BERMUDA ZOOLOGICAL SOCIETY

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Oceanic Island Ecology of Bermuda

written by

Dr. Martin L. H. Thomas

Project Nature

Field Study Guides for Bermuda Habitats

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Oceanic Island Ecology of Bermuda

(Third Edition)

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Field Study Guide

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Oceanic Island Ecology of Bermuda
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**Cover photograph of a fossil palmetto leaf in South Shore cliffs,
Spittal Pond Nature Reserve by Martin L. H. Thomas**

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Foreword

It is no accident that the mission of the Bermuda Aquarium, Museum and Zoo is 'to inspire appreciation and care of island environments' and that the exhibit theme is 'islands of the world', Bermuda is one of the most remote oceanic islands in the world.

Oceanic islands have been described as crucibles of evolution, places where the mechanics and results of natural selection are most obvious. Bizarre living relics and brand new animal and plant oddities make islands living museums for study. Isolated and with limited land area, they are also the most threatened environments on earth, critically impacted by man and his introductions.

Education staff at BAMZ have helped in the development of the 'oceanic island' strand in the middle school science curriculum. This latest field study guide in the Project Nature series of publications, will provide an important and timely resource to support this important study. It will also be of great interest to anyone who is curious about island ecology. Dr. Thomas has once again produced an excellent and accessible guide which will further the appreciation and care of island environments.

Richard Winchell
Past Principal Curator
Bermuda Aquarium, Museum and Zoo
February 2002

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Jack Ward, Principal Curator of the Bermuda Aquarium, Museum and Zoo paved the way for its production and enthusiastically supported the work. Mary Winchell, Educational Coordinator actively helped in all stages of the production of this guide and is largely responsible for the entire Project Nature series, now comprising five field guides. Liz Nash took on the mammoth task of preparing the manuscript for printing, including setting up the text, assembling all the illustrations and inserting them in the text and producing the final copy for photocopying. Her dedication to this task ensured that the final product would be most attractive and relatively error free.

Many people have assisted in the background field, library and museum work essential to a task such as this. Without their help and encouragement the guide would be much less complete and practical than it is. Grateful thanks are extended to: Joseph Furbert, Heather DeSilva, Anne Glasspool, Lisa Greene, Brian Lightbourn, Sandra Rouja, Bobbi Cartwright, Judi Clee, Wolfgang Sterrer, Margaret Emmott, Penny Hill, Richard Winchell, Jeremy Madeiros and David Wingate.

The illustrations of the species of plants and animals important in the island ecology of Bermuda were adapted, with permission, from a variety of sources including “Bermuda’s Marine Life” by W. Sterrer, “Bermuda’s Seashore Plants and Seaweeds” by W. Sterrer and A. R. Cavaliere, "Marine Fauna and Flora of Bermuda" by Wolfgang Sterrer, posters on birds and amphibians and reptiles of Bermuda by David Wingate and "Some Bermuda Insects and near Relatives" by Christine Phillips; others are re-used from previous Project Nature series publications. David Wingate drew the rats and Andrew Dobson contribributed the drawing of the Yellow-Crowned Night Heron. Others were prepared especially for this publication by Janet Percy and the author.

No guide that considers the plants of Bermuda would be complete without acknowledgement of Nathaniel Lord Britton for his book "The Flora of Bermuda". Now, sadly, out of print, this book is an invaluable source of information on the plant life of Bermuda and has been an inspiration to many of us.

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Introduction

There are two general types of island, **oceanic islands** and **continental islands**. Bermuda is an oceanic island because it is not situated on a continental shelf, but rises up directly from the deep ocean floor. Examples of oceanic islands are the Hawaiian group, the Galapagos Islands, Iceland and Easter Island. Examples of continental islands are Newfoundland, Madagascar, Britain, Australia and Java. Continental islands may be very large and oceanic ones smaller although both types include lots of tiny islands.

Bermuda is a very small group of islands in a very large ocean. The one word which sums up its situation is **isolated**. The closest points of land are Cape Hatteras, U.S.A. which lies 960 km or 600 miles northwest and Nova Scotia, Canada, which is 1,280 km or 800 miles due north. All other land-masses are much further away but, as we shall see, it is not merely distance which gives isolation. Although the Caribbean islands are one and one half times further away than Canada, Bermuda has more in common with them. Bermuda has a land area of only 55 km^2 or 21 square miles whereas the Atlantic Ocean in which it lies comprises over 137 million square kilometres or 30 million square miles! In other words you could fit 2 1/2 million islands the size of Bermuda into the Atlantic Ocean! If you were a bird swept off the coast of West Africa in a violent gale, the chances of finding Bermuda before you died of exhaustion, starvation or thirst would seem to be infinitesimally small. However, it does happen now and again. So although Bermuda is small and isolated it does have some natural communication with far-away places. You will notice that I said natural communication; this is because this whole picture of isolation and communication has become monumentally altered by man. Not only has man introduced new species to Bermuda from all over the world, but since the islands were colonised in the early 1600s, has also managed to totally change the animals and plants on land, so that any resemblance to a natural condition has to be carefully sought out and interpreted.

When we look at the isolation of Bermuda in relation to its natural history, we find that it is not a simple picture, but varies with the habitat or living space of the organism involved. For instance some marine creatures are not really isolated at all. A good example of this is the Spiny Lobster (*Panulirus argus*), an example we will return to later. Many of the Spiny Lobsters in Bermuda have come from eggs laid in the Caribbean Islands. We know this by looking at the **DNA** profiles of Bermudian lobsters and comparing them to Caribbean ones. If these two groups or **populations** of lobsters were truly isolated from one another, their DNA profiles would differ, but they do not. But how can these two distant populations not be isolated from each other.

This is where we have to consider other factors than just sheer distance and small size as determining the degree of isolation. In this case the answer lies in ocean current patterns, which in turn result from general global wind systems. To explain what is happening here we have to go to the Northeast Trade Wind Belt. The Northeast trades are winds that blow constantly from the Northeast just north of the equator in the Atlantic Ocean. In the days of sail, ships used these winds to cross the Atlantic Ocean from east to west. Sailors quickly learned that these winds blew all year round and that they could rely on them. Well, of course these winds also created waves which in turn spawned currents moving from east to west. Now geography comes into the picture, too; Figure 1 shows the situation. The current created north of the equator carries water to the west, and most of it ends up in the Gulf of Mexico where it is confined. The result is quite predictable, the water level in the Gulf of Mexico is 1 m (3 ft) higher than outside the Gulf. This may not seem much, but the Gulf of Mexico is huge (Figure1) and a 1 m (3 ft) layer of water this size is a huge volume. The water in the Gulf of Mexico has what is termed a **head**, which will tend to flow downhill. It can't go east because that is where the water is coming from, so instead it flows north through the Straits of Florida, between the U.S.A. and Cuba. This northward flow is called the **Gulf Stream,** and to give some impression of its size, it carries

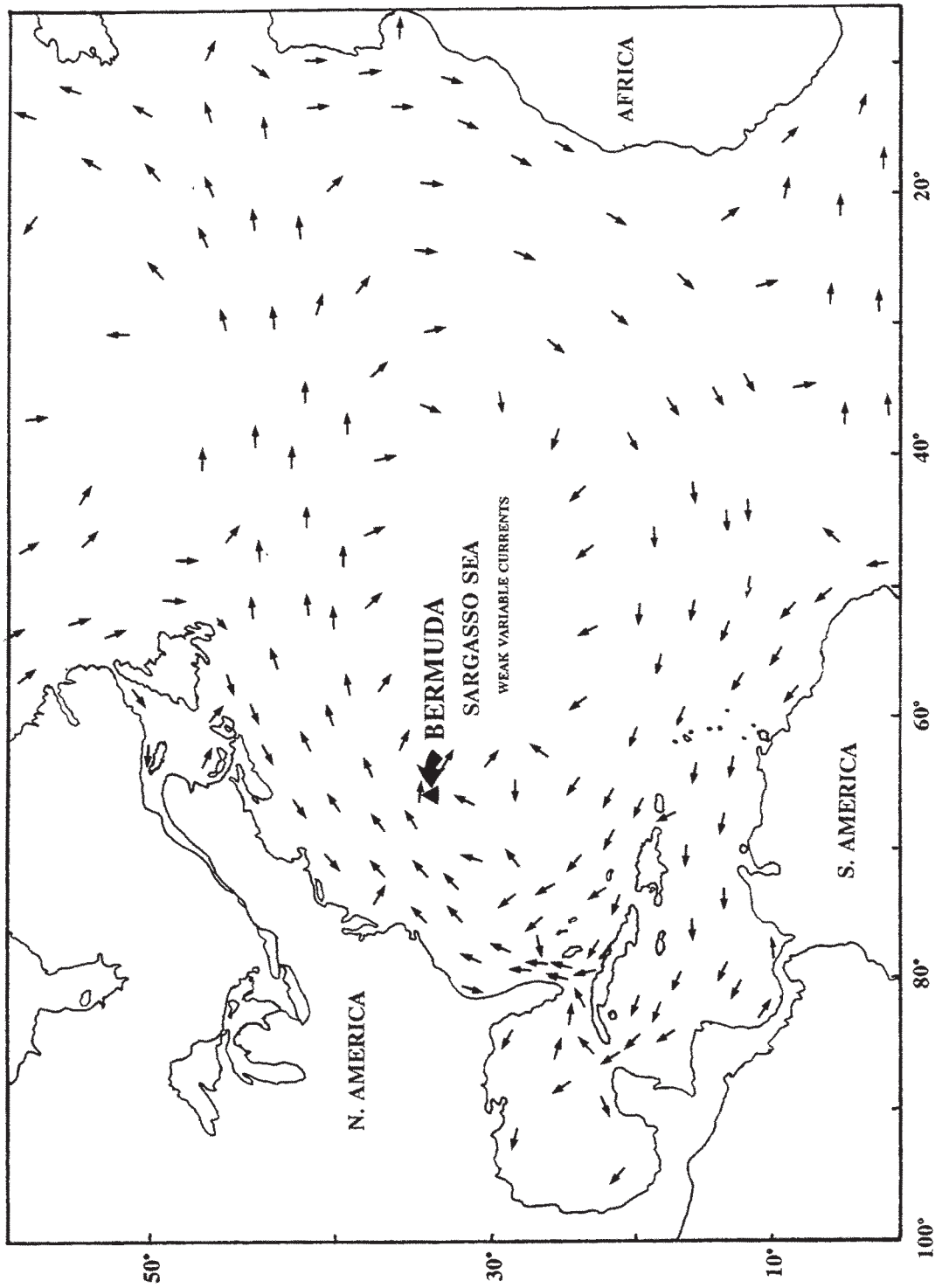


Figure 1. Surface current flow patterns in the North Atlantic Ocean.

more water than all the rivers in the world put together and is virtually immune to wind until it gets up, off the coast of Canada where it turns east across the Atlantic Ocean. Not all the water goes through the Straits of Florida, but smaller portions flow between the Caribbean islands. At any rate, this water comes from tropical areas and it is warm. It flows just past the west coast of Bermuda. Side branches of the main current spin off and include Bermuda in their path. Now we can see how lobster eggs from the Caribbean could get carried to Bermuda. In actual fact the eggs hatch into larvae with limited swimming power, that travel on the Gulf Stream. It does not take much imagination to see that fishes and other marine creatures can come by the same route. Later we will see that cooling and other factors occurring as the water moves north result in the death of most of the possible immigrants coming this way, and others find no suitable available habitat when they arrive. In other words it is quite a selective mode of transport.

The above example serves to show how some marine creatures get here, and one may suppose that a few land animals and plants might also travel this way on logs or as floating debris. More important to **terrestrial** organisms is travel by air. Tiny seeds and very small animals may simply get blown over the sea. For example, some spiders routinely travel by air on a long thread of spider silk. Some seeds have wing-like or parachute-like parts that keep them aloft and most birds and insects can fly. However, as in the case of the ocean currents the situation is not as simple as it seems as winds alter the picture. We have already seen that the winds to the north of the equator blow from easterly directions, as we move north from there we pass through an area of low winds often referred to as the 'doldrums', and where in the old days ships would become becalmed for days on end. Still further to the north, in somewhat more temperate waters the **prevailing winds** are westerly. Bermuda lies in the southern part of the great wind belt called the 'westerlies'. Compared to the Northeast Trade Winds these winds are less reliable but still blow from westerly directions most of the time. In consequence they are most likely to transport animals and plants from continental North America. Additionally, as we know, violent storms can come from almost any direction, adding the possibility of transportation from other than the west. But here, the distance and small size of Bermuda become critical factors, since a creature carried on air may fall into the water or run out of essential resources (such as stored fat), long before there is a chance of landfall.

One aspect of island ecology is looking at what animals and plants got here by natural means and how they did it. We can also look at organisms which we would have expected to find here but do not, as this may give us ideas on what characteristics are needed to colonise a new area across a stretch of ocean. Below in this field study guide, we will look at examples of the **native flora** and **fauna** of Bermuda and try to decide what features they had that enabled them to get here. However, getting there is only part of the story. Bermuda has a unique structure and climate which do not suit all living things and which had changed with time. To be successful in a new location arrivals must be either **pre-adapted** to similar conditions elsewhere, or be **adaptable** enough to adjust to new conditions. Those which have these characteristics have a chance of survival in a new place but time also enters the equation. In the beginning we know Bermuda was home to only a handful of animals and plants. So early arrivals, if they could stand the basic environment did not have to **compete** with others, of either their own kind or other **species**, for the **resources** that living things need. Because of this, they had it easier than later arrivals and if they were very adaptable could quickly colonise large areas. Less adaptable species would probably be confined to more limited localities.

There is yet another critical aspect to this situation where organisms are taking over a new area over a very long time period, and this is the **evolution** of new species. As organisms breed, there is always some variation in the offspring, and some will differ genetically from their parents. Some of these may be better adapted to conditions in the new environment, and through **natural selection** will be more successful. As this proceeds through numerous generations, the difference from the original parent becomes obvious and a new species has been created. The new species is distinctly different from the original, both in its genetic makeup and physically or physiologically. Often

when this happens, the original coloniser dies out, but in other cases both the original and a new species may remain. Another important aspect of this process is that although some useful characteristics are gained, characteristics that were important in their original locations may be lost. For example a tree growing in tropical America, may develop resistance to common pests or diseases, that is passed on from generation to generation. However, if the disease or pest was left behind during travel, the resistance could be unimportant in a new location and that characteristic lost. What then if, at some later time, that same problem arrives by another means? Then the originally resistant species is susceptible and serious problems may arise. This may seem unlikely, but it happens, particularly when man enters the picture. Examples of all these things in Bermuda will be explored below.

Those colonising organisms that arrive after the pioneers have become established, face other problems before they can be successful. To survive, they must be able to compete with the earlier colonists for needed resources. These resources may be simply suitable space in which to live, but may also involve less obvious requirements such as food, water, light, mineral nutrients, or other things. On the other hand, the habitat required by a new arrival may have been created by the earlier ones. For example small creatures of the forest floor could never be pioneers, but have a chance of success later, whereas a new forest tree species that requires high light levels would probably not find suitable conditions once the forest is established.

The events and processes outlined above are assumed to take place in the absence of man. Once colonisation by man took place, the whole situation changed and these later changes will be explored below. The arrival of man placed two principal types of stress on the animals and plants that had become established. First those useful to man as food, drink, building materials, utensils or clothes were harvested altering the natural balance, particularly where houses and farms were located. Secondly, man brought with him, either accidentally or on purpose, a huge variety of animals and plants from elsewhere. Probably also significant was an increased probability of forest fires. All these things put together placed a tremendous stress on terrestrial animals and plants, and a lesser but still significant one on marine creatures. The effects of man on Bermuda will be a major topic of this field guide.

There are several terms, concerning the origins of animals and plants, that will be frequently used in this field guide that you should be familiar with. Animals or plants that have evolved in Bermuda to form new species are called **endemic**. Endemic species form a very small and very important part of Bermuda's fauna and flora. Organisms that arrived in Bermuda by natural means and have persisted until today are termed **native**. Examples that have been added to the natural complement through the activities of man are known as **introduced**. Introduced species that have spread on the islands, and that now reproduce naturally here are called **naturalised**. If an endemic species that is still confined to Bermuda is eradicated it is **extinct**; an extinct organism has ceased to exist on earth. Any animal or plant that became native or naturalised and was subsequently lost from Bermuda is termed **extirpated**, providing it still occurs elsewhere. This term, extirpated, would also, strictly speaking, apply to an endemic species that had been introduced elsewhere on earth from Bermuda and then have disappeared from the Bermudian fauna or flora. If a species exists anywhere on earth it is not extinct.

Studies of island ecology on a worldwide basis have shown that several important generalisations can be made. More isolated islands have lower biodiversity, a higher proportion of endemic flora and fauna and a higher rate of extinction. Island size also affects the picture in that larger islands show these effects less than smaller ones. Another universal feature that emerges, is that man has a high capacity to reduce biodiversity and increase the rate of extinctions. Bermuda is an excellent example to study all these effects in practice.

Geological Background

The Origin of the Bermuda Islands

Bermuda had its origins on the Mid Atlantic Ridge of the Atlantic Ocean about 110 million years ago. This puts Bermuda in the sub-group of oceanic islands called **ridge islands**. The Mid Atlantic Ridge is a largely underwater geological feature running down the centre of the Atlantic Ocean. The Mid Atlantic Ridge is a site of intense geological activity because it lies at the junction between the European and American **tectonic plates**. There are two types of these junctions. At some the surface of the earth is enlarging as molten **magma** from within, rises to the surface and solidifies. Such junctions are called spreading junctions. At the other type, one plate slides beneath the other, causing earthquakes and building mountain ranges. The West coast of North America is an example of the second type. Sometimes islands are produced in this situation too; these are called **island arcs** because they often occur in arc shaped groups. Along the Mid Atlantic Ridge, molten magma from within the earth rises to the surface and hardens to form the plates. This is a continuous process, and as a result the two plates move slowly apart at about 4 cm/year. Together with the spreading come frequent small tremors, some earthquakes, and the creation of a variety of volcanoes. One of these erupting 110 million years ago later became the Bermuda islands. The volcano appeared just to the West of the ridge and produced a large sea mount which rose close-to or above the surface. This volcano, which has been called Mount Bermuda, then moved slowly away from the ridge, covering 1,200 km or 750 miles during 60-80 million years without further volcanic activity, it then went through a second phase of eruption. At this time, Mount Bermuda was enlarged to form the Bermuda Seamount, consisting of three volcanic peaks: the Bermuda Pedestal, the Challenger Bank and the Plantagenet or Argus Bank. If Bermuda had arisen solely as a result of a volcanic eruption away from the Mid Atlantic Ridge, it would be a **hot spot island** rather than a ridge island.

The group of peaks rises sharply about 4,000 m or 13,000 ft from the seabed, but the Bermuda Pedestal is the only one above sea level. The Bermuda Seamount has moved a further 800 km or 500 miles away from the Mid Atlantic Ridge in the last 30 million years or so, to lie where it is today. Luckily, volcanic activity is a thing of the past for the Bermuda Seamount as it now lies in a stable area of the earth's crust. However, occasional earthquakes still occur as weaknesses in the underlying rock give way under the stress of the spreading process. The last significant earthquake, centered 370 km southwest of Bermuda, occurred on March 24, 1978 and measured 5.8 on the Richter scale!

Development of the Island Habitats

Fascinating as this early history is, it is only the last 900,000 years or so that has been really important in determining the biological character of Bermuda. This period mainly falls in the middle and late part of the **Pleistocene epoch**. The Pleistocene was the time of the last great glaciation on earth when huge ice-caps built up at the poles lowering sea levels world wide by up to 125 m (350 ft). However, during the Pleistocene the climate was not uniformly cold, but rather slowly changing from warm to cold, and back again. There were at least four such climatic changes in the last 900,000 years. This lowering of sea level in the cooler periods was important because it brought previously submerged features close-to or above the surface of the ocean, and this is when the biological activity which produced the present Bermuda land mass got underway. At first, the early marine communities formed only a narrow band along the steep sides of the volcano; later, when the peak was just submerged they spread over the top and started to deposit the limestone which makes up Bermuda today.

The limestone of Bermuda has all been formed by biological activity in well lighted sea water. The two main groups of organisms that have laid down this huge cap of limestone are **calcareous algae** and corals, which together form reefs. Calcareous algae are sheet-like seaweeds that

deposit calcium carbonate (limestone) within their tissues to become rock hard.

Thus, reefs formed on top of and around the edges of the volcanic seamount. Low spots in the reefs were more sheltered than the reef-tops, and soon filled with calcareous sand produced by a host of animals and plants associated with the reef environment. Further material was added to the sediments by erosion of the reef rock. The whole process of the production of rock and sediment by biological action, is referred to as **biodeposition**. In the early days of the production of the limestone cap of Bermuda, biodepositors laid down large quantities of calcium carbonate so that places that were up to at least 10 m (30 ft) deep rose to the surface.

We know that terrestrial communities existed on Bermuda at least 400,000 years ago, because a fossil land tortoise occurred then. However, 125,000 years ago, a warm period caused sea level to rise so that all but 5% of Bermuda was flooded. This certainly wiped out most land communities and all freshwater ones.

The last 12,000 years, are the most important from the point of view of terrestrial communities of plants and animals. By this time a cap of limestone and calcareous sediments up to at least 24 m (75 ft) thick, had developed on top of the old volcano, and because sea levels were 30 m or 100 feet lower than at present. Much of this was exposed to the air and formed an island at least ten times the size of present day Bermuda. From East to West, Bermuda was probably 60 km (42 miles) in length! We know from the geological record, that Bermuda at this time consisted of a vast tract of sand dunes. Details of the old dunes are known because although they were **mobile dunes**, that moved slowly about with the wind, they were subject to rain action.

Rain water is slightly acidic and therefore dissolves limestone until the water becomes saturated with calcium carbonate. Thus at the surface of dunes, every rainfall resulted in sand grains losing a little of their substance, and the percolation of lime-saturated water to deeper layers. In dry periods, this water slowly evaporated and its cargo of calcium carbonate was deposited between the sand grains cementing them together. The resulting rock, called **aeolianite**, was often still quite porous, but this same process was repeated many times, forming ever denser limestone. In this way entire sand dune formations were **fossilised** exactly as they had been laid down. We know that the old dunes were very large since their fossilised remains, which are the hills of Bermuda, now rise up to 60 m or 200 ft above present sea level. Since sea level then was 30 m or 100 ft lower than now, dunes of at least 90 m (300 ft) in elevation were probable. These were huge dunes for limestone sand situations. We also know that these hardened dunes were subject to erosion back to sand, and that there were many periods of active dune building, followed by periods when dunes were converted to aeolianite. Many places along the shores of Bermuda and in road cuttings clearly show old dune surfaces, as well as eroded dunes with others on top of them.

Thus, the rock on top of the volcanic seamount came to be composed of two types of limestone, reef rock and aeolianite. On land, we mainly see aeolianite as it makes up at least 95% of the rock mass. However, small areas of reef rock can be found. Coring would reveal deeper layers of reef rock followed by volcanic rock.

As a point of interest, Bermuda has often been called an **atoll**. It is, however, not a true atoll, since atolls are formed around sea mounts that did not reach the surface. In such cases a ring-shaped island forms with a lagoon in the centre. An atoll is the result of marine biodeposition by corals and calcareous algae. It forms as a ring because of the more vigorous growth of corals and algae around the outer edge. There would be no aeolianite on a true atoll.

Biological Background

Development of Habitats and Colonisation by Organisms

In places, particularly along the south shore, the limestone rock is rich in fossil remains of Palmetto stumps and fronds, terrestrial and marine snail and clam shells, Ghost Crab burrows, and some other material. However, on the whole the fossil record in Bermuda provides only a poor record of the biological past.

The illuminated top and sides of the seamount provided the primary habitat which was colonised by marine organisms carried as spores, larvae and even some adults on the Gulf Stream.

There was, however, at this stage, a very low diversity of habitats, and because of this many organisms reaching the area in ocean currents, could not find suitable living spaces and either did not settle, or settled and failed either to survive or to reproduce. Because of this problem, progress toward a more diverse island community was slow. The appearance of sediments improved matters but it was only when marine deposits were exposed to the air, that a huge increase in habitat diversity paved the way for a more diverse natural community. Emergence into the air saw the addition of intertidal sedimentary and rocky habitats, a harsh terrestrial zone just above that subject to wave and spray action, and then as height increased, a variety of coastal habitats behind which true terrestrial and some primitive freshwater habitats were created.

Although many habitats were created early, it was only the truly marine ones that would be rapidly colonised by organisms. Organisms that did not have larvae or spores that could live for an extended time in open-sea water would not have a good chance of colonising the newly created habitats of Bermuda. If colonisation was difficult for some marine creatures it was doubly so for many terrestrial animals and plants and exceedingly so for fresh-water organisms.

Non-marine Organism Transportation to Bermuda

When we look at mechanisms by which these non-marine organisms could be transported to Bermuda, we have already covered one very important, but seemingly unlikely one, this is transport by ocean currents. Ocean currents such as the Gulf Stream which flows just to the west of Bermuda, can transport more than marine organisms, because floating logs, debris etc would almost certainly carry intertidal and shoreline living things occasionally. This method of transportation is augmented for floating things, by the fact that Bermuda lies in a zone of prevailing westerly winds. Such winds would tend to push floating things eastward where they would be more likely to strike Bermuda. In fact many coastal plants have large, salt-tolerant seeds that float readily in sea water. Others have parts of the plant, such as rhizomes, bulbs, corms etc. that can break away and perform a similar role to seeds. No doubt quite a variety of salt-tolerant animals also arrived clinging to logs or riding on top of them. It is easy to imagine that the Diamond-back terrapin, an estuarine turtle in Eastern North America, could have arrived in this way. However, for the fully terrestrial and freshwater species that got here, other methods were probably more or at least as important as floating.

A major one of these other methods is certainly the wind. Many plant seeds and spores can be carried long distances on the wind. Indeed many plants are adapted especially for transport in this way being either very tiny and light, or having wind-catching feathery or parachute-like seeds. Examples of these among the native plants of Bermuda are Jamaica Dogwood (Dodonaea viscosa), and many members of the daisy family (Compositae) such as Shrubby Fleabane (Pluchea odorata) and Low Cudweed (Gnaphalium viliginosum). Although most fresh-water and marsh plants are poor candidates for wind transport, there are those such as the Narrow-leaved Cattail (Typha angustifolia) that can move in this way. Many animals too are adapted for wind transport. Winged insects are an obvious example, as are birds and bats. But non-flying creatures such as spiders may

also arrive on the wind. Many tiny animals, such as protozoa, have small spores or resting stages that can be wind-borne. A great help in wind transport is the position of Bermuda in the westerly wind belt which flows over the North American continent before going out over the Atlantic Ocean. Storms from other directions would also bring things from other locations, particularly those to the North and South. Wind transport from the East is also possible in storms but the distance is huge and the chances of success small; nevertheless, European birds are seen here from time to time, and if they can be blown that far, no doubt other things have also made this journey. It is difficult to look back and make assumptions about how much of the flora and fauna arrived on the wind; however, there are a great many native species that are poor candidates for this mode of travel. For example, we can rule out those that are large and/or heavy. For these other terrestrial and particularly the fresh water living things, transport on the bodies of, or in the intestines of, migrating or wind born flying creatures also certainly played a part. Many seeds are highly resistant to digestive processes and some only germinate rapidly when the protective seed-coat has been thinned and softened in this way. Mud clinging to a bird's feet is also a very probable means of seed and spore transport. Migrating waterfowl probably brought most of the original freshwater creatures and plants.

However, compared to dispersal on continents the chances of any terrestrial organism reaching a distant oceanic island are very low indeed. We must never forget that Bermuda is a small group of islands far from any other coast; these factors more than any others limited the colonisation by new organisms and kept the biotic diversity relatively low. If one looks at islands around the world, biotic diversity is lowest on small islands far from the nearest shore. We can safely assume then that terrestrial and fresh-water diversity were always very low, and increased only slowly over a very long time period.

Another important facet of this whole process of natural colonisation is that because physical or habitat diversity was low, the ecological conditions required for most arriving species to grow and reproduce would quite likely not have existed. Because of this, many potentially colonising species probably died out before they became established. This process of continual extirpation also helped to keep biodiversity at a low level.

Succession in Early Bermuda

The development of new biological communities in a newly created environment follows a very predictable pattern. The first stage, Primary succession, is assumed to be exceedingly slow and takes place with only bare rock and water present. Examples of primary succession in nature are rare, and hard to study because events take place so slowly. However, events such as the creation of the new volcanic island Surtsey off the Icelandic coast do show this process in operation.

Secondary succession, which starts when sediment starts to accumulate, is a much faster process, that is more frequently observed in nature. In secondary succession, the first stages or **seres** are typified by a small number of readily dispersed plants. As succession proceeds, animal and plant diversity increases, organic content of the sediment rises and the overall complexity of habitats increases. In theory, secondary succession proceeds until as diverse and stable a community and environment as possible are achieved, and then remains this way as the climax.

In the case of Bermuda we can assume that the marine communities followed the classical course from primary through secondary succession, to some semblance of climax. It probably began on the volcanic peak long before limestone started to be laid down, and progressed over thousands of years, probably accelerating as the limestone cap was laid down to finally become the relatively stable and diverse community we see today.

If we consider the land, however, the course of succession was probably different from this classical form. It obviously commenced later than that in the sea, but probably also progressed much faster. This is because sediments produced previously in the sea, were available for transfer to the land by wave action and during sea level changes. These sediments were undoubtedly then dispersed over the available land surface principally by wind, but also by gravity and

water movement. Probably, a completely bare limestone rock island never existed. As soon as sea bed was exposed, both rock and sediment would be present. **Thus** primary land succession may have occurred only in small pockets, and secondary succession on the sand proceeded at the same time. Secondary succession producing a fairly diverse land community may have been a fairly rapid process.

Development of Biological Communities

The Early Terrestrial Communities

Most coastal flowering plants found along both rocky and sedimentary shores are adapted to dispersion by floating on the sea as described above. Even though Bermuda is far from the nearest shore we can safely assume that these colonising plants appeared as soon as land was available, because many cross entire oceans all the time and are exceedingly widely distributed! Plants such as Seaside Goldenrod (Solidago sempervirens), Seaside Purslane (Sesuvium portulacastrum), Sea Oxeye (Borrichia arborescens) and Seashore Rush Grass (Sporobolus virginicus), probably quickly established themselves on rocky coastlines. The first tree may well have been Buttonwood (Conocarpus erectus) which can exist as a stunted form in very exposed locations. At the same time sand dune inhabitants would start to grow along windswept sandy shores. Closest to the sea, at the strand-line, Scurvy Grass (Cakile lanceolata) would act as a sand stabilizer, while behind this area, plants such as Seaside Evening Primrose (Oenothera humifusa), Seaside Morning Glory (Ipomoea pes-caprae), Bay Bean (Canavali lineata), and others, would quickly become established, further stabilising blowing sand. In more sheltered sedimentary, coastal areas, where mud would gather, the Red Mangrove (Rhizophora mangle) probably soon became established, trapping further water borne sediment and quickly creating more sheltered areas in its **lee**. There, the Black Mangrove (Avicennia germinans) would grow, and behind that, salt-marsh plants such as Woody Glasswort or Marsh Samphire (Salicornia perennis), Sea Lavender (Limonium carolinianum), Sea Rush (Juncus maritimus) and Saltmarsh Oxeye (Borrichia frutescens), among others probably thrived.

All these newcomers would help to stabilise coastlines and their fallen leaves transported inland, would enrich the primitive sandy soil. At first the inland areas consisted of large tracts of mobile sand dunes. These dune fields would have been difficult for plants to colonise because the sand shifted with every wind, and despite generally significant rainfall, the rapid drainage of water through the sand kept the surface dry and somewhat salty. Nevertheless, some plants probably formed patchy communities among the dunes. Even though these patches may have often been short-lived, their remains would improve soil structure, and over time they would pave the way for true inland plants.

Permanent colonisation of inland areas would certainly have been slower than along the coasts, and the first arrivals are much harder to predict. However, it is certain that the developing coastal communities would attract a fair variety of migratory and storm-blown birds, which would carry seeds and other parts of organisms. Thus, slowly other plants suited to the environment would appear. At this stage, chance would play a much larger role than it had done earlier. Who knows what seed, stuck in a bird's feathers, fell in a suitable place for growth and then received sufficient moisture to germinate and prosper? The odds for survival were very low indeed, but it happened. As a community built up, microhabitats were created which supported yet other species.

The Establishment of Freshwater Habitats

We can say with reasonable confidence that the freshwater habitats and communities would be very slow to develop. This is due to several factors. Firstly, the sediments derived from limestone, are very porous to water. Even today, torrential rain just disappears into the ground in most locations. Because of this there would have been no permanent streams or ponds. In limestone soils, freshwater only gathers where a considerable layer of organic plant remains, forming a **peat deposit**, compresses into an **impermeable** layer, sealing the sediment surface. The accumulation of peat is a very slow process and consequently, freshwater ponds were certainly slow to develop. Once there, however, they would pave the way for succession to freshwater marshes and swamps which themselves would accelerate peat production.

To help us look back at the colonisation process, it is useful to consider the evolution of new species (the endemics) on Bermuda. This will be covered in more detail below but some general facts are useful here. Evolution is normally very slow, and so it is reasonable to assume that species unique to these islands arrived a long time ago, as closely related species from elsewhere. Additionally, early survivors would have a very wide variety of habitats available to them, if they could adapt to the island conditions. In pioneering communities competition for such essential resources for life, as light, space, water and plant nutrients, would also be at a low level. So, perhaps we can fairly safely say that species that evolved here in Bermuda and came to occupy a very wide range of habitats, compared to their forebears elsewhere, probably arrived while biodiversity was still comparatively low. We do know that when Bermuda was first discovered by man, it was almost totally forested and it is reasonable to assume that trees were the characteristic species of inland areas, practically from the start. Additionally, tree fragments are common in old peat deposits and some fossil tree remains such as Bermuda Palmetto (Sabal bermudana) roots are common.

Development of the Early Bermudian Forest

Sadly we have precious little hard information on the make-up of the Bermudian forest at the time of colonisation by man. Early settlers obviously had other things to do than describe what they found in detail. In addition to this it is certain that hogs and probably rats (Rattus spp.), were left by earlier visitors to many of the islands, and these animals had already affected significant changes, particularly in the under-story of the forests. Hogs tend to root around under the trees, eating edible material and decimating the delicate ferns, mosses and small herbs of the ground layer, as well as radically disturbing the entire habitat. Rats are known to eat the seeds of many forest plants. Together, these two animals probably rapidly disrupted natural regeneration in the forest, and drove out birds and other animals that used the forest floor for habitat or nesting. Some non-native plants such as tobacco were also present, and other things, such as some weeds, probably had come with them. We have to rely on later records and what survives today in the most undisturbed places, to piece together the story.

In the future it may be possible to get a much more accurate description of the early forest flora from pollen studies (palynology). Pollen is well preserved in peat and freshwater sediments, and the pollen of virtually every species is distinct from every other. Cores of ancient peat and sediment deposits, such as those in the bottom of Harrington Sound, can be retrieved, and layers in these cores can be reasonably accurately dated. The pollen assemblage from each layer could then reveal details of the make-up of the flora at that time. An example of results from recent pollen studies is that the Bay Grape (Coccoloba uvifera), although native as assumed, has only been in Bermuda for about 800 years. Indeed, its spread from a limited part of the south shore since the arrival of man has long been noted.

Two endemic trees were dominant in the forests of Bermuda when man first described what he found there. These are the Bermuda Cedar (Juniperus bermudiana) and the Bermuda Palmetto (Sabal bermudana). They are also represented in fossil remains and there is little doubt that their predecessors were among the first to colonise inland areas. The probable ancestor of the Bermuda Palmetto in Central America is characteristic of low, damp areas whereas the Junipers from which the Bermuda Cedar arose are more typical of higher and drier areas. It is probable that when both these species of tree reached Bermuda there was a sparse vegetational cover and very little competition for space. The Cedar has highly edible berries and quite likely arrived in the intestines of birds. The Palmetto on the other hand has larger, less edible fruits that float well. They may well have been transported to Bermuda's shores on ocean currents. We can only speculate as to which arrived first but the probable modes of dispersal are more likely to have taken Bermuda Cedar to higher inland areas and Bermuda Palmetto to the shorelines. In any case both trees evidently grew and reproduced well, and both were able to occupy a much wider range of habitats than their mainland predecessors. At the time that colonisation had progressed to the stage where forests were described, it is evident that Cedars **dominated** the higher, drier areas while Palmettos were more abundant in lowland situations. However, both species were common in virtually all habitats. Figure 2 shows a reconstruction of an early upland cedar forest. The forested swamps show a particularly

interesting historical situation. The swamps of Devonshire Marsh were dominated by Cedars whereas in Paget Marsh, Palmettos were the major tree. Early descriptions of Pembroke Marsh suggest that trees were sparse there, but early digging in the peat, showed masses of remains of Cedars. Presumably, well before man arrived Pembroke Marsh contained a Cedar swamp! There is an interesting parallel situation with mangrove swamps in the inland saltwater ponds; in summary, many ponds have either Red Mangroves or Black Mangroves, but not both. One may speculate that in both situations whichever tree colonised the area first was able to virtually exclude the other.

There is one other endemic tree that must have arrived early on; this is the Bermuda Olivewood (Cassine laneana), a beautiful compact tree up to 15 m or 45 ft high. However, there is no evidence that it formed stands in which it dominated; it is suspected that it grew scattered among the Cedars, Palmettos and other native trees that were early arrivals. Trees that are native to Bermuda could well have arrived as early as those that became endemic, but for some reason they did not evolve into new species. Probably, they lacked a sufficiently broad niche that would allow them to colonise all the new habitats available, and only grew successfully after Cedars and Palmettos had established a true forest habitat, to which they were adapted. At any rate, several native trees were quite common when the islands were settled. One of the most interesting is the Yellow-wood (Zanthoxylum flavum). Native in parts of the Caribbean, it was formerly common in Bermuda, but is now very rare and endangered. Its beautiful, hard wood was prized for furniture making, and it was heavily exploited; at present this tree shows no natural reproduction. Another tree of the early forest was Southern Hackberry or Hackberry (Celtis laevigata), now quite rare this 15 m (45 ft) tree prefers sheltered valleys, where it probably grew in clumps among the Cedars and Palmettos. Lamarck's Trema (Trema lamarckiana) was a small tree of untidy growth form which is now rare, but may well have once been a common forest inhabitant.

Evolution of New Species

The Forest as an Example

In the introduction, the basic concepts of the evolutionary process were explained. The establishment of the Bermudian forest by the evolution of two new tree species, is a very good example of one possible course of events. There is a lot of evidence that the two trees that were to dominate the forests, Bermuda Cedar and Bermuda Palmetto, arrived very early when there was a lot of space available, and very little competition for natural resources. Natural competition between species often limits their distribution in diverse communities where space is limited. For example, mangrove trees, which are confined to coastlines, are perfectly capable of living in inland freshwater localities, but cannot compete with species that naturally evolved there. In Bermuda, the Cedar and Palmetto became established and spread rapidly. In each new generation of trees there would be considerable **natural variation,** and some of the new trees would be better adapted to the island conditions than their parents, from which they would differ genetically. **Natural selection** of the new, better adapted, trees would result in their increasing importance, until the original trees were gone. Of particular importance at this stage would be competition between individuals of the same species, a process called **intra-specific competition**. Individuals of the same or very similar species compete very vigorously and the result is **competitive exclusion**, where one competitor persists and the other dies out. We can safely assume this happened in these two cases because the colonising species completely disappeared.

In other situations this did not happen; instead, the colonising species persisted in some habitats and new species arising from it occupied other habitats or **niches**. A niche is simply the unique habitat of one species. A famous example of this second evolutionary path is the case of Darwin's Finches in the Galapagos Islands where one finch gave rise to a whole group of related species; this is termed **adaptive radiation**. In the case of the Cedar and Palmetto in Bermuda, both new species were able to colonise a very wide range of habitats, from freshwater swamps to dry uplands.

However, the cases of both the Bermuda Cedar and the Bermuda Palmetto serve to show not only how evolution can enable a species to better survive in a new habitat, but also how other potentially useful features or **traits** may be lost. Consider the ancestor of the Cedar on the mainland co-existing with the disease Cedar Blight, because it had developed an **inherited** resistance to it. Any individuals lacking the genetic trait of disease resistance, would be eliminated in natural selection. However, in a new location where the disease was absent this would not occur, and those lacking disease resistance would persist if they were better fitted to succeed in other ways! This is what happened in Bermuda, and later, when man accidentally introduced the disease on introduced junipers, the Bermuda Cedar was almost wiped out. Bermuda Palmettos were also attacked by introduced pests and diseases but were not so severely affected; perhaps they retained partial resistance.

Returning to the development of the forests, one other naturally arriving tree, the Bermuda Olivewood (*Cassine laneana*), a beautiful, very compact tree up to 15 m or 45 ft high, evolved into a new species. However, in this case it did not evolve to occupy diverse habitats but was restricted to reasonably sheltered, but well drained forest situations. It might be reasonably assumed that it arrived after the Cedars and Palmettos became dominant and could only compete with them in a specific habitat.

As the forest became established, a unique new habitat was created under the trees, and other new species evolved in this damp, stable environment. In these cases, evolution was made possible by the creation of a new forest habitat that suited their ecological needs. Examples of these other new species are the Bermuda Sedge (*Carex bermudiana*), the moss Bermuda Trichostoma

(*Trichostomum bermudanum*), the Bermuda Maidenhair Fern (*Adiantum bellum*) and the shrub Bermuda Snowberry (*Chiococca bermudiana*).

Native species are those that arrived in Bermuda by natural means but remain essentially identical with their forbears elsewhere. Thus they arrived by the same means, as the endemics but did not evolve into new species. The reasons for this may never be clear, perhaps they arrived later than those which formed the endemics but had characteristics which adapted them to the structure of the already created upland forest. Alternatively they may have arrived very early but were not well adapted to Bermudian conditions and only flourished after the endemics evolved to dominate the forest. Several of these formerly quite common trees are now very rare and endangered. Perhaps the best known of these is the Yellow-wood (*Zanthoxylum flavum*) now existing as only a few specimens in the Walsingham limestone formation. The Southern Hackberry (*Celtis laevigata*) was also probably widely distributed on sheltered hillsides. This tree, up to 15 m (45 ft) high, is native of the southeast United States. Like the Yellow-wood it was probably scattered or in small clumps among the Cedars and Palmettos. Another interesting native tree is Lamarck's Trema (*Trema lamarckiana*), a small shrubby tree of untidy growth form. Now quite rare, this tree was probably much more common before the arrival of man.

Endemic Species in Bermuda

Above we have used the early forest, with particular emphasis on the trees, as an example of one habitat in which the evolution of new species took place. However, it occurred in all living things, and many groups have been studied in enough detail, to be able to list both the endemic and native components with considerable confidence.

The situation among the plants and plant-like cyanobacteria was roughly as follows. In the case of the **vascular plants** there were 156 species of native plants exclusive of the 11 species which have proved to be endemic. Among the **liverworts** there were 25 native, and the **fungi** and **lichens** numbered 747 non-endemic natives to which can be added the 50 endemic species. The seaweeds or **algae** including the **blue-green cyanobacteria** plants, which resemble seaweeds, were quite diverse with 833 non-endemic native species plus 9 endemics.

The **protozoa** numbered about 200 native species, none of which are proven endemics.

The marine **invertebrate** animals were, as expected, the most diverse group with 2,915 native species identified to date, to which we can add 94 endemic animals. By contrast, the freshwater invertebrates had only 8 natives plus 2 endemics (insects not included). **Terrestrial invertebrates,** exclusive of the insects are another group of moderate diversity with 175 natives plus 13 endemics. The terrestrial and freshwater insects were the most diverse non marine group, with 1,116 native plus 41 endemic species described to date. The group of invertebrate animals including the **spiders**, **ticks** and **mites** were of intermediate diversity, containing 32 non-endemic native species plus 9 considered to be endemic. So far 79 parasitic invertebrate animals have been described, none of which were certain endemics.

Turning to the vertebrate animals, the marine fishes were the most diverse group, with 423 species which were non-endemic natives, to which we can add the 7 known endemics. In freshwater, on the other hand, there were no native species, but 3 are considered to be endemic species. There were no native or endemic amphibians and only 4 native, marine reptilian species and a single brackish-water species to which we can add 1 endemic, terrestrial species. The birds, on the other hand, were a quite diverse group, with 334 probable non-endemic natives to which can be added 2 endemics. There were no terrestrial mammals, but the marine species number 36 natives.

When we look at the totals, the numbers are quite illuminating; for the marine environment the total number of non-endemic native species is 4,499, to which can be added 111 endemics, for a total of 4,610 species. The terrestrial group numbers 2,448 non-endemic native species, and 126 endemics, for a total of 2,574 species. The smallest group as expected is from freshwater

habitats, with 59 non-endemic natives and 5 endemics to total 54 species. Seventy-nine parasitic species have not been assigned to the above groups because they form a special case. The grand totals are 7,085 natives and 242 endemic species, for 7,327 species in total. Thus the percentage of endemics or **endemism** as it is often called, is 3.4% overall, 2.5% for marine organisms, 5.1% for terrestrial organisms and 8.5% for the freshwater environment.

So the percentage of endemic species, or the amount of island evolution, is highest in the least diverse freshwater group and lowest in the most diverse marine group. This may seem peculiar, but it makes sense if you consider the three main environments in terms of isolation. The sea is obviously the least isolated as it has a direct connection through water to other localities, and it continuously receives new individuals of a host of species. Indeed for a few species, such as the Spiny Lobster, cited above, most individuals found here may have come from the Caribbean as larvae. The terrestrial or land environment is much more isolated than the sea, and new individuals can only arrive by more tenuous transportation routes such as on the wind, or in association with flying creatures. The freshwater environment is certainly the most isolated of all, and the high percentage of endemic species is more striking when we consider that the freshwater community has certainly developed over a shorter time period than the others. We know that evolution of new species is generally a very slow process.

Compared with other oceanic island situations at similar latitudes, such as Hawaii, there is a much smaller total number of species here, and the proportion of endemic species here is very much lower. Of course Hawaii is a larger and more physically complex series of islands which probably offers more habitat diversity than Bermuda. It also lacks a real counterpart to the Gulf Stream which as pointed out above acts as a sort of conveyor belt bringing organisms to Bermuda and reducing its apparent isolation.

Better Known Examples of the Bermudian Endemic Species

You should have noticed that in the examples of species that evolved in Bermuda given above, that the second part of the scientific name, given in italics, was some variation of the name Bermuda. This specific epithet as it is called, normally gives some descriptive information about the organism, in this case its Bermudian origin. This happens in the case of most but not all Bermudian endemic species, as you will see below. Curiously, finding a specific epithet with some derivation of Bermuda does not necessarily mean that it is endemic to Bermuda. For example, in the case of a beautiful red seaweed called the Heartweed (Halymenia bermudensis), it merely signifies that it was first found in Bermuda, even though it also lives elsewhere.

The seaweeds or marine algae have several very interesting endemic species. One of the most spectacular ones of these is the Bermuda Sargasso Weed (Sargassum bermudense). Sargasso Weeds are best known for the floating mats that come ashore from time to time, particularly in winter. However, some species of Sargasso Weed are attached to the bottom, as are most seaweeds and one of these is the Bermuda Sargasso Weed, which is occasionally found on near-shore rocks. It is, however, sometimes seen in some of the Bermudian saltwater ponds where it forms impressive large bunches of brown fronds up to 3 m (10 ft) high!

The mosses are not a very diverse group in Bermuda, but they do boast two endemic species. The Bermuda Trichostoma or Bermuda Moss (Trichostomum bermudanum) is a tiny dark green moss that is exceedingly common on damp rock or soil. By contrast the other endemic moss, the Bermuda Campylopus (Campylopus bermudiana) is very rare and confined to a specific **microhabitat** in Paget Marsh.

Ferns are another group that show a surprising amount of endemism, in that there are only19 species including the four endemic ones. Only one of these endemic species, the Bermuda Maidenhair Fern (*Adiantum bellum*), is at all common, occurring on shaded rock faces, walls etc. The other three are now exceedingly rare. The Bermuda Cave Fern (*Ctenitis sloanei*) is now confined to a couple of sites in the Walsingham area. The Bermuda Shield Fern (*Dryopteris bermudiana*) was once abundant in the Walsingham area, but is now on the verge of extiction. Perhaps even more threatened is Governor Laffan's Fern (*Diplazium laffanianum*),

now absent from the wild, and perpetuated only by a few specimens at the Botanical Gardens. Note that only one of these endemic ferns bears a specific epithet signifying Bermuda, the others have other descriptive words, for example signifying who they were named after.

Smaller endemic plants of the forest floor include the Bermuda Sedge (Carex bermudiana), a small grass-like plant of fairly open forests, now uncommon. However, it has been re-introduced in restored habitats (discussed below), and Wild Bermuda Pepper (Peperomia septentrionalis) which lives on rock rubble and rock ledges in wooded areas, and is now rare except in the Walsingham area. Among the forest shrubs, Bermuda Snowberry (Chiococca bermudiana) is now found in the wild only in Walsingham, but is also frequently cultivated as a garden plant because of its showy white berries. Another forest endemic, formerly abundant but now also almost confined to the Walsingham area, is the Bermuda Bean (Phaseolus lignosus), a small vine with yellow, pea-like flowers.

Three endemic flowering **herbs** of more open areas are St. Andrews Cross (*Hypericum macrosepalum*) which has 4-petalled yellow flowers, Darrell's Fleabane (*Erigeron darrellianus*) a member of the daisy family occasionally found on banks and in wasteland, and Bermudiana (*Sisyrhinchium bermudiana*) which is looked upon as the national flower. Once so common as to be a pest it is still widespread in many habitats and has lovely purple flowers in spring.

The one endemic marsh plant, the Bermuda Spike Rush (*Eleocharis bermudiana*), a small rush with grass-like leaves, is now an **endangered species** surviving only as scattered individuals in Paget and Devonshire marshes.

The insects boast a large number of endemic species but few that can be said to be common; in fact many endemic insects are now extinct. Two recent extinctions that were formerly quite common are the Cicada or Bermuda Singer (Tibicen bermudiana) known from its nocturnal singing in trees and the Bermuda Flightless Grasshopper (Paroxya bermudensis).

The **land snails** too have some examples of recent extinctions; these include at least two species of endemic Poecilozonites (*Poecilozonites* spp.), which were eaten to extinction by a predatory snail, the Rosy Euglandina (*Euglandina rosea*), which was introduced by man hoping to control the Edible Snail (*Otala lactea*) which had become a pest.

The Poecilozonites snails were of great interest because they were Bermuda's best example of **adaptive radiation**; the better known example of Darwin's Finches in the Galapagos Islands was mentioned earlier. These snails originating from a single ancestor evolved, at first to produce six new species in Bermuda (*Poecilozonites bermudensis*, *Poecilozonites cupula*, *Poecilozonites nelsoni, Poecilozonites reinianus, Poecilozonites circumfirmatus* and *Poecilozonites superior*). Some of these species then continued evolving until there was a total of 15 species and sub-species varying in size from 5-45 mm (3/8-2 in). Probably all of these are now extinct, although three species *(Poecilozonites bermudensis*, *Poecilozonites reinianus* and *Poecilozonites circumfirmatus)* were found alive in 1969. However, fossil specimens are common, as are dead shells of some species, and can be found quite easily in some cases.

There are not many endemic species among the fishes but a few are well known. One of the most interesting is the Bermuda Killifish (*Fundulus bermudae*), a small but tough fish of Bermuda's saltwater ponds. It can live in water that is very low in oxygen, and is quite common. A second *Fundulus* species (*Fundulus relicta*) is recorded from a single pond. This is another small example of adaptive radiation and it is significant that it happened in the relatively isolated saltwater ponds. Another well known endemic fish is the Bermuda Bream (*Diplodus bermudensis*), very common in bays and coastal waters and reaching a size of 40 cm (16 in).

The once very common endemic lizard, the Bermuda Skink (*Eumeces longirostris*), is declining in numbers and now only common on islands in Castle Harbour, including Nonsuch Island. It has been preyed upon by man's introductions, cats, rats and the Great Kiskadee (*Pitangus sulphuratus*). Reaching a length of 15-18 cm (6-7 in), the young ones have a bright blue tail, mature specimens being a greyish-tan with orange chin patches.

Of the two endemic birds, the Bermuda White-eyed Vireo or Chick-of-the-Village (*Vireo griseus*), and the Cahow or Bermuda Petrel *(Pterodroma cahow*), the Cahow is by far the most famous; indeed it is probably the best known example of Bermuda's endemic species. This species was thought to be extinct, but was re-discovered in 1951 when eight pairs were found breeding on small islands in the Castle Harbour area. With careful husbandry, particularly by Dr. David Wingate the former Conservation Officer, the numbers of this bird are rising steadily, but it is still an endangered species. The Cahow is an oceanic bird that only comes ashore to breed. It is rarely seen as it only approaches the breeding areas at night. The Cahow was abundant when Bermuda was settled, but was easily caught by man and dogs and rapidly declined. In these early days it bred in tunnels under fallen cedars in the forest, a habitat that now scarcely exists, and if present is far from safe. Breeding now takes place in artificial tunnels on islands where predators are absent. The Bermuda White-eyed Vireo is a distinct endemic **race** of the White-eyed Vireo. A race is not distinct enough from the parent species to be given the status of a new species. However, in time it may become more distinct and its status may be changed.

The Influence of Man

Before man visited or colonised Bermuda, it must have been an idyllic location. The climate was excellent; the soil easily workable, there was an abundance of plants useful to man, as well as plenty of seabirds and turtles. The forests offered a wealth of trees suitable for firewood, shipbuilding, furniture making, house construction, clothes and rope as well as other things. Indeed the Bermuda Cedar (*Juniperus bermudensis*) is one of the toughest and most rot resistant woods in the world. Additionally the surface rock was relatively soft and easily worked for building or readily smoothed off for roads.

Human Visits Before Colonisation

Before colonisation in the 17th century, Bermuda was certainly visited by a variety of seafarers, including buccaneers and pirates during at least the previous century. However, they did not seem to appreciate much of what the islands had to offer. They did use some Cedar and no-doubt took turtles and seabirds for food. However, they dubbed the islands "Devil's Islands" supposedly because they mistook the sounds of numerous sea birds, for the utterances of supernatural beings. The area also had a bad reputation for serious storms. These early visitors must have thought they might return, however, because they released hogs to serve as future food. Rats may well have been accidentally introduced at this time. There is also a record of early settlers finding patches of tobacco. The islands were named in 1510 when a Spanish ship commanded by Juan de Bermudez visited the area. Captain Bermudez evidently thought enough of the location to name it after himself! However he did not stay. These early visitors set in motion a severe destructive influence on the natural history of Bermuda which continues today. The area most affected was certainly the inland forest where the pigs and rats disturbed the forest floor and ate plants and seeds. This pre-colonisation disturbance undoubtedly started the decline of the endemic petrel, the Cahow (*Pterodroma cahow*). Cahows nested in holes in the forest floor, such as under the root-mass of blown-down Bermuda Cedars. Such locations would be highly vulnerable to the depredations of both hogs and rats. Since the nature of the early forest was changed for all time before man became resident, details of the character of the early forest were never recorded.

Events that Followed Colonisation by Man

The deleterious influence of man, can be looked at under two main categories, first exploitation of island natural resources and second the introduction, either accidentally or on purpose, of **exotic** animals, plants and diseases. Another factor now emerging as one of great importance has been the widespread use of **herbicides** and **pesticides**. The recent appearance of gross deformities in the introduced frog populations, is attributed to pesticides in the environment. Another example is the softening of Cahow eggs by DDT, when it was in common use and for some time afterward.

As mentioned above, the process of change started with introductions, but on first colonisation, emphasis changed to exploitation, later it returned to introductions. At first exploitation was concentrated on readily usable species. Cedars were felled for building and shipbuilding, as well as for firewood and furniture, Palmettos (*Sabal bermudana*) were used for thatch, rope and hats. Additionally their cabbage-like heart was used as a vegetable. So the two most important endemic tree species were used immediately. Marine turtles, particularly the Green Turtle (*Chelonia mydas*), were readily caught while feeding in seagrass beds, or at breeding time on the beaches. Also used were the Cahows during their winter breeding season. Like many island birds, cahows were docile and easily caught; huge numbers were eaten. Very early on, the easily accessible and flatter sections of the coastal and valley forest were cleared for agriculture and housing, as well as for roads. Very soon after first colonisation the introduced species began to take their deadly toll. The settlers brought seeds, pests such as rats and mice, pets such as dogs and cats, and domestic animals such as cows and goats; unseen on all these things were diseases, parasites and pests. All were destructive influences but some were much worse than others.

Bermuda had been an isolated island for thousands of years, and during this time competition among the limited number of native species was at a very low level. Additionally there were no large **predatory** mammals, amphibians or reptiles on land, and the resident birds were mainly small land birds or marine species. Bermuda was really too small to support populations of large predatory birds such as eagles. This lack of predatory pressure had led to either native species that had no fear of man and his associated animals, or to endemic species with similar traits. Thus most things worth eating were simple to capture, and this exploitation was increased by a poor supply of imported food. So native and endemic species were decimated as were the introduced hogs. All these effects were much worse on land than in the sea, and less severe in coastal areas than inland. For instance, although many mangrove swamps were removed in the course of coastal development, the great majority were left virtually untouched. The intertidal area too was not really hard-hit, although large marine snails such as the West Indian Top Shell (*Cittarium pica*) were no doubt collected in large numbers.

As time progressed, the very useful tree species were severely reduced in numbers. Bermuda Cedar was certainly the most heavily exploited, since its wood could be put to so many uses and the berries were also used for flavouring alcoholic drinks. It was also such an attractive wood that a great deal was exported; this export was passively increased by the use of cedar for packing crates. So severe was the exploitation of Cedar that restrictions on its use were put in place in the early 1600s and its export as wood was banned in 1657; much however, still left as packing crates. Yellow-wood, a native species, never very abundant but common among the Cedars and Palmettos, was so heavily used for furniture that the population fell to such a low level that natural reproduction ceased. This was almost certainly aggravated by habitat destruction first from foraging pigs, and later by other domestic animals. Palmettos were also heavily exploited. Leaves were used intact as thatch, and split for hats, rope and 'plait'. The growing heart of this fan palm was used as a vegetable, somewhat like cabbage, and the sap was tapped to make the alcoholic beverage called 'bibby'. However, Palmettos were not so severely decimated as Bermuda Cedars and Yellow-wood. For at least the Cedar and Palmetto, these population reductions were further complicated by introductions.

Introductions by man have undoubtedly been the most harmful factor in the degradation of the Bermudian fauna and flora. As mentioned above, they started before colonisation and continue till today. Generally speaking, there are two main types of introduction of new species by man, intentional and unintentional. Intentional introductions have involved pets, domestic animals, food plants, ornamental plants, medicinal plants and biological controls. Accidental introductions can involve all manner of things but most commonly are diseases or small pests carried on intentional introductions or inanimate objects imported into or calling at Bermuda. For instance there are several introduced plants now radiating out from the airport! Introductions that have adapted to life in Bermuda well enough that they persist and reproduce successfully, are termed naturalised species.

Introduced species are a potentially serious problem particularly on islands, not only because ones suited to this environment can spread rapidly in the absence of serious competition, but also because endemic island species have not developed mechanisms that would allow them to compete successfully with the introductions. In the case of introduced pests and diseases, their effects are usually much more severe on endemic species than they were on closely related parent species from the mainland. This is attributed to a lack of resistance mechanisms that on the mainland evolved from a very long association between host and pest or disease. It is also true that a species from elsewhere may change its dietary or habitat preferences radically on introduction to a new environment. This makes the potential effect of planned introductions difficult to predict.

Accidentally introduced pests and diseases have produced some of the most catastrophic results, particularly in relation to endemic trees. In 1940-42, two species of scale insects, the Oystershell Scale (*Insulapis pallida*) and the Cedar Scale (*Carulaspis minima*), were accidentally brought in to Bermuda on ornamental species of Juniper. These insects carried and spread Cedar Blight. These tiny insects are covered by

a hard impervious shell-like covering, and are difficult to control. Ladybirds introduced to control the scale had little effect. By 1949 over 15,000 dead Cedars had been cut down, by 1953 90% of Cedars were dead and by 1971, 99%. Fortunately, there were some cedars that had some resistance and Barry Phillips, a government horticulturist, made it a special project to propagate from these and re-plant the cedars. Many thousands of cedars have been re-planted, and the species is making a slow comeback. Another accidentally introduced scale insect, the Palmetto Scale, (*Comstockiella sabalis*) attacked the endemic Bermuda Palmetto but fortunately the tree had retained some resistance to this pest.

Some of the introductions have achieved almost ludicrous status. The Jamaican Anole (*Anolis grahami*) was brought in 1905 to control another pestilential insect, the Mediterranean Fruit Fly (*Ceratitis capitata*). Once here it made little if any inroads on the Fruit Fly, but instead ate a wide variety of insects, including the ladybirds introduced to combat Cedar Scale, and became a pest itself. To control the anole, the large yellow tropical flycatcher the Great Kiskadee (*Pitangus sulfuratus*), was introduced to Bermuda in 1957. It too failed to live up to its lizard-eating reputation and instead, ate all manner of things including the eggs of the endemic Bermuda White-eyed Vireo (*Vireo griseus*), as well as those of a variety of native birds! While not all intentional introductions for the purpose of biological control of introduced pest species have resulted in unforseen problems, many of them have.

An example of an apparently harmless introduction was that of the Eastern Mosquitofish (*Gambusia holbrooki*) to control mosquitos, which in the past carried malaria. Locally called 'guppies' these fish were introduced in the 1940's into drainage ditches and freshwater ponds. They controlled mosquitos well and do not seem to have displaced any native or endemic species. This is probably because no other fish occupied that habitat. The endemic Bermuda Killifish (*Fundulus bermudae*) is typical of brackish waters and while some Eastern Mosquitofish can be seen in the same general habitat as the Killifish, they appear to occupy different niches.

Another fairly innocuous introduction was that of the Giant Toad (*Bufo marinus*), to control cockroaches. These very large toads do eat large numbers of cockroaches but also other insects; cockroaches are still very plentiful.

In total, introduced species have done a huge amount of damage, and have changed the face of Bermuda for all time. As an example of the scale of these introductions, there is but a single native or endemic palm, the Bermuda Palmetto, while there are at least 40 introduced species. All the amphibians, two species of frog and the toad, are introduced. Among the land reptiles all lizards except the Bermuda Skink (*Eumeces longirostris*) are introduced. In the case of introduced species, it is the terrestrial environment which has suffered the greatest, while fresh water communities are moderately affected, and marine ones hardly at all. If we take the most extreme example of the higher land plants, there are 11 endemic species, 142 native species and about 2,900 introduced species! Only 5% of these plant species are native or endemic. At the opposite extreme, in marine environments there are about 5,402 native species, 740 endemics and 103 introduced. There 99.3% of the fauna and flora is native or endemic.

As an example of how introduced species can out-compete similar endemic ones, consider the Chinese Fan Palm (*Livistonia chinensis*) which is remarkably similar to the Bermuda Palmetto. Almost every small fan palm that you will find in Bermuda now is the Chinese Fan Palm. Additionally, the introduced species reproduces much more successfully under today's conditions. Almost every seedling palm you will find will be of the introduced species. Adult palms can be distinguished by the toothed leaf-stalk on the Chinese Fan Palm, as compared to the smooth one on the Bermuda Palmetto. Additionally, in the Bermuda Palmetto, the leaf stalk or petiole extends through the leaf as an elongated point whereas in the Chinese Fan Palm it ends more abruptly as a blunt point. This latter feature is most useful in small specimens which may lack the spines on the leaf stalk in the Chinese Palmetto.

In conclusion, man has altered the terrestrial fauna and flora of Bermuda so that there is nowhere on these islands where introduced species are not seen in number.

The Restored Habitats

The only bright spark in this situation is that David Wingate, the Bermuda Conservation Officer from 1966 until the year 2000, has worked tirelessly to restore some situations where sufficient control was available to do this. The main site is Nonsuch Island in the Castle Roads area of Castle Harbour and a second one is Paget Marsh. Additionally some parts of the Walsingham Nature Reserve and the Spittal Pond Nature Reserve have been started in this direction, and Abbott's Cliff in Harrington Sound will be tackled in the future. Both locations tackled extensively so far are nature reserves and access to Nonsuch Island in particular is very restricted. At these locations introduced plants and some animals have been slowly removed. Rapid removal would have created an unstable ecological condition with unpredictable results. Now after years, the original Bermudian upland forest is taking shape on Nonsuch while a Palmetto swamp-forest is reappearing at Paget Marsh.

Nonsuch Island

The restoration of Nonsuch Island has been called the "Living Museum" project. The island consists of 5.9 ha (14.5 acres) of land: although this is quite small it contains most of the land habitats available in Bermuda, and also has a coastline with rocky shores and sandy beaches. For this type of restoration the small size has an advantage in that the entire island can be monitored with minimal personnel and new introductions can be eliminated promptly. Nonsuch Island did retain many native and exotic species before the project began and so the start was not quite from scratch. Unfortunately before restoration began in 1963 the heavy cedar stand on the island was decimated by Cedar Blight, and as on the larger islands almost all the cedars died. This was a particular problem on Nonsuch as the island has an open southerly exposure, and is also receiving large ocean swells which may arise in the southern hemisphere but reach the south shore with little impediment. Because of this combination of factors, there was considerable concern that erosion would degrade island soils and that reintroduced plants would not have a suitable habitat in which to grow. To get around this, the decision was made to plant Casuarina (*Casuarina equisetifolia*) as a temporary windbreak.

Nonsuch Island has an interesting history. Privately owned from 1700-1860, it was leased out for livestock rearing. The Bermuda Government acquired the land in 1865, and in subsequent years it was put to various uses. From 1865 to 1914 Nonsuch Island served as a yellow fever quarantine station and hospital. During this time, docks, various buildings, a mortuary and cemetery were built. In the years from 1928-1931 the island was on loan to the New York Zoological Society as a marine research station. During this period it was occupied by Dr. William Beebe and Dr. John Tee Van and it was from this base that the historic deep descents by the "bathysphere" were organised. The Admiralty water barge 'HMS Supply' was also moved to Nonsuch Island during this period, and sunk touching the north shore to serve as a breakwater and fish holding tanks. Once in place it was re-christened the 'Sea Fern'. Following its scientific debut the island became a Junior Training School for Delinquent Boys; this was run from 1934-1948, and finally abandoned due to the isolation and difficulties with a safe anchorage. By 1948 Bermuda Cedar was already in decline and the ecosystem of Nonsuch began to deteriorate. What really got Nonsuch Island biological recognition, was the discovery of 7 breeding pairs of Cahows by Robert Cushman Murphy, of the American Museum of Natural History, and Louis Mowbray, Curator of the Bermuda Aquarium. These endemic birds had been considered to be extinct for over 300 years, and their re-discovery was a really astounding event. Although they were not on Nonsuch Island itself but on adjacent small islands, Nonsuch was an obvious base for conservation and study of this highly endangered species. Especially after the breeding islands gained sanctuary status in 1951.

It was in relation to the Cahow that David Wingate's association with Nonsuch began. He was vitally interested in the preservation of this species and his biological career had recently begun. Bringing the Cahow population back to a viable level was to be a lifetime passion.

The project began in earnest in the late 1960's with the installation of artificial burrows. As mentioned earlier, Cahows almost certainly nested in the forests of early Bermuda. They very likely used cavities under storm-felled tree root masses. Pigs, rats and forest exploitation rapidly spoiled this breeding habitat, and at the same time adults were slaughtered wholesale when they came ashore to breed. The small islands were a good refuge from predators, including man, but were short of good breeding habitat. The addition of artificial burrows was to break this barrier and were successful, except that other seabirds that nest in burrows, such as the Longtail (*Phaeton lepturus*), competed for this space. By 1961 the breeding population had risen to 11 pairs and a baffle in the nest tunnel solved the competition problem.

In1962 David Wingate was installed as Warden of Nonsuch and in 1963 began the "Living Museum" project; in 1966 he became Bermuda's first Conservation Officer. With Nonsuch being the centre of conservation work in Bermuda, it was natural that a project attempting to restore a breeding population of the Green Turtle (*Chelonia mydas*), should be centered there, especially as the South Beach on Nonsuch was a former nesting site. During the period 1967-1978 16,000 Green Turtles were hatched there and released to sea. If they have survived as a viable population, they should begin returning early in the new Millennium.

By 1975 the restoration of the native flora of Nonsuch Island was well underway, but the natural habitats did not include **wetlands**. Other wetlands were drastically reduced and to provide examples that could be managed, two ponds were planned for Nonsuch. The freshwater pond was dug in a central location but leaking problems necessitated its re-excavation and the addition of a permanent liner in 1993. The saltwater pond was excavated behind the south beach, creating a small dune habitat between it and the sea. Red Mangroves and the Bermuda Killifish were introduced in 1976. In 1992 it was enlarged and Black Mangroves were added to the flora.

Nonsuch was also the site of two notable re-introductions of species that had been extirpated. During the period between 1976 and 1978, forty-four Yellow-crowned Night Herons (*Nyctanassa violacea*), hand -reared on a diet of Land Crabs (*Gecarcinus lateralis*), were released. This heron had previously been common in Bermuda but had been extirpated; its natural prey were Land Crabs and the two lived in balance. With the herons gone, the Land Crab population exploded, and attempted control with DDT had disastrous side effects. About 8 years after their re-introduction, Yellow-crowned Night Herons were breeding naturally in the Walsingham area, and now the success of the re-introduction is assured. Land crab populations have dropped to a very low level indicating that a full ecological balance may be some years away. A second re-introduction, that of the West Indian Top Shell, which had been collected to extirpation for food, was carried out on Nonsuch in 1982, when a quantity of these large gastropods became available fortuitously. By 1986, they were breeding successfully and have spread widely since. However, although they are a protected species they are again being decimated by use as human food.

By 1990, the new forest on Nonsuch had progressed to the state where successful self-propagation of many species had begun, and the Casuarinas installed as a wind break could be started to be cut back or removed. The area has survived Hurricanes Emily, Dean, Felix and Gert without severe damage! Much remains to be done. but the Nonsuch experiment has been an unprecedented success, which serves an example to the rest of the world. Dr Wingate has said "The 'Living Museum' has succeeded beyond my wildest dreams and I believe this is because I took a holistic approach to the restoration, i.e., by reintroducing everything within its original context the native heritage has restored itself. You can turn the clock back by understanding nature and working with it, rather than against it".

Paget Marsh

Freshwater systems are described in the Project Nature Field Guide, "Bermuda's Wetlands". Here I will just briefly outline why Paget Marsh is important and how restoration has worked. Paget Marsh lies in a big sink hole in the central part of present-day Bermuda. Disturbance at this site was much less severe than in other peat marshes, and in about 1965 the Bermuda National Trust

and the Bermuda Audubon Society together obtained most of the marsh to protect it for all time. This was principally a Bermuda Palmetto **swamp-forest** but also contained stands of Saw Grass (*Cladium jamaicense*), and impressive communities dominated by the Giant Fern (*Acrostichum danaeifolium*). The site was also rich in other fern species and contained two endemic mosses and a few specimens of the very rare leafless, primitive plant Psilotum (*Psilotum nudum*). Quite a number of very large Bermuda Cedars were also present. The marsh had been drained for mosquito control and the large ditches created were colonised by the Water Fern (*Salvinia olfersiana*). Also present in the central part of the marsh was a Red Mangrove stand, around an almost fresh pond. Although this basis of a natural peat marsh-palmetto swamp was there, the location had been extensively invaded by introduced shrubs, mainly Guava (*Psidium guajava*) and Ardisia (*Ardisia polycephala*). Much of the marsh has been carefully cleared of these and other invasives, and the area has returned to a condition closely resembling a pre-colonisation peat marsh. To walk in the Palmetto forest of Paget Marsh is a wondrous and uplifting experience, truly stepping back into the past. In 1999, a boardwalk was constructed to allow public access without undue disturbance.

Other Restored Areas

The principles employed at Nonsuch and Paget to entire natural systems have also been applied to parts of other reserves. While re-invasion is faster in such places than in more isolated ones, their unique biological character makes the process worthwhile.

One of the major secondary areas is in the Walsingham Tract. This area on the oldest limestone formation in Bermuda, had eroded over 800,000 years to produce a very rugged topography which held back development. The area is riddled with caves, sink-holes, marine ponds and other fascinating features. Several rare, native and endemic species have survived there including, Lamarck's Trema, Yellow-wood, Southern Hackberry, Bermuda Olivewood, Wild Bermuda Pepper (*Peperomia septentrionalis*), Wild Coffee (*Psychotria ligustrifolia*) and Bermuda Bean (*Phaseolus lignosus*). There are also rare and endemic ferns such as the Bermuda Shield Fern (*Dryopteris bermudiana*) and the Bermuda Maidenhair Fern (*Adiantum bellum*). It was also the habitat of Governor Laffan's Fern (*Diplazium lafanianum*) now existing as only 4 or 5 specimens at the Bermuda Botanical Gardens. Two areas selected in 1978 have been partially cleared of invasives but much remains to be accomplished there.

The Spittal Pond Nature Reserve has also had areas partially cleared, and it is hoped that an early start can be made on the face of Abbott's Cliff in Harrington Sound, where up until recently the majority of the flora was either native or endemic

It must be appreciated that restoration of these areas is very labour-intensive and not without hazard. It is amazing that so much has been done so far. Without the dedication of David Wingate and his assistants, we would certainly have lost all that remained of natural land areas.

Plants & Animals Important in Island Ecology

List of Species Mentioned and/or Illustrated in this Guide

Key to Habitat Codes

B = Lagoons, Bays and Coastal Waters	**OC = Open Coastal**
C = Coral Reefs	**R = Rocky Shores**
CA = Caves and Cave Mouths	**S = Sandy Shores**
CL = Cliffs and Steep Rocky Coasts	**SD = Sand Dunes**
EX = Extinct	**SG = Seagrass Beds**
F = Forest	**SP = Saltwater Ponds**
FW = Freshwater Habitats	**U = Urban Environments**
M = Mangrove Swamps and Salt Marshes	**W = Wasteland, Open Spaces, Wayside**
O = Open Ocean	

Note: Common names are listed in the first column except where there is no accepted common name, in these cases the scientific name is used. For each group of organisms, the common names are in alphabetical order. The habitat codes defined in the key show where the organisms are commonly found. The illustrations following the list are in the same order as the list and are also accompanied by habitat codes.

Common Name	Scientific Name	Taxonomy	Habitat Code
Bermuda Sargasso Weed	Sargassum bermudense	Seaweeds - Brown Algae	SP
Heartweed	Halymenia bermudensis	Seaweeds - Red Algae	B, SP
Bermuda Campylopus	Campylopus bermudiana	Mosses	F, FW
Bermuda Trichostoma	Trichostomum bermudanum	Mosses	F, FW, OC, U, W
Bermuda Cave Fern	Ctenitis sloanei	Ferns	CA
Bermuda Maidenhair Fern	Adiantum bellum	Ferns	CA, CL, F, W
Bermuda Shield Fern	Dryopteris bermudiana	Ferns	F, CA
Giant Fern	Acrostichum danaeifolium	Ferns	FW
Governor Laffan's Fern	Diplazium laffanianum	Ferns	EX
Water Fern	Salvinia olfersiana	Ferns	FW
Psilotum	Psilotum nudum	Clubmosses	F, FW
Saw Grass	Cladium jamaicense	Grasses	FW
Seashore Rush Grass	Sporobolus virginicus	Grasses	OC, R
Bermuda Spike Rush	Eleocharis bermudiana	Rushes	FW
Narrow-leaved Cattail	Typha angustifolia	Rushes	FW
Sea Rush	Juncus maritimus	Rushes	M
Bermuda Sedge	Carex bermudiana	Sedges	F
Bermudiana	Sisyrinchium bermudiana	Herbaceous Flowering Plants	OC, U, W
Blodgett's Spurge	Euphorbia blodgetti	Herbaceous Flowering Plants	CL, OC, W
Darrell's Fleabane	Erigeron darrellianus	Herbaceous Flowering Plants	W
Low Cudweed	Gnaphalium viliginosum	Herbaceous Flowering Plants	W
Saltmarsh Oxeye	Borrichia frutescens	Herbaceous Flowering Plants	M
Scurvy Grass or Sea Rocket	Cakile lanceolata	Herbaceous Flowering Plants	S, SD
Sea Lavender	Limonium carolinianum	Herbaceous Flowering Plants	M
Sea Oxeye	Borrichia aborescens	Herbaceous Flowering Plants	OC
Seaside Evening Primrose	Oenothera humifusa	Herbaceous Flowering Plants	SD
Seaside Goldenrod	Solidago sempervirens	Herbaceous Flowering Plants	OC
Seaside Purslane	Sesuvium portulacastrum	Herbaceous Flowering Plants	OC, R
St. Andrew's Cross	Hypericum macrosepalum	Herbaceous Flowering Plants	FW, W
Wild Bermuda Pepper	Peperomia septentrionalis	Herbaceous Flowering Plants	CA, F
Woody Glasswort or Marsh Samphire	Salicornia perennis	Herbaceous Flowering Plants	M
Bay Bean	Canavali lineata	Vines	F, OC, SD
Bermuda Bean	Phaseolus lignosus	Vines	F
Seaside Morning Glory	Ipomoea pes-caprae	Vines	SD
Virginia Creeper	Parthenocissus quinquefolia	Vines	F, FW

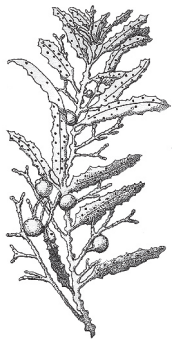
West Indian Cissus	Cissus sicyoides	Vines	F, FW
Bermuda Snowberry	Chiococca bermudiana	Shrubs	F
Jamaica Dogwood	Dodonaea viscosa	Shrubs	F
Poison Ivy	Rhus radicans	Shrubs	F, FW, W
Shrubby Fleabane	Pluchea odorata	Shrubs	F, FW, W
Wax Myrtle	Myrica cerifera	Shrubs	FW, W
Wild Coffee	Psychotria ligustrifolia	Shrubs	F
Allspice	Pimenta dioica	Trees	F
Ardisia	Ardisia polycephala	Trees	F, FW
Bay Grape	Coccoloba uvifera	Trees	F, OC
Bermuda Cedar	Juniperus bermudiana	Trees	F, OC, U, W
Bermuda Olivewood	Cassine laneana	Trees	F, U
Bermuda Palmetto	Sabal bermudana	Trees	F, OC, U
Black Mangrove	Avicennia germinans	Trees	M
Buttonwood	Conocarpus erectus	Trees	M, OC
Casuarina, Australian Whistling Pine or Whispering Pine	Casuarina equisetifolia	Trees	F, OC, W
Chinese Fan Palm or Chinese Fountain Palm	Livistonia chinensis	Trees	F, U, W
Guava	Psidium guajava	Trees	FW, W
Lamarck's Trema	Trema lamarckiana	Trees	F
Papaya or Paw-paw	Carica papaya	Trees	U, W
Red Mangrove	Rhizophora mangle	Trees	M
Southern Hackberry or Hackberry	Celtis laevigata	Trees	F
Yellow-wood	Zanthoxylum flavum	Trees	F
Cicada or Bermuda Singer	Tibicen bermudiana	Insects - Cicadas	EX, F
Bermuda Flightless Grasshopper	Paroxya bemudensis	Insects - Crickets and Grasshoppers	EX
Mediterranean Fruit Fly	Ceratitis capitata	Insects - Flies and Mosquitos	U
Cedar Scale	Carulaspis minima	Insects - Scales	F, W
Oystershell Scale	Insulaspsis pallida	Insects - Scales	F, OC, U
Palmetto Scale	Comstockiella sabalis	Insects - Scales	F, OC, U
Spiny Lobster	Panuliris argus	Crustacea - Lobsters	B, C
Land Crab or Red Land Crab	Gecarcinus lateralis	Crustacea - Crabs	OC
Edible Snail	Otala lactea	Gastropoda - Snails	W
Poecilozonites	Poecilozonites spp.	Gastropoda - Snails	EX, F
Rosy Euglandina or Predaceous Snail	Euglandina rosea	Gastropoda - Snails	F, U, W
West Indian Top Shell	Cittarium pica	Gastropoda - Snails	R
Mosquito Fish	Gambusia holbrooki	Fish - Mosquito Fishes	FW, SP
Bermuda Killifish	Fundulus bermudae	Fish - Killifishes	SP
Bermuda Bream	Diplodus bermudensis	Fish - Chubs and Breams	B
Giant Toad	Bufo marinus	Frogs and Toads - Toads	F, FW, U, W
Bermuda Skink	Eumeces longirostris	Lizards	F, OC
Jamaican Anole	Anolis grahami	Lizards	F, M, U, W
Green Turtle	Chelonia mydas	Turtles and Terrapins - Turtles	B, O, SG
Common Crow	Corvus brachyrhynchos	Birds – Crows and Jays	CL, F, U, W
Great Kiskadee	Pitangus sulphuratus	Birds - Flycatchers	F, U, W
Yellow-crowned Night Heron	Nyctanassa violacea	Birds - Herons	F, M, SP
Cahow or Bermuda Petrel	Pterodroma cahow	Birds - Petrels and Shearwaters	O, OC
House Sparrow	Passer domesticus	Birds - Sparrows	U, W
White-tailed Tropic Bird or Longtail	Phaethon lepturus	Birds - Tropic Birds	B, CL, O
Bermuda White-eyed Vireo or Chick-of-the-village	Vireo griseus bermudianus	Birds - Vireos	F, U
Black Rat	Rattus rattus	Land Mammals	F, U
Brown Rat or Norway Rat	Rattus norvegicus	Land Mammals	F, U

Species Illustrations and Descriptions

Seaweeds

Brown Algae

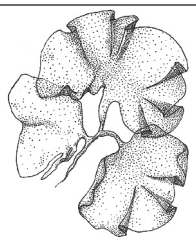
Bermuda Sargasso Weed
Sargassum bermudense
A large seaweed, of which there are at least a dozen different forms, it is often found washed up on the rocky shoreline. Most often free-floating, it has "leafy" branches, often with spine-like projections and spherical float bladders. It commonly harbours small marine animals such as shrimps and crabs. Up to at least 2 m (6 ft) high. **Endemic**.



SP

Red Algae

Heartweed
Halymenia bermudensis
A beautiful bright-red seaweed of quiet waters and saltwater ponds. The fronds are broad and flat and the plant is up to 30 cm (1 ft) across. **Native.**



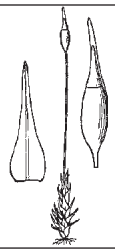
B, SP

Mosses

Bermuda Campylopus
Campylopus bermudiana
A rare moss found at the bases of Bermuda Palmetto trees in Paget Marsh. The moss is dark green in colour, about 6 cm (2.5 in) high and has bunches of leaves along the stem. **Endemic**.

F, FW

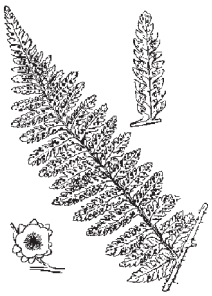
Bermuda Trichostoma
Trichostomum bermudanum
A very common moss only about 2.5 cm (1 in) high, occurring in bright green to yellowish green patches on rocks, walls and in marshes. **Endemic**.



F, FW, OC, U, W

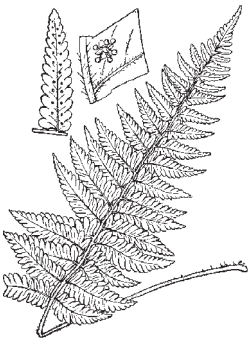
Ferns

Bermuda Cave Fern CA
Ctenitis sloanei
A delicate and now, very rare fern surviving in only a few locations in the Walsingham area. The leaves are twice-pinnate and the leaflets have toothed edges. Rather similar to the Bermuda Shield Fern. Up to 30 cm (1 ft) high. Also found in Florida, where it is called the Florida Tree Fern. **Native.**

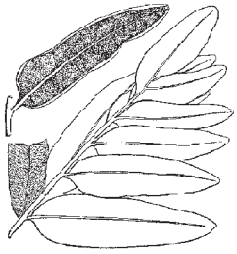


Bermuda Maidenhair Fern CA, CL, F, W
Adiantum bellum
A dainty fern endemic to Bermuda.The leaves are thin and delicate and are divided into fan-shaped leaflets. The stem is black and wiry. This delicate plant varies in size and texture according to the amount of light it receives. It is common throughout the island on shady rocks and walls. Spores are held in clusters on the underside edge of the fan shaped. The leaves are 10-15 cm (4-6 in) long. **Endemic.**

Bermuda Shield Fern F, CA
Dryopteris bermudiana
A very rare endemic fern, once common in the Walsingham and Castle Harbour areas but now on the verge of extinction. This fern has very attractive, twice-pinnate leaves arising in a clump from a compact centre. The leaflets are smooth edged. Dark sporangia appear in rows along the underside of the leaflets. Up to 30 cm (1 ft) high. **Endemic.**

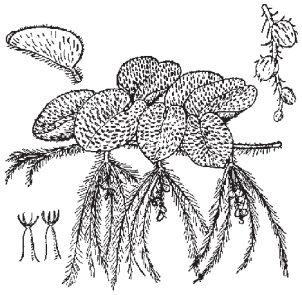


Giant Fern FW
Acrostichum danaeifolium
This is a simply huge fern often growing in near-pure stands of about 2.6 m (8 ft) in height. The leaves are fairly simple and leathery. Common around the edge of Paget Marsh and in N. Devonshire Marsh. **Native**.



Governor Laffan's Fern EX
Diplazium laffanianum
Extirpated from the wild by 1905 and now only exists in captivity. It is a medium sized fern of shaded cave mouths. The pinnae (small leaflets) are toothed and oval in shape. Up to 25 cm (10 in) high. **Endemic.**

Water Fern FW
Salvinia olfersiana
The only floating water fern. This species is quite small with several simple leaves about 1 cm (3/8 in) long from a central stem creeping along the water surface. Short roots hang down into the water. Droplets on the leaves often shine in the sun. **Naturalised**.



Clubmosses

Psilotum F, FW
Psilotum nudum
Psilotom is an exceedingly interesting plant of great antiquity. Psilotum is a small, stiff, leafless plant with green stems, Not common except in Paget Marsh. About 15-20 cm (6-8 in) high. **Native.**

Grasses

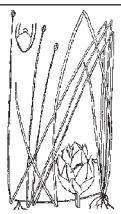
Saw Grass FW
Cladium jamaicense
A very large grass which can form large, dense stands. It has long leaves with saw-tooth edges which give it its name. It is the only marsh grass to show this feature. The flower is a diffuse spray. 1-3m (3-9ft) high. **Native.**

Seashore Rush Grass
Sporobolus virginicus
This is a fairly low trailing grass of partly salty places. The stems are stout, firm and scaly rising above the soil. The narrow 4 mm (1/8 in) wide leaves are numerous, and their basal sheaths overlap. About 40 cm (15 in) high. **Native.**

OC, R

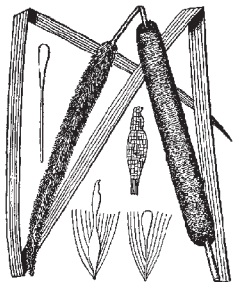
Rushes

Bermuda Spike Rush
Eleocharis bermudiana
A small rush with small, rounded, flower heads. The Bermuda Spike Rush lives in marshes and is extremely rare. 15 cm (6 in) high. **Endemic.**



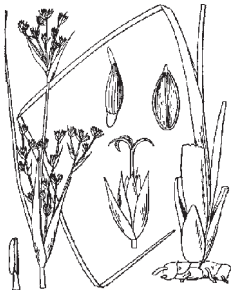
FW

Narrow-leaved Cattail
Typha angustifolia
A well known rush 1.3-2.5 m (4-10 ft) tall. The flowering stems are very characteristic with a very large, dark-brown, compact, club-shaped flower up to 15 cm (10 in) long and long strap-shaped leaves. In quite wet places and often forming large, virtually pure stands. **Native**.



FW

Sea Rush
Juncus maritimus
Common in eastern North America but confined to a few locations in Bermuda. Most easily observed at the East end of Spittal Pond. This rush has spiky, round, hollow leaves up to about 1 m (3 ft) high in dense clumps. The flowers are in inconspicuous greenish sprays. **Native**.



M

Sedges

Bermuda Sedge
Carex bermudiana
This sedge has triangular stems and flat leaves as long as the stems. Fertile stems have several compact flower clusters at the tip. 50-85 cm (1.5-2.5 ft) high. Endemic**. Native**.

F

Herbaceous Flowering Plants

Bermudiana
Sisyrinchium bermudiana
Often called the National Flower of Bermuda, Bermudiana grows from a bulb and bears blue flowers in spring. The plant has strap-like leaves. Very common. 15-30 cm (6-12 in) high. **Endemic.**

OC, U, W

Blodgett's Spurge
Euphorbia blodgettii
This is a small, tough plant that grows almost in contact with the ground, never rising more than a few millimeters (1/8 in), however, it may spread at least 20 cm (8 in). The leaves are small and rounded, well spaced out along the branching stem. The flowers are small and insignificant. **Native.**

CL, OC, W

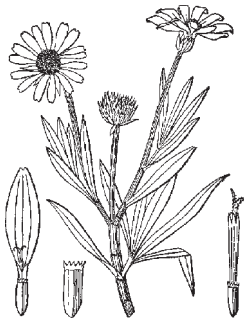
Darrell's Fleabane
Erigeron darrellianus
Darrell's Fleabane is a shrubby, perennial plant. In spring it is covered with masses of tiny daisy-like flowers. The flowers are white with yellow centers. The leaves are spear shaped with toothed edges. The lower leaves grow from 3 to 5 inches. This plant is named for Mr. J. K. Darrell. Grows from 30 cm to 1.5 m (1-4 1/2 ft) high. **Endemic.**

W

Low Cudweed
Gnaphalium viliginosum
A plant with greyish-green leaves and small globular, yellow flowers in spring. Likes sandy locations. 30 cm (1ft) high. **Introduced**.

W

Saltmarsh Oxeye
Borrichia frutescens
A herb with thick, fleshy leaves and stout stems. It occurs in salt-marshes and the back of mangrove swamps. The flowers are daisy-like and yellow about 2.5 cm (1 in) across. The outer whorl of petals is somewhat irregular, with occasional gaps. Up to 1.5 m (4.5 ft) high. **Native.**

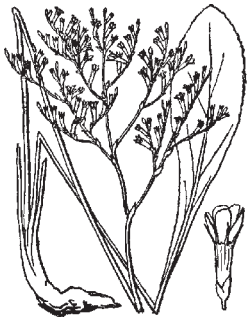


M

Scurvy Grass or **Sea Rocket**
Cakile lanceolata
This is a fleshy plant most typical of the strand-line of sandy shores, but also occurring in mangrove swamps and salt-marshes. The plant grows up to 70 cm (24 in) high. The 2-7 cm (1-2 1/2 in) long leaves are somewhat dished and the edges wavy. The 4-petalled flowers are white in a terminal spike. **Native**.

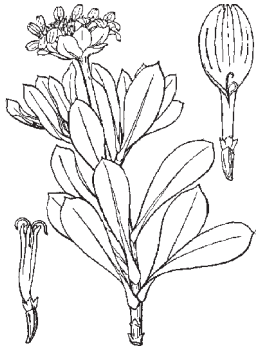
S

Sea Lavender
Limonium carolinianum
This rare salt-marsh plant has a basal rosette of leaves up to 15 cm (6 in) long which taper very gradually away from the base and then become broad near to the tip. The tall flower has small but pretty blue flowers arranged along vertical thin stalks. About 30-60 cm (12-24 in) high when in flower. **Native**.



M

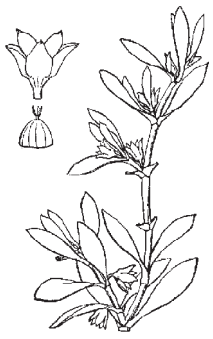
Sea Oxeye OC
Borrichia arborescens
Also native, the sea oxeye is a shrubby herb seen very commonly along Bermuda's rocky shoreline. It is variable in height, sometimes growing low to the ground and sometimes reaching 1.5 m (4 ft) or so in height. The colour of its leaves can also vary between grey and green, often on the same plant. It bears single, yellow, daisy-like flowers at the top of the stem, throughout most of the year. **Native.**



Seaside Evening Primrose S, SD
Oenothera humifusa
This native grows mostly along the ground in sunny areas. Its yellow flowers turn pinkish-maroon by the end of the day, and bloom during summer and autumn. About 20 cm (8 in) high. **Native.**

Seaside Goldenrod OC
Solidago sempervirens
This herbaceous plant has an exceedingly wide geographic distribution and occupies a wide range of habitats. The stem is stout with the long leaves closely arranged around the stem. The stem is crowned by a long flower head with very numerous, small yellow flowers, each daisy-like in appearance. Flowers in summer and autumn. About 70-100 cm (2-3 ft) high. **Native.**

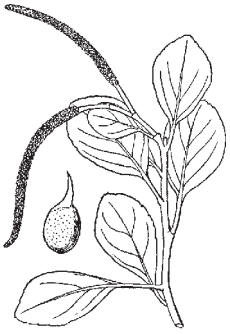
Seaside Purslane OC, R
Sesuvium portulacastrum
Seaside Purslane has a fleshy, creeping stem on which very fleshy leaves are borne in opposite pairs. The whole plant rises no more than about 5 cm (2 in) above the ground. The blunt-tipped leaves are broadest about 2/3 of the way along and are often tinged with a reddish colour. The pretty flowers are solitary and pink. Frequent at the backs of mangrove swamps. **Native.**



St. Andrew's Cross
Hypericum macrosepalum
Plant about 45-70 cm (18-24 in) high. Leaves narrow and without stalks, arising in whorls from the stem. Flowers single, showy and yellow, about 1.5 cm (3/4 in) across, with 4 petals. Rare. **Endemic**.

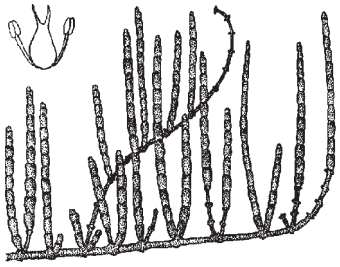
FW, W

Wild Bermuda Pepper
Peperomia septentrionalis
This plant lives in shaded areas and cave mouths. It is only locally common. It has rather fleshy leaves broadest close to the tip but with a slight indentation there. The flower spike is very characteristic, being brown and pencil shaped with very minute blossoms. About 15 cm (6 in) high. **Endemic.**



CA, F

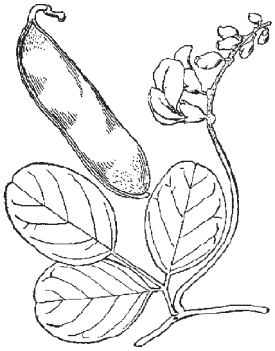
Woody Glasswort or **Marsh Samphire**
Salicornia perennis
This most interesting plant of the backs of mangrove swamps is often called samphire and is quite edible. The plant is leafless but the stalks are fleshy and green and rise up to about 50 cm (18 in) above the mud. The flowers are minute. **Native.**



M

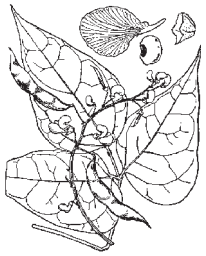
Vines

Bay Bean
Canavali lineata
This is easily confused with seaside morning glory when it is not in bloom. It has rounded leathery leaves which grow on little branches, in threes, along the vine. Its flowers, which look like miniature purple sweet peas, can be seen in the autumn and winter. Wide pods can be seen on the vine all year. It has the capacity for rapid vertical and horizontal growth so it can deal with the problem of shifting sand. The vine may grow as long as 7.5 m (25 ft). **Native**.



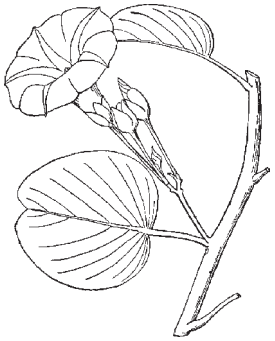
F, OC, SD

Bermuda Bean
Phaseolus lignosus
The Bermuda Bean is now rare, but was once very common. The flowers are pea-like and vary from yellow to blue. The leaves are heart-shaped with a sharp tip. It is a vine up to 3.2 m (10 ft) long. **Endemic.**



F

Seaside Morning Glory
Ipomoea pes-caprae
As Seaside Morning Glory is able to grow horizontally and vertically it can escape from being buried by shifting sand. This native vine has leaves which are rounded at the base and notched at the tip. Its purple-mauve flowers can be seen during the summer and autumn. (The bay bean's leaves are similar and often confused.) Up to 10 m (30 ft) long. **Native.**



SD

Virginia Creeper
Parthenocissus quinquefolia
A tall-growing clinging vine. Easily recognised by the vine habit and the leaves with five prominent leaflets. The leaves turn red in autumn. Common in swamps. Up to at least 10 m (30 ft) high. **Native.**

F, FW

West Indian Cissus
Cissus sicyoides
A tall, clinging vine of the swamps and marshes. May completely cover small trees with its foliage. It has characteristic heart-shaped, shiny, light green leaves about 6 cm (2.5 in) long. Up to 7 m (20 ft) high. **Native.**

F, FW

Shrubs

Bermuda Snowberry F
Chiococca bermudiana
A sprawling shrub that normally grows to two meters (six feet) but Bermuda Snowberry is sometimes vine-like and branches can grow up to 5 m (10 ft) long. It has shiny leathery leaves 5-10 cm (2-4 in) long. The leaves are shaped like an oval that is pointed on both ends. They grow opposite one another on the stem. Sprays of small yellow bell flowers appear in autumn and develop into pure white berries. Up to 2 m (6 ft) high. **Native.**

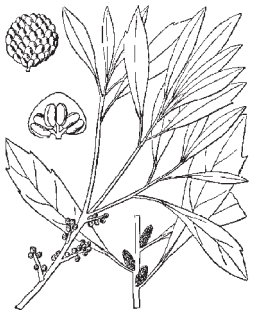
Jamaica Dogwood F
Dodonaea viscosa
A shrub whose bark on the trunk is a reddish brown and it has string like strips. The yellow green leaves are lance like to 12 cm (4 3/4 in) long. They are rough textured with distinctive veins, particularly the central vein. The stems of the leaves are angular. The flowers are tiny and grow on short spikes. Pinkish-brown papery fruit made up of three capsules or segments produce winged seeds. This plant is sticky. About 2 m (6 ft) tall. **Native.**

Poison Ivy F, FW, W
Rhus radicans
This nasty little shrub or low vine, up to 1 m (3 ft) high is common both in swamps and marshes and also occurs at the back of mangrove swamps and around ponds. The three-lobed leaves are shiny, but varied in shades of green, and sometimes exude a black liquid. The whole leaf is about 7-10 cm (3-4 in) across. About 1 m (3 ft) high. Very poisonous. **Probably native**.

Shrubby Fleabane
Pluchea odorata
This is an aptly named shrub with typical fleabane character. The leaves are oblong from 8-16 cm (3-6 in) long. White flowers are small and daisylike. Numerous flowers are arranged in flat topped clusters. Growing from 1-2.5 m (3-8 ft) tall. **Native.**

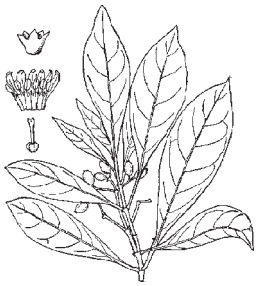
F, FW, W

Wax Myrtle
Myrica cerifera
Wax Myrtle is a large shrub that may form almost pure stands in some marsh-swamp habitats, such as parts of Devonshire Marsh. The leaves are quite long, pointed at the end, with 2-3 large teeth on the outer part of each leaf-edge, and leathery in texture. The flowers are rather inconspicuous. Up to 6.5 m (20 ft) high. **Native.**



FW, W

Wild Coffee
Psychotria ligustrifolia
This is a rare shrub growing in woodland. It flowers in spring and then bears bright red fruits. The leaves are elongate and pointed without marginal teeth. The leaves leave prominent leaf scars on the stem when they are shed. Up to about 1.5 m (5 ft) in height. **Native**.



F

Trees

Allspice
Pimenta dioica
Allspice is a tree. The leaves are narrow oblong or slightly lance shaped, approximately 10 cm (6 in) long. They are leathery and shiny. When crushed they produce the fragrant smell of allspice. The small white flowers are produced in broad flat-topped clusters. They are followed by green berries which turn black when ripe. The green berries are dried and ground to make the culinary allspice. The bark has a mottled olive-green and tan appearance, like camouflage. Growing up to 13 m (40 ft) high. **Introduced** and **naturalized**.

F

Ardisia F, FW

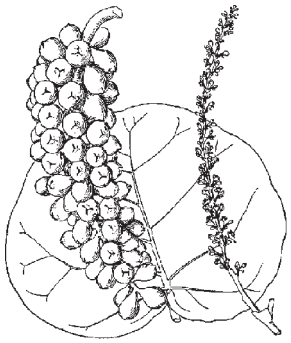
Ardisia polycephala

An invading shrub of the swamp-forests. The leaves are 10-15 cm (4-6 in) long and pointed. The greenish-purple flowers are in flat groups at the end of branches or on side shoots. Up to about 3-3.5 m (9-10 ft) high. **Introduced.**

Bay Grape F, OC

Coccoloba uvifera

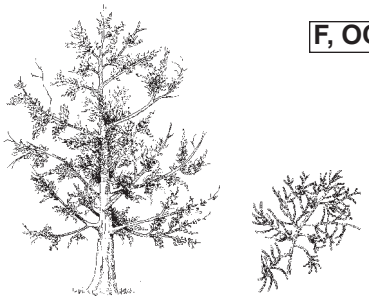
Commonly found either as a large shrub or a tree, this native plant has a short, twisted trunk and large rounded leathery leaves, highly resistant to salt spray. The flowers are borne on long spikes from spring to autumn and are tiny and whitish in colour. The fruit that follow resemble grapes in size and colour and are often used in jams and jellies. Variable in height 2-18 m (6-18 ft). **Native.**



Bermuda Cedar F, OC, U, W

Juniperus bermudiana

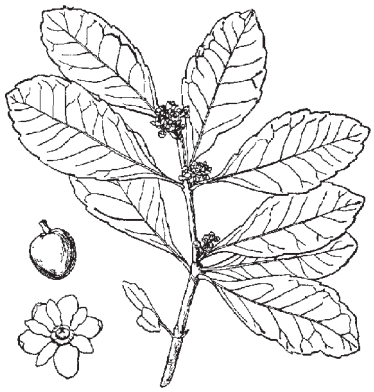
Bermuda Cedar was a dominant upland tree when the islands were colonised but has since been decimated by exploitation and insect damage. The wood is highly aromatic. Cedar is a large tree with scale-like foliage and purple-black berries. Up to 13 m (40 ft) high. **Endemic.**



Bermuda Olivewood F, U

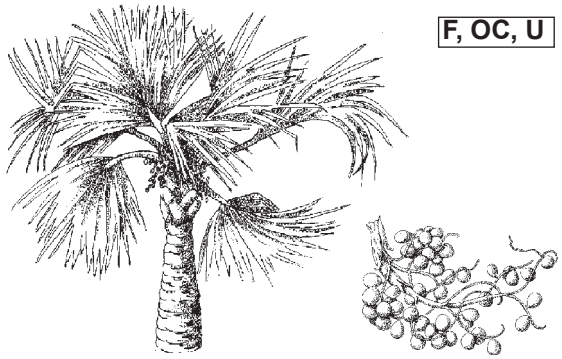
Cassine laneana

An endemic tree. Compact and oval when young. The mature leaves are dark green and somewhat leathery. They are slightly toothed. The edges of the leaf are rolled toward the underside. The leaves are egg shaped with the broader end above the middle of the leaf. The young leaves are a light yellowish-green, contrasting with the dark green older foliage. Small greenish or white flowers are either male or female and grow in clusters. The female flowers produce a fleshy yellowish, olive-shaped fruit about an inch long. The bark was used for tanning in the early days of Bermuda. Can grow to 10 m (30 ft) tall. **Endemic.**



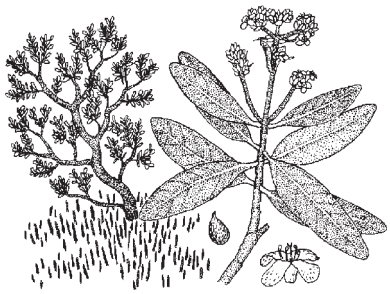
Bermuda Palmetto
Sabal bermudana
Bemuda Palmettos were once the dominant lowland tree of Bermuda. They have been exploited quite heavily in the past and are out-competed by some introduced fan-palms. The trunks are stout with numerous leaf-scars and the fan-shaped fronds emerge in a mass from the top. Fruit black in large clusters. Up to 8.5 m (25 ft) high. **Endemic.**

F, OC, U



Black Mangrove
Avicennia germinans
The characteristic tree of the back of mangrove swamps. The size is very variable but it can be a big tree. The trunk is scaly black and the leaves a leathery elongate oval, blunt at the tip and a greyish-green in colour. A definitive diagnostic character are the pencil-like pneumatophores or air breathing roots, rising out of the sediment. Up to 17 m (50 ft) high. **Native.**

M

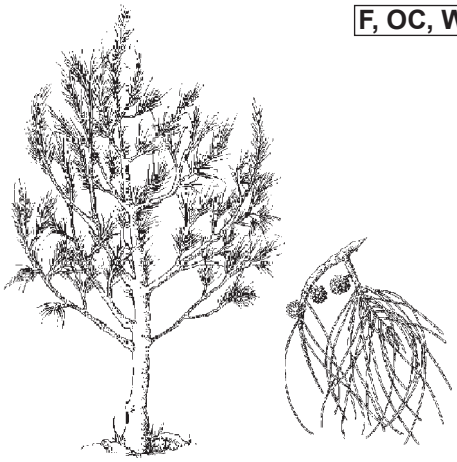


Buttonwood
Conocarpus erectus
A tree which does not live up to its “erectus” name since some specimens in exposed places are sprawling or even ground hugging. A tree of very varied height. Sometimes considered a mangrove, it is common as the rear tree of mangrove swamps or forming fringing stands along sheltered coasts. The leaves are oval, fairly broad and leathery and have two little keels on either side of the leaf stalk. The flowers are white fuzz-balls and the fruit small cone-like structures, turning red when mature. Height from a few cm (in) to 6.5 m (20 ft). **Native.**

M, OC

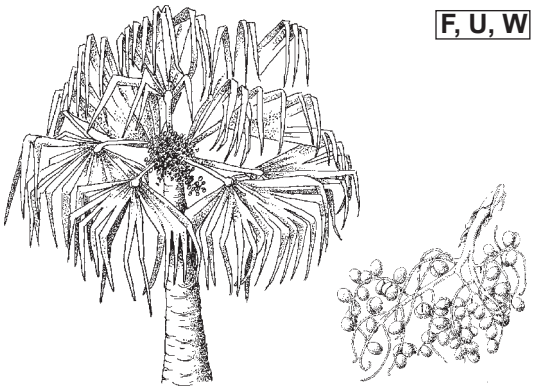
Casuarina, Australian Whistling Pine
or **Whispering Pine**
Casuarina equisetifolia
Casuarina is a shallow rooted tree. It resembles a conifer but the "pine needles" are segmented branchlets about 1 cm.(3/8 in) long with tiny leaf scales appearing at the segments. The branchlets appear in sprays. There are separate male and female flowers. The female flowers produce a prickly cone with tiny winged seeds. This fast growing tree was planted in large numbers during the 1940s, following the Bermuda Cedar blight. Grows from 10-25 m (30 to 80 ft) high. **Introduced.**

F, OC, W



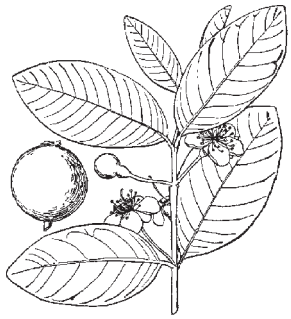
Chinese Fan Palm or **Chinese Fountain Palm**
Livistonia chinensis
This fan palm has leaf stalks that are toothed toward the base. The large leaf blade has prominent accordion pleats. The leaves droop producing a fountain-like effect. Flowers are produced in clusters of up to 6. The resulting fruit are blue-green, egg shaped and are nearly 2.5 cm (1 in) long. The pulp of the fruit is an intense orange. Growing up to 10 m (30 ft) or more high. **Introduced.**

F, U, W



Guava
Psidium guajava
An evergreen shrub or small tree with blunt, oval leaves 6 cm (2.5 in) long. The yellow fruits are spherical and about 1.5 in (3.5 cm) across. A useful identification feature is that the bark sheds in patches, leaving areas of varying colour on the trunk. Up to 10 m (30 ft) high. **Introduced.**

FW, W

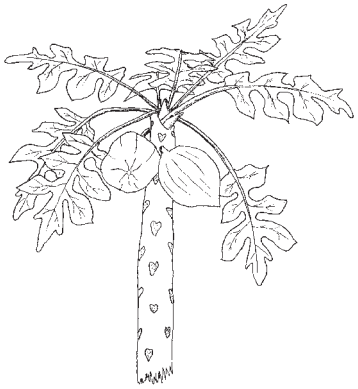


Lamarck's Trema
Trema lamarckiana
A small tree with a rather straggly growth form. Rare now but formerly much more common. Up to about 3 m (9 ft) in height. **Native.**

F

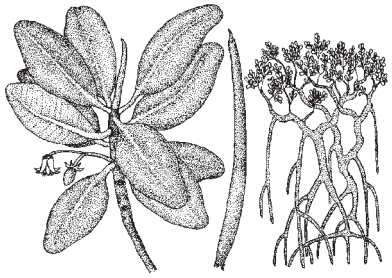
Papaya or **Paw-paw**
Carica papaya
This small tree with edible fruit originated in Columbia. The trunk is thick but not hard and shows prominent leaf-scars from dropped leaves. The leaves, in a clump at the top of the trunk, are very distinctive being large with seven lobes. Male and female trees are separate. The large fruit can be eaten green as a vegetable or when ripe and yellow as a fruit. Up to about 7 m (23 ft) high. Naturalised widely. **Introduced.**

U, W



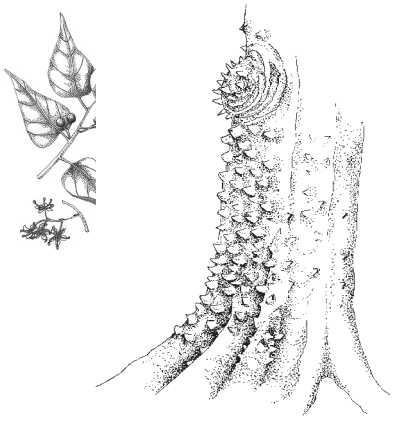
Red Mangrove
Rhizophora mangle
This is the most highly adapted of the Bermuda mangroves to a salt-water existence. The diagnostic feature are the wide-spreading prop roots arching into the water. Adventitious roots dropping from the branches are also present. The leaves are dark green, large, broad and shiny; the flowers are yellowish-white and fragrant. A second unique feature is the large embryos. Commonly 3-5 m (15-25 ft) high but it can be much larger. **Native.**

M



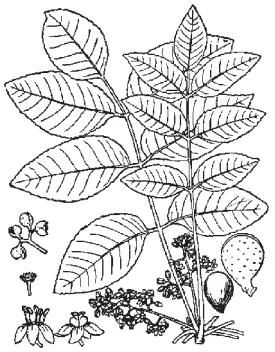
Southern Hackberry or **Hackberry**
Celtis laevigata
A deciduous tree with thin, pale green, spear like, rough textured leaves which are alternate on the stem and grow up to 10 cm (4 in) long. The flowers are small and greenish. They produce small orange-red fruit that ripen to dark purple. Hackberry is fairly uncommon but can be found in Walsingham and small pockets of upland forest. The bark can have a warty appearance. Southern Hackberry spreads by root suckers. Grows to 13 m (40 ft) high. **Native.**

F



Yellow-wood
Zanthoxylum flavum
Yellow-wood trees were common in the upland forests when Bermuda was colonised. They form beautiful, robust trees that have wood that was highly prized for furniture making. Sadly, now only a handful of these trees survive and young ones are not found. They need special protection. The tree has nice compound leaves. The clusters of white flowers are followed by purplish-black berries. Up to 13 m (40 ft) high. **Native.**

F

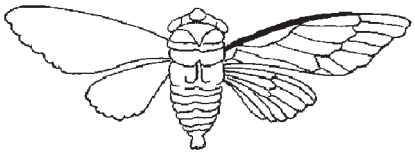


Insects

Cicadas

Cicada or **Bermuda Singer**
Tibicen bermudiana
One of the earliest insects recorded from Bermuda, being mentioned by Butler in 1691 as the "good housewife" by virtue of the sound they make like the whirring of a spindle. Singers were formerly widespread and common. Numbers dropped dramatically in the 1950s after the blight on the cedar trees and the introduction of the Kiskadee. The Cicada nymphs feed on the root of the Bermuda Cedar during their seven-year larval period. It is also thought that the Kiskadee has been a major predator of the cicada. 3 cm (1 1/4 in) long. **Extinct.**

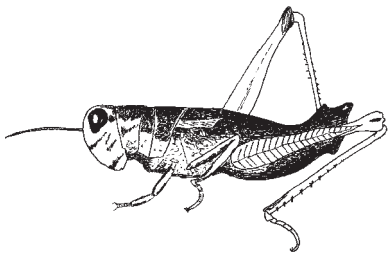
EX, F



Crickets and Grasshoppers

Bermuda Flightless Grasshopper
Paroxya bermudensis
This grasshopper is of typical grasshopper form except that in the adult, the wings are useless stubs. It could still, however, move around by jumping. It fed on a variety of vegetation. Up to 5 cm (2 in) long. **Extinct**.

EX



Flies and Mosquitos

Mediterranean Fruit Fly
Ceratitis capitata
A small fly; a pest of fruit crops. Now extirpated. 9 mm (3/8 in) long. **Introduced.**

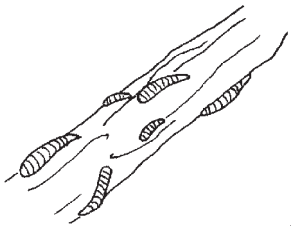
U

Scales

Cedar Scale F, W
Carulaspis minima
This tiny pest species was first found in 1945, and eventually resulted in the death of over 90% of the Bermuda Cedars. It is an inconspicuous flattened insect adhering tightly to cedar leaves. 3 mm (1/8 in) long. **Introduced.**

Oystershell Scale F, OC, U
Insulaspis pallida
A tiny insect with an elongated larva, found on Bermuda Cedars. 3mm (1/8 inch) long. **Introduced**.

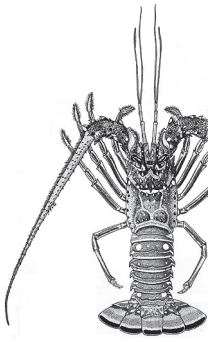
Palmetto Scale F, OC, U
Comstockiella sabalis
This scale attacks the Bermuda Palmetto. The scale was first recorded in 1921 when it was restricted to the eastern end of Bermuda; by 1933 it had spread throughout the islands. About 4 mm (1/6 in) long. **Introduced**.



Crustacea

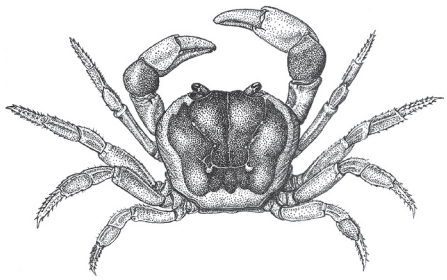
Lobsters

Spiny Lobster B, C
Panulirus argus
The Spiny Lobster is the main lobster fished for food in Bermuda and the Caribbean. Living in crevices and caves within the reefs, it emerges at night to feed on a wide variety of food. These lobsters can measure up to 50 cm (1.5 ft) or more in length. They have no large claws but do have long, robust antennae. The colour is reddish brown. **Native**.



Crabs

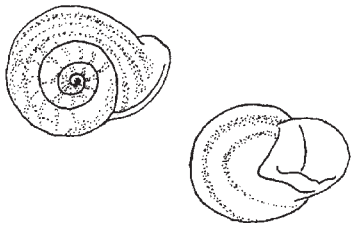
Land Crab or **Red Land Crab** OC
Gecarcinus lateralis
The most common land crab in Bermuda, this species inhabits burrows in the treed and grassy areas of the shoreline. The carapace is oval in shape, wider rather than long. It is coloured dark, reddish brown. The chelipeds are red or purple and are large and unequal in the male. The legs are paler and narrow at the tips, making them unsuitable for swimming. To 4.5 cm. **Native**.



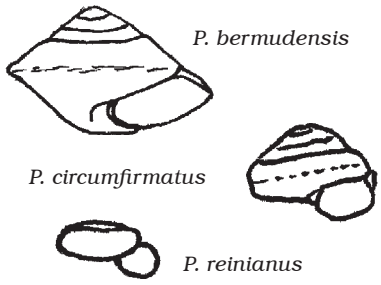
Gastropoda

Snails

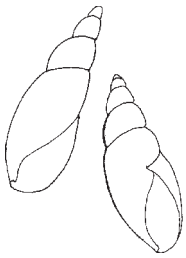
Edible Snail W
Otala lactea
A serious garden pest which is now found island-wide. It is one of the edible snails of Europe, recognized by its large size (diam. 4 cm) and brown and white spiral bands which vary in width and darkness with habitat. The thick shell has a lip at the aperture in mature snails; dark brown columella, and a low spire. Up to 3 cm (1 1/4 in) in diameter. **Introduced.**



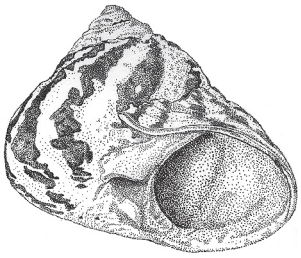
Poecilozonites F, EX
Poecilozonites spp.
This snail, unique to Bermuda, evolved into 15 species, most of which subsequently died out during high stands of interglacial seas. Living specimens of three *(P. reinianus , P. circumfirmatus* and *P. bermudensis)* were collected by well-known biologist Stephen Gould in 1969; however, however only *P. circumfirmatus* have been reliably observed since then. Varied in size. 5 mm to 6 cm (3/16-2 1/2 in). **Endemic** or **Extinct.**



Rosy Euglandina or **Predaceous Snail** F, U, W
Euglandina rosea
Introduced from Cuba as a biological control of the Edible Snail *Otala lactea*, it is carnivorous and common in the inland forest. The adult has a pale pink shell which is translucent in younger specimens. Up to 5 cm (2 in) long. **Introduced**.



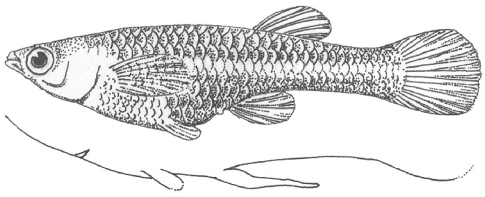
West Indian Top Shell R
Cittarium pica
This is the largest Bermudian marine snail. It has a checkered black and white shell and may reach at least 10 cm (4 in) across. Extirpated then recently re-introduced and now doing well. Up to 12 cm (5 in) in diameter. **Native**.



Fish

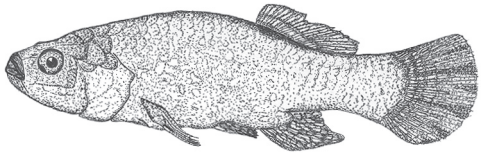
Mosquito Fishes

Mosquito Fish FW, SP
Gambusia holbrooki
A tiny but important fish. Mosquito Fish can live in water of very poor quality because they are able to breathe atmospheric air. Introduced to control mosquitos. They are in virtually all ponds and ditches and mass at the surface when water quality is very bad. Often called "Guppies" they can grow up to 7 cm (2.5 in) long but are commonly only half this length. Female above, male below. **Introduced.**



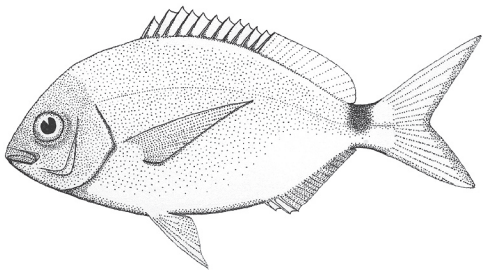
Killifishes

Bermuda Killifish SP
Fundulus bermudae
The Killifish is a small fish up to about 4 in (10 cm) in length. The colour varies from light brown to pale greenish-yellow. The body is rather cylindrical in shape and the tail rounded. Very common in saltwater ponds. **Endemic**.



Chubs and Breams

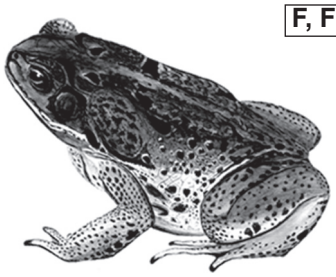
Bermuda Bream B
Diplodus bermudensis
The Bermuda Bream is similar to but smaller than the Bermuda Chub growing to 40 cm (16 in). Bermuda Bream have relatively small heads and eyes, and are a dull silvery-grey in colour. The Bermuda Bream and the Bermuda Chub are easily told apart by the presence on the Bermuda Bream of a large dark spot, just above the base of the tail. **Endemic.**



Frogs and Toads

Toads

Giant Toad F, FW, U, W
Bufo marinus
The Giant Toad can be quite large measuring up to 23 cm (9 in) long. It is brown with darker blotches and has poison secreting glands behind the head. The only amphibian that can stand quite salt water. Breeds in ponds but lives in a wide variety of habitats. **Introduced**.



Lizards

Bermuda Skink F, OC
Eumeces longirostris
This is the only non-introduced lizard in Bermuda. It is now endangered being reduced to a few small populations mostly along the south shore. This is a small, rather stiff lizard with short legs and clawed feet. Blunt-nosed and dark greyish-brown except for mature adults which have a reddish throat. Length 15-20 cm (6-8 in). **Endemic.**

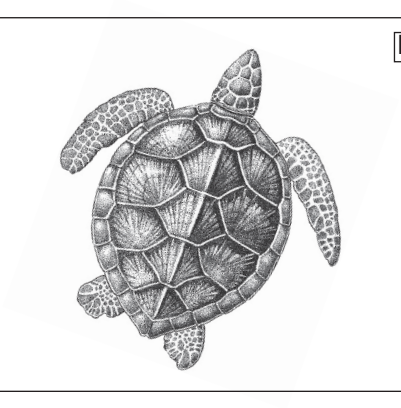
Jamaican Anole F, M, U, W
Anolis grahami
The common lizard of Bermuda. The colour is a blueish green but some males are a chocolate brown. In virtually all habitats. The length with tail is up to about 17 cm (7 in). **Introduced.**

Turtles and Terrapins

Turtles

Green Turtle
Chelonia mydas
The Green Turtle is the commonest of the marine turtles seen in Bermuda and used to breed here. Up to at least 1 m (3 ft) long, they may be any shade of colour between dull, dark green and virtually black. The adults feed on sea-grasses and seaweeds and the occasional sessile invertebrate. Always present in Walsingham Pond and occasionally seen in others. **Native**.

B, O, SG



Birds

Crows and Jays

Common Crow
Corvus brachyrhynchos
This bird is black everywhere, feathers, beak, legs and eyes. The Common Crow is one of the largest common birds in Bermuda, up to 45 cm (18 in) in length. They are considered among the most intelligent of birds. Common Crows were introduced to Bermuda and rapidly became naturalised, they are considered a pest species and are not protected. **Introduced**.

CL, F, U, W

Flycatchers

Great Kiskadee
Pitangus sulphuratus
This is a large, basically yellow flycatcher with a black and white striped head and a raucous call. It is 27 cm (10 1/2 in) long and has a broad black beak. The back is browner than the underparts. **Introduced** to control lizards.

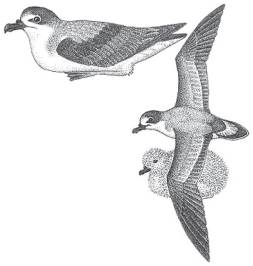
F, U, W

Herons

Yellow-crowned Night Heron F, M, SP
Nyctanassa violacea
A rather small heron. The adult is slate-grey with a black head capped with a yellowish crown and plumes. The beak is black and the legs yellow to orange. Has become very common after its introduction in 1976-8. Eats mainly land crabs. 56-69 cm (22-27 in) long. **Introduced**.

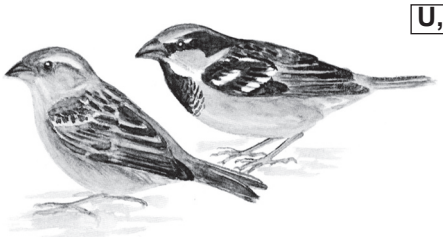
Petrels and Shearwaters

Cahow or **Bermuda Petrel** O, OC
Pterodroma cahow
This bird is endemic to Bermuda where it breeds on islands in the southeast. Most of its life is spent at sea where it feeds on near-surface plankton. This bird is rarely, if ever, observed over the ocean. 38 cm (15 in) long. **Endemic**.



Sparrows

House Sparrow U, W
Passer domesticus
An introduced sparrow which is really a weaver finch. This bird is common from the artic to sub-tropics virtually everywhere where man has colonized. A patchy red-brown in colour, 15-18 cm (6-7 in) long. **Naturalized**.



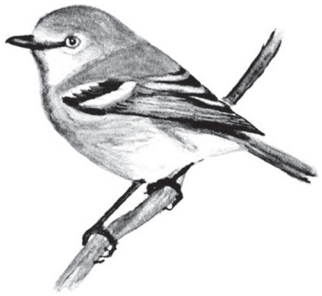
Tropic Birds

White-tailed Tropic Bird or **Longtail** B, CL, O
Phaethon lepturus
The Longtail or White-tailed Tropic Bird is a summer breeder in Bermuda. It nests in holes in the cliffs and suffers competition from Rock Doves and predation from rats. The distinctive feature of this bird is the extremely long and graceful tail feathers. The wingspan is about 90 cm (3 ft). **Native.**

Vireos

F, U

Bermuda White-eyed Vireo or
Chick-of-the-village
Vireo griseus bermudianus
The "Chick of the Village" is a small vireo measuring 13 cm (5 in) long. It is olive green above and white below with yellow sides. The adult has a white eye but more distinctive is the yellow eye-ring and double wing-bar. The Bermuda sub-species is **endemic.**



Land Mammals

F, U

Black Rat
Rattus rattus
The species is said to have been introduced into Bermuda on a captured Spanish grain ship towed into St. Georges by the privateer Frith in 1613. Blackish-grey in colour, the tail is always longer than the body. The eyes and ears are relatively large and the nose pointed. Adult body size, 17-23 cm (7-9 in). **Introduced.**

F, U

Brown Rat or **Norway Rat**
Rattus norvegicus
The Norway rat probably reached the island on ships about the mid 18th Century. The tail is always shorter than the body and the nose blunt. Eyes and ears are relatively small. The pelt is rough and brownish and the underside grey. Adult body size, 20-28 cm (8-11 in). **Introduced**.

Field Trips

General Notes

This set of field trips is designed so that you can observe as far as is possible the principles of island ecology. They will concentrate on native and endemic animals and plants, extinction and the effect of man. In all cases it must be remembered that many aspects of these subjects are now historic and cannot be seen first hand. This makes it vital that students have read this guide before attempting any field work. Additional reading from the sources given in the bibliography is encouraged. It would also be helpful to have a working knowledge of forest and wetland systems in Bermuda. Two other Project Nature Field Guides will help with this. They are "The Bermuda Forests" and "Bermuda's Wetlands". Having a few copies of these other guides along on field trips will help in the identification of many animals and plants not illustrated here.

These field trips are not in hazardous locations but it is always possible that a student will touch poison ivy or get a minor cut or abrasion. Isopropyl rubbing alcohol will be effective against Poison Ivy (*Rhus radicans*) contact and can cleanse scrapes; it should be taken along on each trip as should a good first aid kit. A cellular telephone is not essential but is a good idea in case you need to contact someone while in the field.

It is strongly advised that teachers visit the field trip site before they actually take a class there. This will allow you to plan the trip more effectively and to keep students away from possible hazards. If the class size is large, several supervising staff members will be needed.

While in this series of field guides we have tried to illustrate the plants referred to in the text, we cannot possibly show pictures of all those that will be encountered on field trips. The best source of pictures for the identification of plants is Christine Phillips-Watlington's "Bermuda's Botanical Wonderland". It would be a good idea to have one along on all these field trips. If your school library does not have a copy, request one. Several of the field trips include coastal locations for which the book "Seashore Plants and Seaweeds" by Wolfgang Sterrer and A. Ralph Cavaliere and published by the Bermuda Zoological Society and the Natural History Museum will be a good aid. Seashore animals are covered in the Project Nature Field Guide to Rocky Shores.

Field Trip # 1, General Island Ecology

Preparation. Read this field guide and if possible look at two other Project Nature Field Guides, "Bermuda's Wetlands" and "The Bermuda Forests".

Equipment. As many copies of "Oceanic Island Ecology of Bermuda" (Project Nature) as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands". Clip board and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. A bottle of isopropyl rubbing alcohol and paper towel for the group.

Dress. Wear long pants and sturdy footwear.

Location. Several locations are possible for this field trip. Parks are suggested because they provide plenty of space and have washroom facilities. Parks that have coastline as well as open and wooded areas are the best. Excellent parks are as follows; Lagoon Park, Fort Scaur, Hog Bay Park, South Shore Park, Astwood Park, Spanish Point Park, Spittal Pond, Blue Hole Park, Coney Island and Ferry Point Park

Observations

1. First look at the area in general and learn its typical and unusual features. Does it have sandy shore, rocky shore, a coastal area, open ground, woodlands, hills, valleys etc?

2. List as many **habitats** as you can find. Note that a habitat is a distinct area supporting living things that can have both physical (e.g. rock) and biological (e.g. shrubs) components.

3. In one habitat find a **microhabitat** and describe it. A microhabitat is a tiny habitat, such as under a rock, in a crevice or under leaves.

4. Look for as many different living things (species) as you can see. Make a table with the species in a column at the left and additional columns headed: type of organism; habitat; endemic, native, introduced or naturalised; abundance; and comments. Under type of organism state whether it is a tree, shrub, fern, invertebrate, bird etc. The next column requires some advance knowledge gained from this or other field guides or your teacher. Under abundance write whether it is abundant, common, frequent, uncommon or rare. The comments is for your own special observations, for example is the organism in good condition or stressed in some way? Does this organism support others, as food, shelter, nest site etc.?

   This is the main part of this field trip, spend plenty of time on it, explore different parts of the area and use the binoculars to look beyond the foreground and to identify things such as birds that could go away if approached.

   The longer your list of species and the more completely the table is filled in the better.

5. Think about this situation. How much of it is natural and what parts have been created by man? How might this area be improved? Remember that man's activities put animals and plants under stress, how can this be minimised? What can be done to make it a better site for educational visits such as this one? Is trash being removed and properly disposed of?

Possible Hazards. There are no great hazards if the trip is carefully planned, but keep away from cliffs if they are present. There will be safe places to look at cliffs to see what living things are there. Watch out for trash, particularly broken glass or rusty metal. If poison ivy is found stay clear of it, if you accidentally touch it rub the area with a paper towel moistened with isopropyl rubbing alcohol.

Field Trip # 1, General Island Ecology

Use this sheet in conjunction with the information and instructions on the opposite page.

Location:					
Habitats observed:					
Micro habitat description:					
Species (living things) identified	Type of organism	Habitat	Endemic Native Introduced Naturalised	Abundance	Comments

How much of the area is natural and how much created by man? _____

_____

How might the area be improved? _____

_____

What could be done to make it a better site for educational visits such as this one?

_____

_____

Is trash being disposed of properly? _____

Field Trip # 2, Fossils and Extinct Species

Preparation. Read this field guide and if possible look at two other Project Nature Field Guides, "Bermuda's Wetlands" and "The Bermuda Forests".

Equipment. As many copies of "Oceanic Island Ecology of Bermuda" (Project Nature) as possible. Clip board and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. A bottle of isopropyl rubbing alcohol and paper towel for the group.

Dress. Wear long pants and sturdy footwear.

Location. Fossils are best exposed along the coastlines and particularly along the south shore but also in some north shore and island rocks. Unfortunately many of these locations are difficult for school groups due to poor access or the requirement for a boat. Two places with good access are the north shore at Lovers Lake in the Ferry Point Park and Ariel Sands on the south shore. The latter site is private and can only be used with special advance permission from the management. Another alternative might be to arrange a visit to the Natural History Museum at the Bermuda Aquarium asking in advance that a range of fossils, including *Poecilozonites* be put out for observation.

Observations

1. Look for as many different fossils as you can find and name as many as possible.

2. From those identified, decide whether they are from marine, freshwater or terrestrial habitats. Do the terrestrial fossils occur at higher levels than the marine ones?

3. Look at the rock in which the fossils appear. Is it coarse or fine grained, does it show layers or any other clues as to its origin?

4. Look especially for the fossil land snail *Poecilozonites*. From what you see, what you have been taught and what you have read, say why this is an especially important group of fossils in Bermuda. When and why did the last specimens of *Poecilozonites* become extinct? In what way do they resemble Darwin's Finches from the Galapagos?

5. Look at the types of animals and/or plants that occur as fossils. Why have these species been preserved in this way while other species never appear as fossils here?

6. Look around at this location in general and decide how it has changed since Bermuda was colonised. Some of the changes may be natural, others because of man. List the changes that you can deduce and state their cause.

Possible Hazards and Limitations. There are no great hazards if the trip is carefully planned, but if cliffs are nearby keep away from them. Most fossil localities are small so only take small groups. For shoreline places it is essential to go at low tide time.

Field Trip # 2, Fossils and Extinct Species

Use this sheet in conjunction with the information and instructions on the opposite page.

Location:

Fossils found:

Name of fossil	Drawing	from Marine, fresh water or terrestrial habitat?	Description of rock in which found

Do the terrestrial fossils occur at higher levels than the marine ones? _____

Did you find any poecilozonites (fossil land snails)? _____

Why is this an important group of fossils in Bermuda? _____

_____

When and why did the last species become extinct? _____

_____

In what way do they resemble Darwin's Finches from the Galapagos Islands?

_____

List some of the changes that you think have occurred in this area since Bermuda was colonised and state their causes (use the table below).

Changes that occurred	Possible causes

Field Trip # 3, An Old Hillside Palmetto Forest

Preparation. Read this field guide and if possible look at two other Project Nature Field Guides, "Bermuda's Wetlands" and "The Bermuda Forests".

Equipment. As many copies of "Oceanic Island Ecology of Bermuda" (Project Nature) as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands" Clip board and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. A bottle of isopropyl rubbing alcohol and paper towel for the group.

Dress. Wear long pants and sturdy footwear.

Location. Butterfield Park at Point Shares. Note this is not a large park and trampling could severely damage it. All observations must be made from the path. There are endemic species under the trees that are endangered.

Observations

1. Look at the hillside from the road to the top of the park and notice that all around there are lots of introduced species, while on the hillside native and endemic forest plants predominate.

2. List all the animals and plants that you can identify and note whether they are endemic, native, introduced or naturalised. In addition note the habitat that you see them in (e.g. road verge, forest edge, forest, top of slope etc.). Note that the best way of showing this information is in table form. Try to design a good table for this purpose. Be very careful to distinguish between the Bermuda Palmetto and the Chinese Fan Palm and in the case of these two, look for seedlings. Note that this is one of the few locations where the endemic Bermuda Sedge grows naturally. Look for its picture in this guide and try to find it in the forest (Do not touch or trample on this plant, it is endangered!). Make special note of any introduced plants invading the hillside.

3. Look carefully at the old Bermuda Palmettos on the hillside and see if you can see 'Bibby Marks' on the trunks. Bibby was a drink made from Palmetto sap and it was gathered by making a V shaped slash in the bark. Sap would run to the bottom of the V where it was collected in a vessel. How old do you think these 'Bibby Marks' might be?

4. This location is a dry hillside whereas other groves of palmetto trees are usually found in damp places, for example Paget Marsh. The mainland ancestor of the Palmetto also lived in wet locations. What factors and processes in the past fitted the Bermuda Palmetto to live in a wide range of habitats? If you are sure you have seen Bermuda Palmettos (rather than Chinese Fan Palms) in other locations, list the types of habitat they were in.

5. It is almost a miracle that this piece of old forest has survived. Why are forests the most man-altered natural systems in Bermuda? What should be done to ensure the survival of other surviving remnants of the old forest?

Possible Hazards. There are no great hazards if the trip is carefully planned.

Field Trip # 3, An Old Hillside Palmetto Forest

Use this sheet in conjunction with the information and instructions on the opposite page.

Location: Butterfield Park at Point Shares

Species (living things) identified	Type of organism	Habitat	Endemic Native Introduced Naturalised	Abundance	Comments

☑ if you spot the following:

Bermuda Sedge ☐

Bibby marks on the Palmetto trunks ☐

Sketch some of the differences between the Palmetto and the Chinese Fan Palm.

List other areas where you have seen Palmetto Forests. _____

Were these areas marshy or dry? _____

Why are forests the most man-altered natural environments in Bermuda? _____

What do you think we should do to protect the surviving remnants of old Bermuda forests? _____

Field Trip # 4, Paget Marsh Restored Habitat

Preparation
Read this field guide and if possible look at two other Project Nature Field Guides, Bermuda's "Bermuda's Wetlands" and "The Bermuda Forests".

Equipment. As many copies of "Oceanic Island Ecology of Bermuda" (Project Nature) as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands" Clip board and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. A bottle of isopropyl rubbing alcohol and paper towel for the group.

Dress. Wear long pants and sturdy footwear.

Location. Paget Marsh Boardwalk.

Observations

1. As you descend to the marsh and before you go on the causeway look around. This location is in a deep depression in the old aeolianite limestone and is consequently damp and sheltered. There are some excellent explanatory panels provided, read them. Note that in the past, the middle of the swamp was once a marine environment. Succession to a freshwater swamp from a marine mangrove swamp is still underway, look for evidence of this. On the start of the boardwalk note that the ditch and ponds around the edge are man made. The ditches were dug both for drainage and to control mosquitoes that carried diseases. The ponds were added to increase the diversity of habitats so that more wildlife would use the area. The boardwalk was put in place so that the area could be observed without trampling the undergrowth. Several rare and endangered species persist in this marsh including the Bermuda Campylopus a moss growing in the habitat created at the base of Bermuda Palmetto trees, Psilotum (*Psilotum nudum*) an ancient primitive plant, related to the clubmosses, without leaves and also found at Palmetto bases, Wild Bermuda Pepper, Bermuda Sedge and Bermuda Spike Rush.

   The forest on the slopes around the edge of the depression is dominated by introduced trees notably the Allspice (*Pimenta dioica*) and it has not been restored. Within the marsh, however, invading species particularly the shrubs Guava and Ardisia have been carefully removed.

2. Before you proceed on to the boardwalk, list all the animals and plants that you can identify and place them as the left column of a table. In other columns state type of organism (e.g. tree, shrub, invertebrate etc); habitat; whether they are endemic, native, introduced or naturalised; their abundance and add any general comments on their condition, whether they attract birds etc. Note that the Project Nature guide to Wetlands would be a big help in this! Use the binoculars to add species to your list.

3. Once on the boardwalk (at last!) Proceed through a series of natural communities dominated by native and endemic plants. Name them in order as you go. You will find or see Saw Grass (*Cladium jamaicense*) marsh, Bermuda Palmetto swamp, Giant Fern beds, Red Mangrove swamp etc. Look for plants typical of each community and list them. For example the vines Virginia Creeper (*Parthenocissus qinquefolia*) and the West Indian Cissus (*Cissus sicyoides*) are characteristic of the Palmetto Forest while Wax Myrtle (*Myrica cerifera*) is scattered among the Sawgrass.

4. Note particularly that both Bermuda Palmettos and Bermuda Cedars both occur in the swamp-forest and speculate on how this may have come to pass given that the ancestor of the cedars was a dry upland, tree.

5. At the end of the boardwalk look around and imagine the presence of thick growths of invasive shrubs such as Ardisia and Guava that are now removed. This removal was carried out very slowly, over many years, for good reasons. Why was it done this way? What were the hidden benefits of this approach?

6. Make a second table similar to that in 2) above and then comment on the most obvious differences between the two locations.

Possible Hazards. There are no great hazards if the trip is carefully planned. Don't leave the boardwalk and don't interfere with the natural fauna and flora of the location.

Field Trip # 4, Paget Marsh Restored Habitat

Use this sheet in conjunction with the information and instructions on pages 10-8 and 10-9.

Location: Paget Marsh open area before entering the boardwalk

Species (living things) identified	Type of organism	Habitat	Endemic Native Introduced Naturalised	Abundance	Comments

Location: Paget Marsh boardwalk

Community	Species identified	Type of organism	Habitat	Endemic Native Introduced Naturalised	Abundance
Saw Grass Marsh					
Bermuda Palmetto Swamp					
Giant Fern Beds					
Red Mangrove Swamp					

Comment on differences between the first location and the second.

Field Trip # 5, Nonsuch Island Restored Location

Preparation. Read this field guide and if possible look at two other Project Nature Field Guides, "Bermuda's Wetlands" and "The Bermuda Forests".

Equipment. As many copies of "Oceanic Island Ecology of Bermuda" (Project Nature) as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands" Clip board and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. A bottle of isopropyl rubbing alcohol and paper towel for the group.

Dress. Wear long pants and sturdy footwear.

Location. Nonsuch Island Nature Reserve. Note that this is a restricted area and the trip must be planned in advance either through the Bermuda Biological Station for Research or the Education Department of the Bermuda Zoological Society and the Aquarium. Some charges may be applied! A qualified guide is required.

Observations

1. On approaching the island note that it is isolated from the land by water and that it has significant elevation. Both of these are important since a wide variety of habitats have been restored and created. Think about how the isolation both mimics the original isolation of Bermuda as a whole and makes the restoration easier to manage. However, the isolation in this case is slight, what difference does that make? As a suggestion, when on the island look for the types of introduced species that you see and speculate how they got there. Are there some introduced species that it is totally pointless to control on Nonsuch?

2. On your guided tour of Nonsuch Island make a list of the different habitats that are pointed out to you. Describe each in general terms and state whether they are natural, restored or man made.

3. List all the endemic species that you see and give a habitat for each. Add to the list further endemic animals or plants that are on Nonsuch Island but that you did not see. In each of these cases state reasons that you may not have seen them.

4. What reptile is it hoped to restore to Nonsuch? Is it native or endemic? When might it re-appear? What problems are related to its return (or failure to)?

5. Sometimes animals and plants are so close to extinction that they appear to be gone forever. There is a particularly famous example of this for the Nonsuch area. What creature is involved? Give a brief description of the creature and the history concerning it. Speculate of the success of the restoration of this population.

6. One person deserves the bulk of the credit for the restoration projects in Bermuda, without him we would have lost habitats and species for all time. Say what you know about this person.

Possible Hazards. There are no great hazards if the trip is carefully planned. However, sometime freshwater is unavailable on the island so have some with you.

Field Trip # 5, Nonsuch Island Restored Location

Use this sheet in conjunction with the information and instructions on the opposite page.

Location: Nonsuch Island	
Habitats Observed	Description of Habitats (Include whether natural, restored or man-made
Endemic species observed	Habitat
List other endemic species on or near Nonsuch that you did not observe	State reasons why you may not have seen them

Write on the reverse of this sheet what you know about Dr. David Wingate.

Information about Dr. David Wingate:

Additional Classroom and Field Activities

Island Development Activity

Summary: Students role-play as land planners to experience the potential conflicts of island development.

Focal concept: Isolation, limited space and unique ecosystems often accentuate the problems and constraints of development on islands.

Story Background

The island is an imaginary island in the Great Sound, it is the last pristine island ecosystem remaining in Bermuda. The island is home to endemic plants and animals found nowhere else on earth. Invasive exotic plants and feral animals have not yet been introduced to the island.

The Island's owner Mrs Trott, whose family has held title to the island for over 200 years, has recently considered selling the island because of financial difficulties. Mrs Trott would prefer to keep the island in the family.

Because of its pristine condition, several environmental organizations want to keep the island off-limits to all people. Its size, however, prevents any non-profit organizations being able to afford to buy it. Other organizations have expressed an interest in the island for tourism, exclusive housing, business and even government for a prison. To determine the best course of action, Mrs Trott has assembled a board of advisors to evaluate the final proposals submitted by various interested groups but will follow the advice of this board to develop the island.

The groups submitting plans are:

1) Business - tourism, service, retail, financial etc .
2) Government - prison, schools, waste disposal site, recreation etc.
3) Real Estate - exclusive housing
4) Conservation - wildlife park, nature reserve
5) Agriculture and Horticulture

The groups must submit proposals illustrating their planned development of the island, indicating, if pertinent, the location of buildings, water supply, sewage treatment, power, housing, land transport, island access, shops, etc...

The board wants the successful proposal to demonstrate wise use of the island. It should preserve the unique habitat and endemic species in perpetuity and generate a modest profit.

Science Process Skills:

applying	communicating
comparing	inferring
observing	organizing
relating	

Vocabulary

relic	endemic
pristine	introduced
exotic	feral
perpetuity	habitat
unique	topography

Time: about 90 mins: 40 minutes for developing proposals
50 minutes for presenting proposals

Materials:

Each group needs: 1 large sheet of paper
set of crayons or coloured markers

Action:

Prepare the students by narrating the story and defining the vocabulary words. Assign the students into representative groups. Each group receives an identical island outline, on same sized poster paper and crayons or markers to illustrate their plan.

Have students write their names on the island map. If necessary, explain that this will be a cooperative activity, with each student evaluated by the result of the group. It will be in the students best interest to participate as much as possible.

Instruct the group members to design their island map from the perspective of their development category. Give out cue cards to assist in focusing the students.

Allow 30 minutes plus to plan and illustrate their island maps. Circulate among the groups to encourage everyone's participation. Encourage them to develop the island for self sufficiency as much as possible. Mention transport, water, sewage, refuse, communication, power etc, need to be worked into each plan. Stress the notion of efficiency and practicality. Some categories, such as business and recreation, often generate flamboyant plans.

The objective is to "develop" the island in the most ecologically-sound and economically-feasible way according to the given perspective.

After planning and iliustrating their islands, each group will select two spokespersons and one 'board' member. The board member will sit on the judging committee to select the "best" development plan. Additional students or adults may be on the board.

Each team presents its proposal to the board, trying to convince the board that its proposal is the best.

For this exercise "best" is the most practical and imaginative plan that is both economically and environmentally sound. (This must be stressed to the assembled board.)

Rules of Order.

- Two spokespersons only
- 3 minutes for presentation, 5 minutes for questions
- Each member of the board may ask one question only
- Questions must be answered by the spokespersons.
- Post the map after each presentation

Extension

Beforehand have students "design" the physical feature of their own island. Select the outline the entire class will use as the map of the island,

To track individual participation in the island development phase of this activity, give each student within a group a different coloured crayon or marker. Have the student sign the back of his/her island map with his/her marker and use only this marker when drawing on the map.

Business

Decide on a business application:- office, tourist facility, retail, private enterprise or other business.

Do not forget to include where necessary transport, water, sewage, refuse, communicaiton, power etc.

Be as practical as possible.

The plan must include proposals to preserve the unique habitat and endemic species.

Remember it must make a modest profit.

Be sure to consider topography in your plans.

Agriculture/Horticulture

Decide carefully on the areas to be used and specify the crops, stock etc. in each.

Remember profitable agriculture requires modern services.

Do not forget to include where necessary transport, water, sewage, refuse, communication, power etc.

Be as practical as possible.

The plan must include proposals to preserve the unique habitat and endemic species.

Remember it must make a modest profit.

Be sure to consider topography in your plans.

Board of Advisors
Rules of Order

For this exercise "best" proposal is the most practical and imaginative plan that is both economically and environmentally sound.

There will be:

- Two spokespersons only
- 3 minutes for presentation, 5 minutes for questions
- Each member of the board may ask one question only
- Questions must be answered by the spokespersons
- Post the map after each presentation

Conservation

Decide on type of facility and necessary services.

Do not forget to include where necessary transport, water, sewage, refuse, communication, power etc.

Be as practical as possible.

The plan must include proposals to preserve the unique habitat and endemic species.

Remember it must make a modest profit.

Be sure to consider topography in your plans.

Real Estate

Decide on nature of the housing, include size, number of sites, services etc.

Do not forget to include where necessary transport, water, sewage, refuse, communication, power etc.

Be as practical as possible.

The plan must include proposals to preserve the unique habitat and endemic species.

Remember it must make a modest profit.

Be sure to consider topography in your plans.

Government

Decide on one use, e.g. prison or waste disposal or deep water port or housing or recreation or any other use.

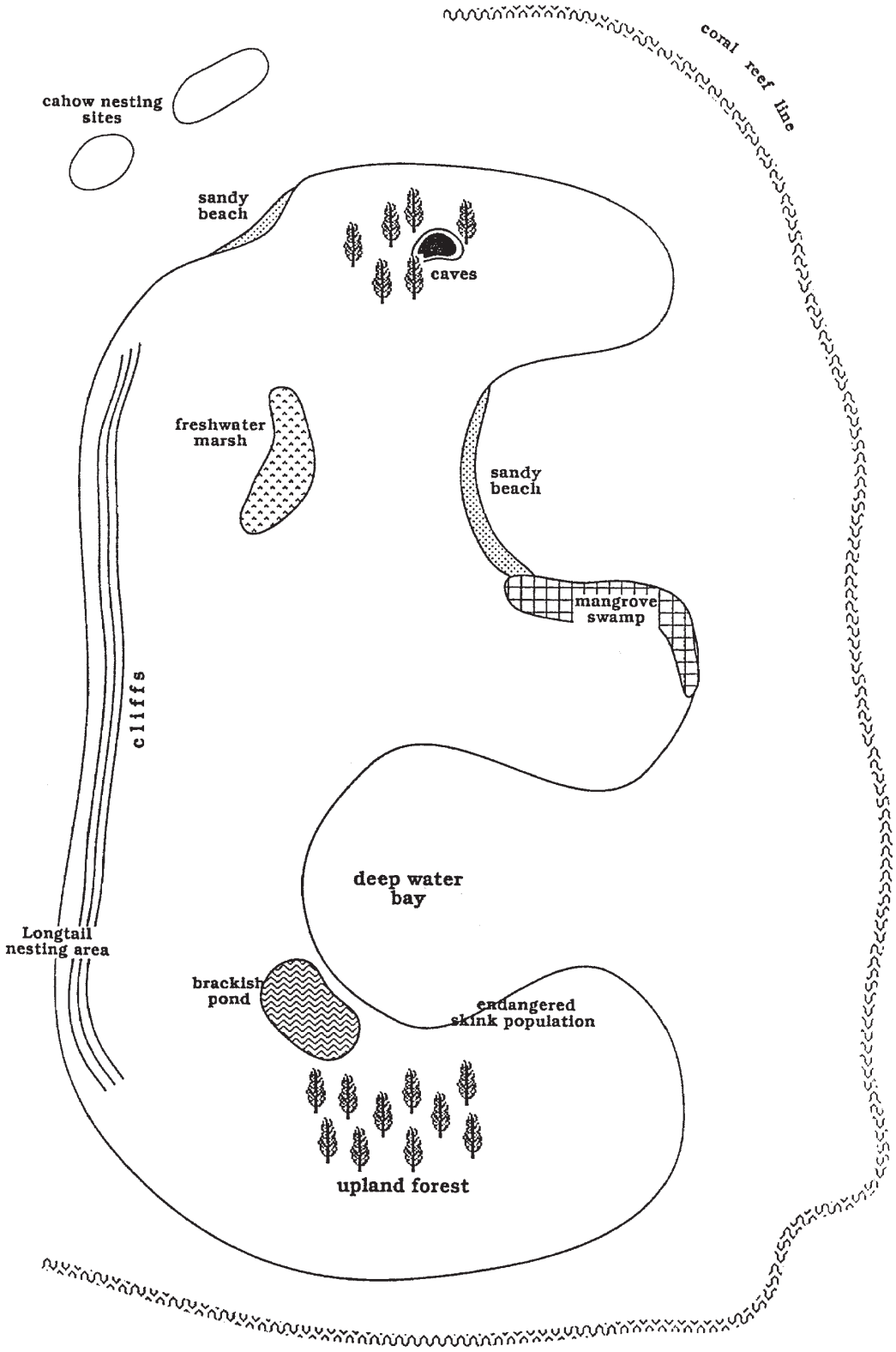
Do not forget to include where necessary transport, water, sewage, refuse, communication, power etc.

Be as practical as possible.

The plan must include proposals to preserve the unique habitat and endemic species.

Remember it must make a modest profit.

Be sure to consider topography in your plans.



The island is approximately 1 kilometer long and 1/2 kilometer wide and has an area of approximately 60 acres.

Glossary

Adaptable	Able to change to live in new or changing habitats. To colonise new areas organisms need to be adaptable.
Adaptive radiation	Evolution of a group of species from a common ancestor. Each of the new species is adapted to different environmental conditions..
Aeolianite	Rock created by the lithification of wind-blown sand.
Algae	Photosynthetic, plantlike organisms generally found growing in aquatic or damp locations.
Atoll	A tropical oceanic island usually in the form of a circle, formed by the growth of marine corals and calcareous algae around the edge of a just-submerged seamount.
Biodeposition	The creation of rock by biological processes.
Biodiversity	In its simplest form the number of different species present at a location. More complex measures of diversity also incorporate relative abundance or biomass.
Blue-green Cyanobacteria	Large colourful bacteria that carry out photosynthesis like plants. They are very highly adapted to life under harsh conditions.
Calcareous Algae	Algae that incorporate calcium carbonate into their tissues. They are hard or firm to the touch and pastel coloured. After death, many become important contributors to the sediments.
Compete	A biological process where two or more organisms attempt to utilise the same essential resource.
Competitive Exclusion	When two different species compete for the same niche the result is normally the death of the least fit of the two.
Continental islands	Islands formed on continental shelves rather than in the deep sea, for example Newfoundland and Madagascar.
Dominant	Refers to the most important organism in a community. Usually taken as the one contributing the greatest biomass.
Endangered species	Species that are in danger of extinction or extirpation from a locality.
Endemic	An organism that has evolved to a new species that does not naturally occur elsewhere.
Endemism	The proportion of endemic species arising from native species in a given location.

Evolution	The natural creation of new species.
Exotic species	A species not occurring naturally in an area.
Extinct	Wiped out on earth.
Extirpated	Wiped out from a specific area but still occurring elsewhere.
Flowering plants	Higher plants that reproduce by means of flowers. They may be uni-sexual or bi-sexual. All produce seeds of some sort.
Fossil	Remains of the hard parts of living organisms, buried in sediment or incorporated into rock. The original structure may remain or be replaced by minerals.
Fungi	Plants that lack pigment. they are all saprophytic or parasitic. Most are formed of threads called hyphae. Very important in the production of organic detritus and soil formation.
Gulf Stream	A large current on the surface of the ocean, originating in the Gulf of Mexico and flowing northeast off the eastern coast of the U.S.A.
Habitat	A small area of environment.
Head (of water)	A stand of water higher than its surroundings, which if released will flow down under the influence of gravity.
Herbicides	Poisons used to eliminate unwanted plant growth.
Herbs	Small non-woody flowering plants. Also used to denote plants of medicinal or culinary value.
Inherited	Passed on from generation to generation by genetic processes.
Intra-specific competition	Competition between members of the same species.
Invertebrates	Animals without backbones.
Impermeable	Not allowing fluids to pass through.
Introduced	Brought to a new area by man.
Island arcs	Groups of islands formed along the collision zones of tectonic plates.
Isolated	Separated from other areas or organisms by some barrier.
Land Snail	Snails or gastropod mollusca that live in terrestrial habitats.
Lee	Sheltered from the wind.

Lichens	A symbiotic group of associations between algae and fungi which are accorded specific status and which are very hardy.
Liverworts	A group of small non-vascular plants of damp locations showing alternation of generations in which the gametophyte is a free living plant and the sporophyte is parasitic on the gametophyte.
Magma	Molten rock under the earths crust, circulating in vast convection cells.
Microhabitat	A very small habitat.
Migrating	Migrating animals regularly move between locations on earth usually on a seasonal basis.
Mites	Small eight legged arthropods that may be parasitic or free living and in which the body consists of a single part.
Mobile Dunes	Sand dunes that move slowly downwind.
Native	An organism that has colonised an area by completely natural means.
Naturalised	An introduced organism that has come to live and breed in a new area.
Natural Selection	The process in which the fittest species survive and the less fit become extinct.
Natural Variation	Variation within a species that shows up as differences between individuals that is inherited by their progeny.
Niche	The unique environment of a species. No two species inhabiting the same area can have identical niches.
Oceanic islands	Islands rising to the surface from the floor of the deep ocean usually as volcanoes.
Palynology	The study of plant pollen.
Peat Deposit	A deposit composed of the partially decomposed remains of plants that is compressed into a distinct layer. Peat is normally quite acidic.
Pesticides	Poisons used to eradicate animals or plants that have become pests.
Pleistocene Epoch	The last epoch which was characterised by the development of huge ice caps at the north and south ends of the earth.
Population	A group of individuals of the same species in a given area.

Pre-adapted	A species arriving in a new area to which it is adapted to survive because of its previous existence elsewhere.
Predatory	Using animals as food.
Prevailing westerly winds	Winds that blow from a westerly direction most of the time.
Prevailing winds	The most usual winds in a given area.
Resources	Environmental components that are essential to life. Resources may be living or non-living.
Ridge islands	Islands that originate along mid-ocean ridges, for example Bermuda.
Sere	A stage in succession.
Species	A group of similar organisms that can breed freely among themselves and whose characteristics are genetically inherited.
Specific Epithet	The second name in a scientific name; it is descriptive in nature.
Spiders	Eight legged predatory arthropods whose body is divided into two distinct parts.
Succession	A natural and predictable series of changes in community structure that results in the most stable community possible.
Swamp Forest	A tree dominated community growing where the water table is mostly above ground.
Tectonic Plates	Large rock plates on the surface of the earth which move under the influence of convection cells in the molten magma beneath.
Terrestrial	Living on land.
Ticks	Parasitic eight legged mites.
Traits	Characteristics that are inherited from generation to generation.
Vascular Plants	Plants that have tissues organised in regular tracts for the transportation of fluids.
Wetlands	Natural systems where the water table is at or above the soil most of the time.

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