flora of Antigua and despite over 300 years of European occupation by the time their list was produced, very little in the way of botanical work had actually been done to document the native plants and ecosystems of Antigua when the Europeans arrived and the subsequent centuries after during which they cleared the island of its native vegetation.

Photo 6.0. *P. biaurita*, growing at Mount Obama, is believed to be the first pteridophyte species formally recorded for Antigua.

Earlier efforts to document the flora of Antigua did not result in any publication of the results. Collectors such as a Dr. Robertson, mentioned by Alston and Box in their paper, simply passed their specimens off to private herbariums or European collectors (which eventually ended up in national herbariums and academic institutions), but little is available in the way of the personal efforts of these collectors and what they encountered and found.

In 1939, Box paid a brief visit to Redonda. Unfortunately, due to an injured leg, he was unable to climb to the top, but from the shore, he was able to record a number of plant species. He published his observations in a paper entitled *A Note on the Vegetation of Redonda, B.W.I.* Box lists three species from Redonda, all from the genus Pityrogramma. One of the most curious of his species is *P. trifoliata* (*Gymnogramme trifoliata* in his paper). He calls it the “silver fern” on account of the sometimes silver powdery deposits on the underside of the leaves. *P. trifoliata* is not present on Redonda today, and it is not reported for any of the Lesser Antilles by Proctor and other experts.

Nine years after Maxon's list of 13 ferns for Antigua, Alston and Box published their work and added an additional 23 species to the list.

In the 1940s, more than a decade passed before the eminent forester and botanist, J.S. Beard, visited many of the Lesser Antilles, including Barbuda, and reported on the region's natural and human-created vegetation communities. Beard published his *The Natural Vegetation of the Windward and Leeward Islands* in which he listed many of the islands' plant species.

Despite the significance of Beard's work, he did not mention the local ferns for Antigua. He seemed only interested in plant species that were shrubs or trees and so often did not provide a comprehensive overview of all the species, except for grasses because they were so critical to livestock farming at the time. Similarly, for Barbuda, Beard mentions no species. He did not include Redonda in his study.

In 1960, A.R. Loveless published *The Vegetation of Antigua, West Indies*, which was based largely on the fieldwork and notes of H.E. Box and C.F. Charter. Much of the work that went into this paper was done from 1932 to 1938. Loveless mentions at least 15 species of ferns, but did not add any new species to Box's record. He however, provides detailed descriptions of the vegetation communities of the island at the time, including lists of species.

In 1962, David Russell Harris published *The Invasion of Oceanic Islands by Alien Plants: An example from the Leeward Islands, West Indies*. This was a precursor to his much more detailed thesis described below, but in it he summerised his theories and observations on the vegetation of Antigua, including some ferns.

Harris completed his thesis on the influence human habits and actions on the vegetation and species of Antigua, Barbuda and Anguilla. He published his work entitled *Plants, Animals and Man in the Outer Leeward Islands, West Indies: An Ecological Study of Antigua, Barbuda and Anguilla*.

Harris' work coming on the heels of Beard and Loveless is an interesting work, and provides deep insight into the landscapes of these islands during a time of major economic, social and environmental change in these islands. His study contrasts with past reports on the islands and provides some analysis and
conclusions as to what had happened to the islands' biodiversity since the first human's arrived.

Harris list many species of plants, including many of the first, and provides a greater ecological context for their habitats and environments. Though his list of species was not as comprehensive as Alston and Box, it nevertheless, provided an update on the conservation status of many of the islands' plants.

However, Harris did not mention any pteridophytes for Barbuda.

In 1962, Dr. Richard A. Howard, an expert in West Indian botany, visited Redonda and published his observations in the titled *Botanical and Other Observations on Redonda, the West Indies*. He produced the most comprehensive list of that island, and described the vegetation and other observations. Howard lists three species of pteridophytes for the island, including the very rare primitive species, *P. nudum*.

By the 1970s, there was greater focus and interest in the biodiversity of the Lesser Antilles, especially its plants, and Dr. Howard began to publish his series on the flora of these islands (the complete work is in six volumes). To date, the region's most comprehensive work, Flora of the Lesser Antilles: Pteridophyta was completed in 1977, and was authored by the region's most eminent and influential expert on this group of plants, Dr. George R. Proctor of Jamaica.

The most recent work on the pteridophytes of was completed by the ABPCP, and culminated in the book *The Wild Plants of Antigua and Barbuda: An Illustrated Field Guide to the Native and Naturalised Vascular Plants*.

The work of the ABPCP is now being followed up in this project *The Conservation of the Ferns of Antigua and Barbuda and their Forest Habitats,* under which this Conservation Perspective and the Regional Red List have been developed.

4.3 The Pteridophytes Today

Currently, there least over 80 species of pteridophytes recorded for the islands of Antigua, Barbuda and Redonda, a number which includes varieties, subspecies and hybrids. The current list of pteridophytes does not include any representatives of the Lycopodiophyta, Marattioid ferns and Equisetophyta. The species of pteridophytes include:

Psilotaceae
Psilotum (1 species)
Ophioglossaceae
Ophioglossum (possibly 2 species)
Hymenophyllaceae
Trichomanes (07 species)
Schizaeaceae
Anemia (2 species)
Marsileaceae
Marsilea (1 species)
Dennstaedtiaceae
Pteridium (1 species)
Pteridiaceae
Adaiantoideae
Adiantum (12 species & hybrids)
Vittarioideae
Vittaria (2 species)
Pteridoideae
Pteris (03 species)
Acrostichum (2 species)
Pityrogramma (4 species)
Cheilantoideae
Cheilanthes (1 species)
Adiantopsis (1 species)
Doryopteris (1 species)
Aspleniaceae
Asplenium (06 species)
Thelypteridaceae
Thelypteris (15 species & hybrids)
Blechnaceae (1 species)
Dryopteridaceae
Tectaria (03 species)
Nephrolepis (07 species)
Polypodiaceae
Pleopeltis (1 species)
Neurodium (1 species)
Microgramma (03 species)
Campyloneurum (05 species)
Phlebodium (4 species & hybrids)
Serpocaulon (1 species)

The taxonomic classification of the pteridophytes used in updating the current list is based on Smith (2006).

Of the total number of species, Antigua has between 80 and 85, Barbuda at least six and Redonda at least five.

As part of this project's efforts, the taxonomy of the species of pteridophytes has been updated where possible. The names of many of the species have changed since the publication of Proctor's Pteridophytes of the Lesser Antilles: *In* Flora of the Lesser Antilles (1977). The taxonomy of Lesser Antillean ferns has not been reviewed and updated, and so new ideas, revisions of species and groups, new species, new collections, etc. have not happened in this region since then. Though in 1980, Proctor did provide a brief supplement to his work, primarily to correct some errors and gaps in his 1977 work on the Lesser Antilles. However, some taxonomic questions still remain. For example, the complexities of the forms of *Thelypteris tetragona* and *Adiantum tetraphyllum* throughout their ranges in the Neotropics continue to confound many

experts. Many species or varieties of both forms may be involved, and indeed, some populations of both taxa have been revised to be elevated to full species status. Since Proctors monumental work on the Lesser Antillean fern flora, no revision and review of the region's taxa has been done; in fact, there is no single modern work on the pteridophytes of the West Indies biogeographic region; this has enormous consequences for the conservation action and for the long-term protection of many species. Very little is known about the peculiar situation of most of the species on each island and with increasing development impacts and other human pressures, and the potential ecological changes to be brought on by Climate Change and Sea Level rise, there are enormous challenges ahead for the region's pteridophyte flora. But in order for countries such as Antigua and Barbuda to implement effective conservation measures they will need to know and understand the species that occur there. It is critical for modern taxonomic classifications be brought to bear on the islands' native flora, and for field studies to determine the types of species, their populations, distribution and conservation status.

The lack of a comprehensive review affects the conservation of ferns in the region, and in Antigua and Barbuda as well as efforts for conservation, management and for further understanding of the species and their ecologies. For example, if a unique species is maintained as part of a common and widespread species, it is far less likely that people will be compelled or motivated to protect the species and its habitats. But if the unique characteristics warrant its elevation to full species it may spark immediate action, and spur some to intervene to ensure its long-term survival.

Of the more than 80 species of native and naturalised ferns of Antigua, Barbuda and Redonda today, more than 50% of the local fern flora is terrestrial, about 16% are primarily epiphytic/lithophytic, and only about two species (about 3%) are strictly epiphytic. The others are versatile enough to be able to take advantage of any condition to grow. These are rough estimates because the number of species is slowing growing and with further refinement, a few more species may be added, but the overall picture will remain about the same. The conclusion is that very few of the islands' non-terrestrial species are strictly epiphytic.

It is evident that Antigua, and to a much lesser extent, Barbuda, possess the habitats for much greater pteridophyte species diversity, and absent from much of our pteridophyte flora is a diversity of epiphytic/lithophytic species. With nature, the presence or absence of a species from a region may be coincidental, but in the local situation, the ecological collapse as a result of deforestation and extinctions may have had more fundamental ecological effects than can be immediately realised.

So why is this? What may be the reasons for the relatively low representation of epiphytic ferns from the flora? It may be that with the elimination of large old growth

trees and native old growth forests, many of the epiphytic species would have succumbed to the declining habitat and limited availability of old growth trees, and so they disappeared. These species require more stable humid habitats than many of the terrestrial species, and as a result of deforestation, these unique micro-environments would have been obliterated.

But a curious phenomenon is now happening in Antigua, and there is hope that many of the "lost" species are now returning. In areas of secondary moist forests in the volcanic south where some areas—resembling lower montane rainforest communities of nearby islands such as St. Kitts—a number of new epiphytic/lithophytic species are being recorded. The number has grown from one species, *Trichomanes krausii*, to now include perhaps six additional species. Photo 7.0 shows one such species, *T. punctatum* var. *punctatum* growing at Christian Valley on a large boulder. This species can be found in large colonies all along moist ghauts in the area.

Photo 7.0. *T. punctatum* var. *punctatum* growing on boulder at Christian Valley, Antigua.

Trichomanes are not the only new species recorded for Antigua; several others have recently been added to the local record. Two of the curious additions include *Ophioglossum reticulatum*, and possibly *O. harrisii*, the latter a West Indian endemic

found in Jamaica and the Lesser Antilles. It is smaller than *O. reticulatum*, often growing in larger colonies.

These two species were discovered in Antigua in 2011. Each species is known only from a single location separated miles apart. They inhabit grassy upland moist areas. Photo 8.0 shows *O. harrisii*.

Photo 8.0. The rare primitive fern, O. harrisii, growing in the southern hills of Antigua.

In addition to the primitive *Ophioglossum*, there are at least two, and most likely more, hybrid ferns. The first hybrid was reported by Alston and Box, though they provide very little in the way of details. In those days, hybrids were often considered unimportant and hence, few paid any attention to them. The fern, *Thelypteris* x *rola*ndii, is a cross between *T. tetragona* and *T. poiteana*. It is no surprise that this hybrid would be in Antigua since it is fairly widespread wherever its parent species are found growing together. *T*. x *rolandii* is widespread in parts of the Neotropics.

One hybrid, recently discovered in 2011, is a cross between *Adiantum pyramidale*, a West Indian endemic, and *A. villosum*, the latter species widespread in the Neotropics. This new plant is known only from one location in Fig Tree. It has not been previously

reported for any place in the region, but it is not surprising since other hybrids involving one of the parents and other species have been reported from the Greater Antilles, including Jamaica and Cuba.

The hybrid offspring shares characteristics of both parents. Non-fertile leaves often resemble *A. villosum* (though much smaller), and in fact, if a plant does not have fertile fronds, it may be mistaken for that plant, except for the divided pinnae at the base of some its leaves (which it gets from *A. pyramidale*). Photo 9.0 shows the hybrid at Fig Tree, Antigua.

Photo 9.0. The hybrid *T. pyramidale* x *T. villosum* at Fig Tree, Antigua.

Another possible hybrid is the fern Adiantum x *variopinnatum*, a result of a cross between *A. latifolium* and *A. petiolatum*. The possible hybrid has been observed in the upper moist forest at Christian Valley and Dunnings. The conclusion that this is indeed a hybrid species is not yet definite because *A. petiolatum* has not been recorded from

Antigua. Attempts to locate *A. petiolatum* in the area have so far proved futile, though is still considerable area to cover. However, the unique characteristics as described and attributed to *A*. x *variopinnatum* have been observed in small colonies located in this area. Photo 10.0 shows this species in moist slopes at Christian Valley.

Photo 10.0. The possible fern hybrid Adiantum x variopinnatum at Christian Valley, Antigua.

For aquatic ferns, there are three species recorded for Antigua and Barbuda: *Acrostichum aureum* and *A. danaeifolium*, both often called swamp ferns. Their fronds (leaves) may grow to more than 4 meters in length.

The other species, a species with clover-like leaves, is *Marsilea nashii*, found on Barbuda and nowhere else in the Lesser Antilles. The species is endemic to Cuba, the Bahamas, Turks and Caicos and Barbuda.

One of the most primitive of the pteridophytes is *Psilotum nudum* or Whisk Fern. It does not resemble a fern in any way, but scientist believe that on morphology, ecology and

through fossil records, the species is an early precursor to modern ferns and dates back many millions of years. *P. nudum* is known from Antigua and from Redonda.

Appendix I provides a comprehensive list of the pteridophytes of Antigua, Barbuda and Redonda, including species, subspecies, varieties and hybrids.

4.4 Ecological Factors and Pteridophyte Species Diversity in Antigua

By using the native and naturalised pteridophytes, we can study, understand and theorise on the consequences of wholesale deforestation, land degradation, species extinctions and ecological dysfunction and loss—this can also easily be observed in the native and naturalised orchids and bromeliad species—on the biodiversity and long-term environmental sustainability of these islands.

The British arrived in Antigua in the 1600s and Barbuda about the same time. Having cleared most of Antigua of its native forests, they set about to cultivate the land until it was exhausted of its fertility and productivity. This destruction was a major ecological event for the native species of plants and animals. Before the area was deforested, it was likely that in the south of the island, Antigua had what would have resembled simple form of lower montane rainforest. Much of this was quickly destroyed for agriculture and for fuel, and soon, only small poorly developed tracts remained in one or two locations.

Overall, most of the relict forests in the south of the island that remained were of well-developed seasonal formations, or patches of dry and seasonal forests, and these retained some aspects of their original architecture. Over decades (from the early 1900s until today), as the land was allowed to revert to some natural cover, the increasing networks that the different pieces created via small corridors and intervening systems of grasslands and shrubbery, allowed the exchange of genetic materials (seeds and other forms), the buildup of moisture and humidity, the increase in species diversity and the return of some aspects of the island's native ecological frameworks. However, given the years of soil loss, declining fertility, loss of organic matter, disruptions in ecological processes (chemical and others), loss of species and so on, it is expected that this process would take at least 100 years to allow for even some semblance of the former systems to appear, but in the end, it would never truly return to what it once was. For drier forest communities, especially in the north and east, and in Barbuda, this will take much longer.

The wholesale clearing of land—especially large tracts, over short periods of time and by the removal of all size classes and species—creates environmental shock. This is usually followed by a slow decline in the ecological framework, and eventually, biological collapse: *this is what happened to Antigua after European colonisation*.

With increasing cover in some parts of the volcanic south, it is very likely that biodiversity and ecological framework stability would increase as well. But forest fragmentation, today, caused by commercial developments, road building, housing developments and wildfires—especially for forest systems that are increasingly more reliant on higher levels of moisture, soil stability, on thin soils, on higher humidity—have

shorter dry seasons (droughts) and under forest cover—will create disruptions, and will likely have a domino effect on system integrity, occurring over years. This will then either lead to wholesale system retardation and even to wholesale or area collapse (some aspects of the area simply decline and collapse).

For Antigua to retrieve some of its historical and pre-colonial natural diversity (species, landscapes and ecological frameworks), it needs large tracts of forests and other plant associations (communities), each connected in some way, and each large enough to withstand desiccation, environmental exposure, invasive species, human disruptions, diseases, pests and disasters. As forests become fragmented, even one aspect or factor can cause immense adverse effects and destroy the forest and systems that rely on it.

There are small patches of lower montane forest returning in some of the steep sheltered valleys and ghauts, but these are rather poorly developed and somewhat retarded by fragmentation, relative size, vulnerability to disasters (storms, floods, landslides, erosion, etc.), to species loss and extinctions, and to increased human disturbance.

One such example can be found in the upper reaches of Christian Valley near McNish. An access road has been cut from lower Dunnings up to the summit of McNish where a communications tower is now located. The road now bisects the forest—with the northern and northeastern half the drier secondary seasonal formation, and the southern and southwestern the wetter secondary lower montane. The road also has disrupted the natural drainage of the area.

During much of the wetter parts of any given year, when traveling this road , near the summit, one may often encounter mist. This happens from early morning to near midday, even on fairly clear days. This strange phenomenon, a natural condensation of the moisture in the air, is not a common feature in Antigua, though fog does occur in some valleys during the early hours of the morning. But condensation of the lower levels of the atmosphere does not occur often because the island does not possess the elevation to create this effect like one would see in nearby Nevis on Nevis Peak for example.

The mechanisms that cause this are not yet understood, but a scenario might be that as warm moist air approaches the forests and woodlands of Brecknocks and Hamiltons from the northeast and east, it then reaches the sharp ridge at McNish and nearby hills to the south. This air mass then encounters cooler moisture-laden air from Christian Valley in the west and where these two columns meet there is some condensation, which one sees as mist.

However, with the road cut into the forest, the disruption of the system, the frequent wildfires in the area, increasing human and mechanical traffic, landslides, erosion and the invasion of non-native species, this may retard the regrowth of the forest and cause widespread disruptions. Photo 11.0 shows a patch of this forest near McNish. The trees are relatively short and stunted due to harvesting for charcoal, and because it was until recently under cultivation.

Photo 11.0. Small patch of secondary lower montane forest at upper Christian Valley near McNish Mountain.

Modern development is now targeting some of the secondary forests of these islands, and a second wave of ecological collapse could cause another wave of widespread extinctions of both species and ecosystems.

The forest near McNish is not the only example of lower montane forest. Small patches exist throughout the southern hills, especially at Christian Valley. However, the most accessible is perhaps Fig Tree Ghaut. However, this system has undergone tremendous disruptions, deforestation, fragmentation and decline since the late 1980s. The biggest threat to Fig Tree now comes from road maintenance and farming. Photo 12.0 shows farming at Fig Tree Ghaut today. Most of the secondary forest has been removed to cultivate bananas, mangoes, citrus, breadfruit and other crops. The soil below the trees has been laid bare and exposed to the elements and also causing major disruptions to the area's hydrology.

Photo 12.0. Fruit tree and crop cultivation along the steep banks of Fig Tree Ghaut, Antigua.

So far, Barbuda and Redonda have fairly low pteridophyte diversity. Yet, very little of the Barbuda flora has been adequately studied, and added to this is the fact that the island has been supporting large flocks and herds of feral and free-roaming livestock, as well as wild deer, for centuries. This has caused severe disruption of many of the islands natural systems, and the almost complete disappearance of unique plant communities. This makes it difficult to determine what species may have been present before these animals arrived, and since the animals consume all palatable plants and cause severe

declines and deterioration in habitats, it is hard to tell what other species may still be present there.

Redonda similarly has undergone a severe transformation. From the late 1700s to the early 20th Century, the island has been the target for its deposits guano and

phosphates, which have been mined for use in fertilisers and for other industrial purposes. Goats were introduced to the island, perhaps as much as 400 years ago, and Black Rats (*Rattus rattus*) abound there, eating the seeds and plants, and along with the goats, causing considerable ecological damage and decline.

5.0 STATE OF THE FORESTS

The State of the Forests is a summary overview of the conditions and circumstances that underlie and affect the current status and long-term conservation of tracts of forests, woodlands and other vegetation communities across Antigua, Barbuda and Redonda. It is an attempt to understand, outline and bring into sharp focus, the interconnectedness of the species of ferns and other native plants with their habitats. This focus will hopefully encourage greater awareness about the need to protect and manage the forests, woodlands, grasslands, wetlands and other plant communities of these islands.

There are 115 forests and other vegetation communities evaluated; these are outlined in table 2.0 below. Though this is an extensive list, it is by no means complete. Nevertheless, every attempt has been made to represent the nation's forest regions, types, and locations in this overview.

The methodology used to evaluate these forests is an informal one, and is based on the knowledge of Kevel Lindsay and other local experts and other individuals, as well as a century of reports from various projects and the work of consultants and local residents. The threats facing most of these areas are real, and in some cases, they are impending and inevitable. For example, Rendezvous Bay and Barters area, which ecologically are a part of the Wallings Forest system, are slated for development. Much of the area is private, but there are few parcels of public lands scattered in throughout. The valley and surrounding areas are the largest tracts of undeveloped wilderness and wild lands that remain today in Antigua, and the only large valley without any residences and commercial developments.

Plans have been drawn up and put forward, and an environmental impact assessment (EIA) has now been completed for that proposed project. If it is allowed to proceed, it may cause irreparable damage to Wallings Forest and nearby areas.

The proposed development of this area is despite the fact that Rendezvous and Barters fall within the boundaries of the Nelson's Dockyard National Park, and much of this region is designated a "Conservation" zone or for agriculture. Photo 13.0 shows a view of the forests and woods at Rendezvous Bay, Barters and Sugar Loaf Mountain.

There are many similar issues facing other areas, especially in the north of the island of Antigua, and in parts of Barbuda. These areas of low limestone forests, woodlands, grasslands, mangroves and other types, are often under-valued and/or represented in the national discussions and efforts to protect the country's flora and fauna. This is in

part due to the dryness of the areas, and many consider dry landscape and systems of little value or practical use. Given the lack of serious scientific and conservation

attention paid to them over the years, they have easily been converted to hotels, private homes and other forms of real-estate developments and the pace has rapidly expanded over the last 10 to 15 years. It is for these reasons, plus the relatively small size and sensitive nature of the plant communities, that they are perhaps the country's most threatened systems. Most of the remaining areas in Antigua are likely to disappear within 29 years, if not sooner, if nothing is done to protect them.

Photo 13.0. Rendezvous Bay on the southern coast of Antigua.

One area in the north that has always been considered of tremendous natural value is Weatherills, part of the Weatherills Estate, a historic property that once grew sugar and cotton. The lands are private, but on them sat a large tract of secondary woodland. In 1964, David Harris singled out this area in his work *Plants, Animals and Man in the Outer Leeward Islands, West Indies: An Ecological Study of Antigua, Barbuda and Anguilla*.

Map. 7.0. Weatherills forest on northwest Antigua (source Google Earth 2012).

He writes of Weatherills:

"[*A*]*t the extreme north-east of the limestone district there is a small area of evergreen woodland that is much less degraded than found elsewhere on the northern hills. It covers Weatherill Hill and consists of a closed-canopy stand of trees up to 30 feet in height*…"

At the time Harris did his work in Antigua, there were few areas of native vegetation in the north. Weatherills would have been the most extensive area of forest in that region.

The late and eminent Antigua naturalist and historian, Desmond Nicholson, whose persistent efforts helped to establish the Historical and Archaeological Society and the Museum of Antigua and Barbuda, as well as the Nelson's Dockyard National Park, often spoke of Weatherills and the need to protect the forest there. He saw it as one of the best examples of its type on Antigua, and one worthy of preservation because it provides an interesting example of the island's flora before European colonisation.

Today, it is surrounded by numerous upscale residences and hotels. No researcher has visited this forest since Harris visited and studied it. No one knows if critical native

species of plants and animals are to be found there. Sadly, it will be consumed by development before anyone has had a chance to study its species, functions and value.

Most of Weatherills has been sold and is now parceled out and divided into housing plots and roads for the development of private and commercial homes.

Another interesting example of the forests of the limestone region is found on the eastern end of the island, at Mill Reef, where another tract of dry evergreen forest and woodlands exist. Since the 1950, Mill Reef has been set aside as a gated community for wealthy expats. It sits on about 202 hectares (500 acres), and consists of low limestone hills and small shallow valleys. Along the coasts are mangroves and beaches. There is a mix of low forests, woodlands, shrublands, patches of savannah and desert, with many native plants, some quite rare. Much of the vegetation is entirely secondary.

Harris recognised this area as significant because of its age and the fact that it has been allowed to regrow. He writes:

"[*T*]*he evergreen woodland that covers much of the Freetown peninsula is more continuous and less degraded than that on the northern hills… It forms the largest area of woodland outside the volcanic district… One part of this woodland is of special interest because it provides an opportunity of observing the vegetation after several years of protection from interference… Since 1950 a large area of scrub woodland has been fenced off, and, though surreptitious grazing and charcoal burning still goes on, it is already responding to freedom from exploitation… It is likely that, given continued protection over a long period, closed-canopy forest would ultimately replace the degraded woodland of today..."*

This assessment by Harris was nearly 50 years ago, and much of the area remains undeveloped, though scattered throughout are homes, a small hotel, a golf course and marina facilities. The areas forests and woodlands are probably over 80 years old, having been allowed to regrow on former cotton and sugarcane lands. It is one of the most remarkable and significant areas of native vegetation on Antigua, but yet, it remains little studied and its species and ecology undocumented. Photo 14.0 shows an area of forest at Mill Reef today.

On Barbuda, the biggest threats to the island's vegetation and plants are feral and free-roaming livestock, indiscriminate land-clearing for residential development, land-clearing for road construction and for agriculture. Sand quarrying, or what is locally called sand mining, remains a severe threat to the vegetation and landscapes at Palmetto Point. In

some areas, especially north of the village of Codrington, indiscriminate dumping of garbage remains a problem. At Two Foot Bay, quarrying has become an issue, though it is localised. The indiscriminate siting of the quarry has eviscerated a large section of

the cliffs of the area, creating an unsightly scar in an otherwise remarkably attractive landscape.

The remaining small tracts of dune forests, woodlands and shrub communities at Palmetto Point are some of the most important and valuable vegetation communities because of their uniqueness. They are also little studied and understood. Photo 15.0 shows a section of a forest at Palmetto.

Barbuda has numerous wetlands, and this is one of the island's greatest natural assets. These wetlands are varied, some consisting of inland mangrove systems entirely cut off from the sea, some are complex freshwater marshes and woodlands, and others are seasonal marshes and pools. All of these areas are being adversely damaged by feral donkeys, horses, cattle, wild boars, sheep and goats.

Redonda's flora is under extreme threat from introduced Black Rats (*Rattus rattus*), and goats (*Capra hircus*). These invasive animals have reduced much of the natural vegetation to herbaceous growth, and much of these are annuals. Many of the plants are also introduced. Photo 16.0 shows the Redonda landscape today. The lone Casuarina tree was planted perhaps sometime early last century.

For the assessment of the state of the country's forests, some of the key issues and factors used in the development of the methodology are discussed below:

Land Ownership: For most of the lands in and surrounding these forests, the situation of ownership is uncertain. This is due mainly to difficulty of access to critical ownership data. Though there may be some indication that the land or some parcels of the area are private (for example, the presence of survey markers and "line stones," which are marks that explicitly show the boundary of a property) or public, the task of undertaking a national mapping of land and property ownership would involve the use of various records from the Lands and Survey office, and this very often requires updating information through detailed research and possibly some re-surveying. This effort is well beyond the scope and resources of this project, but it is something that is badly needed. This mapping would need to be done using GPS and GIS systems.

Photo 14.0. Forest and woodland at Mill Reef Antigua.

Forests: Many of the names of these forests that are provided in table 2.0 are informal in application and derivation. The names are taken from nearby geographical place-names, features and towns. Some area names are historical in nature, for example Wallings and Christian Valley, and have been so called for over 100 years.

None of these are designated forest reserves, though Wallings Forest is proposed as the Wallings Forest Reserve and plans are currently being put in place for its management.

The status: the four categories used here have been adopted from and adapted for use in this context from the IUCN approach, with some modification and simplification. This is preferred because it has been widely applied globally for the conservation of species and for protected areas so it provides some level of familiarity. It has also been used in the development of ***The Regional Red List of Pteridophytes of Antigua, Barbuda and Redonda*** (2012); this allows some consistency in this project and other EAG species conservation efforts.

The four categories used are ***endangered, threatened, vulnerable*** and *stable*. These are defined as follows:

ENDANGERED (RED). A forest is considered *Endangered* when the best available evidence indicates that it meets any of the criteria for Endangered, and it is therefore considered to be facing a very high risk of being totally destroyed, its systems, structure and functions disrupted and/or disabled in such a way as to render the system retarded or irreparably damaged.

THREATENED (ORANGE): A forest is considered *Threatened* when it has been evaluated against the criteria, but does not qualify for the category of Endangered now, but is close to qualifying for or is likely to qualify as being threatened in the near and medium-term.

VULNERABLE (GREEN). A forest area is considered *Vulnerable* when the best available evidence indicates that it meets any of the criteria for Vulnerable, and it is therefore considered to be facing a high risk of threats that may elevate its risk to severe damage and disruption, and may elevate its status to *Threatened* or *Endangered* in the near and medium-term.

STABLE (BLUE): A forest is considered Stable when it has been evaluated against the criteria and does not qualify for *Critically Endangered*, *Endangered*, *Vulnerable* or *Near Threatened*, and when prevailing circumstances do not or will not immediately cause severe damage or loss to the system.

The legend for the table is as follows:

STATUS	**SYMBOL/COLOUR**
ENDANGERED	
THREATENED	
VULNERABLE	
STABLE	

Photo 15.0. Rare dune forest at Palmetto Point, Barbuda.

Photo 16.0. A Redonda landscape showing the lone *Casuarina* tree and another introduced plant, a Cleome sp. that blankets much of the island during the rainy season (*photo: Melanie Pearson, 2010*).

Table 2.0. Overview of the state of the forests and woodlands of Antigua, Barbuda and Redonda.

ANTIGUA					
NO.					
	REGION	FOREST AREA	OWNERSHIP	CONSERVATION STATUS	DISCUSSION
	VOLCANIC				
1		Sugarloaf; Rendezvous Bay; Doiggs; Cherry Hill; Mount William	Private and public ownership mix	Slated for development	Slated to be developed; much of the area forms part of several existing and proposed protected areas: Some lands with the area form part of the Nelson's Dockyard National Park; Wallings proper and is part of the proposed Wallings Forest Reserve; All areas, including some of Sugarloaf, form part of the Sustainable Island Resource Management Mechanism (SIRMM).
2		Wallings; Signal Hill; Bishops	Private and public ownership mix	Part of Rendezvous Bay and will be affected by that valley's development	Roads have been built at Bishops and Signal Hill and some homes built in that area. The core area of Wallings is part of the proposed Wallings Forest Reserve.
3		Fig Tree; Fig Tree Hill; Tremontania	Private and public ownership mix		These areas, including Wallings proper, are part of the proposed Wallings Forest Reserve. These areas are threatened by unsustainable agriculture, road maintenance and landslides.
4		Claremont	Private?		Upper slopes are currently stable. The lower slopes are in commercial farms and the nearby mangroves are threatened with commercial tourism development.
5		Old Road; Cade Peak	Private and public ownership mix		Uncontrolled, unplanned and poorly sited real-estate development have consumed considerable hectarage of the forests in the last 10 years.
6		Urlings; Crab Hill;	Private and public		Feral livestock, road construction, uncontrolled, unplanned and poorly sited real-estate development have consumed considerable hectarage of

		Darkwood	ownership mix		the forests in the last 10 years. The mangroves, lakes and salt ponds have been sand-mined and are now threatened by coastal erosion.
7		Orange Valley; Bolans	Private and public ownership mix		Feral livestock.
8		Mount Obama; Midway Ridge; Dark Valley	Private and public ownership mix		Stable, though a few remaining feral livestock remain in the area; proposed as a park.
9		Christian Valley West; Christian Valley East (incl. upper Dunnings)	Private and public ownership mix		Uncontrolled and unplanned road construction, indiscriminate and unsustainable agriculture threaten parts of this forest. Some areas proposed as a park.
10		Rock Peak; Blubber Valley; Dunnings	Private and public ownership mix		Uncontrolled and unplanned road construction, indiscriminate and unsustainable agriculture and annual wildfires threaten parts of this forest. Some areas proposed as a park.
11		Greencastle Hill	Private and public ownership mix?		Designated a park, the eastern third of the hill is a quarry.
12		McNish	Private?		Uncontrolled and unplanned road construction and annual dry season fires threaten this area.
13		Hamiltons	Private and public ownership mix?		Uncontrolled and unplanned road construction and annual dry season fires threaten this area.
14		Brecknocks; Sage Hill	Private and public ownership mix?		Uncontrolled and unplanned road construction and annual dry season fires threaten this area.
15		Fiennes; Body Ponds	Private and public ownership mix?		Uncontrolled and unplanned road construction, indiscriminate and unsustainable agriculture threaten parts of this forest.

					The riverine forest is too narrow a strip along the stream to sustain the ecosystem. Annual fires also threaten the area.
16		Sleeping Indian	Private and public ownership mix?		Road construction, uncontrolled, unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Houses are being built higher and higher up the slopes and as a result the forest is being destroyed.
17		Yorks; Hermitage; Pearns; New Division	Private and public ownership mix?		Road construction, uncontrolled, unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 years.
18		Five Island	Private and public ownership mix?		Feral livestock (mainly goats, sheep and pigs) and uncontrolled and unplanned development threaten this area.
19		Gray Hill	Private and public ownership mix?		Feral livestock and urban development threaten this area.
20		Shirley Heights	Private and public ownership mix?		Feral livestock (goats, sheep and some donkeys) uncontrolled, unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 years.
21		Mamora Bay/Indian Creek	Private and public ownership mix?		Feral livestock uncontrolled, unplanned and poorly sited real-estate development have consumed considerable hectarage of the forests in the last 10 years.
22		Monks Hill; Morris Looby; Guinea Bush	Private and public ownership mix?		Feral livestock uncontrolled, unplanned and poorly sited real-estate development have consumed considerable hectarage of the forests in the last 10 years.
23		Table Hill Gordan	Private and public ownership mix???		Feral livestock uncontrolled, unplanned and poorly sited real-estate development have consumed considerable hectarage of the forests in the last 10 years.
	CENTRAL PLAIN				
24		Forest on Stones (Buckleys)	Private		Road construction, unplanned and poorly sited real-estate development have consumed considerable hectarage of the forests in the last 10 to 20 years.
25		Aberdeen	Private and public		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.

			ownership mix?		
26		Olivers	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
27		Sherwood Forest	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
28		Stoney Hill	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
29		Burkes	Private and public ownership mix?		Stable
30		Yeamann	Private and public ownership mix?		Stable for now, but unsustainable agriculture and indiscriminate bulldozing threaten this area.
	LIMESTONE				
31		Friars Hill	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
32		Weatherills	Private		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. This forest is largely secondary and had been in slowly regenerating since the early years of the last century; it was even singled out by J.S. Beard in Vegetation of the Windward and Leeward Islands of 1949. Unfortunately, it has been carved up and leveled for commercial real estate development.
33		Santa Maria Hill; Cedar Valley	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
34		New Winthropes/Barnes Hill	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
35		Powells	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.

36		Blackman	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
37		Parham Hill	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
38		Crabbs Peninsula	Public?		Stable for now
39		Coconut Hall; Mercers Creek	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Also threatened by proposed quarrying.
40		North Sound; Vernons; Mount Joy; The Diamond	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
41		Betty's Hope; Elliots; Collins	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
42		Black Ghaut; Gaynors	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Also threatened by proposed quarrying.
43		Comfort Hall; Wickams; Grays; Phillips/Guard Point	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Also threatened by proposed quarrying.
44		Ayers Creek	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Also threatened by proposed quarrying.
45		Hughes Point	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years. Also threatened by proposed quarrying.
46		Browns Bay	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
47		Harmony	Private and		Unplanned and poorly sited real-estate developments have consumed

		Hall	public ownership mix?		considerable hectarage of the forests in the last 10 to 20 years.
48		Mill Reef	Private and public ownership mix?		Stable
49		Soldier Point	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
50		Mannings	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
51		Willoughby Bay	Private and public ownership mix?		Unplanned and poorly sited real-estate developments have consumed considerable hectarage of the forests in the last 10 to 20 years.
	OFFSHORE ISLANDS & CAYS, ANTIGUA				
52		Bird Island	Private		Stable for now.
53		Blake Island	Private		Stable for now.
54		Codrington Island	Private		Stable for now.
55		Crump Island	Private		Commercial tourism and real-estate developments have been proposed for this island for a number of years.
56		Exchange Island	Private		The reintroduction of invasive rats is always a threat.
57		Galley Island Major	Private		The reintroduction of invasive rats is always a threat.
58		Galley Island Minor	Private		The reintroduction of invasive rats is always a threat.
59		Great Bird Island	Private		Threatened by commercial tourism tours and now vendors. Also, the reintroduction of invasive rats is always a threat.
60		Green Island	Private		Threatened by commercial tourism tours and also, the reintroduction of invasive rats is always a threat.
61		Guiana Island	Private		Commercial tourism and real-estate developments have been proposed for this island for a number of years.
62		Hawes Island	Private		Stable for now.
63		Hell's Gate	Private		Stable for now.

		Island			
64		Jenny Island	Private		Stable for now.
65		Laviscounts Island	Private		Stable for now.
66		Little Bird Island	Private		Stable for now.
67		Little Island	Private		Stable for now.
68		Lobster Island	Private		The reintroduction of invasive rats is always a threat.
69		Lobster Island Extension	Private		Stable for now.
70		Long Island	Private		The native vegetation has been virtually wiped out by commercial tourism and real-estate developments.
71		Maiden Island	Private		The native vegetation has been virtually wiped out by commercial real-estate developments.
72		Monocle Point Island	Private		Stable for now.
73		Nanny Island	Private		Stable for now.
74		Pelican Island	Private		Commercial tourism and real-estate developments have been proposed for this island for a number of years. There already is a private residence here.
75		Rabbit Island	Private		Stable for now.
76		Rat Island Major	Private		Stable for now.
77		Rat Island Minor	Private		Stable for now.
78		Redhead Island	Private		The reintroduction of invasive rats is always a threat.
79		Samphire Rock	Private		Stable for now.
80		Smith Island	Private		Stable for now.
81		Whelk Rock	Private		Stable for now.
82		York Island	Private		The reintroduction of invasive rats is always a threat.
83		[no name]	Private		Stable for now.

84		[no name]	Private		Stable for now.
85		[no name]	Private		Stable for now.
86		[no name]	Private		Stable for now.
87		[no name]	Private		Stable for now.
88		[no name]	Private		Stable for now.
89		[no name]	Private		Stable for now.
90		[no name]	Private		Stable for now.
91		[no name]	Private		Stable for now.
92		[no name]	Private		Stable for now.
93		Maiden Island (west)	Private		Stable for now, but has a private residence.
94		Five Islands (four, was six 200-300 years ago)	Public?		Threatened by rising seas and coastal erosion.
95		Hawksbill	Public?		Stable for now.
96		The Sisters	Public?		Stable for now.
BARBUDA					
97		The Highlands	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
98		Goat Island	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
99		Rabbit Island	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
100		Kid Island	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
101		Palmetto Point	Community Ownership		Largely destroyed as a result of sand quarrying. Also threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
102		Coco Point	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
103		Spanish Point	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
104		The Castle	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.

105		Welsh Point	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
106		Pelican Bay	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
107		Castle Bay	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
108		Bull Hole and Freshwater Pond; Inland Mangroves	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
109		Two Foot Bay	Community Ownership		Threatened by quarrying, feral livestock, the introduced Fallow Deer and Wild Boar.
110		Hog Point Area	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
111		Billy Point Area	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
112		Cedar Tree Point	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
113		Low Bay	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
114		Horse Pond Area	Community Ownership		Threatened by feral livestock, the introduced Fallow Deer and Wild Boar.
REDONDA					
115		Redonda Island	Public		Threatened by introduced rats and feral goats introduced to the island perhaps the late 1600s or early 1700s.

6.0 APPROACH AND METHODOLOGY

The field study of the country's ferns and fern allies began as an informal scholarship by Mr. Lindsay over the course of many years. In the 1990s, he undertook studies of the plants growth habits and preferences in nurseries and in the field, and through the following years, he conducted thousands of hours studying historical reports, publications and current research on the subject.

Mr. Lindsay undertook several field visits to Antigua and Barbuda starting in 2009 and continuing into 2011. Mr. Lindsay, in many instances with the aid of volunteers and colleagues, undertook targeted field surveys, focusing on specific habitats and regions because of their known pteridophyte diversity, the occurrence of a particular species, and/or because of the habitat type and its potential to harbour particular species.

For Redonda, Mr. Lindsay has relied on his visits to the island back in the 1990s as well as on numerous colleague visits to Redonda, including 2009 and 2011.

In preparing this document, the author has also relied on previous studies and reports as guides and to understand the historical context.

Mr. Lindsay has also worked with experts and colleagues to help in the identification of difficult species. Nevertheless, several important questions remain about several species—the result of which may further increase the list. Work to overcome these taxonomic challenges is ongoing.

So far, Mr. Lindsay and colleagues have spent more than a month of total survey days in the field on Antigua and about two on Barbuda.

7.0 MAMAGEMENT AND CONSERVATION OF PTERIDOPHYTES

This section outlines and discusses the issues that affect the long-term survival of pteridophytes and their habitats. It should be noted that currently, there are no formally protected pteridophyte species or their related habitats. In fact, the country does not provide legislative and policy protection for the country's native plants, habitats and landscapes. There are attempts by the Ministry of Agriculture, through its Environment Division, to update the natural resources protection and management legislation and fill the existing gaps and shortfalls that existing laws, regulations and institutions. The proposed legislation, The Environment Protection and Management Act, 2010, is under now under review. However, the process of revision and feedback on the document remains laboriously slow, and it remains to be seen if it actually makes it to the Antigua and Barbuda Parliament for debate and eventual enactment.

The section includes discussions on institutional, policy and legislative frameworks, the impacts of invasive species, pests and diseases of pteridophytes, the economics of pteridophyte conservation, and the potential impacts of Climate Change and Sea Level Rise. The section concludes with a set of recommendations and a way ahead for the conservation of the country pteridophyte flora.

7.1 Local Institutional, Policy and Legislative Frameworks

In the long-term, for there to be substantive progress in the effort to ensure the protection and management of the islands' native pteridophyte species, for their habitats, and the threats that they face, there has to be an effective national authority that possesses the requisite mandate to oversee the country's biodiversity and other environmental assets. This is essential in order to prevent further deforestation, allow for conservation intervention, stimulate research and science and demonstrate the nation's effectiveness in the management of its natural resources, and to meet its multinational commitments and obligations.

There is no single existing legislative or policy framework that comprehensively addresses the conservation of ferns and fern allies, their habitats and the treats to them. In fact, this is true for most of the country flora and fauna.

Proposed national legislation in the form of the Environmental Management and Protection (EMP) Bill is an all-encompassing approach that seeks to provide the legal framework for biodiversity and environmental conservation and management in the country. However, the bill remains in draft form and under draft review.

Below is outlined a summary of the institutional, policy and legislative frameworks of Antigua and Barbuda that affect the conservation of the nation's native flora, its management and conservation and of the threats that may affect them. The summary has been adapted from the ***Body Ponds Watershed Land Use Zoning and Local Area Management Plan***, 2010, which provides one of the best overviews of this issue to date.

Though some of the policy frameworks and legislation mentioned may seem irrelevant because they lack direct connection to actual species and issues to do with biodiversity conservation, it is nevertheless worth pointing out that of critical importance to the long-term and effective protection of forests and woodlands is the management of physical development and the employment of environmental studies and assessments to ensure that science, research and investigation such as environmental impact statements (EIAs) and impact studies (EIS) form a significant component and tool to ensure that final decisions and judgments on issues and proposed projects are based on sound data, approaches and advice.

7.2 Existing Legislative Framework

The policy framework for the management of biodiversity and landscape issues includes a number of laws that might be divided into three broad categories:

l) Those developed primarily for conservation and sustainable use of natural resources and ecosystems (e.g., forests, water, wildlife, fisheries),
2) Those developed primarily for public health and environmental pollution control, and
3) Those linked generally to development (e.g., land use planning, infrastructure).

Table 2.0 summarizes principal legislation and the agency responsible, as laid out in that study.

Table 2.0. Principal Legislation and Responsible Agencies.

(Source of table: ESAL, 2008)

Agency	Ministry/ Authority	Legislation	Functions
DCA	Tourism	***Land Development and Control Act (Cap. 235, 1977);***	Review and approve the development of lands.

		Physical Planning Act (No. 6 of 2003)	
Lands Division	MALMA	***Crown Lands Act (Cap. 130, 1917)***	Reallocation and subdivision of government lands for development.
Water Division	APUA	***The Public Utilities Act (Cap. 359 of 1973; amended 1993 and 2004)***	Distribute national water supply and manage surface and groundwater resources.
PCB	MALMA	***The Pesticides Control Act (No. 15 of 1973)***	Regularize the importation, use and disposal of all pesticides used domestically.
Forestry Division	MALMA	***Forestry Act (Cap. 178,1989)***	Manage forested areas.
Fisheries Division	MALMA	***The Fisheries Act (No. 14 of 1983); Marine Areas (Preservation & Enhancement) Act (Cap. 259)***	Develop and manage fisheries.
NPA	Tourism	***The National Parks Act (No. 11 of 1984; amended 2004).***	Establish and manage national parks.
CBH NSWMA	Health	***Public Health Act (Cap 353)*** ***Litter Act (Cap 250, 1984; amended 2004).*** ***Solid Waste Management Act (1995; amended 2005)***	Regulate all matters pertaining to public health including the management of environmental health. Control collection and disposal of solid and liquid waste.
Barbuda Council as the local government Institution/administrator; but since the lands are held in common, final say is vested in people of Barbuda.		***Barbuda Land Act, 2007***	Manage use of lands, and the protection and conservation of natural resources in Barbuda.

7.3 A Main Policy Tool: *The Physical Planning Act (2003)*

The Physical Planning Act represents one of the most significant, comprehensive and important land development control devices currently in existence in Antigua and Barbuda today. This Act regulates structural development and all forms of land use, and some aspects of conservation throughout the country. The Act gives the Development Control Authority (DCA) broad and decisive powers for land use planning, development control, and preservation and improvement of amenities on the land. As stated in its title, the purpose of the Act is to make:

> "…*provision for the orderly and progressive development of land and to preserve and improve the amenities thereof; for the grant of permission to develop land and for other powers of control over the use of the land; for the regulation of the construction of buildings and other related matters; to confer additional powers in respect of the acquisition and development of land for planning; and for purposes connected with the matters aforesaid*."

Among the powers provided, the Act authorizes the Town and Country Planner on his/her own initiative or at the request of the Authority or Minister, to submit proposals for preparation of a development plan for the whole of Antigua and Barbuda or a specified part (s.9, 10). Once the proposal is accepted by the Minister, the Town and Country Planner is to prepare or supervise preparation of the plan, and keep it under review (s. 10).

A development plan must include a statement of the principal aims and objectives of development of the area, existing conditions including the principal physical, social, economic and environmental characteristics, a statement of the policies, proposals and programmes for future development and use of the land including measures for the maintenance and improvement of the environment (s.10(2)). In addition, the Act provides authority to designate specific areas that should not be developed "…*for reasons of flooding, erosion, subsidence, instability, or other hazards, conservation or other environmental considerations* (s.10 (4))*."*

The Act includes an Environmental Impact Assessment (EIA) process for proposed developments. The Town and Country Planner, after consultation with the Chief Environmental Officer, is authorized to require that any applicant for a development permit to prepare and submit an environmental impact statement or feasibility study of the proposed development (s. 20).

The Act also gives the Minister authority to designate by order any area as an "environmental protection area" (s. 54(1)). This authority provides a valuable supplement to other legislation, e.g., the Forestry Act and National Parks Act, which

appear to have lagged in implementation. In effect, it is an option that may offset weaknesses in those conservation-directed laws until they undergo strengthening and reform.

Procedures are laid out in the Act for declaring an area an “environmental protection area”, including the requirement of a survey by the Town and Country Planner, and consultations with affected or interested stakeholders. The Minister is to consider a number of factors when deciding to declare an ‘environmental protection area’ (s. 53(3)), including:

I. The flora and fauna of the area;
II. The natural features and beauty of the area;
III. Any outstanding geological, physiographical, ecological, or architectural, cultural or historical features of the area which it is desirable to preserve and enhance;
IV. Any special scientific interest in the area;
V. Any special natural hazards to which the area is or may be subject; and
VI. The characteristics, circumstances and interests of the people living and working in the area.

An order to designate an ‘environmental protection area’ may have significant meaning for guiding land uses to protect water quality and quality, and promoting biodiversity conservation and sustainable use. As laid out in the Act, such an order may allow only certain types of development or a certain development, it may prohibit all development or authorize works important for protection of the area, provide for control over use of land for agriculture or forestry, and require that an environmental impact assessment be undertake for any proposed activity that is permitted in the area (s. 54(3)).

7.4 Other Existing Legislation

Three key pieces of Legislation should be singled out for their importance in managing lands, protecting habitats and managing structural development. These include:

Forestry Act (1989). While implementation of this Act appears to be limited by human, financial resources and capacity, it is still the main legislation currently in force providing authority and a process for the Minister to declare by order any lands as forest reserves (where timber removal or burning is prohibited without a permit) (s.8), and lands that should be reforested (s. 9).

National Parks Act (1984). This Act appears to be facing similar challenges as the above. Serious efforts are needed to build capacity for strengthened

implementation of this legislation, including specific regulations that may be immediately needed, to advance legal protection of priority biodiversity sites throughout the country.

Public Utilities Act (1973). Given the modern challenges, including alternative energy, carbon footprint, sea-level rise and other issue, this Act appears somewhat outdated in some respects, but is the principal legislation currently in force for providing potable water services to the public in Antigua and Barbuda—that water comes principally from the country's forests and watersheds.

The Public Utilities Act gives the Antigua Public Utilities Authority (APUA) exclusive rights to sell, distribute and maintain water supplies for public use. These powers include to the control, management, maintenance, operation and supervision of all watercourses and waterworks in Antigua and Barbuda (s.8). It is worth reviewing the definitions of these terms to appreciate the scope of the powers involved. 'Water-course' is defined to mean any pond, spring, stream, well, water and water rights whether held together with, or independently of, any land (s.2). 'Water-works' is defined to include wells, beds, pumps, dams, reservoirs, cisterns, tanks, filters, catchments, aqueducts, tunnels, sluices, conduits, mains, pipes, stand-pipes, showers, valves, engines, culverts, desalination plants, water treatment plants and all machinery and appliances, lands, buildings and things used for or in connection with the supply of water constructed or maintained from public funds or constructed or maintained by the Authority (s.2).

The Authority has a strong economic interest in undertaking measures that will ensure well-functioning and sustainable watersheds for purposes of water production. As reflected in the above definitions, its significant powers also carry equally weighty responsibilities to guide, control, and monitor all developments in watersheds that may affect water quality or supply. The Act identifies some specific powers relevant for watershed management, in addition to these overarching mandates. It gives the Authority power, with the approval of the Minister, to declare an area to be a watershed where the drainage or water from the area flows or is conveyed to a watercourse or waterworks (*s. 39*).
The Minister may make regulations specifically for cleaning, maintenance, protection and prevention of obstruction of watercourses and watersheds, including prohibiting within a distance of thirty feet from a watershed the cultivation of any land or the de-pasturing or grazing thereon of any livestock (s. 40). The Authority may make regulations, among other things, relating to the sanitary control of watersheds (s. 41). These powers provide significant opportunity to develop additional tools specifically to support needed actions of the Authority for watershed management.

Significant penalties may apply for offences that threaten quality or quantity of water flowing into any watercourses or waterworks (*s.32*). It is unlawful for any person to trim, cut, or fell any tree the trimming, cutting or felling of which is likely to constitute a danger to any works unless the Authority has twenty-four hours previous notice of such trimming, cutting or felling (s.28).

7.5 Multilateral Obligations

Since the Rio Convention on the Environment in 1992, there has been a sustained focus on the use of Multilateral Environmental Agreements (MEAs) to address global environmental concerns. Antigua and Barbuda has signed onto and ratified many of these International Conventions and actively uses them as instruments to advance its natural resource protection objectives. Some of the conventions which have concerns and plans of action that specifically related to watershed management are:

1. Convention on Biological Diversity (CBD)

The major initial activity has been the production of a draft Plan of Action. The plan has highlighted the biological diversity that currently exists in the Country and has proposed a programme of action to study, protect and conserve this biodiversity, while at the same time identifying opportunities to exploit such diversity in a sustainable way. Antigua's forests, wetlands and reefs form a dynamic repository of this resource.

2. Framework Convention on Climate Change

The Convention on Climate Change seeks to inform and prepare signatory countries for the likely consequences of global warming and sea level rise, so that, as far as possible, countries can prepare for it and take it into account in their planning. The worst effects are expected in coastal areas, where both sea level rise and the damaging effects of more frequent and more intense storms will be experienced. Watersheds and water resources are likely also to be affected by the more intense rains and droughts, causing accelerated erosion, flooding and species loss due to the more severe droughts which are expected. Management systems will need to be improved in order to prepare better for these eventualities.

3. Convention to Combat Desertification and Land Degradation

This convention focuses on the reversal of processes which, in many parts of the world, are leading to the creation of desert where there was none before. While desertification is an extreme scenario for Caribbean countries, many have experienced extensive land degradation due to deforestation of mountain slopes, leading to accelerated erosion and

severe topsoil loss. Desertification as a result of Climate Change is a real possibility in Antigua and Barbuda. This convention is coordinated within the Ministry of Agriculture, where experience with soil conservation and land management resides.

4. Specially Protected Areas and Wildlife (SPAW) Protocol

Antigua & Barbuda is a contracting party to the SPAW protocol and have thereby agreed to protect, preserve and manage the ecosystem in a sustained manner. Some of the protection measures include the regulation and prohibition of:

• Dumping or discharging wastes and other substances in protected areas; and
• Activities involving a modification of the profile of the soil that could affect the degradation of watersheds or the exploration or exploitation of the subsoil of the landward part of a marine protected area.

7.6 Institutional Framework

The Antigua and Barbuda national institutions responsible for the conservation of flora and fauna include:

- The Environment and Forestry Divisions in the Ministry of Agriculture;
- The Prime Minister's Office, a leading agency in the promotion of the Mount Obama National Park;
- The Cabinet of Antigua and Barbuda;
- The National Parks Authority;
- The Antigua Public Utilities Authority;
- The Development Control Authority;
- The Extension Division (Ministry of Agriculture); and
- The Lands and Surveys Divisions (the Ministry of Agriculture)

The key non-government institutions involved in the conservation and protection of the country's fauna is the Environmental Awareness Group.

7.7 The IUCN Regional Red List of Pteridophytes: Summary of Findings

The Regional Red List of Pteridophytes of Antigua, Barbuda and Redonda revised the 2009 Red List of Vascular Plants. It has assessed the conservation status of all of the

native and naturalised species (former list focused mainly on regional (West Indian) endemics), and provides a comprehensive overview of all taxa.

Taxonomic updates and changes since 3007 has allowed some adjustments to the current List, and for our understanding of the native ranges of many of the species, the overall global distributions and the status of many of these species in the West Indian biogeographic basin.

The Regional Red List below presents an update to the 2009 version. It is more comprehensive and compelling in its analysis of the situations of each species in that it values each taxon for it significance as a natural part of the biodiversity of the islands—if any of these were to go extinct, it would represent a major loss to the local bio-heritage and to the aspirations of the people of Antigua and Barbuda. The summary of the findings are presented in table xx below.

Table 3.0. Summary of the Regional Red List of Pteridophytes of Antigua, Barbuda and Redonda.

Categories	**Findings**
Extinct	
Regionally Extinct	Possibly 04 (about 5.5%)
Critically Endangered	18 (24.7%)
Endangered	09 (12.3%)
Vulnerable	14 (19.2%)
Near Threatened	04 (5.5%)
Least Concern	11 (15.0%)
Data Deficient	07 (9.6%)
Not applicable	06 (8.2%)
TOTAL	**73 (100%)**

7.8 Threats to the Pteridophytes

The threats to the native species of pteridophytes include:

I. Annual wildfires in Antigua, especially in the central and southern areas of the island, especially in areas occupied by the introduced invasive Fever Grass (*Cymbopogon citratus*) communities;

II. Feral and free-roaming livestock; especially goats in the southern hills of Antigua, all major livestock breeds in Barbuda, where animals roam free and unmanaged, and goats on Redonda where goats have been present for perhaps 400 years;
III. Road development, real estate expansion into forested areas and commercial hotel development into protected areas and secondary forests;
IV. Marijuana cultivation, which represents a "livelihood" for many, but which represents a security threat to forest managers and to recreationist, and because of the habitat destruction; forest fragmentation, the introduction and spread of invasive species and diseases, and the increased soil erosion potentials;
V. Forest fragmentation cause by roads and other human activities;
VI. Climate Change;
VII. Droughts; this over the years has been exacerbated by human activities and habits;
VIII. The harvesting of forest resources, including wood for charcoal and wattle;
IX. Farming on steep slopes and the deforestation of Fig Tree Drive;
X. Road maintenance and development along the John Hughes to Old Road Corridor;
XI. Disruption of natural hydrology by water extraction, dam construction, infill of wetlands for land reclamation (along Airport Road and Fitches Creek system), tapping of natural springs and development of streams; and
XII. Invasive species and diseases as a result of introductions and human interventions.

7.9 Invasive Species and their Impacts

Invasive species of plants and animals have had a tremendous impact on many of the native flora, fauna, landscapes and ecological functions of Antigua, Barbuda and Redonda. The impacts of invasive species come from three main sources: introduced and naturalised pteridophytes, other introduced and naturalised plants and from invasive animals.

Invasive Ferns: Between three and seven species of ferns have now become naturalised in Antigua; one, possibly two species on Barbuda. There are no introduced pteridophytes known from Redonda. One species, *Phymatosorus scolopendria*, represents a potential future threat, but is here listed as a caution. The naturalised species of ferns include the following (note that some may in fact be native):

Table 4.0. The Naturalised Ferns of Antigua and Barbuda.

SPECIES	STATUS	DISCUSSION
N. biserrata cultivars	Common around hotel gardens and at the V.C. Bird International Airport	In recent years, cultivars of *N. biserrata* have been introduced as border plants in gardens, especially around hotels and commercial buildings, including the grounds of the national airport. These cultivars are extremely aggressive and readily escape the confines of gardens. They can reproduce through both vegetative and sexual means. This represents a potentially major threat to the native wild *N. biserrata*. These cultivars can readily cross with the native species, and given their aggressive and dominant nature, they may drive it to genetic extinction. This is only a prediction, but it is one that could indeed happen. Photo 17.0 shows cultivated plants at the airport in Antigua.
N. brownii	Common around Wallings, John Hughes, Sweetes, Fig Tree Drive and a few scattered areas in the volcanic hills. Also present around towns and villages.	This species probably arrived in Antigua in the 1980s. It was not a major threat until the 1990s, and it now is the most common *Nephrolepis* species in some parts of its current range. It displaces other native species, and may be the most significant factor in the decline and possible extinction of the native *Nephrolepis rivularis*. Other native members of this group may also face similar declines due to its aggressive and dominant habits. The species is native to Asia and the Pacific.
N. cordifolia	Rare. This species is prized by gardeners, and is often found growing as a potted plant. It sometimes escapes cultivation, but this habit is limited to areas around towns and villages.	This species seems confined to towns and villages and has not escaped into the wild. The species is native to Asia and the parts of the Pacific.
N. exaltata	Common, especially around All saints, Liberta, Sweetes, Buckleys, Freeman's Village, Christian Valley and Wallings.	This species has long been suggested to be introduced, but recent studies of the Neotropical members of this group suggest that it has been present in this region for a very long time, and that this population represents a diverging line that is native to this area. It is likely native to Antigua. It is often found growing on the trunks of the introduced Date and Oil Palms.
P. scolopendria	Cultivated. Not known from the wild.	*P. scolopendria* is a species, originally from Asia, which has been introduced as a curiosity and a garden plant. Often planted in baskets and pots,

		some hang them on trees or attach them directly to walls and other structures to which it readily takes. It resembles members of the native *Phlebodium*. It is a species that needs to be monitored because if it great potential to escape cultivation. It has done so in the Greater Antilles, especially in Puerto Rico and the Virgin Islands. Photo 18.0 shows a specimen in Road Town, Tortola. It now naturalised on that island.
P. vittata	Common around towns and villages in Antigua, and at Codrington, Barbuda. Rarely found in the wild.	This species does not seem to represent a major threat to native species, but should be monitored. It is quite similar to the native *P. longifolia*, with which it is often confused. The species is native to Asia.
T. dentata	Common. This species is often found along streams and around banana plants, other agricultural cultivation in the volcanic areas of Antigua. It is found at one location near Codrington, Barbuda (see photo 21.0).	This species is Pantropical in distribution. It has long been suspected as an introduction to the Neotropics where it is fairly widespread. However, this may represent a natural introduction in some parts of the New World tropics. *T. dentata* readily hybridises with the native *T. hispidula* var. *hispidula*, and the offspring of these two species have been found in the upper reaches of Christian Valley. It is not known if these offspring are themselves fertile. This unusual event is rare, but has been reported from a few areas in South America. *T. hispidula* var. *hispidula* is a very rare member of the *Thelypteris* group in Antigua, and if *T. dentata* continues to hybridise so readily with this species, then it may be eventually driven to extinction. Photo 19.0 shows a hybrid offspring of these two species found at Christian Valley. The species is native to Asia.
T. opulenta	Widespread but nowhere common. Found in moist valleys in the volcanic areas of Antigua.	This is a large and beautiful member of *Thelypteris*. It often has a sweet and pungent musky odor. It does not yet seem to be a major threat to native species. The species is native to Asia.

Photo 17.0. *N. biserrata* Cultivar Growing At V.C. Bird International Airport In Antigua.

Photo 18.0. *P. scolopendria* growing in Road Town, Tortola.

Other Invasive Plants: Several other invasive plants pose serious threat and are a challenge to manage and control. These not only affect the pteridophytes, but they have negative impacts on other species and on the ecosystems and landscapes. They also have an untold impact on the social and economic fabric of the country by causing damage to lands and crops, people's homes and property and through the numerous man-hours that are spent trying to control and manage them.

The invasive plants include: *C. citratus*, *Megathyrsus maximus* (formerly *Panicum maximum*), *Valchellia farnesiana*, *V. macracantha* and *V. nilotica* (formerly *Acacia farnesiana*, *A. macracantha* and *A. nilotica*), and *Haematoxylon campechianum*.
C. citratus is native to Asia, but has been introduced throughout the world as a medicinal plant, and as a soil and water control species.

Photo 19.0. *T. dentata* x *T. hispidula* var. *hispidula* hybrid at Christian Valley, Antigua.

However, it has proven to be a difficult and aggressive species, and in Antigua, aided by charcoal burning, land-clearing and through deliberate plantings, it has spread widely throughout the southern areas of the island. These factors by themselves would be enough to encourage the spread of this grass, but since early last century, this species has rapidly invaded forested areas and cleared lands, and is now appearing some areas in the Central Plain. The spread of this grass species is due mainly to annual wildfires, which aid the dispersal of this species by clearing lands of competing plants, and after the burns, it easily takes over. It therefore threatens native species and habitats, and also increases soil erosion, changes soil chemistry and ecology, and allows the rapid runoff of rainfall, and the desiccation of the land. Photo 20.0 shows a March 2012 burn at Body Ponds, Antigua.

Photo 20.0. Recent burn of Citronella grasslands and forests at Body Ponds, Antigua.

M. maximus is another exotic species introduced to Antigua, perhaps as a fodder plant brought to the island in the 1800s. It is widely introduced throughout the world. Like *C. citratus*, it is quite aggressive and dominant, and readily invades open areas and forests, including streams and ghauts. It may stifle the growth of native species, especially herbaceous plants such as ferns, seedlings and native grasses. *M. maximus* is also present on Barbuda, but is much less widespread there (here it is quickly eaten by feral livestock who keep it in check).

The species of Valchellias and *Haematoxylon* are aggressive legumes that are widespread throughout Antigua and on Barbuda. These have been introduced over the last 200 years, most possibly accidentally, the seeds being carried in the stomachs of stock brought to the islands.

Photo 21.0. T. dentata found growing in old quarry east of Codrington Barbuda. The plants are found growing with A. adiantifolia.

Haematoxylon was introduced for its wood, which is pounded and processed for the red dye known commonly by the plants scientific name haematoxylon. It was introduced for the potential to establish plantations to manufacture this product. However, alternatives were soon discovered, and this made its production economically unfeasible. It quickly since escaped cultivation and established large areas, often with members of *Valchellia*.

These species often form almost pure stands, especially in drier areas, and can often exclude native species or depress their growth over many years. Few pteridophyte species colonise forests and woodlands created by these species.

Nevertheless, it must be noted that in the absence of other species, these plants have provide ready and important cover to the land, reducing erosion, desiccation and exposure, and creating certain conditions that eventually allow some native species to colonise.

Invasive Animals: Numerous exotic animals, including livestock, have been introduced to these islands. Many of these are now an integral part of the wild landscape of

Antigua, Barbuda and Redonda. Rats were perhaps the first to arrive, inadvertently jumping ship when the first European boats sailed into bays and near shore. Two

species, the Black Rat (*R. rattus*), and the Brown (*R. norvegicus*), are now well established on all three islands, and the House Mouse (*M. musculus*) is especially common near and around human settlements and habitations, but is absent from Redonda.

These rodents consume large amounts of plant matter, including seeds, shoots, stems, roots and leaves, and also affect the ecology of an area by burrowing into the soil, spreading pets and diseases and by selectively killing plants and animals. They are known to attack the succulent parts of plants, including ferns, especially during dry periods when water becomes scarce.

On Redonda, Black Rats are common, even during the day, and they will often approach visitors without fear. They, along with goats, have helped to reduce the once desert-like vegetation of this island to small patches of ferns, bare rocks, and a few annuals. One fern species in particular, *Pityrogramma trifoliata,* may have once been part of this island's flora, but it may have gone extinct soon after it was reported by H.E. Box in the 1938-39.

Late in the 1800s, private sugar estate owners on Antigua clamored for the introduction of the Small Indian Mongoose (*Herpestes javanicus*) to help rid the cane fields of rats, which were then decimating the canes by chewing at the stems to get at the sugars (Antiguans tell the story that there were two types of rats then: the Cane Piece Rat, which some people found a delicacy, and the regular rat, which was the introduced species. If the former was a native species then the Mongoose is likely to have driven it to extinction). The Mongoose did not drive the rats from the fields, but it quickly found the native fauna more easily available and to its liking. It quickly drove some species extinct. Aside from the Cane Piece Rat mentioned, we know that the Antigua Burrowing Owl (*A. cunicularia amaura*) and the mainland population of the Antigua Racer (*A. antiguae*) disappeared by the early 20th Century.

Though the Mongoose feeds on animals, its effects on other species and on the ecological framework—including species of invertebrates that help to control pets and diseases—must have been enormous. There is no telling what exactly its impacts on pteridophytes have been.

The Mongoose is absent from Barbuda, and the island's local administration passed legislation to prevent its introduction there. The species is not present on Redonda.

Other introductions include Wild Boar (*Sus scrofa*) on Barbuda, Fallow Deer (*Dama dama dama*) on Guiana Island and Barbuda, and a number of livestock breeds,

including sheep, donkeys, cattle, horses and goats on both Antigua and Barbuda. Goats have also been introduced to Redonda. The Helmeted Guinea Fowl (*Numida meleagris*)

was introduced to Barbuda in the 1700 or 1800 as game, as were the Wild Boar and deer.

This menagerie of exotic animals has laid waste to many of the species and systems to all three islands. Barbuda has most of these exotics, and as a result, most herbaceous and some woody plants have disappeared or are now extremely rare. On this island, pteridophytes have undoubtedly been affected. This is mostly of course supposition of course, but it is based on observations of other plants, and the expectation that the island should possess far more species of ferns than has been recorded has been recorded to date.

On Redonda, only goats have been introduced. It is unknown when and why, but it has been suggested that dates range from the 1600s to sometime in the 1700s. The island also had a flock of free-ranging sheep but these disappeared soon after mining operations were suspended in the early 1920s.

In Antigua, most of these breeds roam free in localised areas such as Rendezvous Bay, Christian Valley, Cades Bay, Old Road, Claremont, Signal Hill, Sugar Loaf, Freetown, Five Islands, Mannings, Falmouth and English Harbour. Of these animals, goats and donkeys have had the most severe impacts on the environment. They consume most plants, including pteridophytes, degrade habitats, increase erosion and pollutions, and disrupt systems' functions.

In all these cases, because the animals were introduced long before any meaningful observations or assessments were made and reported, and as a result, the impacts they have on the environment can only be suggested. Today, though these impacts are continuing, so many of the losses may have gone unnoticed, and many affected areas are now relatively stable; it is now difficult to determine exactly which species of pteridophytes have declined or disappeared, and which habitats have been affected. We do know that one particular species of fern has been severely declined because of invasive animals, and this is *Psilotum nudum*. This species is extremely rare on Antigua and on Redonda. Wherever it is found, plants are quickly browsed and easily destroyed.

Nevertheless, it is imperative that these exotic animals be controlled and/or eliminated. In some cases, the financial costs of doing so are very high. This is true for the removal of the Mongoose, because it is so widespread and the population relatively large. It would take millions of dollars and years of commitment to rid Antigua of it. However, the species population could be managed in localised areas as a prelude to wider island-wide control.

An interesting note concerns the goats on Redonda. It is unknown when the breed was introduced, why and by whom. The animals were already established there when

mining operations started in the 1800s. It has been suggested that they were introduced by seafarers in the 1700s or as early in the early 1600s. If this is the case, the goats have developed unique characteristics and/or they may represent a unique breed. This then presents a conservation dilemma: though the goats must be removed from the island, the conservation of this unique island population is necessary and so every care must be taken to rescue both the native biodiversity, including its pteridophytes, and the exceptional goats of this isolated rock perched on the edge of the Caribbean Sea.

7.10 Pests and Diseases

Most of what is reported for pests and diseases of pteridophytes come from gardeners. Under these artificially created circumstances, many of the pets are common to many other plants or to widespread among members of a single group. Similarly, types of diseases are fairly widespread in horticultural conditions.

In the wild, pteridophytes are prone to attack from a number of invertebrates and fungi, and many of these may also transmit diseases or cause mechanical damage to a species' structure or to the surrounding environment in such a way as to impede the growth of plant.

Given that we know relatively little about the pteridophyte flora and their habitats on these islands, knowing and understanding their pests and diseases are only in their early stages. In Antigua, Barbuda and Redonda, most of the damage noted come from Lepidoptera, fungi and possibly aphids and scale insects. Undoubtedly, invertebrates cause considerable damage to the roots and stems, but these are not as easily observed unless the plants are uprooted. But cockroaches, mites and nematodes are known to attack these plants.

In the field in Antigua, investigations and observations show damage by Lepidoptera caterpillars. This is evidenced by the presence of chewed leaves and stems and the silken casing of the pupae that are often attached to the underside of the fronds. This is especially common on members of Thelypteris, and three species seem more vulnerable than others: *T. dentata, T. hispidula* var. *hispidula, and T. hispidula* var. *inconstans*. Photo 21.0 shows a scale insect found on *T. hispidula* var. *inconstans* that was observed at upper Christian Valley.

The insect shown is on the leaf of a species of *Commelina*. However, they may sometimes cover the underside of the fronds and the stems in large numbers.

The fronds of another species, *A. cristatum*, are often covered with small yellow spots or blotches, believed to be the result of damaged caused by aphids and scale insects.

Photo 22.0. Scale insect found on T. hispidula var. inconstans.

These spots are so common to this species that it may often prove a useful feature in distinguishing it from other close members of the *A. cristatum* species complex. Photo 22.0 shows an example of this fern covered in these yellow spots.

Photo 23.0. *A. cristatum* fern covered in yellow spots. This was photographed in upper Christian Valley, Antigua.

Despite the significant that pests and diseases play in the ecology of pteridophytes, and the impacts that they may have on the long-term conservation of species, we currently know too little to determine what the impacts are and are likely to be and how to address issues that may arise as a result of possible epidemics. Only further long-term investigations and studies in these islands will provide sufficient detail and evidence for us to determine how to address conservation needs that may result from impacts of pests and diseases.

7.11 Climate Change and Sea Level Rise

The impact of Climate Change and Sea Level Rise: on the country's species, ecosystems, ecological frameworks, functions and processes, human habits, reactions and interactions—on their responses or declines—virtually remain the purview of research and science. Beyond the diplomatic obligations and requirements for the country to meet multilateral obligations on the Biodiversity Convention, desertification and responses to Climate Change, there are actually no on the ground efforts to study and understand the local impacts of changing climate and rising. The lack of local research and predictive modeling on the nation's biodiversity and the environment means that there is a great information gap in our understanding, and Antigua-Barbuda environmental experts must relax on global studies, programmes and efforts to draw parallel comparisons to local situations, and to then make decisions on the management of species and the environment. We know that increasing Climate Change creates a complex but often cloudy picture of rapidly rising temperatures, erratic and shifting rainfalls, dry seasons, droughts, hurricanes and tropical storms, surging and rising seas. How then do we react to the long-term impacts that Climate Change will have on the nation's biodiversity? The simple answer is that Antigua-Barbuda does not yet know.

For Antigua and Barbuda, much of what is predicted that will happen is actually based on conjecture. This is not to say that the science behind Climate Change is not sound. The sad truth is that Antigua and Barbuda does not currently have the capacity to undertake detailed research, predictive modeling and analysis of the potential impacts and the needed response to Climate Change. The country thus has to rely on external expertise to do this.

For these islands, it is expected that there will be an increase in sea levels, thereby affecting human communities along the coasts, and cause the inundation of wetlands and other low-lying vegetation systems.

Rising temperatures will also result in increase in the number and intensity of tropical storms and hurricanes, an increase in the size and strength of storm surges, an increase in the frequency of drought cycles as well as more intense rains during the rainy season. It will also likely increase the intensity of droughts. Climate Change will affect the cycle of El Nino and La Nina warming and cooling trends in the eastern Pacific region, and this will directly affect the weather and climate patterns across the Caribbean.

Since the late 1990s, Antigua and Barbuda has been experiencing longer wet seasons and less frequent droughts. This phenomenon seems to have resulted in increased plant growth and forest cover in the volcanic hills. This may help to explain the increase in the number of fern species that are recorded for Antigua. However, though there

seem to be fewer periods of severe periods of dry weather, the intensities of droughts and dry seasons have increased as well. These conclusions are based on personal on local observations, and feedback from environmental researchers and agriculturalists, but there is no formal research into these events. Nevertheless, it remains to be seen if this is a short-term trend, something tied to Climate Change or a natural climate cycle.

It is also noted that with increasing number of storms and hurricanes and their intensities, that there are also corresponding increasing in landslides, major erosion events and more severe damage to forests and woodlands. These have implications for biodiversity. For some species of ferns for example, land disturbance may be good because they quickly colonise exposed areas. Species such as members of Pteris, some species o Adiantum, and the primitive Anemia adiantifolia, prefer disturbed sites and, and are common on lowlands and eroded paths in forests. For others, the increased exposure to solar radiation, wind, increased evapotranspiration from leaves and evaporation of water from soils, and the lowering of the relative humidity will result in their death. Damage by storms also increases pest species, both animal and plant, and this will affect the ecology of the forests and its species dynamics.

Along the coast, increasing sea levels and storm surges will inundate mangrove forests, estuaries and marshes; this will likely lead to an increase in soil salinity. Freshwater systems are most vulnerable to this, and will affect the ecology of marshes and ponds. Aquatic ferns such as *Acrostichum* and *Marsilea* are likely to be adversely affected. Barbuda, given its low-lying topography is most vulnerable and susceptible to rising seas and storm surges.

7.12. The Economics of Pteridophyte Conservation

This value of pteridophytes has been summerised in sections 1.0 and 3.0. Yet, when it comes to the issue of the application of monetary or other form of market value to them or their habitats, nothing has been done locally. The biodiversity value of pteridophytes is indisputable. But to make convincing economic arguments the local data is needed. As with the Climate Change and Sea Level Rise issues, there is little actual research and analysis of the cost benefits of national biodiversity and environmental resources in Antigua and Barbuda. This is not to suggest that there is no value attached to natural resources, but the country has been slow to adopt and implement approaches that allow for the economic assessments and valuations of species, ecosystems, ecological framework and functions, including ecosystem declines and loss of species.

For the country's pteridophytes, aside from the aesthetics that these species provide, Antiguans and Barbudans have few direct economic uses for them. There may be a few residents that use a handful of species for medicinal and other cultural purposes, but these remain obscure.

As with other natural resources, ferns and their allies are a critical component of the nation's biological heritage. They provide food and shelter for many other species, and help to maintain the ecological fabric of the country's forests, woods, streams and grasslands. They add texture to the landscape and dimension to people's lives. But how then do we factor these into an economic outlay? Do we even need to do this? Would the country more readily support their conservation and management if it was demonstrated that they provide immense economic value?

For there to be a serious valuation of pteridophytes, there first must be recognition of some form of value. To then develop a pteridophytes cost benefit analysis, first, we would need to start with their uses:

Uses drive values. The value of those benefits, products, experiences then drive an inherent need to weigh the costs or to provide some definitive economic system of measurement so that persons can begin to trade those values and multiply the effects.

An economic valuation of ferns and their allies would be much more readily done if say there were species that were eaten, as some are in Asia and other parts of the world. Trade in edible ferns derive monetary costs, which then allows for the movement and transfer of these products from the harvesters to the consumers—production to consumption. But in the Antigua and Barbuda's case, it is not that clear cut. The value of pteridophytes is far more abstract; seemingly distant. It is quite apparent that they provide natural services and benefits, but so much of this ecological framework remains unknown and difficult to measure. Currently, the country does not yet possess the capacity to undertake assessments of the ecological frameworks or key components such as species. But if conservationists and natural resource managers are to be able to demonstrate the multiple values and importance of biodiversity, it is imperative that the country develop local models for economic, social and quality of life cost benefit analysis and valuation.

One of the critical aspects of the economics of conservation—whether it is ferns or any species, or even the impacts that invasives may have or be having—is who will pay for it. In most instances, the government is expected to be the responsible agent: to develop policy, legislation, provide the necessary infrastructure and the staff. But with the country operating at a budget deficit, and under a voluntary economic restructuring

programme with the International Monetary Fund (IMF) and World Bank, it will be some time before funds are available to undertake extensive conservation of species and

habitats. Even during the best of times, conservation and management of natural resources have not always been a top priority for the Government, at least not as expressed in major on the ground successes.

For there to be effective conservation of pteridophytes and other species, the private sector and civil society will need to bear a major share of the cost. At the moment, the private sector plays a diminished role in conserving and managing the nation's natural resources, and they contribute relatively minor amounts to the financial costs of doing so.

The EAG is the oldest and largest non-government environmental organisation in the country. Since its creation in 1989, it has undertaken a number of conservation projects and programmes. Much of the funds for these have come from international agencies and institutions, local fundraising efforts and donations. Its model of collaborative conservation and management has yielded great success. The best example of this is its programme to conserve the endemic snake, the Antiguan Racer (*Alsophis antiguae*) and its habitats on the offshore islands in North Sound. The EAG has been able to increase the population of the snake and protect its habitat through a collaborative effort that involves national as well as international partner agencies and institutions, individuals and local communities.

This network of collaborative partnership and sharing that has been demonstrated by the EAG works. But how do we then encourage the wider Antigua and Barbuda community to adopt this approach for conservation? The country does not have a strong history of philanthropy and private sector involvement/leadership in conservation. Certainly, private individuals have demonstrated strong commitments to particular causes, but this is relatively rare and isolated.

Local conservation initiatives receive most of its funding from international agencies and fundraising efforts. Funding for this project and the publication of this document is as a result of support from international conservation agencies. For the conservation of pteridophytes and other natural resources to be successful in the long-term, there has to be strong private-public sector partnerships, and economic financial costs shared. Local private companies, institutions, NGOs, societies and individuals need to find ways to engage private sector meaningfully to support local conservation and management programmes and initiatives. It also must be noted that private-public sector partnerships are now becoming a requirement for projects in order for there to be any financial support. This is now being dictated by many international funding agencies, for example, the Global Environment Facility (GEF) of the United Nations.

For the long-term conservation of the country's pteridophytes, the EAG will need to provide long-term vision and commitment to be able to implement steps that lead to

viable populations and stable habitats. This project is expected to run over three years, which will involve hard fought attempts to secure funding for in situ and ex situ conservation of species, and the restoration of habitats. To secure the necessary monetary for this, the organisation will have to develop a creative and viable financial mechanism to provide the support and to demonstrate to others that for the sustainment of the country's biodiversity resources, the private and civil society interest must play their part and share some of the economic, financial and management burden.

7.13 Species Requiring Legal Protection

The following is a proposed list of species that should be included in the schedule of protected species in any species conservation legislation:

Species	Family	Common Name	Notes
All native fern species	Pteridophyta	Ferns	This covers all ferns in the wild.

7.14 The Need for Habitat Protection

An important factor for the conservation of the species of pteridophytes and other endangered plants is the effective protection of habitats. The increase in the number of species recorded may be due in part to increasing forest cover in the southern volcanic hills of Antigua. As native forest cover returns to once devastated and bare hillsides, stable environments are encouraged and this provides the habitats for ferns to return.

Nevertheless, most of these critical habitat areas remain unprotected and are vulnerable to commercial real estate and tourism developments. In addition, the invasive exotic Asian grass *Cymbopogon citratus*, known locally as Fever Grass, has spread throughout these hills. The species often forms monotypic savannas, excluding native species and reducing biodiversity. These grasslands are illegally burnt every year during the annual dry season from January to April. The resulting fires cause widespread damage to forest, native fauna and flora, and result in increasing erosion and land degradation.

The following areas are suggested for critical for the long-term sustainability of native pteridophyte species populations:

Redonda: Entire Island.

For Antigua:

1) Western slopes of Mount Obama
2) Christian Valley west side
3) Upper Slopes of Christian Valley, eastern slopes
4) Dunnings
5) Upper slopes Brecknocks and Hamiltons
6) Wallings
7) Fig Tree Ghaut, Fig Tree Drive and Fig Tree Hill
8) Tremontania
9) Slopes above Orange Valley and Darkwood
10) McNish and Upper Dunnings
11) Sugar Loaf and Rendezvous Bay/Doiggs Watershed
12) Shirley Heights
13) Pearns and Hermitage
14) Sleeping Indian
15) Sutherland
16) Black Ghaut and Gaynors Drainage Basin
17) Fitches Creek Drainage Basin

For Barbuda:

1) Bull Hole and adjacent wetlands
2) Freshwater Pond
3) Highlands

7.15 Conservation: Recommendations for Next Steps and a Future Ahead

Table 5.0. Conservation issues, consequences of inaction and recommendations for moving ahead.

Conservation Issues & Concern	Consequence of No Action/No Change	Short-term Options Long-term Recommendations

ISSUE ONE: Annual wildfires in Antigua.	**Forested areas will succumb to fires, reforestation and regrowth will be retarded, lands will deteriorate and as a result of all this, biodiversity will continue to decline.**	**SHORT-TERM OPTIONS** **1. Identify and map key habitats in need of protection from fires and intervention to protect critical species and systems;** **2. Undertake management of key these critical species and areas through landscape management techniques;** **3. Restore habitats and species.** **LONG-TERM RECOMMENDATIONS** **1. Improve forest fire legislation and policy;** **2. Train federal firefighters and other key natural resources management personnel in prevention and fighting of forest fires;** **3. Restore habitats and species.**
ISSUE TWO: Feral and free-roaming livestock, especially goats in the southern hills of Antigua, all major livestock breeds in Barbuda, where animals roam free and unmanaged, and goats on Redonda where goats have been present for perhaps 400 years.	**The long-term impact of livestock on the landscape and biodiversity in these has long been established. If the livestock are not properly managed, this decline will continue and become magnified, and there is the potential for more species to go extinct. Of major concern is for the potential for complete ecological collapse on Redonda and for partial collapse of some systems on Barbuda.**	**SHORT-TERM OPTIONS** **1. Identify key habitats and species in need of protection and management from livestock;** **2. Develop a comprehensive strategy for control and management of these livestock and restoration of critical areas and species;** **3. Restore habitats and species.** **LONG-TERM RECOMMENDATIONS** **1. Remove livestock from critical areas.** **2. Restore habitats and species.**
ISSUE THREE: Road development, real estate expansion into forested areas and commercial hotel development	**Fragmenting tracts of forests and watersheds will eventually retard forest growth and ecological functions. The development of Rendezvous Bay for example will likely result in the retardation and collapse of the Wallings Forest system.**	**SHORT-TERM OPTIONS** **1. Increase outreach and awareness of the value of large tracts of forests and open areas. Outreach should target key government personnel and communities;** **2. Develop intervention programmes for important forests and open areas highly susceptible to development, including wetlands along airport road, Fitches Creek and along the west coast, as well as coastal dry forests and woodlands at**

		Seatons, Rooms, Lords, Willikies, Ayers Creek and New Field. **LONG-TERM RECOMMENDATIONS** **1. Identify critical habitat areas in need of protection and promote their legal immunity from development;** **2. Develop intervention programmes for important forests and open areas highly susceptible to development.**
ISSUE FOUR: Marijuana cultivation	**Because some growers may see some forest users and the possibility of their cultivation of the illicit plant being discovered as a threat to their livelihood, this is a security risk to people.** **There is a minor risk that some large areas of cultivation can cause fragmentation, species loss and soil erosion.**	**SHORT AND LONG-TERM OPTIONS** **1. Undertake outreach to growers to allay any potential fears and threats to visitors and other forest users.**
ISSUE FIVE: Forest fragmentation caused by roads and other human activities.	**In recent years, some forested areas on higher slopes of Hamiltons, Christian Valley, Cades Bay, John Hughes/Wallings and Signal Hill, have been targeted for road development as a means to develop the higher slopes. The construction of roads in such areas dramatically increase soil erosion, landslides, disrupt the hydrology, cause sedimentation of streams, destroy species and cause species decline, disrupt ecological systems and may lead to the collapse of trees and hence of forests, allow the invasion of non-native plants, animals, pests and diseases. Photo 24.0 below shows road construction and bulldozing of the young secondary forest at Hamiltons in 2009.**	**SHORT-TERM OPTIONS** **1. Identify key habitats and species in need of immediate protection and management from development;** **2. Develop strategy for protecting key habitat areas and increasing awareness about the need for comprehensive protection;** **3. Work with nearby communities to involve them in protection.** **LONG-TERM RECOMMENDATIONS** **1. Develop a federal system to key private lands and to compensate owners.**
ISSUE SIX: Droughts; this over the years has been exacerbated by human activities and habits	**If forested areas are not allowed to expand and grow, springs allowed to flow undammed or tapped, if forests are fragmented into smaller and smaller parcels and if key areas are not reforested then biodiversity will not return and the long-term prospects for the survival of many of the nation's fauna and flora is bleak.**	**SHORT AND LONG-TERM OPTIONS** **1. Identify key areas vulnerable to droughts, dry spells, Climate Change, water deprivation (because of water extraction), and increasing human intervention into the forests;** **2. Restore key forest areas.**

ISSUE SEVEN: The harvesting of forest resources	**In the past, the harvesting of wood for charcoal and wattle, as well as other products, was monitored by the forest rangers/guards. Since the decline of the monitoring forest use by these rangers, many of the harvesters have been cutting swathes and patches in Wallings, and large amounts of wattle here and around Mount Obama. This may cause a retardation of forest growth, the decline of epiphytes and terrestrial pteridophytes and the decline of biodiversity overall.**	**SHORT-TERM OPTIONS** **1. Develop a programme to identify forest harvesters, users, uses, products, markets and issues;** **2. Undertake outreach, awareness building and education to forest users and harvesters;** **LONG-TERM RECOMMENDATIONS** **1. Work with harvesters to identify key species and areas that should not be harvested and work with them to maintain these areas.**
ISSUE EIGHT: Farming on steep slopes and the deforestation of Fig Tree Drive	**This is causing a decline of the flora and fauna of the stream environment, and is also causing severe soil erosion, desiccation of the land and forest, landslides and a loss of the area's unique natural aesthetics.**	**SHORT-TERM OPTIONS** **1. Work with farmers and landowners to institute effective soil control measures and well as sustainable farming practices;** **2. Work with the Ministry of Agriculture to help farmers and to protect the Drive.** **LONG-TERM RECOMMENDATIONS** **1. Restore Fig Tree Drive ecosystem.**
ISSUE NINE: Road maintenance and development along the John Hughes to Old Road Corridor	**Since 1995 after the passages of severe storms and hurricanes, many large landslips have caused damage to the road. The road was therefore shifted in places, and as a result, slopes have been razed and forests removed. This has caused further landslips, collapse of parts of the bank of Fig Tree Ghaut, disruption of hydrology and desiccation of the forests. The Drive is now almost completely open where once there was almost a continuous unbroken natural corridor consisting of large old trees. Much of the habitat is now a mix of herbaceous growth, agriculture and seasonal forest though it should be a lower montane forest. Road maintenance continues to retard forest regeneration and increase the likelihood of the loss of Fig Tree Drive.**	**SHORT-TERM OPTIONS** **1. Work with the Antigua Public Utilities Authority and the Public Works Department to increase the awareness about the value of Fig Tree Drive, to develop more effective measures to maintain the road maintain road safety;** **2. Increase awareness of the issues, problems and value of Fig Tree ecosystem and the Drive to users, drivers, farmers and landowners and others.** **LONG-TERM RECOMMENDATIONS** **1. Undertake a Fig Tree Drive restoration effort.**

ISSUE TEN: Disruption of natural hydrology by water extraction, dam construction, infill of wetlands for land reclamation	**Extracting ground and surface water near streams and wetlands without consideration for the long-term ecological functions and stability will continue to disrupt natural stream flow and moisture availability, especially in lower areas;** **Similarly, the construction of dams in key riparian ecosystems such as the Black Ghaut system, results in the destruction of unique forests, of the decline of wetland species, including ferns, and the loss of overall biodiversity, which has already occurred through the construction of Potworks, Collins and the smaller Black Ghaut dam. There is critical need to restore some of the ecological integrity of this area if it is to continue to survive.**	**SHORT AND LONG-TERM OPTIONS** **1. Undertake field research to determine effects of water extraction of ecosystems and develop restorative and management measures to minimise impacts;** **2. Increase awareness and education amongst the authorities and key personnel of water resource management authorities and institutions about the importance of careful and sensitive water extraction techniques and management.**
ISSUE ELEVEN: Climate Change.	**Without understanding the possible changes that Climate Change may bring about, it is likely that some forest areas may not fully recover from hundreds of years of decline and abuse, and that biodiversity loss will once again rapidly increase.**	**SHORT AND LONG-TERM OPTIONS** **1. Develop a national network of weather and climate monitoring systems for Antigua, Barbuda and Redonda, including localised forest micro-climate monitoring in Antigua, Barbuda and Redonda to understand, predict and manage possible adverse impacts of Climate Change.**
ISSUE TWELVE: Invasive species and diseases as a result of introductions and human interventions.	**Invasive species will continue to expand their range, population and impacts and displace native species, reduce forest habitats, and in the case of the grass *C. citratus*, may continue to encourage wildfires during the dry season.** **One recent fern species introduction, *N. brownii*, of Asian origin, is blamed for dispalacing the native, but quite rare *N. rivularis* throughout the Lesser Antilles. This latter species has not been seen in Antigua in generations.**	**SHORT AND LONG-TERM OPTIONS** **1. Identify key areas in need of management and protection from invasive species, including *C. citratus* and the potential for wildfires.** **2. Develop localised invasive species control measures, especially for *C. citratus*.** **3. If possible, located any remaining *N. rivularis* populations, secure those locations and propagate plants for wild repatriation as well as restoration to key areas.**

Photo 24.0. Forest on the slopes of Hamiltons, Antigua, bulldozed in 2009 for development.

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APPENDIX I

List of Pteridophytes of Antigua, Barbuda and Redonda

NO	Taxon	Family	Common Name
	Pteridophyta		
1	*Acrostichum aureum* L.	Pteridiaceae	Golden leather fern
2	*Acrostichum danaeifolium* Langsd. & Fisch.	Pteridiaceae	Leather fern
3	*Adiantopsis radiata* (L.) Fee	Pteridiaceae	
4	*Adiantum capillus-veneris* L.	Pteridiaceae	Common maidenhair fern
5	*Adiantum fragile* Sw. var. *fragile*	Pteridiaceae	Fragile maidenhair fern
6	*Adiantum fragile* Sw. var. *fragile*	Pteridiaceae	Fragile maidenhair fern
7	*Adiantum latifolium* Lam.	Pteridiaceae	Broadleaf maidenhair fern
8	*Adiantum lucidum* (Cav.) Sw.	Pteridiaceae	
9	*Adiantum pulverulentum* L.	Pteridiaceae	Glossy maidenhair fern
10	*Adiantum pulverulentum* L. x *Adiantum villosum* L.	Pteridiaceae	
11	*Adiantum pyramidale* (L.) Willd.	Pteridiaceae	Pyramid Maidenhair fern
12	*Adiantum pyramidale* (L.) Willd. x *Adiantum villosum* L.	Pteridiaceae	
13	*Adiantum pyramidale* (L.) Willd. x *Adiantum tetraphyllum* Humb. & Bonpl. Ex Willd.	Pteridiaceae	
14	*Adiantum tenerum* Sw.	Pteridiaceae	Fan maidenhair fern
15	*Adiantum tetraphyllum* Humb. & Bonpl. Ex Willd.	Pteridiaceae	Fourleaf maidenhair fern
16	*Adiantum villosum* L.	Pteridiaceae	Wooly maidenhair

			fern
17	*Anemia adiantifolia* (L.) Sw.	Anemiaceae	Flowering fern
18	*Anemia hirta* (L). Sw.	Anemiaceae	Streambank flowering fern
19	*Asplenium barbadense* Jenman	Aspleniaceae	Maidenhair spleenwort
20	*Asplenium cristatum* Lam.	Aspleniaceae	Parsley spleenwort
21	*Asplenium* cf. *ocoense* C. Chr.	Aspleniaceae	Rockledge Spleenwort
22	*Asplenium pumilum* Sw.	Aspleniaceae	Dwarf spleenwort
23	*Asplenium serratum* L.	Aspleniaceae	Birdnest fern
24	*Asplenium* cf. *uniliterale* Lam.	Aspleniaceae	
25	*Blechnum occidentale* L.	Blechnaceae	Hammock fern
26	*Campyloneurum brevifolium* (Lodd. ex Link) Link	Polypodiaceae	
27	*Campyloneurum costatum* (Kunze) C. Presl	Polypodiaceae	Tailed strapfern
28	*Campyloneurum latum* T. Moore	Polypodiaceae	Birdwing fern
29	*Campyloneurum phyllitidis* (L.) K. Presl.	Polypodiaceae	Long Strap fern
30	*Campyloneurum repens* (Aubl.) C. Presl	Polypodiaceae	Creeping strap fern
31	*Cheilanthes microphylla* (Sw.) Sw.	Pteridiaceae	Lip fern
32	*Doryopteris pedata* (L.) Fee	Pteridiaceae	Digit fern
33	*Marsilea nashii* Underw.	Marsiliaceae	Water clover
34	*Microgramma heterophylla* (L.) Wherry	Polypodiaceae	Clinging snake fern
35	*Microgramma lycopodioides* (L.) Copel.	Polypodiaceae	Clubmoss snake fern
36	*Microgramma piloselloides* (L.) Copel.	Polypodiaceae	Hairy snake fern
37	*Nephrolepis biserrata* (Sw.) Schott	Nephrolepidaceae	Giant sword fern
38	*Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.	Nephrolepidaceae	Asian swordfern
39	*Nephrolepis cordifolia* (L.) C. Presl.	Nephrolepidaceae	Narrow swordfern
40	*Nephrolepis exaltata* (L.) Schott	Nephrolepidaceae	Boston swordfern
41	*Nephrolepis* cf. *pectinata* (Willd.) Schott	Nephrolepidaceae	Basket fern
42	*Nephrolepis* cf. *pendula* (Raddi) J. Sm.	Nephrolepidaceae	Long john fern

43	*Nephrolepis rivularis* (Vahl) Mett. Ex Krug	Nephrolepidaceae	Streamside sword fern
44	*Neurodium lanceolatum* (L.) Fee	Polypodiaceae	Ribbon fern
45	*Ophioglossum harrisii* Underw.	Ophioglossaceae	Harris's Adder's Tongue
46	*Ophioglossum reticulatum* L.	Ophioglossaceae	Reticulated Adder's Tongue
47	*Phlebodium aureum* (L.) J Sm. var. *aureum*	Polypodiaceae	Golden polypody
48	*Phlebodium aureum* (L.) J Sm. x *Phlebodium decumanum* (Willd.) J. Sm.	Polypodiaceae	
49	*Phlebodium decumanum* (Willd.) J. Sm.	Polypodiaceae	
50	*Phlebodium pseudoareum* (Cav.) Lellinger	Polypodiaceae	
51	*Pityrogramma calomelanos* (L.) Link var. calomelanos	Pteridiaceae	Silverback fern
52	*Pityrogramma chrysophylla* (Sw.) Link var. gabrielae	Pteridiaceae	Goldback fern
53	*Pityrogramma chrysophylla* (Sw.) Link var. subflexuosa	Pteridiaceae	
54	*Pityrogramma trifoliata* (L.) R.M. Tryon	Pteridiaceae	
55	*Pleopeltis polypodioides* (L.) Andr. & Wind. var. *polypodioides*	Polypodiaceae	Resurrection fern
56	*Psilotum nudum* (L.) P. Beauv.	Psilotaceae	Whisk fern
57	*Pteridium caudatum*	Pteridiaceae	Bracken
58	*Pteris biaurita* L.	Pteridiaceae	Thinleaf brake fern
59	*Pteris longifolia* L.	Pteridiaceae	
60	*Pteris vittata* L.	Pteridiaceae	Ladder brake fern
61	*Serpocaulon triseriale* (Sw.) A.R. Sm.	Polypodiaceae	Anglevein fern
62	*Tectaria heracleifolia* (Willd) Underwood	Tectariaceae	Broad halberd fern
63	*Tectaria incisa* Cav.	Tectariaceae	Incised halberd fern
64	*Thelypteris dentata* (Forssk.) E. St. John	Thelypteridaceae	Downy maidenfern
65	*Thelypteris dentata* (Forssk.) E. St. John x *Thelypteris hispidula* (Decne.) C.F. Reed var. *hispidula*	Thelypteridaceae	
66	*Thelypteris hispidula* (Decne.) C.F. Reed var. *hispidula*	Thelypteridaceae	Rough hairy maidenfern
67	*Thelypteris hispidula* (Decne.) C.F. Reed var. *inconstans*	Thelypteridaceae	
68	*Thelypteris nephrodioides* (Klotzsch) Proctor	Thelypteridaceae	

69	*Thelypteris opulenta* (Kaulf.) Fosberg	Thelypteridaceae	
70	*Thelypteris patens* (Sw.) Small ex R. St. John var. *patens*	Thelypteridaceae	Gridscale maidenfern
71	*Thelypteris patens* (Sw.) Small ex R. St. John var. *scabriuscula*	Thelypteridaceae	
72	*Thelypteris pennata* (Poir.) C.V. Morton	Thelypteridaceae	
73	*Thelypteris pennata* (Poir.) C.V. Morton x *Thelypteris tetragona* (Sw.) Small var. *tetragona*	Thelypteridaceae	
74	*Thelypteris poiteana* (Bory) Proctor	Thelypteridaceae	Darkgreen maidenfern
75	*Thelypteris* x *rolandii* (C. Chr.) comb. ined	Thelypteridaceae	
76	*Thelypteris tetragona* (Sw.) Small var. *tetragona*	Thelypteridaceae	Freetip maidenfern
77	*Trichomanes angustifrons* (Fée) Wess. Boer	Hymenophyllaceae	
78	*Trichomanes krausii* Hook. & Grev.	Hymenophyllaceae	Treemoss bristlefern
79	*Trichomanes lineolatum* (Bosch) Hook.	Hymenophyllaceae	
80	*Trichomanes ovale* (E. Fourn.) Wess. Boer	Hymenophyllaceae	
81	*Trichomanes punctatum* var. punctatum	Hymenophyllaceae	
82	*Trichomanes punctatum* var. sphenoides	Hymenophyllaceae	
83	*Trichomanes pusillum* Sw.	Hymenophyllaceae	
84	*Vittaria graminifolia* Kaulf.	Pteridiaceae	
85	*Vittaria lineata* (L.) Smith	Pteridiaceae	Shoestring fern

Some species listed above are included tentatively. Wherever the abbreviation cf. appears (it means confer or compare), and is an indication that the species appears to be this species but is not yet confirmed. In addition, there are several species and hybrids that are suspected, based on observations, but are not yet confirmed, but due to remaining doubts and questions, these have been omitted from the official list. These include:

***Adiantum petiolatum*:** Because of the presence of a possible hybrid plant between this species and A. latifolium, this species may be present on Antigua.
***Adiantum* x *spurium*:** this species is a cross between *A. lucidum* and *A. villosum*, both recorded for Antigua. Anywhere both plants are found together it can be expected that hybrid plants will occur.
***Adiantum* x *variopinnatum*:** This is a hybrid between *A. latifolium* and *A. petiolatum*. Only A. latifolium is known to be present on Antigua, but forms of an *Adiantum* found at upper Christian Valley match the hybrid plants, suggesting that *A. petiolatum* may be present on Antigua as well.
***Marsilea vestita*:** This species was previously listed for Barbuda, but because of taxonomic revisions, it has now been restricted to Central, North and South America and is said not to be found in the West Indies.