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Implications of climate change for biodiversity in the UK Overseas Territories

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Contents

1. Introduction

There is overwhelming evidence to show that climate change is being driven by human activities, in particular, those that consume fossil fuels and cause changes in land use. The radiation budget of the planet is being changed as a result, which has been causing apparently unprecedented rates of warming. During the 20th century, the global mean temperature rose by 0.6°C, the rate and magnitude of which are believed to have been the greatest of the millennium (IPCC 2001a). There is already a wealth of evidence to show that natural and physical systems may be affected by changes in climate (IPCC 2001b). Despite many uncertainties regarding specific consequences, there is widespread expectation that impacts affecting individual species to entire ecosystems will occur as climate change continues (Walther *et al*, 2002). There is a need to collect more data in order to improve our understanding of the *specific* implications of climate change for biodiversity.

The Intergovernmental Panel on Climate Change (IPCC) identifies small islands, primarily in the tropics and subtropics, as being particularly vulnerable to the potential negative impacts of climate change. There are several common physical (eg geographic isolation and small size) and socio-economic (eg limited funds and human resources) factors that limit the capacity of ecosystems and human communities on small islands to reduce or adapt to a rapidly changing climate (Nurse and Sem 2001). These issues are particularly pertinent to the United Kingdom's Overseas Territories. Apart from the British Antarctic Territory and Gibraltar, the UK Overseas Territories are island nations that span a broad range of ecosystems across tropical and polar regions (Figure 1).

A report by the Joint Nature Conservation Committee (JNCC), *Biodiversity: The UK Overseas Territories* (Procter and Fleming 1999), summarised the major biodiversity features and highlighted many species and habitats of local and international conservation significance. However, potential impacts from climate change were generally not considered. A study by the Natural Resources Institute and the Tyndall Centre for Climate Change Research, *The Impacts of Global Climate Change on the UK Overseas Territories*, was the first attempt to consider the potential consequences of climate change for livelihoods and habitats in the Overseas Territories (Sear *et al*, 2001). For a summary of expected changes in climatic variables – eg sea level, temperature and storm frequency – see Sear *et al* (2001). The threat from global climate change becoming an increasingly important issue for the UK to consider if it is to meet its responsibilities to biodiversity conservation through international conventions and agreements such as the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. Critically, lack of data hinder the development of conservation strategies in the Overseas Territories (Oldfield and Sheppard 1997). The present review is part of a series of new initiatives to assess the implications of climate change for nature conservation in the UK and the Overseas Territories (JNCC 2003).

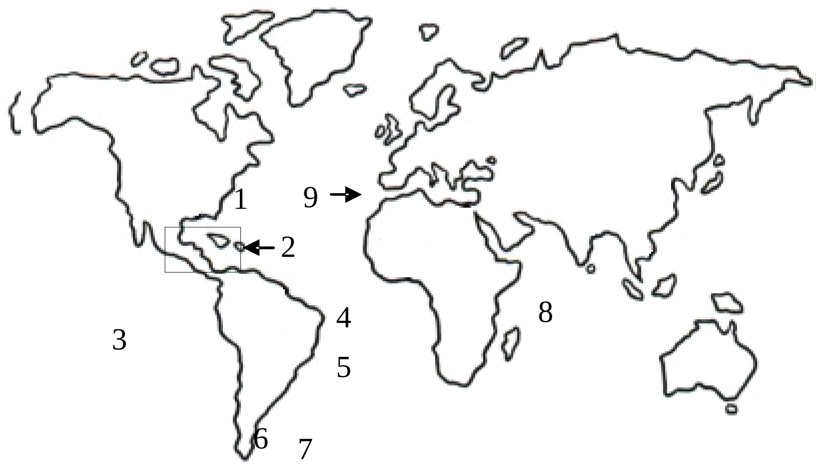

***Figure 1** . Locations of the UK Overseas Territories: (1) Bermuda, (2) Anguilla, British Virgin Islands, Cayman Islands, Montserrat, Turks & Caicos Islands, (3) Pitcairn Islands, (4) St Helena and Ascension Island, (5) Tristan da Cunha , (6) Falkland Islands, (7) South Georgia and South Sandwich Islands, (8) British Indian Ocean Territory, (9) Gibraltar, (not shown) British Antarctic Territory.*

The primary aim of this review is to document the known and perceived threats to biodiversity for each Territory. The research that went into this report revealed the paucity of information relevant to the UK Overseas Territories. Apart from impacts on coral reef systems, there has been very little quantitative research relating to climate change implications for biodiversity in the Overseas Territories (Table 1). In terms of new information on climate change impacts, this review has focused on the threat of sea level rise to species and habitats in the Overseas Territories. However, it should be emphasised most of the information in this review is qualitative. Much more detailed studies are required in order to better understand the implications of rising sea level, which is going to proceed regardless of any short-term mitigation measures to reduce greenhouse gas emissions (Meehl *et al*, 2005).

1.1 Structure of the review

Section 2 provides an overview of issues across the Territories and discusses some of the main threats to habitats and species. Section 3 provides a summary of the main biodiversity features and a more in-depth description of known and perceived threats for each Territory. The British Antarctic Territory is not included, given that there is a wealth of information available through the British Antarctic Survey in Cambridge, UK.

It is important that climate change is not considered in isolation as a threat to biodiversity. There are many other threats that pose serious short- and long-term risks to species and habitats, and thus assessments of the potential impacts of climate change should be regarded as an extension of current threat assessments, rather than an entirely new discipline. It is not the purpose of this review to identify priorities or recommend actions for conservation. Ultimately, that is for the Territories to determine themselves and in collaboration with the UK Government and other institutions.

The availability of information varies substantially among the Territories, depending on the amount of research that has previously taken place. A substantial amount of 'grey literature' (ie not published) is referred to, and it is possible that there are many more such valuable sources of information that have been overlooked. A summary of the main findings is presented in Table 1.

Table 1. State of knowledge regarding potential impacts of climate change on biodiversity of the UK Overseas Territories (SLR – sea level rise).

Territory	Previous local studies	Other species / habitats identified in this review
Anguilla		Coral reefs, seagrass, marine turtles – warming Mangroves, beaches, saltponds, birds, endemic lizards, marine turtles – SLR
Ascension Is.	Marine turtles – warming	
Bermuda	Mangroves – SLR Coral reefs – warming Bermuda petrel – SLR	Seagrass, marine turtles – warming Birds, marine turtles – SLR
British Indian Ocean Territory	Coral reefs – warming All islands – SLR	Seagrass, marine turtles – warming Marine turtles – SLR
British Virgin Is.	Coral reefs – warming	Mangroves, marine turtles, birds – SLR Marine turtles – warming
Cayman Is.	Coral reefs – warming	Wetlands, birds, reptiles, marine turtles – SLR Seagrass, marine turtles – warming
Falkland Is.		Kelp – warming Birds – SLR
Gibraltar		Birds – SLR
Montserrat		Beaches, birds, mangroves, marine turtles – SLR Seagrass, marine turtles – warming
Pitcairn Is.		Coastal plants, birds, marine turtles – SLR
South Georgia	Glacier retreat, invasive species, birds – warming	Birds – SLR
South Sandwich Is.		Invasive species – warming
St. Helena		
Tristan da Cunha	Invasive species – warming	Beaches – SLR
Turks & Caicos	Coral reefs – warming	Wetlands, birds, marine turtles – SLR Seagrass, marine turtles – warming

2. Overview of issues

2.1 Habitats

The Intergovernmental Panel on Climate Change (IPCC) states that current vegetation modelling studies show the potential for significant disruption of ecosystems under climate change. However, these changes will not be consistent because they will be driven by non-linear changes in temperature and precipitation (IPCC 2001a).

Alterations of present biomes will be most evident in the mid- and high-latitude regions, with relatively slight changes expected to occur in the tropics (Groombridge 1992). However, it is expected that migration of ecosystems or biomes as discrete units is unlikely to occur and instead the species composition and dominance will change. There will probably be some redistribution of species as they track changing climatic conditions. Such migration will be possible only if suitable habitats are not too fragmented (Pitelka and Group 1997). Where habitats are fragmented, opportunities for migration will be limited, and the pool of species able to overcome the migratory barriers will be smaller (Bjorkman 1999). This could be a particularly important factor for island biodiversity due to the obstacle presented by the surrounding sea. However, the very presence of the ocean will act as a buffer to island climate change and possibly reduce potential shifts in climate space.

The Modelling Natural Resource Responses to Climate Change (MONARCH) report on climate change in Britain and Ireland illustrated the difficulty involved when attempting to assess the potential impacts of climate change on terrestrial habitats (Berry *et al,* 2001). Each of the species that make up a habitat has its own specific response to changes in climate. Some species will decline, others will benefit, while some may exhibit little change. Furthermore, changes in the spatial extent of habitats are not necessarily directly related to the composition of species within. Net increases in habitat coverage could be achieved regardless of changes in species diversity as long as the gains are greater than losses. The record of plant extinctions across the Paleocene/Eocene boundary indicates that the *rate* of climate change may be just as important as the direction (ie increase or decrease) in causing extinction of plants. Rapid climatic shifts may initially result in declining species richness of plants through accelerated local extinction regardless of whether climate is warming or cooling (Wing 1997).

Unfortunately, the shortfalls in biodiversity and local or regional climatic data for many of the Overseas Territories mean that it is very difficult to project the potential responses of species and habitats to future changes in climate. For example, there do not appear to be any reliable regional climate scenarios that apply to the Overseas Territories in the South Atlantic (Sear *et al*, 2001). Modelling the responses of species and habitats to changes in climate often requires very specific data (Thomas *et al*, 2004). It is therefore important for those engaged in the collection of biodiversity data to be aware of these requirements, if suitable data are to be made available for use in predictive studies.

In this section, broad descriptions of the terrestrial habitats are given for individual Territories. Specific threats to local habitats and/or plant species are also covered. Given the lack of current understanding, it is extremely difficult to make any meaningful assessments of the potential impacts of climate change on terrestrial habitats in these countries. As a starting point, this section identifies those low-lying and coastal habitats that are most likely to be vulnerable to inundation and increased erosion from sea level rise. Based on current data, sea level rise does not appear to pose a significant threat to terrestrial habitats on some Territories. However, given the general lack of information specifically relating to this potential threat, it is strongly suggested that more specific studies need to be carried out before a confident conclusion can be drawn.

Coastal marine habitats are an important feature of the UK Overseas Territories. However, the available information is heavily biased towards coral reef and seagrass habitats in the tropics. In this section, generic threats from climate change to coral reefs and seagrass habitats are described below. Other threats specific to each Territory are described separately.

2.1.1 Coral reefs

i Value of coral reefs

Many human communities benefit from a wide range goods and services provided by coral reefs (Spalding *et al,* 2001). Some of these benefits come from the physical presence of the reef itself (eg coastal protection); whereas other benefits are gleaned from the associated fauna that inhabit coral reefs (eg fisheries):

- Fisheries – reef fish species abundance and diversity are positively related to live coral cover (Bell and Galzin 1984);
- Tourism and recreation;
- Coastal protection from waves (Kalbfleisch and Jones 1998);
- Potential medicinal resources; and
- Provision of sand for beaches

Corals reefs are important sources of sand that build up or replenish beaches. Coral rubble deposited on beaches during storms can be consolidated by vegetation and other processed to create a substrate elevated above sea level. For some small coral islands, this process of rubble supply and consolidation is the only means by which they can exist (Spalding *et al,* 2001). Unfortunately, despite the importance of coral reef ecosystems to many of the UK Overseas Territories, information availability is limited. In a recent global review of the status of coral reefs (Wilkinson 2004), only four (Bermuda, Cayman Islands, British Indian Ocean Territory and Turks and Caicos) of the eight Territories that possess coral reefs made a contribution to the report.

ii Global warming

Coral reefs appear to be among the most sensitive of all ecosystems to increases in temperature (Spalding *et al,* 2001). Corals have a symbiotic relationship with algae that are known as zooxanthellae, which provide the majority of a coral's nutritional requirements through the products of photosynthesis. Stress, such as that caused by temperature, excess solar radiation, pollution or salinity shock, can cause the relationship between the coral and the zooxanthellae to break down, resulting in the expulsion of the latter from the coral host. Corals gain their colour from the photosynthetic pigments contained within the zooxanthellae. If the latter are lost, then all that is left are the translucent coral tissues and the white skeleton beneath. This 'whitening' of the coral is known as coral bleaching. It is possible for corals to regain zooxanthellae if the stress levels are reduced, but prolonged or particularly intense exposure to stress may result in the death of the coral (Brown and Ogden

1993). Although there are many causes of coral bleaching, it is widely accepted among coral reef researchers that elevated temperatures are the primary cause of bleaching events that affect entire reef regions. The link between rising marine temperatures and coral stress means that coral bleaching – associated with global warming – is regarded as one of the foremost threats to coral reefs worldwide (Wilkinson 2004). For reports of coral bleaching in the Overseas Territories and other nations, see the Status of Coral Reefs of the World 1998, 2000, 2002 and 2004, which are available online at http://www.aims.gov.au/pages/publications.html.

Historically, the impacts of coral bleaching have tended to be worse, in terms of spatial extent and subsequent mortality, in the Indo-Pacific regions in comparison to the Caribbean (Wilkinson 2000, 2002, 2004). Large expanses of coral reef have already died as a result of bleaching in the British Indian Ocean Territory, and the frequency of severe bleaching events is expected to increase in the next few decades (Sheppard 2003). Unfortunately, there has been very little research carried out on the remote coral reefs of the Pitcairn Islands, and information regarding bleaching in this Territory is virtually non-existent. In the Caribbean, assessments of threat to coral reef health have tended to focus on stressors other than coral bleaching, such as disease, pollution and overfishing (Gardner *et al*, 2003). Impacts from bleaching in the region have been relatively minor in the past, and it is possible that attention has been drawn away from the threat of global warming and coral bleaching. However, recent research indicates that the spatial extent and intensity of bleaching in the Caribbean will rise with extreme rapidity in the future as baseline marine temperatures increase. An average regional sea temperature increase of only 1°C will result in every coral reef in the region being affected by bleaching every single summer (McWilliams *et al*, 2005). In terms of global warming, a doubling of atmospheric carbon dioxide (CO_2) is expected to result in sea temperature increases of 1-2°C by 2100 (IPCC 1998, McClean and Tysban 2001).

iii Carbon dioxide

In order to create their skeletons, corals must be able to build up deposits of calcium carbonate ($CaCO_3$). As the atmospheric CO_2 increases, so will the partial pressure of CO_2 of oceanic waters. This will markedly decrease the saturation states of aragonite (the form of $CaCO_3$ generally deposited by reef-building corals) and other carbonates, which may have deleterious effects on coral calcification (Smith and Buddemeier 1992). It has been suggested that rising atmospheric CO_2 concentrations could result in a decrease in the calcification rate of corals by 14-30% by 2050 (Gattuso *et al*, 1999; Kleypas *et al*, 1999). The increase in atmospheric CO_2 also has the potential to increase the growth of certain plants such as some macroalgae and seagrasses by stimulation of photosynthesis, depressing respiration, and relieving nutrient and high-temperature stresses (the CO_2 fertilisation effect) (Melillo *et al*, 1990). At the coral reef ecosystem level this potential reduction in calcification on the one hand, and enhancement of photosynthesis on the other, could cause a shift from coral-dominated to turf- and flesh algae-dominated communities on the reef (Smith and Buddemeier 1992).

2.1.2 Seagrasses

i Value of seagrass habitat

There are relatively few direct uses of seagrasses for human exploitation. The primary importance of this ecosystem comes from the services that are provided towards to overall functioning of the coastal zone system (Hemminga and Duarte 2000).

- Seagrass beds enhance the biodiversity and habitat diversity of coastal waters through the provision of foraging grounds and places for refuge;
- They support the production of marine resources, particularly for several commercially important species;
- Water quality is improved by a reduction in particle load and the absorption of nutrients; and
- Sediments are stabilised by the root systems and also by the reduction in currents by the blades of seagrass (Gacia and Duarte 2001).

ii Global warming

Seagrasses, particularly tropical species, appear to be able to survive temporary fluctuations in temperature. However, they are much more likely to be adversely affected by prolonged departures from normal temperatures (Zieman 1982). It is expected that an increase in sea temperature will adversely affect seagrass communities because these ecosystems are already sensitive to land-based pollution and runoff in coastal environments (Edwards 1995). In addition, the distribution of seagrasses could shift as a result of temperature stress, which in turn can cause changes in sexual reproduction patterns (Short and Neckles 1999).

In Florida, for example, optimum productivity of the turtle grass *Thalassia occurs* at 28-30°C and short-term exposure (ie over a tidal cycle) to 33-35°C appears to be tolerated. However, sustained exposures to 33-35°C, or shorter exposures to 35-40°C leads to leaf loss, inhibition of root growth, and eventually death (McRoy and McMillan 1977, Zieman 1982, Vicente *et al*, 1989). In general it appears that sustained elevations of sea temperatures of 4-5°C above summer ambient maxima will cause extensive seagrass mortality. A mean surface temperature rise of 2°C by 2100 will almost certainly exacerbate the stress of seagrasses already living near their thermal tolerance limits in shallow lagoons with poor circulation or near thermal effluents of power plants (Vicente *et al*, 1989). The magnitude of the impact of mean sea temperature rise will depend on whether seagrasses can adapt fast enough to the rising temperature. The temperate eelgrass *Zostera marina* appears to exist as a series of races adapted to local temperature regimes and with varying upper thermal limits (Rasmussen 1977). Therefore, the geographical distribution of these races may shift as mean sea temperatures increase. The problem for tropical seagrasses currently at the limits of their thermal tolerance is that no races currently exist that are pre-adapted to the higher temperatures predicted. Major losses of shallow seagrass communities would be likely to increase shore erosion, alter sediment transport patterns, and have detrimental effects on adjacent coral reef areas and mangroves (Zieman 1982, Fortes 1988).

iii Carbon dioxide

The rates of photosynthesis and growth of seagrasses appears to be limited largely by the rate of supply of carbon as bicarbonate or CO_2 (Beer and Waisel 1979, Zieman 1982). Seagrasses may therefore benefit from increased CO_2 levels. The effect of increased CO_2 in the water column will vary according to species and environmental circumstances, but will probably alter the competition between species, as well as between seagrasses and algal populations (Beer and Koch 1996). Overall, it is difficult to say what the net impact of elevated CO_2 concentrations will be on seagrass communities.

2.2 Species

2.2.1 Native breeding birds

A recent review of the conservation status of birds in the UK Overseas Territories was produced by the Royal Society for the Protection of Birds (Hilton *et al,* 2001), which focused on those species listed as threatened or near-threatened according to criteria from Birdlife International (2000). Here, a more general approach to threat assessment is taken for each Territory. Most of the information pertains to local threats to bird populations, such as predation or habitat destruction. However, aside from concerns regarding the potential impact of rising temperatures on seabirds' prey species in the Southern Ocean, information regarding potential impacts of climate change on bird communities within the UK Overseas Territories is virtually non-existent.

In addition to summarising the known local threats – such as predation and habitat destruction – to bird communities within each Territory, this review provides a baseline for assessing the potential threat of sea level to native breeding bird species in terms of the habitats that they utilise. The aim is to identify those species that rely on low-lying wetland and coastal habitats. Such habitats may suffer inundation and increased erosion as a result of sea level rise, both of which will reduce the total area available for use by birds. Conversely, coastal habitats may be able to migrate inland as new areas become flooded. However, steep inland terrain and/or urban development will be significant barriers to any inland migration. Given the lack of data regarding the impacts of sea level rise on coastal habitats in the UK Overseas Territories, it may be prudent to adopt a precautionary approach and assume that and bird species relying on coastal habitats will suffer a net habitat loss as a result of sea level rise. In some cases, however, it was not possible to locate information on habitat preferences specific to individual territories. It was therefore sometimes necessary to refer to generic guides such as the *Birds of the West Indies* (Raffaele *et al,* 1998), which described general habitat preferences for individual species. These preferences were then matched to the most appropriate habitat within each Territory.

2.2.2 Marine turtles

There are seven species of marine turtles, four of which breed in the UK Overseas Territories: green turtle *Chelonia mydas,* hawksbill *Eretmochelys imbricate,* loggerhead *Caretta caretta* and leatherback *Dermochelys coriacea.* These four species are considered as threatened ('endangered' or 'critically endangered') according to criteria set by the World Conservation Union (IUCN). Marine turtles travel vast distances between breeding and foraging sites; green turtles that nest on Ascension Island for example, spend several months at foraging sites off the coast of Brazil (Hays *et al,* 2001; Luschi *et al,* 2001). A substantial amount of effort has been devoted to researching the status and exploitation of marine turtle populations in the UK Overseas Territories, much of which has been lead by the UK-based Marine Turtle Research Group (www.seaturtle.org/mtrg/). A detailed assessment of the status and exploitation of marine turtles in the wider Caribbean (including Bermuda) has recently been produced by the Marine Turtle Research Group (Godley *et al,* 2004). In addition, the green turtle nesting population at Ascension Island is one of the most intensively researched populations in the world (Broderick *et al,* 2002). Given the amount of research that has been carried out on turtle populations in the Caribbean Territories and Ascension Island, this review gives status summaries only for the British Indian Ocean Territory and the Pitcairn Islands, which have benefited from considerably less attention.

i Potential impacts of climate change

Marine turtle populations throughout the world will potentially be vulnerable to two main impacts from climate change. Firstly, the beaches and coastal vegetation utilised as nesting sites will be subjected to increased erosion and inundation as a result of sea level rise. Secondly and perhaps less well known, the sex of reptiles can be influenced by the temperature at which eggs are incubated. However, there appears to be very little specific research relating to potential climate change impacts on marine turtle populations in the UK Overseas Territories. In addition, marine turtles (particularly green and hawksbill) forage in seagrass and coral reef habitats, which themselves are vulnerable to negative impacts from climate change.

ii Sea level rise

Although turtles nest on a variety of beaches, there is still a substantial amount of uncertainty regarding why they choose one particular beach over another (Mortimer 1995). Without specific studies, it is difficult to predict the impacts of sea level rise on nesting success of individual turtle populations, given that individual beaches will respond differently to changes in sea level. According to the Brunn Rule, a sandy beach would be expected to retreat approximately 100m inland in response to a 1m rise in sea level (Brunn 1988). This of course assumes that there are no significant barriers to migration, such as steep inland terrain, buildings or sea walls. It is important to emphasise that this rule is only a generalisation, and investigations of individual beach responses to changes in sea level are needed in order to properly assess this threat.

iii Global warming – influence of temperature on sex ratios

There is evidence to suggest that a rise in mean temperatures may result in a skewed sex ratio of hatchlings. Even a change of 1 or 2°C can make a considerable difference (Mrosovsky and Yntema 1995). For example, the critical incubation temperature for green turtles is 29°C, with higher temperatures tending to result in a clutch dominated by females (Davenport 1997, Godley *et al,* 2002). On Ascension Island, there already appears to be a bias of 75% females in the nesting green turtle population (Godley *et al,* 2002). It may be possible for turtles to nest at cooler times of the year in order to redress the balance, although there is not yet any evidence for this change in behaviour.

2.2.3 Terrestrial reptiles and amphibians

Information relating to potential impacts of climate change on reptiles and amphibians native to the UK Overseas Territories is extremely limited. The primary impact on reptile populations may be from rising temperatures. Amphibian populations appear to be among the first species to have suffered an extinction as a result of climate change.

i Reptiles

a Global warming

Sex determination in some reptiles is determined by the temperature at which eggs are incubated at. In addition to marine turtles, only a few species of lizards have sex determined by temperature. In contrast, snake and iguana eggs are not influenced by temperature-determined sex (Greenbaum 1999).

ii Amphibians

a Global warming

Amphibian populations have experienced widespread decline and extinctions across the world in recent decades, linked to factors including habitat destruction, pollution and atmospheric changes (Hadar *et al*, 1998). For example, climatic changes resulting in greater UV-radiation exposure and lower water levels in spawning sites due to reduced precipitation have been linked to reduced breeding success in some species in North America, and such changes in precipitation patterns have been linked to El Niño event (Kiesecker et al, 2001). The extinction of the endemic golden toad *Bufo periglenes* from its mountain habitat in Costa Rica has been linked to changes in mist frequency that have arisen from global warming (Pounds *et al*, 1999), and could therefore be the first documented case of extinction caused by current global climate change (Pounds 2001).

3. Issues by territory

3.1 Anguilla

Anguilla is the northernmost island in the Caribbean Leeward Islands chain. Formed from limestone and marls developed on old volcanic rocks, it covers approximately 91km^2 with a maximum elevation of 62m. There are no freshwater sources on the island as the only existing springs are brackish. The population of 13,000 resides on the main island, and there are several smaller, uninhabited cays: Dog Island, Prickly Pear Cays, Sea Island, Sandy Island and Sombrero Island. There are approximately 500 species of plants, of which 321 are native. The only endemic species, *Rondeleia anguillensis* occurs near Deep Waters at the eastern end of Anguilla, and also at Little Bat, near Flat Cap Point (Procter and Fleming 1999). The Anguilla National Trust is currently updating the list of flora. Maps of vegetation communities are available from the Caribbean Vegetation Mapping Project (CVMP 2002). The main coastal marine habitats in Anguilla are coral reefs and seagrass beds. However, there is little recent information available on the status of either of these habitats.

3.1.1 Habitats

i Xeric scrub

More than 80% of mainland Anguilla is covered in scrub: buttonwood *Conocarpus erectus*, sagecop *Latana involucrate*, loblolly *Pisonia subcordata*, white mangrove *Laguncularia racemosa*, frangipani *Plumeria alba* and white cedar *Tabebuia pallida* around the saline ponds, and seagrape *Coccoloba uvifera* along the coasts. Areas cultivated less than a decade ago have returned to scrub, indicating that this habitat type is able to recover quite rapidly from low-intensity agricultural use (Hughes *et al,* 2001).

ii Mangrove

Well developed mangrove stands are rare (Sheppard *et al,* 1995), and are typically associated with salt ponds (UNEP/IUCN 1988, Gell and Watson 2000) that provide important habitat for several bird species (Hughes 2000, Hughes *et al,* 2001).

iii Salt ponds

At least 23 brackish-saline ponds are scattered throughout mainland Anguilla, most of which are separated from the sea only by narrow sand bars. Manchineel *Hippomane mancinella*, red mangrove *Rhizophora mangle* and black mangrove *Avicenna germinans* are commonly found growing around the ponds, which were used for salt production until the 1980s. Several experiments in aquaculture and desalination have failed and the principal economic role of the ponds at present is to provide water catchments during the wet season. Only a few of the ponds retain water throughout the year. Most are seasonal, retaining water only from October to March in most years. Mud around the edge of these ponds provides feeding areas for shorebirds during passage migration and, for some species, throughout the non-breeding period from October to March (Hughes 2000, Hughes *et al,* 2001).

iv Coastal

The coastline consists of low cliffs (mostly limestone, but also some sandstone), sandy beaches and rocky shores. About 19km of the 113km of total coastline is covered by more than 30 sandy beaches. The rocky coast consists of limestone pavement where cacti (particularly *Melocactus intortus*) are the dominant vegetation type, although some scrub also grows here (Hughes 2000).

v Coral reefs

Coral reefs cover approximately 22% of the Anguillan shelf area (Gell and Watson 2000). A major survey of coastal and sublittoral habitats of all islands and reefs in the Anguilla group was carried out as part of the Anguilla Marine Resources Inventory Project. Completed in 1995, the survey reported large areas of shallow reef formed primarily of *Acropora palmata* (an important reef-building species), but that live coral cover on reefs was rarely above 2% (Sheppard *et al*, 1995). A recent diving expedition to two sites on the main island observed very little live coral cover remaining (approximately 3%), with large reef-building species of coral being particularly rare.

There is a distinct difference in the reefs observed off the north and south coast, which is probably caused by the relative exposure to hurricane-generated storm waves. The southern reefs are more extensive, but also tend to have a higher percentage of dead and broken coral. In contrast, the more sheltered northern reefs tended to be characterised by fields of relatively intact stands of *A. palmata* and *A. cervicornis* (UNEP/IUCN 1988). However, these accounts are outdated, and even maps from the relatively recent Inventory Project may also be outdated given the recent damage from hurricanes (see below).

vi Seagrass beds

Seagrass beds in Anguilla cover a total area of about 34km^2 (Gell and Watson 2000). Seagrass communities can cover several square kilometres in some places, particularly in depths greater than 15m (Sheppard *et al*, 1995). They are typically found in large bays, including a large bed at Crocus Bay (UNEP/IUCN 1988). The two primary species are *Thalassia testudinum* and *Syringodium filiforme.* These can form monospecific stands, with the latter species generally found in deeper water, or else may form mixed beds. Seagrass beds are known to be in the following areas; main island - Shoal Bay East (eastern side), Island Harbour (east of the wharf and around Scilly Cay), Junk's Hole Bay, Long Bay to Meads Bay point (extensive beds), Sandy Ground up to Crocus Bay and Little Bay (extensive), Forest Bay, Corito Bay, Blowing Point, Little Bay (inshore and offshore to the east), Rendezvous to Anguillita Island (extensive); offshore cays – Dog Island (North side around Great Bay), Seal Island (southern side) (J. Gumbs, Marine Scientist, Department of Fisheries, pers. comm.).

3.1.2 Threats

i Development

Habitat loss is the single greatest threat to the biodiversity of Anguilla, primarily from the construction projects that are linked with tourism and a growing population (ANT 2000). The coastal location of most salt ponds means that they are typically in prime areas for development, particularly for tourist-related projects. Several salt ponds have been damaged or destroyed by in-filling for development and exploitation for sand mining (UNEP/IUCN 1988). Tourism and housing present the main current threats to these ponds.

ii Overgrazing

Almost all vegetation on Anguilla is subjected to uncontrolled grazing by goats (Procter and Fleming 1999). Xeric scrub habitat for example, is regularly disturbed by grazing by goats, although it appears to be able to recover quickly. In addition, ponds and their associated vegetation communities may be disturbed by grazing goats, tipping of building waste and pollution (Hughes *et al*, 2001).

iii Sand mining

Although sand extraction is prohibited on at least 17 beaches (Procter and Fleming 1999), many others have been heavily damaged by mining (UNESCO-CSI 1996). For example, mining had destroyed the dunes at Siles Bay by 1992, and the subsequent building of a sea wall failed to prevent the remnants of these dunes being washed into the sea. In 1992, Anguilla joined the Coast and Beach Stability in the Lesser Antilles (COSALC) project, which aims to monitor changes in the accretion and erosion rate of Anguilla's beaches. The careful management of beaches, in particular limiting sand extraction and allowing room to retreat inland, will play an important role in determining the future state of the beaches as sea levels rise. Whereas sea level rise is a potentially chronic problem for beach erosion, intense wave action generated by hurricanes is an acute impact that has previously caused major changes to Anguilla's beaches. For example, measurements of 12 beaches in 1995 revealed that Hurricane Luis caused an average retreat of 9m inland, in some cases, reducing the coastline to bare rock (Cambers 1996).

iv Sea level rise

Rising sea level could breach the sand bars that separate the coastal salt ponds from the sea. Conversely, flooding of inland sites may create new areas of salt pond habitat, although this would be at the expense of other terrestrial habitats.

v Hurricanes

While Anguilla has not been directly hit by a hurricane since 1960, several near-misses have generated strong waves that have caused substantial damage to coastal habitats. In 1995 (just after the completion of the Inventory Project), Hurricane Luis caused major damage to coral reef and seagrass habitats, destroying an estimated 20% of the latter (Cambers 1996, Smith *et al*, 2000).

vi Tourism

The expansion of the tourism industry has driven a major development effort to provide sufficient infrastructure. Increasing demand for accommodation, recreational activities (most of which revolve around the beaches and coral reefs), and seafood have to be coped with. The result is a greater pressure on the natural resources and environment of the islands (Procter and Fleming 1999). Some anchor damage has been noted, which is probably associated with tourist activities (UNEP/IUCN 1988).

3.1.3 Species

i Birds

Relatively little was known about the conservation status of bird populations in Anguilla prior to the late 1990s. A proposal to build a satellite launch facility - which has since been rejected - on Sombrero Island raised concerns regarding potential impacts on bird communities. Subsequent surveys carried out by the RSPB provided the first comprehensive study of the islands' avifauna. Important habitats identified included several outlying islands for seabird populations and saline lagoons on the mainland for shorebirds (Hughes *et al*, 2001). The major sources of information regarding avifauna in Anguilla are by Bryer *et al* (2001a) and Hughes *et al* (2001).

There are three broad types of habitats that are important to local bird communities.

ii Limestone-dominated scrub

Scrub covers more than 80% of the main island. Passerines are found at low densities throughout this habitat. Other species, such as American kestrel Falco sparverius and the pearly-eyed thrasher Margarops fuscatus are abundant where the scrub is more open, interspersed with roads, settlements or grazing land.

iii Salt ponds

There are about 23 salt ponds on the mainland, many of which are separated from the sea only by a narrow sand bar. In addition, there are a few small ponds amongst the outer islands. Most of the ponds are seasonal and contain water only from October to March - during the non-breeding period - in most years. Mud around the edges of the ponds provides feeding grounds for several migratory and resident species. Although the shallow ponds rapidly recede during the drier breeding season (April – July), several species remain, including least tern Sterna antillarum, snowy plover Charadrius alexandrinus and Wilson's plover Charadrius wilsonia.

iv Outlying islands

Seabirds are the primary species of interest here, although the outer islands also contain a small number of passerines and shorebirds. The breeding seabirds consist of two species of tropicbird (Phaethontidae), three species of booby (Sulidae) and seven species of tern (Laridae), in addition to magnificent frigatebird Fregata magnificens and laughing gull Larus atricilla. Anguilla contains at least 10% of the West Indies populations of five species: masked booby Sula dactylactra, brown booby Sula leucogaster, laughing gull Larus atricilla, common tern Sterna hirundo and least tern.

3.1.4 Threats

i Development

The tourist industry has been rapidly expanding in recent years (Procter and Fleming 1999). The areas most at risk from destruction are coastal habitats, probably because these are more desirable locations for attracting tourist custom. The principal threat to the salt ponds in the short term is development (tourist and residential), but some are also subject to human disturbance, grazing by feral goats, tipping of building waste and pollution (Hughes *et al*, 2001). The presence of bird colonies on three of the outer islands qualify them as Important Bird Areas but they are not under any current protection from the development proposals that have been put forward, including a coastguard station and expansion of a restaurant (Bryer *et al*, 2001a).

ii Overgrazing

There is uncontrolled grazing of vegetation by large numbers of feral goats, which may disturb nests or destroy habitat.

iii Longline fishing

Fishing is an important industry, but little is currently known about impacts on seabird communities. Some (minimal) mortality is thought to be resulting from this activity (Hilton *et al*, 2001).

iv Sea level rise

There are approximately 40 species of birds that breed locally. Although Anguilla and its outer islands are all low lying and therefore vulnerable to consequences of sea level rise, beaches and salt ponds will be the habitats most at risk from inundation and increased erosion. There are 21 species of birds that are found within these habitats (Bryer *et al*, 2001b), and they may therefore be considered as the species most vulnerable to potential habitat loss as a result of sea level rise. These species are: white-cheeked pintail *Anas bahamensis,* green heron *Butorides virescens,* yellow-crowned night heron *Nyctanassa violacea,* snowy plover *Charadrius alexandrinus,* killdeer *Charadrius vociferus,* Wilson's plover *C. wilsonia,* mangrove cuckoo *Coccyzus minor,* yellow warbler *Dendroica petechia*, magnificent frigatebird *Fregata magnificens,* laughing gull *Larus atricilla,* least tern *Sterna antillarum,* roseate tern *S. dougallii,* sooty tern *S. fuscata*, royal tern *S. maxima,* brown pelican *Pelecanus occidentalis,* pied-billed grebe *Podilymbus podiceps,* American coot *Fulica americana*, common moorhen *Gallinula chloropus,* black-necked stilt *Himantopus mexicanus,* willet *Catoptrophorus semipalmatus* and the Caribbean elaenia *Elaenia martinicia.*

v Changing precipitation

The seasonal nature of the ponds may be sensitive to changing patterns of precipitation that could occur as a result of climate change. However, there is much uncertainty regarding future patterns of precipitation, even to the extent that estimates span both positive and negative changes (Sear *et al*, 2001). Net increases in precipitation may prolong the persistence of seasonal ponds and thus be beneficial to those birds that feed on the muddy fringes. Conversely, a net fall in precipitation may have an opposite effect. Most of the species listed under the *sea level rise* section depend on salt pond habitats.

vi Hurricanes

Anguilla is occasionally hit by powerful storms, which damage habitats and are believed to have contributed to the decline of some species of birds. For example, abundances of greenthroated caribs *Eulampis holosericeus* have been much reduced since Hurricane Luis in 1995, and the Antillean crested hummingbird *Orthorhyncus cristatus* appears to have disappeared entirely from the island.

3.1.5 Terrestrial amphibians and reptiles

Most of the herpetofauna are found on the main island, with a few populations scattered throughout the other islands and offshore cays. There are two endangered species present; the Lesser Antillean iguana *Iguana delicatissima* endemic to the northern Lesser Antilles and the Leeward Island racer *Alsophis rijersmai* endemic to the Anguilla Bank. The Anguilla National Trust has recently published an account of the reptiles and amphibians of Anguilla, *The Reptiles and Amphibians of Anguilla, British West Indies* (Hodge *et al*, 2003).

3.1.6 Threats

i Overgrazing

Urbanisation and overgrazing by feral goats are probably causing habitat loss. In addition, the herbivorous Lesser Antillean iguana may be suffering food shortages as a result of overgrazing by goats. A conservation plan is being developed for this species, involving translocation to offshore cays and captive breeding programmes (Procter and Fleming 1999).

ii Interbreeding

There are concerns that Lesser Antillean iguanas are interbreeding with the non-native green iguana *Iguana iguana,* which is believed to have reached Anguilla by floating on debris during Hurricane Luis in 1995. Efforts are being made to capture the green iguanas in order to reduce the risk of interbreeding.

iii Sea level rise

Two endemic species are restricted to small offshore islands. The Little Scrub ground lizard *Ameiva corax* is only found on the very small, low-lying Little Scrub Island (0.0049 km^2), whereas the Sombrero ground lizard *A. corvine* is restricted to Sombrero Island (0.336 km^2). Any increase in sea level is likely to significantly reduce the habitable area for these highly restricted-range species.

3.1.7 Marine turtles

No information.

3.2 Ascension Island

Since the formal occupation of the island in 1815, Ascension has been heavily impacted by exploitation and the introduction of exotic flora and fauna. The introduction of plants and animals progressed rapidly after Sir Joseph Hooker visited the island in 1843 and advised the Admiralty to appoint a gardener and to import species of trees, grasses, fruits and vegetables (Duffey 1964). In 1858, a shipment of plants from the Botanic Gardens at Cape Town included 228 species, many of which survive on the island today. The current human habitation is sparse, with a small resident population and several military/communications installations. There is one farm to meet local needs.

The majority of the flora is represented by more than 300 introduced species (Procter and Fleming 1999). There are 23 surviving native species of which ten are endemic, although three of the latter may be extinct (Duffey 1964, Ashmole and Ashmole 2000). There are no native forests. Much of the main island is dry and relatively barren, marked by distinctive lava fields and some areas of grass interspersed with the endemic *Euphorbia origanoides*, while a thick scrub of introduced species and *Opuntia* spp. occurs at higher elevations (UNEP 1998a). Detailed descriptions of the natural history of the island are given in *St Helena and Ascension Island: a natural history* (Ashmole and Ashmole 2000).

3.2.1 Habitats

i Lava desert

The landscape has been produced by a long series of volcanic eruptions. In the east, steep-sided hills and cliffs have been produced, and in the west, more recent activity has formed massive outpourings of black lava that is covered in places by a layer of fine cinders, forming volcanic deserts that slope gradually down to the sea. Occasional periods of intense rainfall have eroded gullies within the lava plains. These gullies are often floored with fine cinders that are more suitable for plant growth than the surrounding terrain, and several native species can be found here, including sedge *Cyperus appendiculatus*, grass *Aristida adscensionis*, and straggling hogweed *Commicarpus helenae.* Several introduced plant species also populate the gullies, springing up after rain, but most of these tend to die during the following droughts.

ii The middle levels

This zone encompasses the foothills of Green Mountain, from 200 – 600m above sea level. There is a marked change from the desiccated vegetation of the lava plains to more abundant cover, which may be due to greater rainfall at higher elevations. The original plants are either extinct or very scarce in this area of the island. A notable introduced species is the Bermuda cedar tree *Juniperus bermudiana* that is naturally endemic to Bermuda. This tree is dominant among the vegetation, and continues to spread, probably aided in seed dispersal by mynas *Acridotheres* sp.

iii Green Mountain

The dominant feature of Ascension Island is Green Mountain, which has a summit at 859m. From about 600m to the summit there is a moist region with lush vegetation cover, which amounts to a cloud forest in some places. Originally, the vegetation was dominated by ferns but since the arrival of humans the vegetation has largely been taken over by introduced species. Green Mountain is the last refuge for several native species of plants.

3.2.2 Threats

i Overgrazing

Goats were introduced by mariners sometime in the early seventeenth century. They remained until the last individuals were shot in the mid 1940s by the American soldiers stationed on the island. Several plants were impacted by grazing, including the threatened *Cyperus appendiculatus* and *Sporobolus* sp. Furthermore, the goats heavily grazed the now extinct shrub *Oldenlandia adscensionis*, and may have contributed to its demise during the last 100 years (Ashmole and Ashmole 2000). In addition, rabbits were causing problems on agricultural land. Ferrets were used to control them and current numbers are relatively low. Small numbers of donkeys and sheep also roam about the island, and the latter are periodically rounded up for their meat.

ii Invasive plants

Major introductions of alien plants began after the island was settled in 1815, and a market garden was quickly established on Green Mountain. Fruits and vegetables were planted to support the resident human population. In addition, trees were planted at higher elevations in order to encourage rain, so that the overall vegetative cover of the island might be increased. Imported flora came from Argentina, Africa and Bermuda. The Bermuda cedar, *Juniperus bermudiana*, naturally endemic to Bermuda, is now slowly spreading in some parts of Ascension. The greatest threat to the native flora comes from the continuing spread of exotic species. According to a report from the University of Edinburgh, most of the extinctions that have occurred here are thought to be due to the inability of native flora to compete with introduced species (Fowler 2002). The only surviving flowering plant on Ascension is the endemic Ascension spurge *Euphorbia origanoides*. The spread of the Mexican thorn is considered to be severe, because it thrives in conditions favoured by the spurge (Ashmole and Ashmole 2000). Two nature reserves were established in 1997 to help conserve the endemic flora.

3.2.3 Species

i Birds

Ascension Island consists of a central main island that is surrounded by stacks and other small islands. The main island was once occupied by hundreds of thousands of seabirds. Since the arrival of humans, however, a combination of pressures including predation, hunting, and habitat loss has largely driven surviving seabird colonies to refuges on stacks and offshore islands. There are 11 species of native seabirds, including the endemic Ascension frigatebird *Fregata aquila*. Although endemic land birds once existed here, the only surviving land birds are five species that were introduced by human visitors. A detailed account of the avifauna of Ascension Island is given in *St Helena and Ascension Island: a natural history* (Ashmole and Ashmole 2000).

Despite being totally devoid of vegetation, the main habitat for breeding seabirds is Boatswainbird Island, a flat-topped rock some 365m long and 90m high off the east coast of Ascension Island. The island is very densely populated by birds, which occupy various parts of the island depending on their particular preference for nesting sites. The summit plateau, for example, is dominated by Ascension frigatebirds and masked boobies *Sula dactylactra*.

In contrast, red-billed *Phaethon aethereus* and white-billed tropicbirds *P. lepturus* compete for nest cavities on the sides of the island.

3.2.4 Threats

There appears to be no published information regarding any potential impacts of climate change for the avifauna of Ascension Island. None of the species are restricted to low-lying parts of the island, so it appears that the threat from sea level rise will be probably be negligible.

i Introduced predators

The primary conservation issue for Ascension Island has been the impact of introduced rats and cats (Pickup 1999). Predation by mammals is believed to have caused the extinction of at least one endemic land bird (Hilton *et al,* 2001). Encouragingly, a recently completed programme to eliminate feral cats appears to have been successful; 77 pairs of breeding seabirds from five species have returned to the main island. A project to control rat populations is now being considered (UKOTCF 2004a).

ii Longline fishing mortality

A Japanese swordfish and tuna fishery has been operating locally since 1988 (Ratcliffe 1999). The extent of incidental mortality on seabirds is not well documented, although at least two species have been noted as being vulnerable, including the brown booby *S. leucogaster* (Ashmole *et al,* 1994). In addition, Ascension frigatebirds are sometimes caught on sport-fishing hooks (Ratcliffe 1999). Although the birds caught in this manner are released, this indicates a tendency for the birds to take fishing baits, a habit which makes them potentially vulnerable to commercial longline fishing vessels.

iii Habitat loss – invasive plants

The introduced Mexican thorn *Prosopis juliflora* is the most actively spreading plant on the island. The dense morphology of this species makes it unsuitable for nesting (Ashmole and Ashmole 2000), and may impede the recovery of seabird populations that have recently returned to the island.

3.2.5 Terrestrial amphibians and reptiles

Most of the herpetofauna are found on the main island, with a few populations scattered throughout the other islands and offshore cays. There are two endangered species present; the Lesser Antillean iguana *Iguana delicatissima* endemic to the northern Lesser Antilles and the Leeward Island racer *Alsophis rijersmai* endemic to the Anguilla Bank. The Anguilla National Trust has recently published an account of the reptiles and amphibians of Anguilla, *The Reptiles and Amphibians of Anguilla, British West Indies* (Hodge *et al*, 2003).

3.2.6 Marine turtles

No information.

3.3 Bermuda

The topography is moderately hilly and low lying, with a maximum elevation of 79m above sea level. The shoreline is composed of bays and inlets with coral sand beaches, particularly in the south. In spite of major changes to the terrestrial ecology of Bermuda, especially since 1942, little botanical work has been carried out since the work of Britton (1918) and a major revision is long overdue (Sterrer 1998). The Bermuda Biodiversity Project (BBP) aims to create a comprehensive information management system for Bermuda's natural resources (Glasspool *et al,* 2000). Until the BBP is completed, the list of native vascular flora from Bermuda stands at about 146 species of angiosperms (including a few marine species) and 19 ferns. There are at least 15 endemic species among the vascular plants. In addition, 51 species of mosses (including two endemic) have been recorded (Ferguson *et al,* 1991; Procter and Fleming 1999).

The coral reefs of Bermuda are perhaps the best-studied amongst the UK Overseas Territories, with extensive research carried out by the Bermuda Biological Station for Research. In contrast, much less attention has been focused on the seagrass beds, which form small but important habitats for other species. The proximity of the Gulf Stream to Bermuda maintains shallow water temperatures above 19°C in winter, with a summer maximum of 27°C (Spalding *et al,* 2001).

3.3.1 Habitats

i Dry forest

The dry forests were once dominated by the Bermuda cedar *Juniperus bermidiana* and the Bermuda palmetto *Sabal bermudana.* The palmetto still survives well in protected areas and gardens, but the cedar was nearly completely destroyed by an introduced scale insect (*Lepidosaphes pallida*) during the 1940s and 1950s (Ferguson *et al,* 1991; Rueger and von Wallmenich 1996).

ii Mangroves

The mangroves of Bermuda are the most northerly in the world, but form a relatively impoverished ecosystem. Mangrove swamp development was never very extensive due to the steeply sloped shoreline and lack of estuarine environments (Smith 1998). Three species of mangrove are present: red *Rhizophora mangle*, black *Avicennia germinans* and buttonwood *Conocarpus erectus* (Spalding *et al*, 1997). There are many small stands, usually surrounding large (> 0.005 km^2) anchialine ponds (Thomas *et al*, 1992) or narrow coastal fringes (Thomas and Logan 1992), with the largest section only covering 0.29 km^2 (Smith 1998). Around one third of the mangroves are associated with anchialine ponds, and the rest are present in coastal bays (Thomas *et al*, 1992; Thomas 1993). Those mangrove trees associated with the ponds tend to form monospecific stands of either red or black species (Thomas *et al*, 1992).

ii Coral reefs

The coral reefs of Bermuda are the most northerly in the world. The reef flora and fauna are much less diverse than in the Caribbean, with only one third of Caribbean hard coral species occurring locally. Shoals and reefs surround a central lagoon. The major reef area is found around the shallow water platform north of the islands in North Lagoon (UNEP/IUCN 1988). Approximately 25% of the reefs are protected. The reefs are in relatively good health despite suffering from several bleaching events (Smith 1998). There are two general types of reefs present around Bermuda: coral/algal reefs and algal/vermetid reefs. The latter are constructed from calcareous algae, foraminiferans and vermetid worms. They are widely scattered on the North Rim and form a nearly continuous belt along the length of the south shore, generally following the 8m depth contour. The sides of these reefs are typically devoid of coral growth. In contrast, the much more extensive coral/algal reefs support a diverse assemblage of hard and soft corals.

iii Seagrass beds

Seagrass beds are distributed throughout the patch reefs, the inshore basins, and the shoreward margin of the outer rim reef. The Caribbean Coastal Marine Productivity Program (CARICOMP) has seagrass monitoring sites within Crescent Reef in the centre of the North Lagoon. There are three species of seagrasses present. *Thalassia testudinum* and *Syringodium filiforme* are the dominant species, sometimes forming large monospecific stands. The most extensive *T. testudinum* beds are located off the southwest coast, and the largest bed of *S. filiforme* is located along the North Shore. Within inshore basins, these species tend to occur in mixed stands along with *Halodule bermudensis*. The beds of these inshore areas tend to be small because there is limited substrate available that is shallow enough to support their growth. Some seagrass beds in the North Lagoon are important habitat for protected populations of the queen conch *Strombus gigas* (Smith 1998).

3.3.2 Threats

Bermuda was originally covered in dense plateau forests of endemic trees surrounded by coastal mangrove stands (Mastny 2001). For more than 300 years the native biota has been subjected to clearing, burning, domestic animals, introduced animal pests, introduced weeds, filling of marshland, and increasing habitat fragmentation (Ferguson *et al,* 1991). Intense human activities have reduced the natural habitat to a few small relicts, for example at Paget and Devonshire Marsh, and the upland hills of Castle Harbour and Walsingham (Procter and Fleming 1999). Although there is a comprehensive system of parks and reserves protecting the remaining natural habitats, only about 10% of the land area is covered by forest and woodland (Sterrer 1998, Procter and Fleming 1999).

i Development

Bermuda was considered overpopulated in relation to its resources when numbers reached about 3,000, and many inhabitants were encouraged to emigrate to the West Indies or Virginia (Ferguson *et al,* 1991). By 1996 the population had reached 60,000 (UNEP 1998b). Bermuda is now one of the most densely populated countries in the world, with ca. 500,000 tourists visiting each year (Sterrer 1998). The forest of *Juniperus bermudiana* was cut for shipbuilding, construction work and firewood, but also because it was a nutrient-depleting weed on cultivated land (Ferguson *et al,* 1991). Unusually, this tree was afforded protection as early as 1622 (Rueger and von Wallmenich 1996) and this species continued to recover until the introduction of the scale insect nearly caused its local extinction. It is interesting to note that the Bermuda cedar has been introduced to St Helena and Ascension Island where it continues to slowly expand its range (Ashmole and Ashmole 2000).

Coastal development has substantially reduced Bermuda's wetlands (Sterrer and Wingate 1981). For example, of the 116ha of inland peat marshes present in 1900, only 48ha remain (UNEP 1998b), with many converted to landfills (Rueger and von Wallmenich 1996). The small size of Bermuda means that natural habitats are invariably close to urban areas. The mangroves at Mills Creek for example, are near the town of Hamilton, and are disturbed by boating activity and oil pollution (Ellison 1993).

ii Introduced plants

It has been estimated that some 1,500 species of plants have been introduced to Bermuda since the arrival of humans, with approximately 800 species becoming naturalised (Crowell and Crowell 1976). Exotic trees such as guava and mulberry threaten native plant communities, but culling techniques are being used to keep these under control (Mastny 2001).

iii Sea level rise

It appears that the rate of peat accumulation by the mangroves has not been keeping up with sea level rise over the past few centuries (Ellison 1993). Data from Ellison's (1993) study indicate that the rate of peat accumulation in some mangrove stands of Bermuda is only 8 – 11cm every 100 years. Tidal gauge data for Bermuda since 1933 has shown rates of sea level rise to be between 24cm/100 years (Barnett 1984) and 28cm/100 years (Pirazzoli 1986). The trees at the seaward margin are showing signs of stress with reduced height, diameter and litter production when compared to trees of the interior (Smith 1998), and retreating mangrove margins show problems of erosion that may be exacerbated by creek excavation and hurricane damage (Ellison 1993). Problems of mangrove retreat from inundation by the sea are likely to increase with the rates of sea level rise predicted for the coming century.

There has been relatively little change to the coral reefs in recent years, with coral cover remaining stable at 20% since 1993 (Wilkinson 2004).

iv Urbanisation

The six main islands are all linked by bridges and causeways that enclose four large water bodies; Great Sound, Harrington Sound, Castle Harbour, and St George's Harbour. This has undoubtedly caused changes to current patterns and coastal sediment dynamics. Castle Harbour used to have extensive coral reefs similar to the Southern Rim and Terrace Reefs, but the construction of Kindley Airforce Base (1941-1944) killed most of the corals in the area. The waters have remained turbid ever since and the corals have never fully recovered (UNEP/IUCN 1988).

v Pollution and other activities

Impacts from dredging and ship groundings have been limited in extent (Smith 1998). Domestic waste is the main source of terrestrial pollution (Spalding *et al*, 2001).

3.3.3 Species

i Birds

Bermuda is home to some 22 species of resident and breeding birds. In addition, there are more than 300 migratory species (Dobson 2002).

Intensive urbanisation has removed most of the natural habitat. In addition, the extremely high density of human inhabitants inevitably causes some disturbance to wildlife. Although there is a comprehensive system of protection for the remnant areas of habitat, disturbance from urbanisation remains a problem (Procter and Fleming 1999, Hilton *et al*, 2001).

3.3.4 Threats

i Development

Habitat destruction is believed to have contributed to the decline of some native bird populations. For example, deforestation of the Bermuda cedar *Juniperus bermudiana* probably contributed to the decline of the endemic white-eyed vireo *Vireo griseus bermudianus*, although these birds are still abundant in the remaining parks and woodlands (Procter and Fleming 1999).

ii Predation

The Bermuda Audubon Society considers feral cats to be a significant problem for birds. Predation by rats and cats is a major cause of bird mortality in Bermuda (Procter and Fleming 1999, Wingate 2000, Hilton *et al*, 2001). Several feeding stations for feral cats are sited near to nature reserves, which increase the chances of contact between predator and prey. Although all of the bird species are vulnerable to predation, special attention has been focused on the Bermuda petrel. This species is currently confined to the rat-free island at Castle Harbour (Wingate *et al*, 1998). Suitable (rat-free) habitat has been recently been declared a nature reserve on Nonsuch Island, which has a potential capacity for 10,000 individuals. Efforts are underway to try and encourage members of the petrel population to establish a colony in this new site (Wingate 2000).

iii Sea level rise

Four species of birds (mallard *Anas platyrhynchos,* yellow-crowned night heron *Nyctanassa violacea*, common moorhen *Gallinula chloropus,* pied-billed grebe *Podilymbus podiceps*) reside in wetlands (Dobson 2002). These wetland habitats are probably the most vulnerable to sea level rise. For example, there is evidence to suggest that mangrove stands in Bermuda will suffer from increased erosion and inundation as a result of sea level rise (Ellison 1993). In addition, the heavily urbanised landscape will allow little opportunity for inland migration of coastal habitats in response to rising sea level. More frequent and severe flooding of wetland habitats may reduce nesting success of these four species. For example, nesting activity of the pied-billed grebe temporarily declined after Hurricane Emily caused flooding of marshland at Somerset Long Bay Reserve in 1987 (Wingate 2002).

The endemic Bermuda petrel *Pterodroma cahow* has been reduced to a very small population as a result of exploitation by humans and predation by introduced mammals (Hilton *et al,* 2001). Thought to have become extinct, this species was only recently rediscovered. The coastal burrows in which the petrels nest are prone to flooding (Hilton *et al,* 2001), and sea level rise is a recognised threat to the reproductive success of this species (Nurse and Sem 2001).

3.3.5 Terrestrial reptiles and amphibians

There are no native amphibians on Bermuda, and only one native terrestrial reptile, the endemic Bermuda rock skink *Eumeces longirostris.* The skink population declined soon after the arrival of human settlers, as a result of introduced predators, habitat destruction and, more recently, the impact of roadside litter. The clawed feet of the skink are poorly adapted to movement over smooth surfaces. Discarded bottles trap skinks that enter searching for food, and they often die of starvation, drowning or heat stress.

This species is now largely restricted to a few sites among coastal cliffs and offshore islands. The largest known populations are located at Spittal Pond and some of the Castle Harbour islands. However, skinks have also been discovered in Tucker’s Town, Smith’s Parish on North Shore, Horseshoe Bay, Astwood Park, and Hog Bay Park. The Bermuda Biodiversity Project is currently gathering information about the current distribution, abundance and population structure of this critically endangered lizard (Kitson 2001).

3.3.6 Marine turtles

No information.

3.4 British Indian Ocean Territory / Chagos Archipelago

This archipelago consists of a series of islanded atolls, submerged banks and drowned atolls, which cover a total area of about 60,000 km^2 (Sheppard *et al,* 1999). There are more than 50 islands here, none of which rise more than a few metres above sea level. The original inhabitants were displaced to Mauritius in order to facilitate the building of a US military base on the main island of Diego Garica. The current population consists solely of personnel associated with the base and other visitors to the area are strictly controlled.

There are about 280 species of vascular plants, of which only about 42 are indigenous. Many of the introductions took place over the last thirty years during the development of military facilities on Diego Garcia, the largest island in this territory. No endemic species of vascular plants exist here, probably due to the young age of the islands being insufficient for the evolution of endemic taxa. Most of the information pertaining to the terrestrial habitats is given by Topp and Sheppard (1999) in the *Ecology of the Chagos Archipelago.*

The BIOT is one of the most diverse sites for corals in the Indian Ocean. Its low-lying oceanic reefs contain some 217 coral species from 58 genera. It is believed that this archipelago forms an important “stepping stone” for the east-west flow of coral species across the Indian Ocean (Sheppard 1999c). In terms of coral reef area, these reefs constitute approximately 2.5% of the world's total (Sheppard 1999b). In contrast, seagrass habitats are very limited in extent (Procter and Fleming 1999).

3.4.1 Habitats

There is no consistent pattern of vegetation between islands. Some are heavily forested with *Pisonia* trees (eg North Brother on the Great Chagos Bank) whereas others are devoid of trees and have only low vegetation and grasses. Most islands have an outer ring of the shrubs *Scaevola taccada* and *Argusia argentea* that often extend into the high tidal area. On rat-free islands, the latter species is important for bird nesting, particularly for the red-footed booby (Symens 1999). These shrubs are vitally important in stabilising the sandy beaches, by binding the sand together with its roots reducing wave-induced erosion, and also reducing sand loss after heavy rain. It is important that this species (and other stabilising shrubs such as *Suriana maritima* and *Pemphis acidula*) are not removed, or else beach erosion will be greatly accelerated. The importance of *S. taccada* on Diego Garcia was evident when it was cleared for the officers' quarters, which were sited too close to the sea. Wave action eroded the beach and threatened to undermine the buildings, so a sea wall had to be built (Topp and Sheppard 1999).

Most of the islands have been altered by extensive coconut plantations that were established two hundred years ago. Such plantations largely replaced the original native trees, but since these have been abandoned, the native trees are slowly recovering. Some very small and/or remote islands were never planted for coconut owing to their inaccessibility.

Although there appears to be suitable habitat for mangroves at several sites throughout the archipelago, there is only one stand of *Lumnitzera racemosa* exists that occurs down the middle of the very exposed Eagle Island on the Great Chagos Bank. Sheltered locations in Diego Garcia lagoon and parts of the northern atolls between closely adjacent islands would support *Avicennia* sp. and *Rhizophora* sp. mangroves if any were to reach these places. However, these species many not have established themselves here due to the isolation. Alternatively, given the popularity of mangrove wood for exploitation elsewhere in the Indian Ocean, it is possible that early settlers removed other stands of mangrove trees (Topp and Sheppard 1999).

i Coral reefs

The more turbulent and shallow regions of the reefs are characterised by sturdy, fast-growing reef-building *Acropora* spp, whereas foliose forms such as *Pachyseris speciosa* and *Echinopora lamellosa* dominate in deeper and calmer water. The coral reefs can be broadly divided into three categories: reef flats, reef slopes and drop-offs (Sheppard 1999a). Reef flats are common along the lagoonal sides of the islands. Most of these flats are exposed at low tide and have poorer coral diversity and abundance in comparison to other parts of the reef. The coral cover increases rapidly with depth, from about 10% in 1m to 60% in 5m of water. The reef slopes are the most biologically diverse parts of the reef system, and typically descend from the edge of the reef flat to 10-20m depth. In deeper water, there is often a steep slope that rapidly falls away and may become vertical. The clear water allows corals to survive to about 40m depth.

ii Seagrass beds

The only known area of seagrass beds of significant size are those on the eastern side of the lagoon at Diego Garcia (Procter and Fleming 1999), which include the seagrass species *Halophila decipiens* and *Thalassodendron ciliatum* (Topp and Sheppard 1999). Juvenile green turtles are known to inhabit this lagoon (Mortimer and Day 1999) in addition to a number of fish species that have not yet been seen elsewhere in the archipelago (Procter and Fleming 1999).

3.4.2 Threats

The main impact has been on Diego Garcia where the military base has completely transformed the landscape. Elsewhere, non-climatic threats to the native terrestrial flora are probably very low. There was a historical problem of native vegetation being replaced by exotic species, but this problem does not appear to be critical. Some of the native trees are slowly re-taking ground from abandoned coconut plantations. The remote location means that local human impacts in the coastal marine environment are almost non-existent (Spalding 1999). It is possible that activity associated with the military base at Diego Garcia may be causing damage to seagrass beds in the area, although this has not been investigated.

i Introduced rats

Ship rats (*Rattus* spp.) may damage plants and eat seedlings, thereby affecting the structure and composition of the native vegetation (Symens 1999). However, there appears to be little specific local information relating to this threat.

ii Sea level rise

For islands of such low elevations, the threat of sea level rise is very high. Loss of land area will be exacerbated by loss of beach protection as they are inundated, and the plants that bind the sand together, drowned. Aside from physical loss of land, more frequent swamping by waves may scour some islands free of less tolerant species that had initially survived encroaching seas. The problem is exacerbated by the small size of most islands, which leaves very little room for coastal habitats to retreat inland. The mangrove stand on Eagle Island is likely to be reduced in extent as a result of rising sea level.

iii Global warming

Up to 90% of live coral cover was killed as a result of high seawater temperatures in 1998. The rate of coral loss has been greater than the rate of replenishment, and the reef structure has begun to deteriorate as a result (Sheppard *et al*, 2002). Models predict that temperatures which caused the massive coral bleaching event in 1998 could occur, on average, every five years in one or two decades from now (Sheppard 2003). The repeat time of five years is considered to be ecologically significant because corals typically do not become sexually mature until their fifth year.

3.4.3 Species

i Birds

Information on seabird populations is often poor for isolated island groups. A review by Feare (1984) highlighted the need to collect basic data and for monitoring of these populations. During February and March 1996, a complete census of breeding seabirds was carried out across the British Indian Ocean Territory. More than 167,000 breeding pairs from 17 species were counted, making seabird populations in this archipelago the most diverse in the region. The most common species were terns (sooty tern *Sterna fuscata*, brown noddy *Anous stolidus*, lesser noddy *A. tenuirostris*), which accounted for > 90% of the breeding population. For a detailed account of the most recent ornithological work, see Symens (1999).

There is no consistent pattern of vegetation on the islands. Preferences for nesting sites tend to vary between individual seabird species. For example, several species of terns (Laridae) are ground-nesting, whereas the only two nests of white-tailed tropicbirds *Phaeton lepturus*) recorded were both found in trees 9–10m above the ground (Symens 1999).

3.4.4 Threats

Although quantitative data are limited, it is believed that seabird populations were heavily exploited since the archipelago was discovered in the sixteenth century. The restriction of access to the islands and their natural resources since 1966 has probably allowed some recovery of populations (Symens 1999).

i Longline fishing mortality

There are licensed tuna and reef fisheries operating in local waters, but the extent of incidental mortality of seabirds is not currently known (Hilton *et al,* 2001).

ii Predation by rats

The main current conservation threat to the archipelago is the presence of rats (*Rattus* sp.). These are present on 36 of the 47 islands in the archipelago. The density of nests on most rat-infested islands was significantly lower than that on rat-free islands. A study of brown noddies *A. stolidus* and white terns *Gygis alba* revealed a tendency to nest higher up in trees on islands where rats were present (Symens 1999).

iii Sea level rise

All of the breeding bird species are potentially at risk from sea level rise because of the very low elevations of the islands. Significant areas of land could be lost over the next 100 years because the average island height above sea level is only 1–4 m. In addition to physical loss of land, more frequent swamping by waves would reduce nesting success for species that nest on the ground such as terns (Symens 1999). This problem, coupled with potential reductions in wave protection from coral reefs suffering from bleaching (Sheppard 1999), could be the major long-term concern for seabirds in this archipelago (Hilton *et al,* 2001).

3.4.5 Terrestrial reptiles and amphibians

No information.

3.4.6 Marine turtles

Hawksbill and green turtles have been known to occur in this archipelago for at least the past two hundred years, but little information on their status and distribution was available until the last few decades (Frazier 1975, 1980). During a six-week period in 1996, a survey of 110km of the 226km of total coastline in the archipelago documented significant nesting by these two species (Mortimer and Day 1999). The leatherback and loggerhead turtle are also seen here, although no nesting has been reported.

In addition to identifying nesting sites and turtle tracks during the 1996 study, an assessment was made of the total area that might be suitable for turtles to nest on. Suitable coastline was defined as that having a sand beach platform that was developed enough to allow some nesting, along with a foreshore and an offshore approach that would not completely obstruct the emergence of a turtle form the sea. Of the 226km of total coastline in the Chagos Archipelago (excluding the inner lagoon of Diego Garcia), an estimated 59-70% (134-157km) was considered as suitable for turtle nesting. A breakdown of the data is given by Mortimer and Day (1999).

a Green turtles

i Nesting

The population of females nesting annually is estimated between 400 and 800 individuals. Green turtles nest all year round locally, with nesting activity peaking during the southeast monsoon. The most favoured sites for nesting appear to be the Egmont Islands with a nesting density of 6.28 pits.

ii Foraging

Green turtles are more reliant on seagrass beds, but such habitat is relatively scarce in this archipelago. However, adult green turtles typically migrate hundreds or thousands of kilometres between their nesting and foraging habitats (Akesson *et al*, 2001), so it is possible that nesting green turtles may leave the archipelago to feed elsewhere. Although foraging adults are scare, juvenile green turtles inhabit the lagoon at Diego Garcia.

b Hawksbill turtle

i Nesting

The atoll of Peros Banhos contains the highest density of nesting pits for Hawksbills at 6.89 pits per km of coastline. The nesting activity of the Hawksbill is thought to coincide with the northwest monsoon, probably sometime between December and March. Around 300-700 females are estimated to nest annually.

ii Foraging

There are abundant coral reefs here, which provide ample foraging grounds for Hawksbill turtles.

3.4.7 Threats

i Exploitation

Turtle meat and eggs were heavily exploited by workers manning the coconut plantations from the late 18th to the middle of the 20th century. In addition, livestock and pets were also imported by these labourers (Stoddart 1971), possibly increasing the incidence of predation on the turtle eggs and hatchlings (Mortimer and Day 1999). There was also a heavy trade in turtle shells of both species that was likely to have significantly impacted the population, especially since nesting females were easy targets. The pressure began to be reduced with rising labour costs and transportation resulting in many of the islands being abandoned, and the last islanders were evicted to Mauritius during 1970-71 in preparation for the construction of a military installation. It is suspected that the greatest threat at present comes from illegal fishing by commercial vessels and private yachts, but the extent of this activity is unknown (Mortimer and Day 1999).

ii Sea level rise

As with all other terrestrial habitats in the Chagos Archipelago, the beaches used as nesting grounds are under substantial threat from sea level rise. With most of the islands having very limited area available for beach migration inland in response to sea level rise, it is possible that several nesting beaches might be lost entirely over the next century if islands become completely submerged. On a positive note however, apart from the base at Diego Garcia, there are no land-use conflicts preventing the potential inland migration of beaches, so larger islands may become smaller, but still retain suitable nesting habitat.

iii Conservation

The only permanent human residents are of the military base at Diego Garcia which occupies less than 25% of the land area of the atoll. The movements of the personnel are restricted and all wildlife is protected. The protection of turtles appears to have yielded positive results, with roughly double the population of 300 nesting females for each species recorded in 1977 (Mortimer and Day 1999).

3.5 British Virgin Islands

The British Virgin Islands (BVI) form part of the Puerto Rican Bank in the eastern Caribbean Sea. There are some 40 islands in the group, the four largest being Tortola (most densely populated), Virgin Gorda, Anegada and Jost Van Dyke. Most of the islands were uplifted from submerged volcanoes, and are hilly with steep slopes (UNEP/IUCN 1988, Procter and Fleming 1999). Coral reefs are present throughout the islands, and large areas of seagrass are also found, typically within sheltered bays.

The dominant natural vegetation is cactus scrub and dry woodland, although much of this has been modified. Mangroves are scattered throughout the islands, mostly as scrubby fringe communities. The BVI was a centre of sugar cane production in the past, but this has declined due to the limited soil-moisture capacity, erratic rainfall, and insufficient forest cover to reduce erosion on steep slopes. There are three species of plants endemic to the BVI, in addition to a number that are endemic to the Virgin Islands and Puerto Rico as a group (Procter and Fleming 1999). The locally endemic species are: *Acacia anegadensis* (Leguminosae), a dense, thorny evergreen acacia endemic to Anegada; *Cynanchum anegadense* (Asclepiadaceae) and *Sida eggersii* (Malvaeceae). Maps of vegetation communities on the main islands are available from the Caribbean Vegetation Mapping Project (CVMP 2002).

3.5.1 Habitats

i Tortola

The capital of the BVI is the most heavily developed island in this group. Most of the urbanisation has been along the coast, owing to difficulties in building on the steep slopes inland. In the 1950s, mangroves were present along much of the southern coast of Tortola. Since then, mangroves at Road Town, Sea Cows Bay, Nanny Cay and several other sites have been replaced by marinas, tourism facilities, and housing, although other significant stands remain around Beef Island and Paraquita Bay (Gell and Watson 2000). The mangrove stand at Paraquita Bay is relatively safe from impacts from boating activity because the lagoon is designated as a hurricane shelter for boats, and occupancy of this area is not normally allowed except for a few boats owned by individuals who live in the immediate vicinity.

ii Anegada

This low (8m maximum elevation), flat, limestone island was formed by coral reef growth and limestone accumulation (an elevated coral reef). It is surrounded by about 30km of beaches, which constitutes approximately one third of the total beach length in the entire BVI. Calcareous reef debris moves westwards with the Antillean stream along the north coast and culminates in the formation of dunes up to 4.6m high on the north coast and at West End. The western third of the island consists of a sandy plain with a large salt pond (Flamingo Pond) (UNEP/IUCN 1988). The main human settlement is on the south coast, but the total population of the island is only around 150. Total urban area on the island is about 2 km^2 (Downs 1997). The vegetation is highly disturbed, consisting mainly of cactus scrub and dry woodland. Mangroves are found along the southern shore and fringing the wetlands in the western half of the island. The largest stand of mangroves in the BVI is an area 3.4 km^2 on the eastern end of Anegada (Spalding *et al*, 1997). The Flamingo Pond Bird Sanctuary is the largest area of wetland in the BVI, and is one of the largest remaining saline lagoons in the Lesser Antilles (UNEP/IUCN 1988).

iii Coral reefs

Overall, the coral reefs of the BVI remain in relatively good condition. However, there are localised areas that have deteriorated as a result of human activities (Wilkinson 2000). Detailed descriptions of the reef habitats around the main islands are given by UNEP/IUCN (1988).

iv *Seagrass beds*

Large areas of seagrass are found in sheltered bays around the islands. Most of the shallow beds are *Thalassia testudinum* and deeper beds are usually *Sytingodium filiforme*. Some mixed-species beds are also present along with a third species, *Halodule wrightii*. The tidal range is small, so intertidal seagrasses are limited in extent (Gell and Watson 2000).

3.5.2 Threats

i Overgrazing

Heavy grazing by livestock is a problem on Anegada as they periodically strip areas bare of vegetation (Mitchell 2002).

ii Development

Although there are technical difficulties with building into the hilly interior of Tortola, efforts are still made to develop these areas. Roads are cut into the hillsides to increase the value of undeveloped real estate, and these generate problems of increased runoff and erosion from both the material being removed from the hillsides and also from the impermeable nature of the roads. Such impacts are localised at the moment, but are proceeding at a rapid rate and could be an increasing problem for the future (Gell and Watson 2000).

Even though cutting of mangrove is illegal, many areas are being reduced piecemeal through destruction for coastal developments (Gell and Watson 2000), with most of the habitat lost from Tortola and Virgin Gorda (Spalding *et al,* 1997). Mangrove habitat on Tortola has been reduced by 75% (Petrovic 1998). At Pockwood Pond, one of Tortola's largest stands of red mangroves stood next to a power station, incinerator, cement plant, and rock quarry. The mangroves prevented commercial expansion of these facilities until an oil spill devastated the area. Rather than restore the habitat, permission was granted to reclaim the area for industrial use (Petrovic 1998).

iii Sea level rise

Inland retreat of coastal habitats such as mangroves is likely to be impeded due to steep topography and barriers such as coastal roads. For example, there is a road behind most of the mangroves of Paraquita Bay, in some cases only a few metres behind the innermost trees. Apart from its ecological importance, it would be in the interests of the BVI to preserve this area because it provides relatively safe moorings for dozens of boats in the event of a hurricane.

iv Siltation

Overgrazing by goats, particularly on Anegada, has removed large areas of vegetation and increased the amount of sediment that is washed into the coastal waters (Wilkinson 2000). In addition, land reclamation, dredging and construction projects are increasing the turbidity of coastal waters (Smith *et al*, 1999). Both corals and seagrass communities rely on sunlight for photosynthesis and will therefore be negatively impacted by increased water turbidity. In addition, the particles of sediment may smother the coral polyps and seagrass blades.

v Marine traffic

Anchor damage has been implicated in coral reef degradation (Smith *et al,* 1999). In addition, concerns of the damage to seagrass beds around heavily-used anchorages has prompted the establishment of a monitoring site at Prickly Pear (North Sound) (UNEP/IUCN 1988).

vi Hurricanes

The passage of numerous storms since 1995, and most recently Hurricanes Jose and Lenny in late 1999, caused severe damage to coral at Norman Island, Peter Island, Salt Island, Cooper Island, Ginger Island and Virgin Gorda (Wilkinson 2000).

3.5.3 Species

i Birds

The breeding population consists of a core of resident species that is augmented during the summer by many seabirds that nest on the rugged outer cays throughout the BVI. In September, the departure of the seabirds coincides with the arrival of winter migrants from North America (Roy [no date]). The BVI is considered as one of the most important sites in the Caribbean for breeding seabirds (Hilton *et al,* 2001).

3.5.4 Threats

i Development

Although urban development has been progressing rapidly, the impacts so far have been relatively localised (Gell and Watson 2000). Coastal habitats are probably most at risk from development because the interior of the islands – except for Anegada – is extremely rugged. Removal of mangrove habitat on Guana Island has been suggested as the cause for the local extirpation of the yellow warbler *Dendroica petechia* (Mayer and Chipley 1992). Although reclamation projects have reduced the pressure on the remaining natural coastal habitats, such engineering works bring about their own problems of alteration of coastal geomorphology and marine sediment budgets, potentially causing harm to coastal ecosystems.

ii Sea level rise

The low-lying coastal habitats of mangroves, ponds, swamps, and beaches are at substantial risk from sea level rise. Apart from Anegada, which is relatively flat, the steep terrain of the BVI and the heavy coastal development present major barriers to inland migration of coastal habitats. For example, much of the low coast of Tortola is ringed by a road that is often less than 100m away from the sea (personal observation, May 2002). Rising seas could potentially result in substantial erosion of coastal habitat over the next century.

3.5.5 Terrestrial reptiles and amphibians

The herpetofauna of the BVI is among the most diverse among the UK Overseas Territories. There are some 24 taxa known throughout the islands, including seven endemic species and subspecies (Procter and Fleming 1999).

3.5.6 Threats

i Predation

The endemic Anegada rock iguana *Cyclura pinguis* originally inhabited Puerto Rico, St. Thomas (USVI) and Anegada (BVI). The species now only remains on Anegada, in addition to a small population that was relocated to Guana Island, also in the BVI (Procter and Fleming 1999). The feral cat population has been increasing in recent years, and poses is a major threat to the juvenile iguanas. Efforts are being made by the BVI National Parks Trust to rehabilitate the Anegada rock iguana, which involves captive rearing of juveniles so that they can be released at a size which is not so vulnerable to predation (BVINPT 2002).

ii Habitat loss

The large numbers of livestock on Anegada cause serious damage to native vegetation that provide food and shelter to the Anegada rock iguana (ISG 2003).

3.5.7 Marine turtles

No information.

3.6 Cayman Islands

The Cayman Islands consist of three limestone islands: Grand Cayman, Little Cayman and Cayman Brac, which are formed by the peaks of the submarine mountains that make up the Cayman Ridge. The islands are low lying, with maximum elevation of 20m on Grand Cayman (UNEP/IUCN 1988).

The National Trust for the Cayman Islands is conducting a comprehensive survey of the vegetation of the three islands. This information is part of a wider biodiversity survey, and the habitat data may be used in conjunction with other projects such as the census of the breeding population of the endemic Cayman Brac parrot *Amazona leucocephala hesterna*. The vegetation of the Cayman Islands consists of a mixture of dry evergreen formations and wetlands. Detailed descriptions of the vegetation communities are given by Brunt (1994) and maps of vegetation communities have been developed by Burton (2002).

The three islands support well-developed fringing coral reefs on narrow coastal shelves, covering a total area of 241km^2 (Wilkinson 2000). Seagrass habitats are primarily found at Grand Cayman, and also to a lesser extent at Little Cayman and Cayman Brac (Logan 1994, Bush 1998).

3.6.1 Habitats

i Dry evergreen woodland

The trees form two densely packed canopies, typically 6–12m high and a second 18–25m high. In Grand Cayman, this vegetation type occupies areas in the east and central parts. Stands in the West Bay area have been virtually destroyed. Evergreen woodland occurs in the centre of Little Cayman, and is scattered throughout the Bluff Formation on Cayman Brac.

ii Dry evergreen thicket

Another formation with two layers, thickets are characterised by an upper canopy that may be open or dense 6 – 12m high, and undergrowth that can also be dense or open. This group is mainly present on the eastern side of Grand Cayman, the north shore of Little Cayman, and on higher ground on Cayman Brac.

iii Dry evergreen bushland

This vegetation forms a low, dense impenetrable growth of small trees and bushes 3–4m high. It is well developed in the eastern coastal area of Grand Cayman, where the inland thicket grades into bushland. This type of vegetation covers much of the western end of Little Cayman, but information on its presence on Cayman Brac is not available.

iv Dry evergreen vegetation on rock pavements

Around parts of the coasts of Grand Cayman and Little Cayman, and most of the coast of Cayman Brac, are raised beaches of Ironshore Formation. This consists of coral marl with fissures across the surface, exposed to wind and salt spray. The vegetation consists of irregular and open growths of heraceous and woody plants less that 2m high, typically growing in crevices or in mats of humus upon the rock.

v Wetlands

More than 50% of Grand Cayman is covered by swamp communities that have developed on autochthonous peat substrates rather than the more commonly seen allochthonous silts in other regions (Burton 1994). The Cayman Islands are of limestone origin, with no terrestrial drainage system that supplies terrigenous sediment to the mangrove forests. Therefore, the peat deposits come almost entirely from organic matter produced locally by the mangroves themselves (Woodroffe 1980).

The largest single wetland community consists of the central mangrove swamp on Grand Cayman, which covers nearly 50km^2. This stand represents the largest area of inland mangrove in the Caribbean (Procter and Fleming 1999), and provides a flow of nutrients into North Sound (CNT [no date]) where the main seagrass bed of the Cayman Islands is located (Bush 1998). The communities are mainly made up of the mangrove species Rhizophora mangle, Avicennia germinans, and Languncularia racemosa that cover approximately 36% of Grand Cayman, 40% of Little Cayman, and 1% of Cayman Brac (Spalding *et al*, 1997). In addition, Conocarpus erectus can be found in small areas (Woodroffe 1981).

Approximately 1,500 acres of the Central Mangrove Wetland is protected through the Marine Parks Law, forming part of the Environmental Zone which has been in effect for Little Sound and its fringing mangroves since 1986. Efforts are now underway to increase the area of the Wetland under protection, through conservation land purchase (CNT).

vi Coral reefs

The reef systems around Grand Cayman, Little Cayman and Cayman Brac are quite similar to each other. Shallow-water fringing reefs encircle most of the island and form numerous shallow-water lagoons. The reefs form a series of terraces down to about 20m, descending into a steep reef slope at greater depths. The clarity of the water enables some reef growth to occur as deep as 75m. Detailed accounts of the reef formations are given by UNEP/IUCN (1988).

vii Seagrass beds

The main area of seagrass in the Cayman Islands is in North Sound, the large lagoon ($80km^2$) that dominates the western part of Grand Cayman. Approximately 60% of the North Sound is covered with *Thalassia testudinum*, which is interspersed with the calcareous algae from the genera *Halimeda*, *Penicillus* and *Rhipocephalus* (Wood and Wood 1994). Seagrass density declines towards the sand flats and reef crest at the north edge of the lagoon, with *Thalassia testudinum* and *Syringodium filiforme* interspersed with green algae (Roberts 1994). In Little Cayman and Cayman Brac, patchy development of seagrass beds occurs in the lagoonal areas of both islands. The dominant species is *Thalassia testudinum*, which typically forms monospecific stands. Also present are *Syringodium filiforme* and *Halodule bermudensis*, which may form small monospecific patches or else are interspersed with *Thalassia testudinum* (Logan 1994).

3.6.2 Threats

The majority of the impacts from human activity occur around Grand Cayman, where the bulk of the population lives.

i Development

Major loss of mangroves has resulted since the 1977 Development Plan for Grand Cayman was initiated, with many areas reclaimed for tourist development, road construction, golf courses, marinas and housing (Spalding *et al*, 1997). Mangrove communities along the periphery of the North Sound (Grand Cayman) appear to be receding (Bush 1998). Since the 1960s, large-scale developments have removed more than 60% of the mangroves within 0.5km of the western periphery of the North Sound (Ebanks-Petrie 1993). In addition, exploitation for fuel, house building and boat construction have caused widespread destruction of dry evergreen woodland, particularly on Grand Cayman (Brunt 1994).

ii Sea level rise

The low relief of these islands makes them highly vulnerable to sea level rise. In addition, accumulation of peat in mangroves relies on local sources such as organic material from *R.mangle* and *A.germinans* (Woodroffe 1981). Damage to these species (through storms, development, pollution, etc) could seriously hamper the ability of wetland habitats to keep pace with sea level rise.

iii Hurricanes

Hurricanes or severe tropical storms affect the Cayman Islands at the rate of about four out of every ten years (UNEP/IUCN 1988).

iv Scuba diving

The Cayman Islands are a popular dive destination, and dive sites are probably being over-used. Some sites are receiving more than 15000 dives per year (Wilkinson 2000), and there will inevitably be some accidental damage from collisions between divers and corals.

v Urbanisation

Coastal development projects are proceeding at a rapid pace, and there appears to be relatively little regulation of the impacts on coastal and marine environments (Wilkinson 2000).

3.6.3 Species

i Birds

An overview of the avifauna of the Cayman Islands is given by Bradley (1994). There are 46 species of breeding birds among the islands, which include 17 endemic subspecies. The only endemic full species, the Grand Cayman thrush *Turdus ravidus,* is now extinct. Rapid urban and tourist developments are the main threats to the natural habitats (Burton 1997).

3.6.4 Threats

i Development

Development pressures on Grand Cayman and Cayman Brac are the main threats to biodiversity (Procter and Fleming 1999). Habitats are becoming fragmented due to the growth of tourism and associated facilities (Stattersfield *et al,* 1998). On Little Cayman, for example, the number of buildings has doubled over the past few years. In addition, the proposed development of an airstrip on Little Cayman requires the clearance of a large area of mangrove, which will threaten 18,000 pairs of red-footed boobies *Sula sula* that nest there (Raffaele *et al,* 1998). Many bird species throughout the islands are therefore in danger of habitat loss, apart from a small number that have established themselves in urban environments such as the Eurasian collared dove and monk parakeet *Myiopsitta monachus.* Other species are nesting on small offshore cays that are probably safe from development, but are likely to be particularly vulnerable to sea level rise.

ii Sea level rise

Some 18 breeding species and subspecies in the Cayman Islands nest within low-lying habitats such as the coastal fringe, wetlands, and offshore islets and cays (Bradley 1994, Raffaele *et al,* 1998, Procter and Fleming 1999). These species are therefore potentially the most vulnerable among the local avifauna to habitat loss from sea level rise: West Indian whistling duck *Dendrocygna arborea,* cattle egret *Bubulcus ibis,* green heron *Butorides striatus,* little blue heron Eg*retta caerulea,* snowy egret *E. thula,* tricolored heron *E. tricolour,* white-crowned pigeon *Columba leucocephala,* mangrove cuckoo *Coccyzus minor,* yellow warbler *Denrdroica petechia,* vitellina warbler *D. vitellina vitellina* (endemic subspecies), magnificent frigatebird *Fr*e*gata magnificens,* pied-billed grebe *Podilymbus podiceps,* American coot *Fulica americana,* common moorhen *Gallinula chloropus,* purple gallinule *Porphyrula martinica,* black-necked stilt *Himantopus mexicanus,* willet *Catotrophorus semipalmatus* and Cayman vireo *Vireo magister caymanensis* (endemic subspecies).

3.6.5 Terrestrial reptiles and amphibians

The herpetofauna of the Cayman Islands is remarkable in that approximately 75% of the 26 taxa are endemic. The status of reptiles and amphibians is described by Seidel and Franz (1994), but they caution that there is relatively little ecological information available.

3.6.6 Threats

Habitat loss from development and predation by domestic dogs and cats are the primary threats to the Cayman Islands herpetofauna (Seidel and Franz 1994). The Grand Cayman iguana *Cyclura nubila lewisi* and Lesser Cayman iguana *C. nubila caymanensis* have been studied particularly closely, and it is known that both of these endemic subspecies are suffering threats from multiple sources including predation by cats, dogs and possibly rats, habitat loss to development and grazing livestock, and illegal killing by farmers who perceive them as a threat to crops (Burton 2002, Gerber 2002).

i Sea level rise

The following taxa, all of which are endemic, are found on beaches and may therefore be at risk of habitat loss from rising sea level: Lesser Cayman Islands curly-tailed lizard *Leicocephalus carinatus granti,* Grand Cayman curly-tailed lizard *L. carinatus varius,* Cayman Brac blind snake *Typhlops epactia,* and Grand Cayman blind snake *T. caymanensis* (Seidel and Franz 1994).

3.6.7 Marine turtles

No information.

3.7 Falkland Islands

The cool temperate climate supports communities of tussock grassland, heath, feldmark, and bogs. On the main islands of East and West Falkland, the vegetation has been severely degraded by burning and overgrazing (Procter and Fleming 1999). The main vegetation communities are described in detail by Bingham (2002).

3.7.1 Habitats

i Tussock grassland

Tussock grass tends to form a strip about 300m wide along the coast, as it prefers areas exposed to salt spray. It is dominated by *Parodiochloa flabellate* that typically grows to a height of around 2m. It consists of a tussock-like growth form around a fibrous pedestal. These pedestals provide nesting habitat for birds such as magellanic penguins *Spheniscus magellanicus*, thin-billed prions *Pachyptila belcheri*, sooty shearwaters *Puffinus gravis* and small petrels (*Procellariidae*), which burrow into or beneath it. The leaves, which can grow up to 2m in length, bush out from the living crown and provide valuable nesting cover for passerines, birds of prey (eg turkey vulture *Cathartes aura falklandicus* and short-eared owl *Asio flammeus sanfordi*), and coastal birds (eg kelp geese *Chloephaga hybrida malvinarum*). Tussock grass can be split into two categories, dense tussock where tussock is the dominant vegetation cover, and mixed tussock where tussock is present within another plant community, usually oceanic heath formation (grass or dwarf shrub).

ii Feldmark formation

This habitat is dominated by cushion plants, such as balsam bog *Bolax gummifera* and cushion plant *Azorella* spp. It grows on higher hills and exposed ridges, usually above 600m, where the combination of thin shale soils and exposure to wind exclude faster growing species that lack adaptations to cope with desiccation and nutrient deficiency. A lower diversity of fauna is supported here due to the less habitable conditions.

iii Rocky outcrop

The underlying rock is exposed through the thin soils in many areas. These provide nesting sites for birds such as ground tyrants, red-backed buzzards, crested caracaras and peregrine falcons, and can be colonised by lichens and a small number of vascular plants.

iv Fens

These are areas surrounding ponds, lakes or streams that contain tall freshwater vegetation such as willow herb *Epilobium ciliatum* and rushes (eg *Scirpus californicus* and *Eleocharis melanostachys*). Fens are not abundant in the Falklands, but they provide cover for nesting waterfowl and smaller passerines.

v Bog

This usually consists of wet swampy areas of short rushes or astelia *Astelia pumila*, often with low cushions of oreob *Oreobolus obtusangulus* or patches of *sphagnum*.

vi Fachine and box

There are no native trees, and only two native species which grow as bushes: fachine *Chiliotrichum diffusum* and box *Hebe elliptica*. Both species are sensitive to grazing by livestock, and have declined significantly since human settlement as a result. They are now almost absent from much of East and West Falkland. The surviving stands provide shelter and nesting habitat for several passerines, such as thrushes and siskins.

vii Kelp beds

Extensive kelp beds (mostly *Macrocystis pyrifera* and *Lessonia flavicans*) grow in shallow water (< 30m) around the coast. Most of the kelp beds are 20–30m wide, although some may stretch to 1km in width. The beds provide shelter and feeding grounds for a diverse range of invertebrates, molluscs and fishes, which in turn makes them valuable feeding grounds for seabirds (White et al, 1999).

3.7.2 Threats

i Agriculture

Burning and overgrazing have been the primary threats on the main islands of East and West Falklands where humans have settled (Procter and Fleming 1999), and tussock grasslands have been particularly sensitive to such disturbances (Bingham 2002). An estimated 80% of the tussock area has been destroyed, with most of the surviving stands now on offshore islands (Anon 2002a).

ii Tourism

The tourist industry has expanded quite rapidly over the past decade; but a degree of control has been exerted that was lacking in several of the Caribbean territories during their periods of tourism increase in the 1980s and 1990s. Efforts to develop tourism began after the Anglo-Argentinian War of 1982. Plans were made for tourism to be the tool for revitalising the economy that had been relying on sheep farming which was suffering from falling wool prices. The initial expansion of the tourism industry was slow and controlled in the mid 1980s to early 1990s, and there remained potential for increasing visitor numbers further (Riley 1995). In the second half of the 1990s, visitor numbers rose five-fold from around 4,500 in 1994 to over 22,000 by 1999, and there have been localised problems of erosion along the tracks used by the tourists (Ingham and Summers 2000).

There does not appear to be any information available that relates specifically to threats to coastal marine habitats around the Falkland Islands. There is some evidence, however, which suggests that rising marine temperatures may cause nutrient limitation in kelp beds, although substantial uncertainty remains regarding this effect (Steneck *et al*, 2002)

3.7.3 Species

i Birds

The Falkland Islands are notable for their internationally important populations of breeding seabirds. These islands have the world’s largest concentration of southern rockhopper penguins *Eudyptes chrysocome chrysocome* and one quarter of the world population of gentoo penguins *Pygoscelis papua*. Several species of landbirds are also present on the islands. Among the avifauna are one endemic species, the Falkland steamer duck *Trachyeres brachydactyla*, and 16 subspecies or races that may also be endemic (Procter and Fleming 1999).

3.7.4 Threats

i Predation

Introduced rats, cats and Patagonian foxes *Dusicyon griseus* are widespread, including on many of the offshore islets (Woods and Woods 1997). The present distribution of the endemic Cobb's wren *Troglodytes cobbi* is inversely related to the presence of such predators (Stattersfield and Capper 1998). A rat-eradication programme is underway with the aim of clearing the offshore islands. There are many islands with tussock grass habitats that would be suitable for bird nesting, if the rats can be removed (Brown *et al*, 2001).

ii Loss of tussock habitat

Tussock grass provides important habitat for many species of birds. However, burning and livestock grazing have destroyed much of the tussock grass, leaving relatively small surviving patches that are mostly found on offshore islands (Hilton *et al*, 2001).

iii Longline fishing mortality

Seabirds may be killed by becoming caught in fishing gear or being involved with direct collisions with such gear. Although some species do suffer heavily from mortality associated with longline fishing, this type of fishing activity is conducted at a low level of effort in the waters around the Falkland Islands and therefore does not appear to pose a significant threat to species that forage in local waters (White *et al*, 2000). However, seabirds that travel long distances in order to feed may be more vulnerable to fishing operations beyond local waters. A decline of over 40,000 breeding pairs of black-browed albatrosses *Diomedea melanophris* has been recorded since 1995, and it is believed that longline fishing in the Patagonian Shelf waters (Argentina) is a major contributing factor (UKOTCF 2001a, Falklands Conservation 2002).

iv Fisheries competition

Whilst there is no direct evidence that food availability to penguins has been affected by commercial fisheries (Bingham 1998, Putz 1999), the risk of potential competition between seabirds and local squid *Illex* spp. and *Loligo* spp. fisheries should not be ignored (Thompson 1989, 1992). Squid are part of the diet of several bird species in the Falkland Islands, including the globally threatened rockhopper and gentoo penguins (Thompson 1994).

v Pollution

Oil pollution can cause significant damage to seabird populations (Dahlmann *et al*, 1994). Whilst the reported incidence of oiled seabirds in Falkland Islands waters is low (Smith, 1998), mortality of magellanic penguins *Spheniscus magellanicus* from oil pollution is reported to be severe in the neighbouring Argentine waters. Oil pollution is believed to cause up to 40,000 deaths of magellanic penguins each year, and the possibility of transport of such pollution by winds and currents to Falkland Islands waters should be noted (Gandini *et al,* 1994; White *et al,* 2000).

vi Tourism

Increasing numbers of tourists visiting seabird colonies in the Falkland Islands are causing concern because disturbance of nests may be affecting breeding success for some species. The endangered southern giant petrels *Macronextes giganteus* are thought to be highly susceptible to human disturbance, especially during incubation periods, which may result in desertion of the nest. In an effort to address this problem, hides have been constructed to shield southern giant petrels from human disturbance on Pebble and Sea Lion Islands (White *et al,* 2000).

vii Sea level rise

Beaches are probably the most vulnerable habitat utilised by bird species in the Falkland Islands. The following avifauna nest on beaches (‘E’ denote endemic taxa): tussac bird *Cinclodes antarticus antarticus* (E), blackish oystercatcher *Haematopus ater,* magellanic oystercatcher *H. leucopodus,* dolphin gull *Larus scoresbii,* kelp gull *L. dominicanus,* Cobb’s wren *Troglodytes aedon cobbi* (E), and king penguin *Aptenodytes patagonicus* (Altman and Swift 1989, Woods and Woods 1997). However, none of these species nest exclusively on beaches, apart from the king penguin. In addition, the sand dune system behind many of the beaches (Bingham 2002) may allow inland migration of beaches in response to sea level rise.

3.7.5 Terrestrial reptiles and amphibians

No information.

3.7.6 Marine turtles

No information.

3.8 Gibraltar

Connected to Spain by a sandy isthmus, Gibraltar lies at the southern tip of the Iberian Peninsula. The main feature of Gibraltar is a limestone cliff known as ‘the Rock’, which dominates the landscape. The eastern side is made up of sheer cliffs, reaching a maximum altitude of 426m above sea level. The base is dominated by the massive prehistoric sand dune and by talus slopes on either side. These slopes are largely the product of years of rock falls as pieces of the Rock continue to collapse towards the sea. The western half is very different, with slopes that gently slope towards the sea. Much of its lower half is taken up by the city and the urban zone has spread westwards in recent years as land has been reclaimed from the sea. The upper areas are designated as a nature reserve. To the south of the main mass of the Rock are various wave-cut platforms that were formed by previous changes in sea level: a higher plateau known as Windmill Hill, a lower platform known as the Europa Flats, and narrower and lower segments on the fringes that form rocky beaches.

Most of the original vegetation was probably destroyed by tree felling and grazing animals (Procter and Fleming 1999). In addition, some two thirds of Gibraltar is now covered by developed land. The remaining vegetation consists mainly of dense maquis scrub, but there are other areas of more open, lower scrub (garigue). There is considerable variation in the types of scrub, and also in the variety of habitats available to plants. Apart from scrub there are extensive sea cliffs, a limited but important rocky shoreline, the expansive sand slopes on the east side, rocky limestone outcrops and fissures, the Windmill Hill plateau, and the remains of the sandy isthmus which link Gibraltar to Spain found at North Front Cemetery.

The limestone geology has resulted in alkaline soil formation. In contrast the mountains in the surrounding area of Spain are largely sandstone that produces more acidic soils. As a result, many species found in Gibraltar are rare in the Mediterranean. The following habitat descriptions are taken from Linares (1999). Detailed descriptions of each plant species can be accessed on the website of the Gibraltar Ornithological and Natural History Society (www.gibraltar.gi/gonhs).

3.8.1 Habitats

i Maquis

This consists of a dense, almost impenetrable mass of small trees and shrubs together with creeping and climbing plants 3–5m high. Maquis covers most of the Upper Rock.

ii Garigue

This consists of fairly open vegetation formed by low shrubs, less than 1.5m high. Garigue scrub is generally found in the southern parts of the Rock. The more open nature of this type of vegetation enables the growth of a greater variety of species than is possible in the more overgrown maquis.

iii General coastal

Most of what remains of the natural coastline is rocky shore with a small intertidal range typical of the Mediterranean. This area is exposed to the easterly and south-westerly winds, and the ensuing sea spray provides the ideal habitat for certain plants which are only found close to the sea. The endemic Gibraltar lavender *Limonium emarginated* grows here. Most of the accessible shoreline is exploited by humans to some extent, often on a small scale such as fishing for bait. Recreational angling is an increasing problem and probably disturbs wading shorebirds. The cliffs remain relatively unspoilt, except near industrial activity.

iv Windmill Hill Flats

This plateau has areas of open pseudosteppe, low scrub, and higher maquis. There is an artificial pond here. Military training disrupts vegetated areas, and is thought to discourage some bird species from nesting here, such as the corn bunting *Miliaria calandra*) and black-eared wheatear *Oenanthe hispanica*. This area has thin, poor, stony soil, and is subject to strong winds. Despite this, many plant species survive, including several not found elsewhere in Gibraltar, including *Crocus serotinus salzmannii*, *Salvia verbenaca, Echium parviflorum, Plantago serraria, Hedysarum coronarium, Mantisalca salmantica, Minuartia* *geniculata, Tetragonolobus purpureus,* and *Lathyrus annuus*. Introduced plant species are out-competing natural vegetation in some parts.

v The Upper Rock

This zone is mainly vegetated by high maquis, about 2–3m tall, with some areas of lower scrub to 1m and other areas cleared as firebreaks. The vegetation here provides the main feeding sites for the Barbary partridge and rabbits. There are cliffs and other rocky slopes where endemic plants survive. These areas might be more protected from invasive flora that threatens the more accessible open parts of the Upper Rock. The semi-wild Barbary macaques *Macaca sylvanus* inhabit the Upper Rock in more open habitats where they cause heavy damage to plants by trampling, eating and by causing erosion.

vi Rocky outcrops

This encompasses the limestone cliffs which form the North Face of the Rock and the East side, the rocky upper ridge and the outcrops and roadsides within the maquis. The endemic Gibraltar champion *Silene tomentosa* was believed extinct until three examples were rediscovered here in 1994. Attempts are being made by the Gibraltar Botanic Gardens and the Royal Botanic Gardens at Kew (UK) to repopulate this species in the wild (Procter and Fleming 1999). Two other endemic plants, *Ononis natrix ramosissima* and *Saxifraga globulifera gibraltarica* also grow in this habitat.

vii Great Eastern sand slopes

These are prehistoric consolidated sand dunes, created by wind-blown sands during a time when sea levels were much lower than at present. The plants that can survive in this habitat are adapted to withstand salt-laden winds, high temperatures with no cover from the sun, and drought conditions.

viii Seagrass beds

Seagrass beds are only present on the west coast of Gibraltar. Two main monospecific beds are present: *Zostera marina* in the Bay of Gibraltar on the border with Spain, and *Posidonia oceanica* within the confines of the Harbour (Shaw 1993). The latter species is dominant in the Mediterranean (Marba and Duarte 1997).

3.8.2 Threats

i Introduced species

Several species have been introduced either deliberately or accidentally, particularly via soil imported for cultivation. Many of these exotics come from countries with a climate similar to that of Gibraltar, such as South Africa and parts of South and Central America. As a result, many of them have rapidly spread, sometimes to the detriment of native species. Among these plants are *Oxalis pes-caprae, Agave Americana, Opuntia ficus-indica, Freesia refracta,* and *Aloe arborescens*. Some were introduced as ornamental plants, whereas others such as *Carpobrotus edulis* were planted in order to stabilise the great eastern sand slopes. In comparison to the native flora, however, invasive plant diversity is relatively low, unlike on several of the other Territories.

ii Habitat destruction

Most of the original vegetation has been destroyed, and at least two thirds of Gibraltar has been urbanised. Tourism is particularly intense, with approximately 6 million visitors annually.

iii Urbanisation

The loss of *Posidonia* seagrass beds began with construction of docks in the 1890s. Once these projects were completed, the seagrass beds remained relatively undisturbed until the 1970s when a programme of coastal reclamation for housing began within the confines of the harbour, causing the destruction of another $0.05km^2$. A second reclamation project was carried out in 1989 within the bay, but with undetermined consequences for the seagrass community there (Shaw 1993). The water circulation within the Harbour has been completely changed and there is little tidal flushing to remove the build-up of pollutants from coastal settlements and boats within the Harbour. Between 1997 and 2000, the remaining seagrass communities were reduced by 60% as a result of more construction work, which included the extending of sea defences. A further 15% is thought to be at risk from current and planned development activities (Reed 2002). *Zostera* seagrass beds are more tolerant of pollution than *Posidonia* communities, and it is possible that there could be a shift in species composition towards *Zostera*-dominated communities in the Harbour as a result of pollution.

iv Invasive species

Introduced species of green algae *Caulerpa racemosa* and *C.taxifolia* are invading seagrass habitats in the Mediterranean, particularly in the southeast and northwest. No cases of invasion of the Gibraltar beds have yet been documented, but preservation of the health of these communities is important to resisting invasion because studies have shown that there is a positive relationship between shoot density in *Posidonia oceanica* beds and resistance to *Caulerpa* spp. invasion (Ceccherelli and Cinelli 1999, Ceccherelli *et al,* 2000).

3.8.3 Species

i Birds

More than 300 species of birds have been recorded in Gibraltar. The resident breeding population consists of some 40 species, including the globally threatened lesser kestrel *Falco naumanni.* A checklist of resident and migratory species is given by Garcia (2001), and typical habitats utilised by the birds are listed by Reed (2000). This Territory is an extremely important stopover point for migratory birds. Approximately 250,000 Paelaearctic breeding birds that winter in Africa pass through the Strait of Gibraltar in a season, with a further 200,000 seabirds passing through on migration between the Atlantic and the Mediterranean (Hilton *et al,* 2001).

3.8.4 Threats

i Development

The primary threat to wildlife on Gibraltar appears to be from urban development, which has taken over approximately two thirds of the land area. There has been substantial pressure for further development on the remaining un-developed land, but this has relaxed a little due to recent land reclamation schemes (Hilton *et al*, 2001). Few areas are free from disturbance; these are probably limited to steep slopes and cliffs inaccessible to humans and predators.

ii Disturbance from tourism

Although tourists visit many of the UK Overseas Territories, Gibraltar deserves special mention owing to the intensity of disturbance to wildlife that is likely to results from the sheer volume of tourist traffic. Approximately 6 million visitors are recorded each year, which is an extremely high density given that the total land area is only 6.5 km^2.

iii Longline fishing

Information relating to seabird bycatch from fishing activity in the Mediterranean is poor. There is however, evidence to suggest that mortality from longline fishing is a significant cause of mortality for Cory's shearwaters *Calonectris diomedea* that breed in Spain (Cooper *et al,* 2003). The potential impact of fishing mortality on the seabirds (great skua *Catharacta skua,* yellow-legged gull *Larus cachinnans,* Western Mediterranean shag *Phalacrocorax aristotelis,* Cory's shearwater, Balearic shearwater *Puffinus mauretanicus,* Levantine shearwater *P. yelkouan,* and European storm petrel *Hydrobates pelagicus*) that breed in Gibraltar should be a matter for future consideration.

iv Sea level rise

There is very little information available to assess the potential impacts of sea level rise on resident breeding birds. It seems likely however, that the seabirds nesting on the coastal fringe will be the most vulnerable. For example, the sea caves used by the Western Mediterranean shag may be less suitable for nesting in the future as sea level rises.

3.8.4 Terrestrial reptiles and amphibians

No information.

i Marine turtles

No information.

3.9 Montserrat

Situated in the Caribbean, Montserrat is a volcanic island within the Antilles island chain. The terrain is generally rugged and there is only a narrow coastal plain. Most of the beaches are located on the west coast of the island, varying between volcanic sand and boulder beaches. There is one coral sand beach at the northern end of the west coast, at Rendezvous Bay (Cambers 1996).

Cultivation and hurricanes have almost completely removed the primary rainforest, which has subsequently been replaced by secondary rainforest: palm break and elfin woodland on ridges, and thickets and dry scrub woodland at lower altitudes. North-facing slopes are wetter and support more vegetation compared to those slopes that face south. Before the eruptions, approximately 11% of the total land area was cultivated, and a further 10% urbanised (Johnson 1988). Maps of vegetation communities are available from the Caribbean Vegetation Mapping Project (CVMP 2002).

Montserrat has a high energy coastline subject to substantial erosion, as there is no barrier coral reef for protection. Strong groundswells affect the west coast, and the east coast is exposed all year-round. The narrow coastal shelf provides limited opportunity for the establishment of benthic marine communities. Small scattered patch reefs are present along all but the windward (east) coast, and small seagrass beds are scattered around the island.

3.9.1 Habitats

i Forests

The original tropical rainforests have been largely replaced with scrubby secondary forests as a result of various human-related and natural (eg storms) impacts (Anon 1994). A small area of virgin rainforest remained on the western slope of South Soufriere Peak, but its current status after the eruption is uncertain, when a large proportion of the island's hill forests were destroyed. Before the eruption, secondary forest covered a total area of 20–30km^2, with some being exploited for timber, and other inaccessible parts remaining relatively untouched by human activities. In the northern Silver Hills, Dry scrub woodland has been degraded by clearance and overgrazing.

ii Wetlands

Mangroves are poorly developed owing to the steeply shelving shores. There are several tiny ponds and marshes, and two small patches of coastal mangroves at Fox's Bay and Little Bay. The larger stand was at Fox's Bay, measuring only 0.06km^2 (Gell and Watson 2000). However, this mangrove habitat has been destroyed as a result of the recent volcanic eruptions (Macnamara, pers. comm. 2002).

iii Coral reefs

The reefs of Montserrat consist of a series of patch reefs interspersed with sand and sediment. Substrates are primarily covered with coral (20-45%), algae (23-41%) and some sponges. Coral diversity is high for the Caribbean, with 37 species recorded, but individual coral colonies tend to be small (Brosnan *et al,* 1997).

iv Seagrass beds

There are three species of seagrass around Montserrat: *Thalassia testudinum*, *Syringodium filiforme*, and *Halophila baillonis* (Brosnan *et al*, 1997). The narrow coastal shelf provides limited suitable sites for seagrass beds (Gell and Watson 2000). The location of seagrass habitats varies between accounts. A report that focused on coral reef systems mentioned seagrass beds off the northern and southern edges of the island, around Bransby Point and off Blackburne Airport (UNEP/IUCN 1988). Gell and Watson (2000) list three main seagrass beds. The largest (7.5km^2) is off the northern tip of the island, whereas the other two are located off the east and west coasts.

3.9.2 Threats

Investigations have been made by the UK Overseas Territories Conservation Forum (UKOTCF) and the Royal Botanic Gardens at Kew with the aim of restoring vegetation in terms of both natural habitat and agriculture, both of which have been badly damaged by human activities and natural disasters (UKOTCF 2002b). A proposed list of species for replanting has been created towards this goal, to rebuild communities from lowland to mountain habitats (Macnamara 2002).

i Introduced species

The agouti *Dasyprocta leporine* is common and is an agricultural pest in some areas (Johnson 1988). In addition, regeneration of forests after storm damage is seriously hampered by grazing livestock (Anon 1994).

ii Impacts of volcanic activity

Much of the southern half of the island was directly impacted by lava flows, and areas further north, including the Central Hills, were affected by ash fallout. Pyroclastic flows destroyed an estimated 17% of the island's vegetation, and a further 15% was destroyed by other volcanic-related causes (eg gas emissions and acid rain) (Brosnan and Akackaya 2000). The hill forests suffered the most damage, with about 60% being destroyed (UKOTCF 2002a). The total loss of vegetation near the crater summit has caused severe problems of erosion, resulting in sediment-laden runoff reaching lower reaches of the mountain and entering into the sea (Brosnan 2000).

The acidity of the Chances Pond, near the eruption crater, has been substantially increased by acid rain. Normal acidity levels were probably around pH 5, and in January 1996 the waters were measured at a pH 2, which is 1,000 times more acidic than a pH of 5 (Brosnan 2000). The effect on the biological community of the lake is not known, but it would be important to establish the status of the lake since it is one of the few areas of wetland on the island.

iii Sea level rise

Rising sea level will probably impact two habitats: beaches and coastal wetlands. Beaches will probably constrict in their range, owing to the steep inland terrain and mining of sand (Anon 1994). The consequences of rising sea level for wetlands are less clear. Coastal wetlands, such as the mangrove stand at Fox's Bay may suffer increased erosion as a result. Alternatively, an increase in sea level might actually benefit this habitat because it dries out seasonally. Therefore, more frequent inundation by the sea could be beneficial by reducing desiccation and helping to flush out sediments that were causing problems even before the volcanic eruptions increased the sediment loading of terrestrial runoff (Johnson 1988).

iv Hurricanes

The vegetation has been substantially influenced by tropical storms over the decades, contributing to the decline of primary rainforest and its succession by secondary regeneration (Johnson 1988). In 1979, Hurricane David caused damage, and in 1989, Hurricane Hugo passed directly over the island, causing extensive damage to both natural habitats and human settlements. Further damage was caused by the passage of Hurricane Luis in 1995, causing an average reduction in beach width of 10.9m. Four months after the Hurricane, beaches were still an average of 7m narrower than pre-hurricane widths, but beach recovery in Montserrat after Hurricane Hugo was still occurring four years after the event (Cambers 1996).

There appears to be little impact to marine environments from coastal development and pollution (Brosnan *et al,* 1997). There is no mention of threats specifically relating to seagrass beds, but it seems likely that volcanic ash will have impacted seagrasses off the east coast, given that the main areas of Montserrat affected by the eruptions were in the south and east.

v Volcanic activity

The reefs were relatively pristine prior to volcanic activity. The recent volcanic activity has had localised impacts on the reefs, directly through sedimentation from ash fallout, and indirectly from increased terrestrial runoff resulting from destruction of vegetation cover (Brosnan *et al,* 1997).

vi Nutrient runoff

The steep slopes of this island predispose it to greater runoff and nutrient input when compared to more low-lying islands in the same region. Comparisons of volcanic and low-lying coral islands in the Seychelles indicate that marine algae are more abundant around volcanic islands because there is greater nutrient input to coastal waters from greater rainfall and more dense terrestrial vegetation (Littler *et al,* 1991). Excess runoff and nutrient supply would favour algal over coral growth and survival, and eutrophication has been known to contribute to shifts in community dominance from coral to algae (Lapointe 1989).

3.9.3 Species

i Birds

Historical information on the status of the avifauna in Montserrat is limited. There has been a recent increase in survey effort since the eruption of the Soufriere Hills volcano, which damaged or destroyed substantial areas of forest habitat. Surveys of the status of bird populations have concentrated on the endemic Montserrat oriole *Icterus oberi* and other forest-dwelling species such as the forest thrush *Cichlherminia lherminieri*. Seabirds and species that live in more open habitat have generally not been included in surveys. A proposal for a project to preserve the forest ecosystems and implement sustainable management has been submitted in order to try and save habitats that have survived destruction from the volcanic eruptions, and rebuild those that did not (UKOTCF 2002).

3.9.4 Threats

i Volcanic eruptions

Montserrat has undergone major changes since the volcanic eruptions began. The southern half of the island has been impacted by pyroclastic flows, and many parts of the island have been subjected to acid rain and ash fallout. The Montserrat oriole and the globally threatened forest thrush suffered serious population declines as a result of the volcanic activity, which destroyed more than half of the suitable habitat within the Central Hills area (Arendt *et al,* 1999; Hilton *et al,* 2001).

ii Hurricanes

Hurricanes may be a major source of disturbance to biodiversity on many tropical islands. There is concern that levels of disturbance may increase in the future if the frequency and/or intensity of tropical storms increase as a result of climate change (Hilton *et al,* 2001).

iii Sea level rise

Of the 49 breeding species of birds, 11 species prefer to nest at low elevations on beaches, inland and coastal wetlands (Raffaele *et al*, 1998; Arendt *et al*, 1999). Rising sea level may increase flooding and erosion of these habitats, exacerbating the damage caused by volcanic eruptions and beach mining (Gunne-Jones and Christopher 1997) (Macnamara, pers. comm.). The steep inland terrain of the island may impede the retreat of coastal habitats in response to sea level rise, potentially resulting in a net loss of habitat. The bird species that nest in low-lying areas are: pied-billed grebe *Podilymbus podiceps*, brown pelican *Pelecanus occidentalis*, magnificent frigatebird Fr*egata magnificens,* great egret *Ardea alba*, little blue heron Eg*retta caerulea*, cattle egret *Bubulcus ibis*, green heron *Butorides virescens*, black-necked stilt *Himantopus mexicanus*, laughing gull *Larus atricilla*, royal tern *Sterna maxima* and yellow warbler *Dendroica petechia*.

3.9.5 Terrestrial reptiles and amphibians

There appears to be relatively little information available on the native herpetofauna (UKDTCF 1996). In 1995, the *Montserrat Biodiversity Project of the Fauna and Flora Preservation Society* focused on an assessment of the mountain chicken *Leptodactylus fallax*. This species originally inhabited at least five major islands in the Lesser Antilles. However, a combination of hunting, habitat loss and the introduction of alien predators has reduced its range to Dominica (where it is still heavily hunted) and Montserrat. The mountain chicken primarily inhabits forested areas above 300m (Procter and Fleming 1999).

3.9.6 Threats

i Habitat loss – volcanic activity

On Montserrat, the distribution of the mountain chicken has declined to less than 17 km^2. At least 10% of the species' original (in 1995) habitat in Montserrat has been destroyed by pyroclastic flows, and all other areas have been impacted by acid rain and volcanic ash fall-out. There are also indications that reproduction has been suppressed in the increasingly toxic, acidified environment (Daltry and Gray 1999).

3.9.7 Marine turtles

No information.

3.10 Pitcairn Islands

The Pitcairn Islands are an extremely isolated group of islands, located in the South Pacific Ocean. There are four main islands: Pitcairn Island, Henderson Island, Oeno Atoll and Ducie Atoll. Pitcairn is the only island that is permanently inhabited, and the vegetation has been heavily modified as a result. The other three islands have seen little human influence, and have therefore largely retained their original vegetation. Detailed descriptions of the vegetation communities are given by Waldren *et al* (1995a).

The islands of the Pitcairn group support a relatively poor diversity of coral species that reflects their extremely isolated location in the Pacific Ocean (Irving 1995). Pitcairn alone does not support a coral reef. No seagrass habitats have been described for any of the islands.

3.10.1 Habitats

i Pitcairn Island

Pitcairn is a volcanic island, rising 333m above sea level. Until recently, the population lived a largely subsistence existence, hence, much of the arable land was used to grow a variety of crops. In addition, introduced goats have exerted heavy grazing pressure, and woodlands have been over-exploited for timber, fuel and carving material. The only strip of completely native vegetation that remains on the island is a small cloud forest that runs along a ridge called the Highest Point. Other native species are scattered throughout the island mixed in with exotic flora (Procter and Fleming 1999). Overall, more than 30% of the island is covered by native forests, which are restricted to remote valleys (Kingston and Waldren 2003). The coastline is generally steeply sloping with little beach or strand vegetation. Species such as *Agusia argentea* (important for beach stabilisation) and *Pemphis acidula* are rare, possibly as a result of disturbance. Elsewhere, native species are commonly interspersed with exotic flora. In less disturbed valleys there is forest dominated by the endemic *Homalium taypau*. Some of the valleys and middle slopes are dominated by monospecific stands of *Syzgium jambos*, a species that was introduced for fuel wood. However, cutting of *S. jambos* is much less intense than previously, allowing the species to rapidly spread and threaten native flora. Rapidly spreading exotic scrubs such as *Dicranopteris linearis*, *Latana camara* and *Lablab purpureus* are threatening other natural and semi-natural plant communities (Waldren et al, 1995b).

ii Henderson Island

The inhabitants of Pitcairn occasionally come here to harvest the vegetation, but the flora remains relatively pristine. The porous nature of the limestone has allowed very little accumulation of soil within the island’s interior reaches. In contrast, the coastal zones are characterised by dense vegetation. Henderson is unusual among Pacific islands, in that there are few exotic species present.

iii Oeno Atoll

This atoll consists of a small central island surrounded by a lagoon and fringing patch reefs. The island has been virtually untouched by human activity, hence, the vegetation is almost pristine apart from coconut plantations (*Cocos nucifera*) in the northern part of the island.

iv Ducie Atoll

Ducie is the most remote of the Pitcairn Islands, and consists of four small islands surrounding a central lagoon. The vascular flora is very impoverished with only two species (*Pemphis aciduola* and *Argusia argentea*) present.

v Coral reefs

a Henderson Island

A coral reef surrounds two thirds of the island, consisting of a reef flat, reef margin and fore-reef, which descend gradually into deeper water. The range of sublittoral habitats provided by this topography is limited, reflecting a low level of coral diversity. Spur and groove formations of the fore-reef are present around the northern end of the island. The remaining unprotected coastline in the south is characterised by vertical cliffs that are undercut to form large caves and caverns. Live coral cover on the fore-reef is approximately 10–30%, but at sites off the east coast it reaches 80% (UNEP/IUCN 1988, Irving 1995).

b Oeno Atoll

This low coral atoll encompasses a shallow lagoon (2-3m deep) surrounded by a fringing reef. Coral development is poor within the lagoon, and patch reefs occupy only about 20% of the substrate. The fore-reef gradually descends to over 30m depth, and coral cover can be as high as 70% down to 30m, but beyond this the cover falls to a maximum of 30% (UNEP/IUCN 1988, Irving 1995).

c Ducie Atoll

This is the most easterly atoll in the Indo-Pacific province, and is the most southerly atoll in the world. It consists of a lagoon surrounded by four islands, the largest of which is Acadia Island. The fore-reef generally has very high coral cover, several places having between 80-100% hard coral cover down to depths of 40m. In contrast, there are a few areas of extensive coral rubble fields that cover up to 95% of the substrate (UNEP/IUCN 1988, Irving 1995).

3.10.2 Threats

i Invasive species and habitat destruction

The main threats to native flora are from invasion by exotic species and habitat destruction (Waldren *et al,* 1995b, Kingston and Waldren 2003). Thickets of exotic *Syzygium jambos* trees, and the scrubs *Latana camara* and *Lablab purpureus* are the primary threats to native flora, but *Ipomoea indica* and *Passiflora maliformis* are also spreading and be problematic in the future (Waldren *et al*, 1995a). On Pitcairn Island, the introduced *Syzygium jambos* tree is invading native woodlands. There are concerns for the future of the flora and fauna if proposed plans go ahead to build tourist facilities on the islands. These include an airstrip on Oeno, and hotels on Pitcairn and Henderson (UKOTCF 2002).

ii Sea level rise

The geology of the four islands in the group varies considerably, ranging from the volcanic island of Pitcairn to the low-lying Oeno and Ducie atolls. The atolls rise only a few metres above sea level, hence, there is a very real danger that even small rises in sea level will cause substantial loss of land area. Even if the islands within the atolls are not completely inundated, the likelihood of periodic flooding will increase, making it difficult for plants to remain established. Based on descriptions of species' distributions (Waldren *et al*, 1995a), there appear to be at least seven species of plants that are found only in low-lying areas such as beachfronts and the strandline (*Pemphis acidula, Argusia argentea, Mariscus javanicus, Solanum americanum, Plantago major, Suriana maratima*, and *Triumfetta procumbens*). In addition, the low-lying Oeno Atoll contains the endemic plant *Bidens hendersonensis* var. *oenoensis*. These species are therefore most at risk from habitat loss as a result of sea level rise.

New development proposals are underway to develop tourist facilities on some of the islands. These plans have the support of Pitcairn Islanders who want to improve their economy. These include an airstrip on Oeno, and hotels on Pitcairn and Henderson (UKOTCF 2001b). However, more recent information regarding the status of these projects does not appear to be available.

3.10.3 Species

i Birds

The Pitcairn Islands contain internationally significant populations of avifauna. Of the 20 resident breeding species, five are endemic landbirds (Brooke 1995a). In addition, the islands support major populations of seabirds. Ducie atoll may be the world's main breeding station of Murphy's petrel *Pterodroma ultima,* with an estimated 250,000 breeding pairs (Brooke 1995b).

3.10.4 Threats

i *Predation*

Pacific rats Rattus exulans were introduced by Polynesian settlers hundreds of years ago, and used to be present on all of the islands in the Pitcairn group. They have been successfully eradicated from Oeno and Ducie, but this was unsuccessful on Pitcairn, and no attempt has been made on Henderson (Hilton *et al*, 2001). Predation of chicks by rats has severe impacts on the reproductive success of gadfly petrels *Pterodroma* spp. (Brooke 1995a). The endemic Henderson fruit dove *Ptilinopus insularis* is probably suffering from predation of eggs and chicks by rats, but might also be suffering from competition with this mammal for fruits on which it relies upon (Hilton et al, 2001).

ii Longline fishing mortality

There is no commercial fishing legally taking place in local waters, but some subsistence fishing does occur (FAO 1997). Substantial illegal fishing by Korean and Taiwanese vessels in local waters does occur (Procter and Fleming 1999), but the threat to locally-breeding seabirds is unknown (Hilton et al, 2001; Hays et al, 2002).

iii Sea level rise

Of the 20 breeding species, five nest exclusively on low-lying sites that are likely to be most vulnerable to sea level rise. The following species nest only on the low-lying islands of Oeno and/or Ducie atoll: Sooty tern *Sterna fuscata*, Phoenix petrel *Pterodroma atrata*, and Christmas shearwater *Puffinus nativitatis*. Murphy's petrels and masked boobies *Sula dactylatra* are found on Oeno, Ducie and Henderson Island, nesting on beaches or coastal vegetation. Although the following species may lose nesting habitat on Oeno and Ducie, they are also found on elevated parts of Henderson and/or Pitcairn Island: kermadec petrel *Pterodroma neglecta*, great frigatebird *Fregata minor*, black noddy *Anous minutus*, masked booby *Sula dactylatra* and red-footed booby *S. sula*.

None of the endemic species appear to be threatened by sea level rise. They all nest in the plateau forests of Henderson Island, except for the Pitcairn reed-warbler *Acrocephalus vaughani Vaughani*, which is widespread across Pitcairn Island up into the hills.

3.10.5 Terrestrial reptiles and amphibians

No information.

3.10.6 Marine turtles

The only known nesting is by green turtles on Henderson Island. There are no suitable nesting habitats on Ducie or Pitcairn, and although there appears to be suitable nesting terrain on Oeno, no nesting is known . The lack of local seagrass beds suggest that green turtles only come here to breed. Hawksbill turtles are vagrants in the area, and probably forage on local reefs.

a Green turtle

i Nesting

The nesting population consists of about ten female green turtles, constituting some 1% of the total population in French Polynesia. They nest from January to March on all of the beaches, but more commonly on the east coast, where East Beach is the major site .

3.10.7 Threats

i Exploitation

It is thought that green turtles were hunted in the past by Polynesian settlers. However, this no longer occurs and the surviving population may be a small but important reserve to bolster other green turtle populations that are declining beyond the Pitcairn Islands .

ii Sea level rise

All of the beaches on Henderson Island are backed by cliffs (Blake 1995). These cliffs may pose a serious obstacle to beach migration inland in response to sea level rise.

3.11 South Georgia

Located in the South Atlantic, this isolated and mountainous island is uninhabited except for a small number of military, government and scientific research staff. Most of the information in this section comes from the *Environmental Management Plan for South Georgia* (McIntosh 1999). The cold waters originating from the Antarctic contribute to the harsh climate, with approximately 50% of the island covered by permanent snow and ice. The coastline of South Georgia is characterised by extensive wave-cut platforms surrounding headlands, with beaches of sand or shingle forming within sheltered bays. Glacial meltwater transports sediment to construct some of the largest sand and gravel beaches found south of the Polar Frontal Zone. Raised beaches of 1 – 10m above sea level generally occur as tussock-covered flat-topped terraces underlain by smooth beach cobbles and shingle, just inland from the existing beaches. The native vascular flora consists of only 25 species. With the exception of the hybrid, *Acaena magellanica* x *tenera*, no endemic higher plants are known, although there are a few endemic bryophytes (mosses and liverworts) and lichens. Five broad categories of terrestrial plant communities exist and generally occupy habitats in the coastal lowlands up to around 100m (or 200m in sheltered areas) above sea level.

3.11.1 Habitats

i Grassland communities

There are four types of grassland communities: tussock, dry, wet and introduced grasslands. Tussock grass *Parodiochloa flabellata* is widely distributed, forming a zone in wet to moderately dry areas along most of the coast, and also on raised beaches and coastal cliffs. Seal and penguin colonies are often found in tussock grassland wherever there is low-lying ground behind the shoreline, and localised physical damage to the grasses can sometimes occur. Some species of albatross and burrowing petrels are also common on steep hillsides covered by tussock. Dry grasslands cover much of the relatively sheltered north-east coast of South Georgia, forming climax communities dominated by tufted fescue *Festuca contracta*. Wet grasslands of *Deschampsia antarctica* typically dominate flat areas on raised beaches, particularly behind the tussock zone but also on other horizontal sites that retain water. Introduced meadow grassland (*Poa* spp.) occurs in some areas as a result of long-term grazing by reindeer of several native species, and may form extensive lawns where disturbance is high.

ii Bog and mire communities

These communities occur where there is poor drainage and an abundant supply of water. Bogs occurs most extensively where there is poor drainage on low lying ground in valley floors and in basins between low hills. Mire communities may develop on seepage slopes and along the margins of small streams. Although extensive peat development may occur in bogs, it is rarely associated with mire communities.

iii Herbfield community

Dominated by the woody-stemmed *Acaena magellanica*, herbfields are found on sheltered slopes near the shore and on flat stony flood plains adjacent to streams.

iv Moss bank community

These mosses, dominated by *Polytrichum strictum*, build up a thick turf that is interspersed with rushes *Juncus scheuchzerioides* and a few other vascular species.

v Fellfield community

This occurs on dry stony ground, usually in exposed windswept sites. Several vascular flora are present, with no single species emerging as particularly dominant.

3.11.2 Threats

Human visitors to the island are strictly controlled, and there are designated areas where tourists are allowed access. The current level of direct human impact on the terrestrial flora is therefore low. The Government of South Georgia considers the control of reindeer to be a priority in the context of native floral conservation (McIntosh 1999).

i Introduced grazers

Rabbits were the first introduced mammals to South Georgia in 1872. In addition, there have been introductions of domestic and other stock such as horses, cattle, sheep, goats, pigs, reindeer, foxes and even monkeys (Anon 2001). However, reindeer *Rangifer tarandus* is the only mammal species to have become permanently established on the island. There is substantial concern regarding the problem of overgrazing by reindeer herds (Leader-Williams *et al*, 1989). In the summer they graze on meadows and herbfields, completely removing the latter from certain areas. In the winter the only accessible vegetation type during snow-cover is tussock grassland, which forms the primary diet of the reindeer, although they also eat seaweed on the beaches. Overgrazing of tussock grassland is so severe in places that soil erosion is being reported. Although no species of native plant is currently threatened with extirpation as a result of current grazing (Leader-Williams 1988), retreating glaciers could allow reindeer access to more of the island, which could lead to further degradation of plant communities (Moen and MacAlister 1994).

ii Introduced plants

Approximately 70 species of plants have been introduced, most of which were associated with the whaling stations and the settlement at King Edward Point. These introductions often resulted from seed inadvertently imported from Europe with foodstuffs for poultry, sheep, cattle, pigs, etc which were kept as a food supply at several of the whaling stations. However, several of these exotics could only survive near these stations because of the warmth generated, and have declined following the abandonment of the whaling stations. Most of the surviving exotics, such as dandelion *Taraxacum officinale* and the creeping buttercup *Ranunculus repens*, are still found around the whaling stations. In contrast, the more hardy meadow grass *Poa annua* and chickweed *Cerastium fontanum* are more widely distributed (Anon 2002c). Native herbfields have been replaced by *P.annua* in some places, but the Government of South Georgia considers the threat of introduced plants to be small. About 40 exotic species persist of which about 25 are naturalised; they are able to grow around and sometimes beyond the whaling stations where they originally became established (McIntosh 1999).

iii Sea level rise

The wide coastal vegetation zones and the highly elevated terrain suggest that sea level rise is unlikely to pose any substantial threat to native floral biodiversity in the near future.

iv Global warming

Since the mid-1980s, an increase in seedling production by several naturalised exotic species may be indicating that fertile seeds are being produced more often. This may be a response to increasing summer temperatures on the island, and could be the first signs of a potential shift in the composition of vegetation communities in response to climate change. Although the threat of non-native plant species is considered as a low priority at present, occasional monitoring of plant abundances and distributions was suggested in the *Environmental Management Plan for South Georgia* (McIntosh 1999). In addition, tussock communities could suffer increased levels of grazing if retreating glaciers allow reindeer access to more of the island.

3.11.3 Species

i Birds

South Georgia is a key sub-Antarctic breeding location for birds. At least 81 species have been recorded, of which 31 (including 27 seabirds and one endemic land bird) are known to breed locally. This Territory probably contains at least half of the world's breeding population of the following species: macaroni penguin *Eudyptes chrysolophus*, grey-headed albatross *Diomedea chrysostoma*, northern giant petrel *Macronectes halli* and Antarctic prion *Pachyptila turtur* (McIntosh 1999).

3.11.4 Threats

i Predation

Settlers to whaling stations accidentally introduced brown rats *Rattus norvegicus*, which rapidly spread across the main island. These rats threaten most species of nesting birds on the main island, where the endemic South Georgia pipit *Anthus antarcticus* is regarded as particularly vulnerable (Hilton *et al*, 2001; Hays *et al*, 2002). Other species that nest in inaccessible locations, such as storm petrels *Oceanites oceanicus* and the South Georgia diving petrel *Pelacanoides georgicus* tend to be less affected (McIntosh 1999). The rats have failed to reach 22 of the offshore islands, where bird communities tend to thrive.

ii Loss of tussock habitat

Tussock grass provides important habitat for the avifauna, but trampling by Antarctic fur seals *Arctocephalus gazella* and grazing by introduced reindeer *Rangifer tarandus* is causing severe destruction in localised areas. Ironically, part of the problem has resulted from a massive increase in fur seal population since they became protected. The Government of South Georgia is however, considering a culling programme for the reindeer (McIntosh 1999).

iii Longline fishing mortality

Incidental bycatch of seabirds is a major conservation concern for the Government of South Georgia (McIntosh 1999). Longline fishing vessels have been targeting the Patagonian toothfish around South Georgia, both legally and illegally, since 1990 (Walker *et al*, 1997). The South Georgia Government and the UK Foreign & Commonwealth Office are enforcing a sustainable management regime on the longline fisheries around South Georgia. This has resulted in the third successive year of significantly decreased mortality of albatrosses and Petrels. Losses are now only 5% of those five years ago, when new fishing regulations to protect seabirds were introduced under the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). Illegal and unregulated longline fishing now poses the major threat to South Georgia albatrosses (Anon 2002d).

iv Global warming – indirect impacts on introduced species

Rats and reindeer are currently unable to reach certain parts of the main island that are blocked off by glaciers. However, rising temperature may cause the glaciers to melt, which in turn may allow these introduced species access to more of the island where they will cause problems of predation and habitat destruction (McIntosh 1999).

v Global warming – declining krill/squid prey

Changing environmental conditions (including temperature rises) have been suggested as a cause for falling krill biomass in the southern Atlantic and Southern Ocean (Loeb *et al*, 1997). Declines in some bird species (for which long-term data were available) that depend on krill were shown for South Georgia, including the gentoo penguin *Pygoscelis papua*, macaroni penguin, and black-browed albatross *D. melanophris* (Reid and Croxall 2001). Annual squid stocks also appear to be related to water temperature; warmer than average temperatures resulting in reduced survival of larvae (Waluda *et al*, 2001). Squid fisheries operate in the region, and there could be increased competition for resources between humans and seabirds if environmental conditions further contribute to population declines in squid.

vi Sea level rise

Two species, the king penguin *Aptenodytes patagonicus* and the gentoo penguin, prefer to nest on beaches and coastal tussock grass. These species may be most at risk of habitat loss from rising sea level.

3.11.5 Terrestrial reptiles and amphibians

No information.

i Marine turtles

No information.

3.12 South Sandwich Islands

This Territory consists of a chain of 11 volcanic islands distributed over 400km in the South Atlantic. The South Sandwich Islands are unusual among the UK Overseas Territories (and most other oceanic islands) because there are no non-native plants or animals present, despite archaeological evidence of sealing parties having stayed on Candlemas Island for several weeks (Convey *et al,* 2000).

3.12.1 Habitats

There is only one species of vascular plant present (tussock grass *Deschampsia Antarctica*) whereas there are some 95 species of lower plants (Convey *et al,* 2000). The flora forms consists of two major components that are associated with geothermally-heated and non-heated ground, although there are also some plants that are associated with 'moribund' ground, which refers areas that were once heated in the past.

The low diversity of vascular plants is typical of the Antarctic botanical zone, ie south of 60°S. The flora of the unheated ground is relatively impoverished compared to that of the heated ground. Flora associated with unheated ground are similar to maritime Antarctic fellfield communities that are typically dominated by lichens and mosses. Geothermally-heated communities contain both maritime and sub-Antarctic components, indicating the importance of geothermal warming for a greater diversity of flora. Three of the eleven islands in this archipelago have widespread areas of heated ground; Leskov, Candlemas, and Bellinshausen (Convey *et al,* 2000). The flora on these islands associated with heated ground has changed since the survey in 1964 (Baker *et al,* 1964), with shifts in plant communities associated with changes in the distributions of heated and unheated ground (Convey *et al,* 2000).

Tussock grass is associated with unheated and previously-heated ground, and has only been seen on Candlemas Island. Its range has been increasing since the survey in 1964, but the reason this is unknown (Baker *et al,* 1964; Convey *et al,* 2000).

3.12.2 Threats

i Human activity

Tourists occasionally arrive by ship, although there are no permanent facilities available. There is no information available on human impacts.

ii Sea level rise

Tussock grass is probably most common on the coast, but is also likely to be found growing on steeper slopes inland. The coastline of Candlemas Island rises steeply from the sea, and therefore this species is probably safe from sea level rise on the steep slopes. However, if the land area available were to decrease significantly, studies of non-Antarctic geothermal flora (Given 1980, Glime and Iwatuski 1997) indicate that *D.antarctica* would probably out compete lower plant taxa.

iii Global warming

The low diversity of vascular flora is probably due to a combination of geographical isolation and harsh climatic conditions. Rising temperatures might make the islands more vulnerable to colonisation by non-native species, assuming that viable seedlings were able to reach the island. It is important that any human visitors to the island are carefully controlled or screened in order to minimise this possibility.

3.12.3 Species

i Birds

There are only 16 species of birds that are known to breed on these isolated islands. Most of the land area is permanently covered in snow and ice. Locations of breeding colonies and the extent of snow and ice cover are described by (Convey *et al*, 1999). The vegetation cover of the islands is sparse, mainly consisting of mosses and lichens. Most of the birds nest on cliffs or gentle slopes near the coast, partly because these areas are free of ice, and in the case of flightless birds such as penguins, they are probably minimising energy expenditure by not travelling far from the sea.

3.12.4 Threats

Landing on the islands is hampered by consistently poor weather and rough seas, hence, few visits are made. The difficulty of access may be an important benefit to the native biodiversity, because human influence is minimal (Convey *et al*, 1999). The islands are noteworthy in that no non-native species appear to have been able to survive here. There appears to be very little specific information available relating to potential climate change threats to avifauna on these islands. For potential impacts of global warming on prey species, see section under South Georgia.

3.12.5 Terrestrial reptiles and amphibians

No information.

i Marine turtles

No information.

3.13 St Helena

This volcanic island is located in the sub-tropical South Atlantic. Discovered in the 16th century, St Helena was a popular stop-over for ships travelling between the East Indies and Europe. Many species of plants and animals were imported to provide provisions for settlers and ships crews, to the detriment of native flora. The current vegetation is now almost entirely anthropogenic, and semi-natural forest covers less than 1% of the country in isolated remnants of the central mountain ridge (Procter and Fleming 1999). The original communities have been replaced by grazing, erosion, harvesting for timber and fuel, clearance for agriculture, and invasion by exotic species (Cronk 1983, 1986a, b, Cairns-Wicks 2002). A detailed account of the natural history of the island is given in *St Helena and Ascension Island: a natural history* (Ashmole and Ashmole 2000). The floral biodiversity is exceptional for its level of endemism; approximately 50 out of the 60 native species of plants are unique to this island (Procter and Fleming 1999).

3.13.1 Habitats

i Semi-desert zone (0-250m)

The arid lower part of St Helena contains a badly eroded semi-desert with steep rocky slopes and gullies with a few scattered plants. In a few places, this zone reaches up to 600m above sea level.

ii Scrub zone (200-400m)

Consisting of mostly introduced species, this zone occupies the north-western part of the island. There is some woodland at upper elevations, and in the lower regions there is sometimes a poor distinction between this zone and the semi-desert region. The endemic scrubwood *Commidendrum rugosum* is slowly spreading back into some areas, after efforts to control grazing began several decades ago. All of the land birds except for the moorhen and pheasant may be found in the scrub.

iii Creeper waste (325-425m)

This refers to large expanses of level, partially saline and heavily eroded land that are dominated by spreading mats of the introduced creeper *Carprobrotus edulis*. There are intentions to stop the erosion and restore some semi-natural woodland in this area, and the Endemic Section of the Agriculture & Forestry Department is attempting to restore semi-natural vegetation by establishing plantations of endemic gumwood and scrubwood trees *Commidendrum* spp. (Smith 1997). The area dominated by creeper wastes was once the main habitat of the giant ground beetle *Aplothorax burchelli* and the giant earwig *Labidura heculeana*. However, both of these endemic species are thought to have become extinct as a result of native habitat loss and also from predation by introduced mice and centipedes *Scolopendra morsitans*.

iv Arable land, pasture and New Zealand flax (450-700m)

The majority of the island at this level is devoted to agriculture and forestry. There is much pasture and woodland, and large areas are occupied by abandoned plantations of New Zealand flax *Phormium tenax*. Pasture has replace the original dry gumwood forest, but the native grasses *Cynodon dactylon* and *Digitaria ciliaris* still survive here despite overgrazing. Several exotic shrub species have invaded the pastures, in particular the blackberry *Rubus pinnatus*. The drier and more level grasslands are the primary habitat of the endemic wirebird *Charadrius sanctaehelenae*. Much of the uplands are still covered by New Zealand flax although there has been no commercial use for it in the last few decades. The abandoned plantations are slowly being converted back into pasture, but some are being left as erosion control. The control of the flax is important because it readily out-competes native vegetation.

v Woodland

Woodlands dominated by introduced species are prominent between 400–700m, although some areas extend along valleys into lower areas. About 450ha are designated for timber production, another 650ha for fuel wood, and also 200ha set aside as conservation forest. There are some areas of natural woodland remaining. The largest gumwood stand is located at Peak Dale.

vi Central ridge

The central ridge dominates the landscape from 600m to over 800m. Tree-fern thickets can be found here, which constitutes the only original vegetation community that still exists to a significant extent. This habitat has probably survived relatively intact because it is found in the highest parts of the central ridge on leached soils and steep slopes unsuitable for agriculture. The rainfall on the ridge is higher than anywhere else on the island, and parts of it are considered to be cloud forest. Pasture, flax and forestry plantations have eliminated the natural vegetation in places along the western section of the ridge, but small areas have survived near High Peak. The Endemic Section has been trying to re-establish native vegetation here, but is limited by funding, technical difficulties, and lack of ecological understanding (Smith 1997). The primary threat to the surviving native species is posed by the invasion of flax, but several other introduced species are also present.

3.13.2 Threats

The flora is highly threatened. The 1997 IUCN Red List of Threatened Plants contains 68 species for St Helena, including 11 extinct and three on the verge of extinction. Although *Chenopodium helenense* is listed as extinct under the 1997 IUCN listing, it was discovered growing wild in 1986 in Bilberry Field Gut (Ashmole and Ashmole 2000).

i Invasive plants

The introduction of alien trees and plants started with the discovery of the island in the early sixteenth century, and as a consequence, the native vegetation has suffered greatly. Many alien species were deliberately introduced for use as animal feed or for human consumption. Some of these species quickly spread out of control and caused problems with agriculture or threatened native species. For example, blackberry rapidly spread to overrun pasture areas, and New Zealand flax is threatening native species on the central ridge (Ashmole and Ashmole 2000).

ii Overgrazing

Feral goats exerted heavy grazing pressure for approximately 400 years before they were finally brought under control in the early 1960s. They posed a serious threat to the native flora because native plants had no historical pressure to develop defences against herbivores. The St Helena ebony *Trochetiopsis ebenus* was eradicated from most of its range by goats because it lacked any defences against grazing. Some threat is still posed by rabbits, as it is thought that they might restrict the endemic *Hypertelis acida* to areas that are inaccessible to grazers.

iii Other introduced species

An introduced homopteran bug *Orthezia insignis* (known locally as the Jacaranda Bug) killed many gumwood trees *Commidendrum* spp. and would probably have continued to do so if it weren't for the introduction of a predatory ladybird *Hyperaspis pantherina* by a biological control specialist (Ashmole and Ashmole 2000).

iv Sea level rise

There does not appear to be any substantial threat to native flora from sea level rise. None of the species are confined to low-lying coastal areas.

3.13.3 Species

i Birds

The ten species of native breeding birds currently found on the St Helena represent only about half of the species diversity that existed around the time of the island's discovery in 1502. Eight species seabirds and two land birds are present, the latter including the sole remaining endemic species, the wirebird *Charadrius sanctaehelenae*. In addition, there are at least another nine species of introduced birds that have become naturalised. A detailed description of the avifauna is given by Ashmole and Ashmole (2000).

No significant threats from sea level rise were identified for breeding birds on St Helena. None of the breeding birds are restricted to low-lying coastal areas for nesting. Species found on the main island range from cliff ledges to widespread inland sites. Four species are only found on offshore stacks. Two of these species (sooty tern *Sterna fuscata* and brown noddy *Anous stolidus*) have nesting sites on Speery Island, which rises very steeply from the sea to a height of approximately 135m. The other two stack-nesting species (Madeirian storm-petrel *Oceanodroma castro* and masked booby *Sula dactylatra*) have nesting sites on Egg Island, which rises quite steeply from the sea to form a pyramid shape, and covers an area of more than 3.5 hectares.

Although there are major concerns about the spread of exotic plant species across the main island, this is more concerning the preservation of the indigenous flora rather than preserving bird nesting habitats. Most of the seabirds nest on ledges and cliffs among the offshore stacks that are sparsely vegetated, and those birds that breed on the main island are widespread in their habitat distribution, not particularly threatened by changes in vegetation composition.

3.13.4 Threats

i Predation

As on so many other islands elsewhere, cats and rats were introduced deliberately and also inadvertently by humans. At least six species of endemic seabirds and land birds are believed to have become extinct, and predation is likely to have been a major factor. Most of the surviving avifauna seabirds appear to be restricted to nesting on the offshore stacks such as George, Shore and Egg Island. For example, abundant quantities of bones and feathers of Maderian storm petrels have been found at Gill Point on the main island, which may be evidence of intense predation pressure by feral cats and possibly rats. Fossil remains of sooty terns and masked boobies have also been found on the main island, but these species are now only able to breed on the offshore islands (Ashmole and Ashmole 2000).

ii Longline fishing mortality

Some licensed fishing occurs in local waters, most of which are low-intensity pole-and-line and potting activities. No assessment of bycatch has been made (MEPL 2003).

iii Habitat loss

Introduced herbivores (livestock, rabbits and rodents) have severely degraded the native vegetation communities on St Helena. Interestingly, the endemic wirebird appears to have adapted to the habitats created by human activity, with a significant portion of its current habitat consisting of pasture grazed by livestock. Breeding success appears to be linked to specific grazing that keeps vegetation cover and height to a suitable condition. A study investigating the decline of this species between 1989 and 1999 suggested that the cause was attributed to localised changes in vegetation at three sites. The causes included (1) a cessation of grazing in one paddock, (2) a change of livestock from sheep to cattle in another site that resulted in vegetation structure, and (3) a switch from arable cultivation to pasture (McCulloch and Norris 2001).

3.13.5 Terrestrial reptiles and amphibians

No information.

i Marine turtles

No information.

3.14 Tristan da Cunha

The Tristan da Cunha group consists of four main volcanic islands: Tristan, Gough, Inaccessible and Nightingale. The islands have broadly similar vegetation communities, although the influence of human activity varies substantially between them. Gough Island is the most pristine whereas Tristan, the only inhabited island in the group, is the most impacted by human activities. The level of floral endemism is high, with 20 endemic taxa present among the 46 angiosperms and 33 pteridophytes that comprise the vascular plant biodiversity

(Wace 1961, Wace and Dickson 1965). The habitat descriptions are based on Wace (1961), Wace and Dickson (1965) and Trowbridge (2001).

3.14.1 Habitats

i Tristan Island

The vegetation is zoned according to elevation and topography. Coastal strips (0-100m) were originally dominated by tussock grass *Spartina arundinacea* and *Phylica arborea* trees. Clearance and burning, and grazing by introduced animals (primarily livestock) have resulted in substantial change. Few native species remain abundant, and usually occur in areas that are inaccessible to herbivores. Cliff communities (0-600m) consist of a mixture of native and introduced plants that are subjected to grazing by livestock and cutting. The vegetation of the Tristan Base (300-900m) has remained relatively untouched. Fern-bush covers most of the ground up to about 750m, whereas wet heath, dominated by *Empetrum rubrum*, forms the primary habitat at higher elevations. Communities above 900m generally consist of a mixture of native and introduced species of grasses and ferns, although there are some monospecific stands of the exotic sorrel *Rumex acetosella* that occupies larges areas around 900m. The vegetation on the uppermost parts of the peak (around 1800m) is relatively impoverished due to the instability of volcanic cinders and the lack of shelter. The only vascular plant in the crater is *Empetrum rubrum* that forms a few scattered and dwarfed patches. Outside the crater, bryophytes and lichens are found within crevices of stable rocks.

ii Nightingale Island

Tussock *Spartina arundinacea* is the dominant species on the island, which forms monospecific stands in some places. Large colonies of rockhopper penguins *Eudyptes crestatus* and greater shearwaters *Puffinus gravis* nest here. In wet areas, *Phylica* spp. trees are often found scattered amongst the tussock. Peat mires are found in an area known as the Ponds. *Phylica* trees are also found here along with *Blechnum palmiforme* ferns. The area is surrounded by *Scripus sulcatus* rushes. Human activity is generally limited to residents of Tristan visiting the island each year to collect shearwaters. A few alien species are present, for example New Zealand flax *Phormium tenax* has been planted in a few places along a cleared path.

iii Inaccessible Island

The island is ringed by steep cliffs, but there is one main valley that is covered with fern-bush. As on Nightingale Island, tussock dominates with scattered Phylica trees, the latter usually found on the upper parts of the cliffs. There were a small number of human residents and livestock on the island in the past, but none remain. However, there are several alien species present, mainly around the remains of a cottage at Saltbeach.

iv Gough Island

The vegetation communities vary with elevation and associated climatic differences. Tussock grassland (*Parodiochloa flabellata* and *Spartina arundinacea*) dominates the coastal zone, reaching up to 300m on the more exposed western side of the island, and to around 100m on the more sheltered eastern side. Fern-bush (100 – 500m) dominated by *Histiopteris incise* and *Blechnum palmiforme* is found above the tussock zone, covering extensive areas of the island in the east and south. *Phylica arborea* trees are scattered throughout. Beyond the fern-bush is a diverse wet heath (300 – 600m) community of ferns, sedges, grasses, angiosperms and mosses. The terrain above 600m is characterised typically either by peat bogs or, in more exposed areas, moorland, feldmark and montane rock communities where the soil layer is thin or even non-existent.

3.14.2 Threats

Although Tristan is the only island supporting a permanent human population, threats to native flora exist of some of the other islands as a result of previous human activity.

i Overgrazing

The most widespread alteration of native plant communities, particularly on Tristan, has resulted from the introduction of domestic livestock, including cattle, donkeys, goats, rabbits and geese. These exerted heavy grazing pressure, and some native flora was cleared in order to convert land to grazing pasture. In an effort to reduce the impact of grazing livestock, residents on Tristan are allowed to keep only two cows and seven sheep per family (Swales 1996). Although feral populations of livestock species have failed to establish themselves on the islands, populations of the European house mouse (*Mus musculus*) are common and may be problematic due to the consumption of native plant seeds, although firm evidence of this threat has yet to be documented locally (Jones *et al*, 2003).

ii Invasive plants

Several agricultural plant species have been deliberately introduced to the islands, but the main threat appears to come from species with invasive tendencies that were accidentally introduced. On Gough Island for example, several invasive species (eg *Agrostis stolonifera, Holcus lanatus, Poa annua, Rumex obtusifolius,* and *Sonchus oleraceus*) are widespread and driving back the native vegetation inland especially on to the sites of peatslips.

iii Sea level rise

The threat to native vegetation appears to be negligible because there are no native communities that are restricted to low-lying coastal areas. However, there may be some reduction in the spatial extent beaches because the steep cliffs behind the beaches will be a barrier to inland migration.

iv Global warming

A significant rise in temperature of 0.6°C was recorded on Gough Island between 1963 and 2000, raising concerns that warmer temperatures may favour populations of non-native species such as invasive plants and the house mouse (Jones *et al*, 2003).

3.14.3 Species

i Birds

The uninhabited islands in the Tristan da Cunha group (Gough, Inaccessible and Nightingale Island) are among the most important sites for seabird colonies in the world (Hilton *et al*, 2001). The land bird species are also noteworthy, as all six are unique to this territory. There are 30 breeding species among the four islands: 15 on Tristan, 20 on Inaccessible, 22 on Gough and 16 on Nightingale (Holdgate 1965; Procter and Fleming 1999).

3.14.4 Threats

The avifauna has had a history of disturbance from human activity, primarily on the main island of Tristan. Workers in the sealing industry in the 1800s took thousands of eggs and adult birds for food, introduced predators, destroyed nesting habitat and probably contributed to the extinction of two land birds (Holdgate 1965).

i Habitat destruction

On Tristan, most of the vegetation has been substantially modified as a result of grazing by livestock, resulting in the destruction of most of the coastal tussock habitat. In order to reduce the impact of grazing, each family is only allowed two cows and seven sheep to reduce the impact of grazing.

ii Mortality associated with fishing - trawlers

Thousands of birds are estimated to die annually from collisions with trawlers operating the rock lobster fishery around Tristan da Cunha. Fifteen species of seabirds (seven breed locally) were seen to follow the trawlers, scavenging for food. Eight species of breeding seabirds were recorded as killed by collisions with the trawlers. Although not all of them necessarily followed the ships to scavenge food, they would have been disorientated at night by ship-lights, such incidents being more frequent on overcast/misty nights. Finally, there is no evidence for competition between seabirds and the rock lobster *Jasus tristani* fishery, nor is there evidence for a significant increase in food availability from discards (Ryan, 1991).

iii Longline fishing mortality

Mortality from this activity in local waters and the Southern Oceans is a major threat to several of the seabird species (Hilton *et al,* 2001). The main threat to the endemic Atlantic yellow-nosed albatross *Thalassarche chlororhynchos* is thought to be longline fishing (Stattersfield and Capper 1998) with high mortality occurring in Brazilian waters (Olmos *et al,* 2000).

iv Predation

Rats are present on Tristan. The other islands are free of introduced mammal predators, except for a house mouse *Mus musculus* population on Gough Island. There is recent evidence to suggest that house mice may be a significant cause of mortality for Atlantic petrel chicks *Pterodroma incerta* (Jones *et al,* 2003).

v Egg collection

Intensive harvesting of seabirds and their eggs occurred in the past, but now only occurs on Nightingale Island where chicks and eggs of great shearwaters *Puffinus gravis* are taken, and eggs and guano of rockhopper penguins *Eudyptes chrysocome moseleyi* are also collected (Hilton *et al,* 2001). However, data on sustainability of this practice are not available.

vi Sea level rise

The preference for beach habitat suggests that brown noddy *Anous stolidus stolidus* and Antarctic tern *Sterna vittata tristanensis* are most at risk of habitat loss from sea level rise (Holdgate 1965).

3.14.5 Terrestrial reptiles and amphibians

No information.

i Marine turtles

No information.

3.15 Turks and Caicos Islands

The eight islands of the Turks and Caicos group are located at the southeast end of the Bahamas archipelago in the Caribbean. The main habitats on the islands are wetlands, woodland and scrub communities (Hilton *et al,* 2001).

The Turks and Caicos Islands consist of two archipelagos across two limestone platforms. The larger of these is known as the Caicos Bank, which covers an area of 8,000km^2. Water depth at the edges of both platforms typically is around 20 - 30m before plunging steeply to abyssal depths (Procter and Fleming 1999). The marine and coastal areas of South Caicos were recently mapped in a project through the Department for International Development (DFID) (Clark *et al,* 1997; Mumby *et al,* 1998; Green *et al,* 2000).

3.15.1 Habitats

i Forest, scrub and dry woodland

The Caicos Islands are fertile and support scrub bush, trees and cacti. North Caicos, for example, contains significant stands of pine forests, but mature stands of trees are generally rare among the islands because of the demand for fuelwood and charcoal production. In contrast, the soil of the Turk Islands is thin, sandy and unproductive. Only a sparse vegetation of sedge and cacti exists, with scrub forest covering approximately 90% of the land area of the Turk Islands (Procter and Fleming 1999).

ii Wetlands

Extensive saltmarsh and mangrove wetlands cover more than 50% of the land area. The main areas of mangrove are on the southern portions of North, Middle and East Caicos (Spalding *et* *al*, 1997), much of which has been designated as internationally significant under the Ramsar Convention (UKOTCF 2004b). These habitats serve several important functions, such as coastal protection and as nurseries for juvenile fishes and invertebrates.

iii Coral reefs

The four largest islands (Providenciales, North Caicos, Middle Caicos and East Caicos) have fringing reefs along the entire northern coast. The three larger islands in the eastern portion of the chain have fringing reefs along their eastern coast. Shallow water patch reefs are common around all of the islands and cays (Wilkinson 2000).

iv Seagrass beds

The seagrass beds were comprehensively mapped during a study in 1995 using a combination of remotely sensed images and ground-truth data (Mumby *et al*, 1997). *Syringodium filiforme* and *Thalassia testudinum* are the main species present, but *Halophila baillonis* is also found occasionally. The total area of seagrass beds is approximately 910km^2, with the largest patch occurring some 15km south of Providenciales (Green *et al*, 2000). Seagrass beds are important as nursery grounds for several species of fishes and invertebrates, particularly conch and lobster (Procter and Fleming 1999).

3.15.2 Threats

i Deforestation

Development and exploitation are the main causes of deforestation on the islands (McNary Wood 2002). The demand for building material and charcoal production exerts heavy pressure on forest resources. Mangroves have historically been used for building material, charcoal and salt manufacture. Although the decline of these activities is allowing the recolonisation of mangrove stands in certain areas, other sites have been cleared for tourist infrastructure and urban development; mangrove forests often occupy prime coastal development sites.

ii Introduced species

The introduction of exotic plant species threatens native communities in some areas. Species such as the Brazilian pepper *Schinus terebinthifolius*, Scaveola *Scaevola taccada* and Australian cedar *Casuarina equisetifolia* aggressively invade native plant communities. At Leeward Point on Providenciales, for example, Australian cedar has almost completely replaced the native coastal plant communities. Other threats that exotics bring are pests and disease. For example, the Oleander moth *Syntomeida epilais* was probably introduced with imported Oleander *Nerium oleander* and is now a common pest (McNary Wood 2002).

iii Sea level rise

Given the vulnerability of coastal wetlands to erosion as a result of rising sea level (Nicholls *et al*, 1999), there should be cause for concern about the future state of the wetland habitats. However, there do not appear to be any studies specific to the Turks and Caicos Islands that examine this threat.

The low human population density and vast areas of habitat mean that the marine habitats are overall at low risk from direct human activities. However, there are some localised problems, particularly around population centres such as Providenciales (Procter and Fleming 1999). There do not appear to be any specific studies relating to the impacts of human activities on coastal marine habitats, but fishing, boat grounding, diving/snorkelling damage, sedimentation and pollution from coastal development are all suggested as likely to be causing problems (Wilkinson 2004).

3.15.3 Species

i Birds

There are about 47 species of birds that breed amongst these islands. The extensive wetlands are a major feature of this Territory, and form important habitats for at least a third of the resident bird species. In addition, the wetlands are visited by migratory species on their annual migration between North and South America. Whilst much attention has been focused on the wetland avifauna, there are also noteworthy species that live within dry woodlands and scrub environments. Woodland on Middle Caicos is now recognised as an important habitat for the rare Kirtland's warbler *Dendroica kirtlandii,* which breeds in the USA and spends much of the non-breeding season in the Bahamas and the Turks and Caicos (Ground 2001, Anon 2002c).

3.15.4 Threats

i Urbanisation

The majority of the population live on Providenciales and Grand Turk. Few people live on the other islands, and some are entirely uninhabited. The rapid expansion of the tourism industry (Hilton *et al,* 2001) could lead to increased development pressures in the future.

ii Predation

There appears to be little information on the impacts of introduced predators such as cats on the native avifauna. However, there is substantial concern regarding the predation of native iguanas by cats (Mitchell *et al*, 2002), so it seems likely that bird species are also at risk.

iii Sea level rise

Coastal wetlands are particularly vulnerable to sea level rise, given their extremely low elevation (Nicholls *et al,* 1999). Those species listed within the *Birds of the Turks & Caicos Islands* (Ground 2001) as preferring saltpond, mangrove or mudflat habitats were considered to be most at risk from habitat reduction as a result of sea level rise: West Indian whistling duck *Dendrocygna arborea,* tricolored heron Eg*retta tricolour,* reddish egret *E. rufescens,* cattle egret *Bubulcus ibis,* green heron *Butorides virescens,* Antillean nighthawk *Chordeiles gundlachii*, snowy plover *Charadrius alexandrinus*, Wilson's plover *Charadrius wilsonia*, yellow warbler *Dendroica petechia,* least tern *Sterna antillarum,* pied-billed grebe *Podilymbus podiceps*, least grebe *Tachybaptus,* clapper rail *Rallus longirostris,* common moorhen *Gallinula chloropus,* American coot *Fulica Americana*, black-necked stilt *Himanotopus mexicanus* and willet *Catoptrophorus semipalmatus*.

3.15.5 Terrestrial reptiles and amphibians

Data on herpetofauna are being collected as part of the Darwin Project in the TCI (UKOTCF 2001c). There do not appear to be any native amphibians present, although several endemic snakes and lizards are found here (Procter and Fleming 1999). Until the publication of the results from the Darwin Project, much of the existing information on herpetofauna pertains to the critically endangered Turks and Caicos Ground Iguana *Cyclura carinata carinata*. A survey in 1995 recorded this species on 56 cays out of 120 that were visited, with the population in the wild estimated to be around 30,000 adults (Gerber and Iverson 2002). More than 50% of the population is located in the Ambergris Cays area (Procter and Fleming 1999).

3.15.6 Threats

i Predation

Few of the Turks and Caicos ground iguanas are present on islands where there are cats or dogs (Procter and Fleming 1999). An estimated 5000 adult iguanas were killed by cats and dogs on Pine Cay over three years (Iverson 1978). It is thought that 13 populations of ground iguanas have been eliminated from the TCI over the last 20 years, mainly from relatively large islands (Gerber and Iverson 2002).

ii Habitat loss and competition - herbivores

Feral livestock (eg goats, cows, donkeys, and horses) are also present a significant threat to ground iguanas because they compete for food and trample iguana burrows (Gerber and Iverson 2002).

iii Habitat loss – urbanisation

Major development projects on Big Ambergris Cay are causing habitat destruction for the ground iguana. Efforts are underway to relocate some iguanas to the uninhabited island of Long Cay (Mitchell *et al*, 2002).

3.15.7 Marine turtles

No information.

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