Climate Change
ON THE ROCK
WHAT IT ALL MEANS

By Dr Anne Glasspool
Illustrated by Gretchen Gurr

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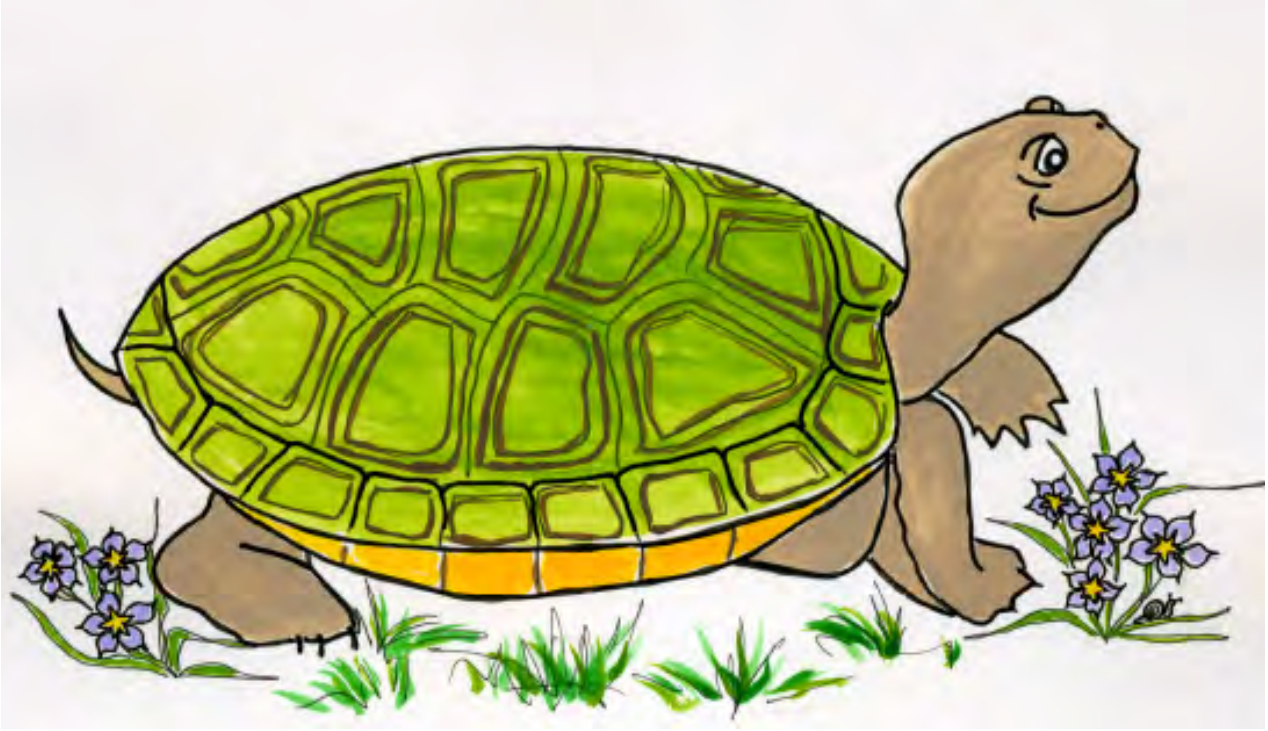
They say 'a picture speaks a thousand words' and the Trust is ever grateful for the wonderful illustrations in this publication so thoughtfully and expressively created by Gretchen Gurr. Gretchen graduated from Endicott College in 1981 with a degree in graphic arts. For several years she designed and operated a tee shirt company for the local market. Gretchen is a successful artist and photographer whose work has been shown in local galleries and on charity Christmas cards. Gretchen works with pen and ink and gouache when not using her camera.

Design and layout by Dace McCoy Ground and Chantelle Emery

Disclaimer:

The author is responsible for the choice and the presentation of the facts in the text of this publication and for the opinions expressed therein, which are not necessarily those of the Bermuda National Trust and do not commit the organisation.

I'M 'TRUSTY'



I am a Diamond Back Terrapin, one of Bermuda's native species. The world's climate is changing and it will continue to change. Come with me while we learn about what is happening, how it affects us and what we can do about it!

Viewers of the digital version can click on words in **LIGHT BLUE** to find out what they mean in the glossary at the end of the document.

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INTRODUCTION

We've all heard people talking about climate change: politicians on TV, scientists in the newspapers, concerned citizens on the web and on social networks and teachers in school. Climate change, or global warming as it is sometimes called, is a very real and urgent global issue causing many problems for us, and for our environment. It is not just something that is going to happen one day in the future; it is happening all around us now, all over the world. We need to understand climate change and its effects so we can make informed decisions about how to slow it down and how we can **ADAPT** to the changes it brings.

Climate change is caused by rising levels of certain gases, known as the greenhouse gases. We will learn more about these in the next section, but they are causing our planet to warm up. The average global temperature has risen by 1°C in the past 100 years and scientists expect this to rise by another 2-6°C over the next 100 years. This may not seem like a lot, but a small change in temperature can cause huge changes on earth. During the last interglacial period about 125,000 years ago, the planet was about 3-5°C warmer than it is now, and sea level was 4-6 metres higher.[1]

So, the predicted increase of 2-6°C is serious. Climates in every region of the world will change. As the temperature rises, the ocean will swell, and more ice will melt causing sea level to rise. This will cause flooding of low-lying land and coastal communities. Changing weather patterns and increased **DESERTIFICATION** will affect how food is produced and how much freshwater there is. This may trigger more fighting as there will be fewer resources. Air pollution will increase, affecting our health, and much of the wildlife will be lost. Our homes, **LIVELIHOODS** and recreation - every part of our lives will be impacted.

If the change happens slowly enough, we should be able to find ways to adapt. We know that the Earth's climate has changed before during its history. However, the impacts of climate change have started to **ACCELERATE**, and this has global leaders worried. Because these changes are believed to be caused by our increasing production of greenhouse gases, the sooner we start taking action the better. Many people think that because Bermuda is so small, what we do doesn't make a difference. Think again! Because of our relatively wealthy life style, the average Bermuda resident actually contributes a lot more to climate change than the average global citizen. Moreover, as an island, Bermuda will be more **VULNERABLE** than many other countries, so it is important that we step up to the wicket and take responsibility for our own actions. We can also show the rest of the world how amazing our little island is by setting good examples of how we take care of it.

This book tells you what you need to know about climate change, what it means for the world, for Bermuda and for each of us. It also recommends some of the things that we can do about it. We can't pretend it will be easy to make all the changes that are needed. But if we are going to slow global warming before it completely changes our way of life, then we must act now.

As global citizens, we all have an important role to play in protecting our planet but we needn't do it alone. We can act together with our friends, our schools and neighbourhoods, our island community and with the other nations of the world.

THE FIRST STEP IN TAKING ACTION IS TO UNDERSTAND THE PROBLEM, SO READ ON…

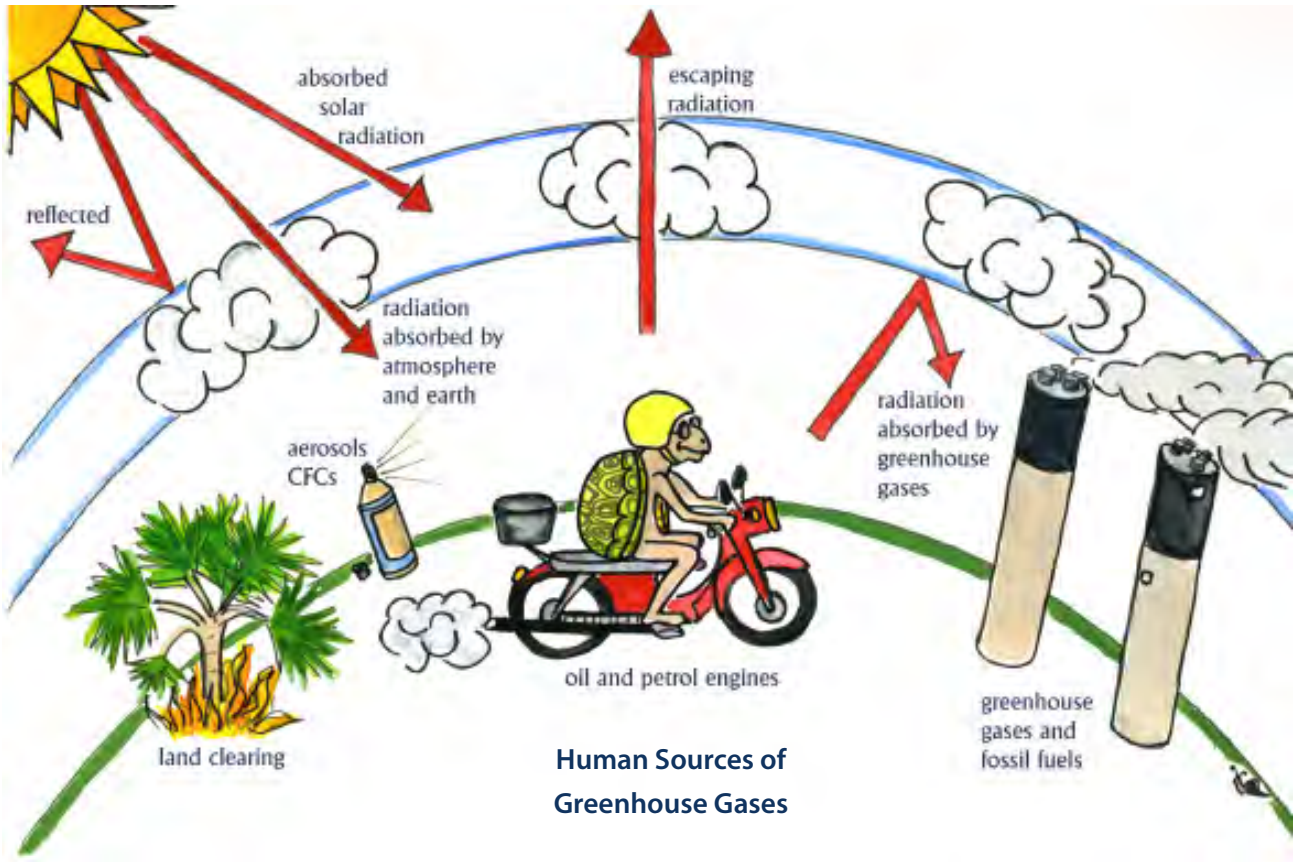
SECTION 1:
What is Climate Change?

TO ANSWER THIS QUESTION WE FIRST NEED TO UNDERSTAND SOMETHING CALLED THE 'GREENHOUSE EFFECT'.

The earth is surrounded by the **ATMOSPHERE**, which is made up of layers of gases, mostly nitrogen and oxygen, but also several other **TRACE GASES** which occur in smaller amounts. This is the air that we breathe. Go ahead, take a deep breath.

As we know, the earth is warmed by solar energy or **RADIATION** coming from the sun (sunshine). In exchange, some of the heat is released from the warmed earth. This heat would escape if not for the trace gases in our atmosphere, which trap some of it and direct it back to earth. This is important! It keeps the planet warm enough for us to live on, a bit like a layer of clothing. Without this happening, the temperature of the earth would be about –19°C, way too cold for humans and most of the plants and animals we know to survive.

This natural warming effect is called the 'Greenhouse Effect' because the trace gases act like the glass in a greenhouse, letting the sun's rays shine through but then trapping the heat so that the temperature inside the greenhouse rises. These gases are called the 'Greenhouse gases' and make up less than 0.5% of the atmosphere. (You may not have stood in a greenhouse, but it's similar to sitting in a car in the hot sun with all the windows closed!).



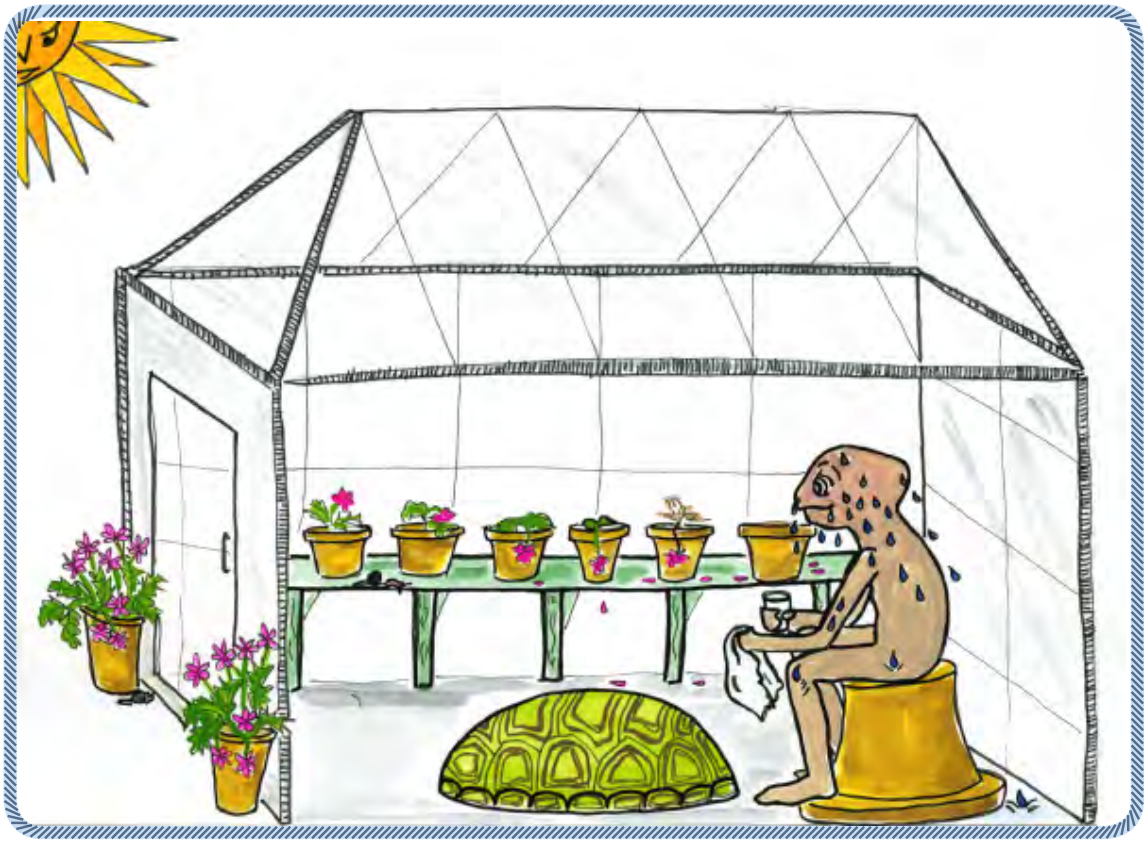
Human Sources of Greenhouse Gases

The Greenhouse Effect: Sunshine is absorbed by our atmosphere and warms the earth. In return, heat from the warmed earth is released but some of it is prevented from escaping by the trace gases in our atmosphere. These trace gases act like the glass in a greenhouse, which let the sun's rays shine through but then traps the heat so that the temperature inside rises. Trace gases occur naturally, but this picture shows some human sources of greenhouse gases which we will talk about.

The GREENHOUSE GASES

THE GREENHOUSE GASES, WHERE DO THEY COME FROM AND WHY ARE THEY NOW BECOMING A PROBLEM?

The greenhouse gases responsible for climate change are: carbon dioxide, methane, nitrous oxide, water vapour, ozone and halocarbons. Some of these occur naturally, but human activities have produced more of them in the atmosphere. Others, such as some of the halocarbons, are not naturally occurring but have been created by humans. Black carbon, or soot, also contributes to warming. Can you think of any human activities that release these gases into the atmosphere?



A GREENHOUSE:

These small glass houses are built to grow plants and crops in. The sun shines in and the glass traps the sun's heat inside, keeping it hotter and helping the plants to grow faster.

1. CARBON DIOXIDE OR CO_2

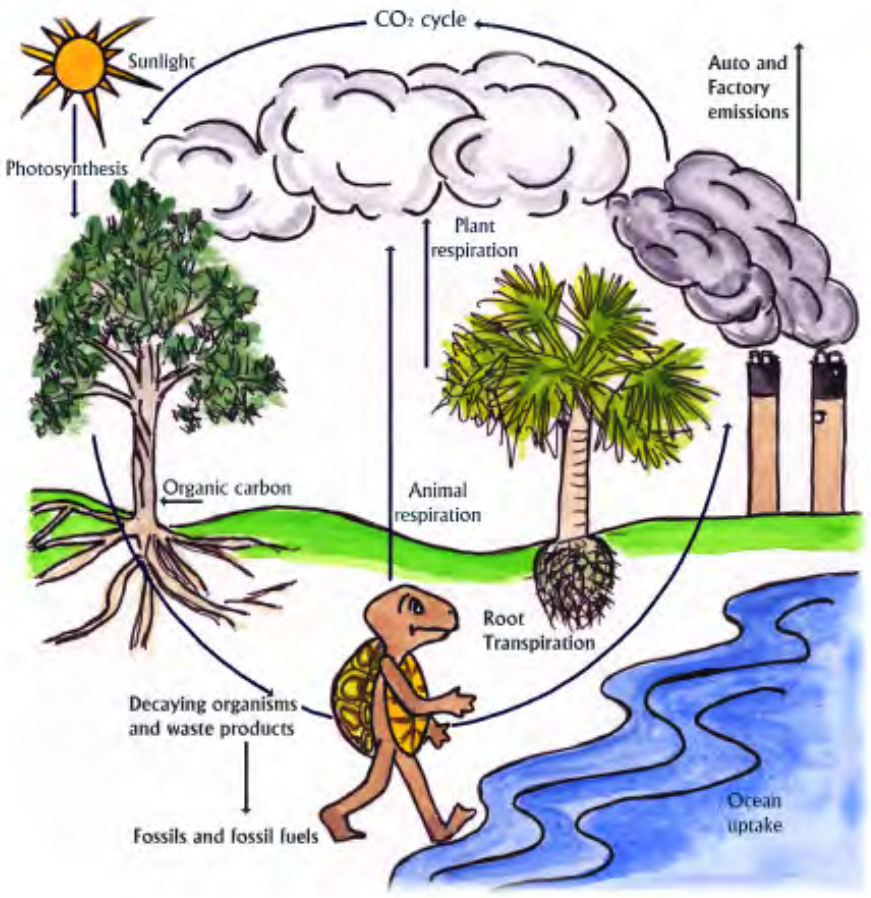
Carbon dioxide, which is the fastest growing greenhouse gas, occurs naturally in the air that we and other animals exhale when we breathe. We inhale oxygen and exhale carbon dioxide, which is then removed from the atmosphere naturally by plants and trees, which use it to grow through **PHOTOSYNTHESIS**. So for them it is carbon dioxide in and oxygen out. Thanks, trees!

Carbon dioxide is also produced from natural forest fires, erupting volcanoes and decaying plant and animal (**ORGANIC**) matter. This plant and animal matter builds up into layers, which over time are covered by sand and silt until they eventually harden into rock. Pressure and heat convert this decayed organic matter into coal, oil and natural gas – the '**FOSSIL FUELS**'. When we burn these fossil fuels to provide us with the energy to drive cars, power factories, fuel electricity and **MANUFACTURING** plants, homes and offices, huge amounts of the carbon dioxide that has been stored within are released.

A lot of carbon dioxide pollution also comes from the burning of trees in many countries to make space for farmland to grow food. To add to this, we are also cutting down so many trees for manufacturing that there are fewer trees to remove the carbon dioxide that builds up in the atmosphere. Remember? They take in carbon dioxide and release oxygen.

Carbon dioxide was the first greenhouse gas shown by scientists to be increasing. Before technology really changed the way that we make things (during the **INDUSTRIAL REVOLUTION**), carbon dioxide levels were 280 ppm (parts per million). Now they are at 393 ppm and rising.

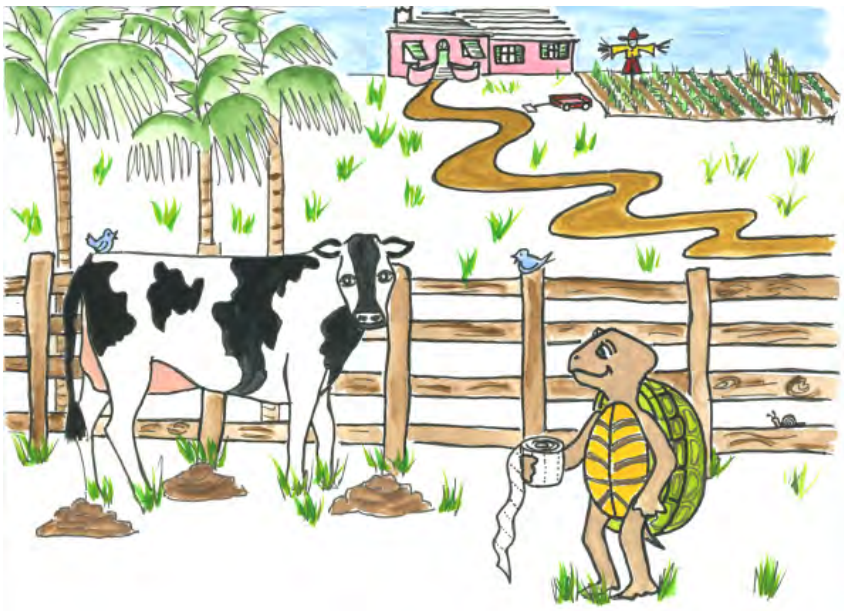
ALL LIVING THINGS ARE MADE UP OF CARBON AND IT IS CONSTANTLY BEING MOVED FROM THE AIR TO LAND TO SEA AND BACK. FOR EXAMPLE, CARBON DIOXIDE IN THE AIR IS USED BY PLANTS TO GROW, AND WHEN THEY DIE AND DECAY, THE CARBON MAY BE TURNED INTO COAL AND OIL OVER MILLIONS OF YEARS. IF HUMANS THEN BURN THIS, IT TURNS BACK INTO CARBON DIOXIDE IN THE ATMOSPHERE. ANIMALS ALSO BREATHE OUT CARBON DIOXIDE AND THIS GOES BACK INTO THE AIR, TO BE RECIRCULATED.



2. METHANE

Methane is a natural gas produced by bacteria that live in the guts of animals like cows and sheep. It is also produced by bacteria causing the decay of plant and animal matter in wetland habitats such as marshes and mangroves (for example Hungry Bay). There is a huge amount of decayed plant and animal matter in the Arctic soil or **PERMAFROST** and as this melts, the methane is released.

Humans add to the atmospheric levels by burning natural gas (which is mainly methane) to heat our homes and fuel our stoves and other household appliances. Methane is used to make products such as steel, paper, glass, paints, fertiliser, medicines and plastics. It is also released from landfill sites and trash dumps made by humans, like Marsh Folly dump. In many parts of the world, methane from such landfills is being **EXTRACTED** and burnt as a fuel source.



Here Trusty meets Dunkley the cow. She naturally releases methane as she digests her food. The more meat humans eat, the more cows are bred, and the more methane is released.

3. OZONE

Ozone is the third most important greenhouse gas. A natural '**OZONE LAYER**' is found in the troposphere (outside our atmosphere) but human activities also cause ozone to form in our atmosphere. Exhaust emissions from vehicles and pollution from factories increase carbon and nitrogen molecules, which form ozone when sunlight interacts with them. Although ozone does not remain for long, levels of it have risen by 30% since the Industrial Revolution.

4. HALOCARBONS

Halocarbons are **COMPOUNDS** containing carbon, halogens such as chlorine, bromine and fluorine, and sometimes hydrogen. They are used in medicine and agricultural products, and in oils and greases and products such as Teflon. Whilst some do occur naturally, others such as chlorofluorocarbons (CFCs), are only produced by humans. CFCs, which were used in aerosol cans and in refrigerators, are now strictly controlled because they were found to be causing a hole in the ozone layer. They have been replaced by other halocarbons which are less damaging to the ozone layer but still act as greenhouse gases. Although there are less halocarbons than other greenhouse gases, their warming effect is 3,000-13,000 times greater than that of carbon dioxide!

5. NITROUS OXIDE

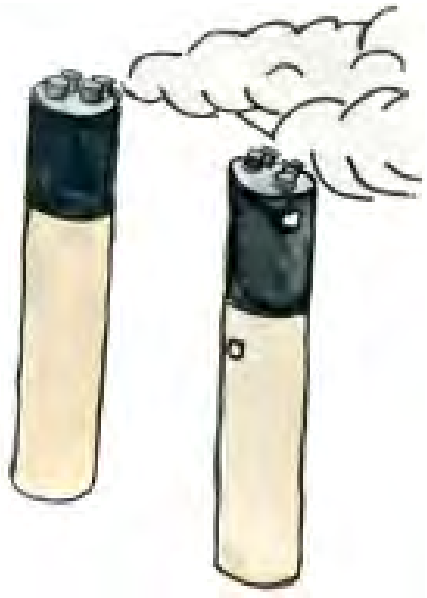
Most of the nitrous oxide in the atmosphere comes from man-made or **ARTIFICIAL FERTILIZERS**, used by some farmers to produce more crops. Nitrous oxide is also produced through sewage treatment and burning fossil fuel. In nature, it is produced mainly from **MICROBIAL ACTION** in soil and water. Although it is not the most significant greenhouse gas, it lasts for 150 years.

6. WATER VAPOUR

You know that when water freezes it forms ice. Well, when water gets warmer, for example when you boil the kettle, it turns into water vapour, a gas. Water vapour is the most significant greenhouse gas that absorbs heat from the earth, but it is not thought that human activities directly change the amount of water vapour in the atmosphere. (Don't worry about boiling the kettle -we're talking about much, much larger quantities here). However, as the earth's temperature increases through global warming, more water will evaporate from the oceans, rivers and soil because the air is able to 'hold' more water when it is warmer. This will increase the amount of heat that is absorbed, increasing the greenhouse effect, causing more warming and therefore more water to evaporate. This is known as a **POSITIVE FEEDBACK MECHANISM**.

7. BLACK CARBON

Black carbon otherwise known as 'soot', is not actually a greenhouse gas. It comes from smoke, which arises from natural events such as forest fires, as well as human activities like vehicle and factory emissions and cooking stoves. But it is now thought to be one of the most important causes of global warming.



Is climate change different from GLOBAL WARMING?

In a nutshell, they are the same thing. More greenhouse gases are causing the average temperature of the earth to increase (global warming), but one of the effects of this is to cause the climate to change in different parts of the world. At this point it is very important that we understand the difference between climate and weather.

CLIMATE VERSUS WEATHER

Weather relates to the temperature, the number of hours of sun, the wind, and the rain, snow or hail that we see around us when we go outside. The weather changes from hour to hour and day to day. One minute it can be raining, the next sunny.

Climate is the average or typical weather that we see over much longer periods of time, say 30 years. Bermuda's climate is often called **SUB-TROPICAL** to describe the average temperature, wind conditions and rain that are typical of our island. Different parts of the world have different climates such as desert, polar, tropical.

WILL IT GET HOTTER EVERYWHERE?

Yes. We're all in this together! The world is warming even though some parts of the world may experience colder weather patterns in the short term. However, some parts of the world such as the Arctic have been warming twice as fast as the rest of the world because the ice, which normally reflects the sunlight and keeps the surface cooler, has been melting. Greenland has warmed by 4°C already since 1991.[2] Land heats up faster than water, and as there is more land in the northern hemisphere than the southern hemisphere, the north will warm faster.

HAS CLIMATE CHANGE OCCURRED BEFORE?

Yes! The earth's climate does change naturally. The earth is 4.5 billion years old, and its climate has changed dramatically over its life, often leading to mass extinctions of plants and animals. Much of the relatively small climate variability over the last 1,000 years leading up to the Industrial Revolution can be explained by changes in the sun's energy, or in the earth's orbit around the sun. However, these have not changed much over the past few decades, whilst global temperatures have risen significantly. Other natural factors such as volcanic eruptions or changes in ocean circulation due to **EL NIÑO** can also affect the climate. However, the current rate of change, which has scientists and global leaders so worried now, is believed to be due to human activities.

CAN WE SEE SIGNS OF CLIMATE CHANGE YET? YES!

The world is getting warmer. The global temperature has risen by an average of 0.74°C since 1900 and an average of just over 0.15°C per decade since the mid-1970s[1]. The 10 warmest years on record have occurred since 1997. However global warming does not mean that each year will be warmer than the last. Remember, climate change is about longer term trends. In the short term, some countries will experience warmer weather than usual and others colder weather.

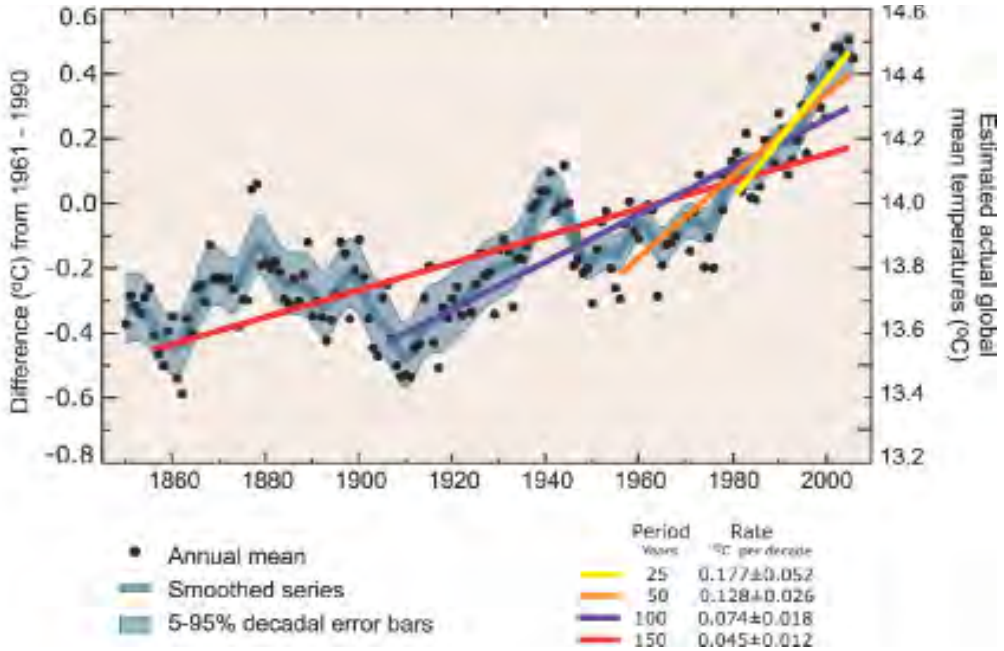
The sea level is rising. The average sea level has risen by 10-20 cm in the past century and one low-lying country Kiribati, which lies only 2 metres above sea level, is already planning to buy land in Fiji so that the whole population of 113,000 will have somewhere to live when their country becomes submerged.[3] How many metres will the sea have to rise before Bermuda is submerged under the sea?

Warmer temperatures are causing coral reefs to die. When it gets too warm, the corals **EXPEL** the **ALGAE** that live within them, and which provide them with food. This means the corals then starve. Coral growth is also affected by rising carbon dioxide levels, which cause the ocean to become more acidic. This means that corals cannot build their skeletons as quickly, nor other marine animals grow their shells as fast.

Snow and glaciers are melting. Snow cover across the world has decreased by 10% since the late 1960s. In the Arctic, some scientists predict that the summer sea-ice, which has been rapidly shrinking, could disappear completely by the summer of 2015.[4] Most of the worlds' glaciers are also shrinking (retreating) at a faster rate.[4]

Plants and animals are moving (migrating) in response to the warming conditions. 40% of all species have migrated towards the cooler poles or up mountainsides. For example, mosquitoes are now living in higher altitudes that have become warmer, causing malaria to spread to new areas. Of course some species can't adapt by moving to new regions and it is feared that 20-30% of all species will be at greater risk of **EXTINCTION** if the earth warms by 1.5-2.5°C above the global temperature of 1990. If it rises by more than 3.5°C, 40-70% of species may become extinct.[5]

The weather has become more **ERRATIC**. More rain is falling in many parts of the world, causing flooding and mudslides. However, in parts of Africa and Asia, droughts have worsened causing crops to be destroyed. This means less food leading to starvation in poorer countries. Hotter temperatures during the past 30 years in sub-Saharan Africa may also have led to more civil war. Indeed, many people argue that the genocide in Darfur is a 'climate change war', triggered by a decline in rainfall over the past 30 years.[6]



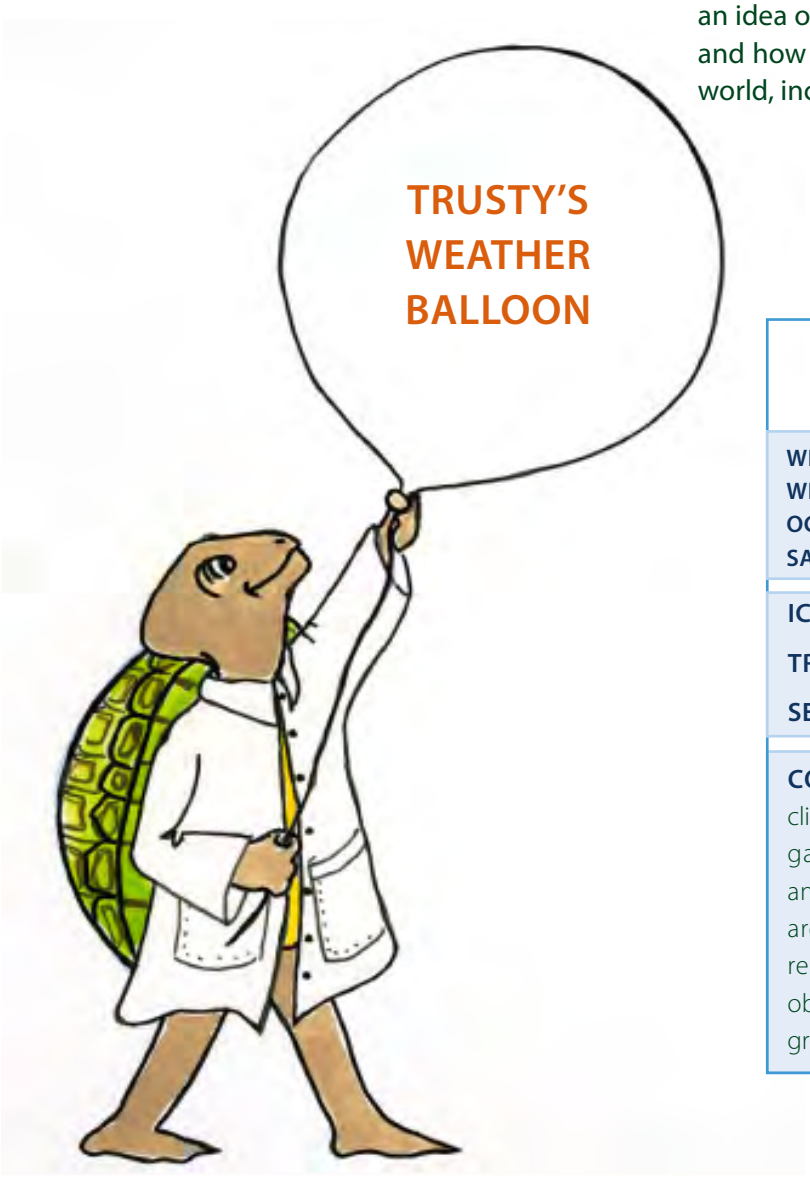
Analyse this graph: it shows the rise in the world temperatures between 1860 and 2010. The bottom axis shows the date and the vertical axis shows temperature. The red line shows the average rise in temperature over time. The yellow line shows the rise over the last 25 years. Notice how much steeper the yellow line is. That means that temperatures are rising much faster now then they were in the past.

Source IPCC 2007: WG1-AR4

HOW DO WE KNOW ALL THIS?

Scientists from all over the world have been studying the earth's climate for decades and many of them have been warning us that the earth's temperature has been rising. This is now such a serious issue that two large international organisations, the World Meteorological Organisation and the United Nations, launched a worldwide study in 1988 to be undertaken by the International Panel on Climate Change (IPCC) to look into the changes that are occurring and their impacts on our world. While Bermuda's government needs to take care of Bermuda, these organisations are concerned about the impacts all over the world.

152 scientists from more than 30 countries have been working on this project and looking at all the data from around the world. More than 60 experts have reviewed their data. Every few years the IPCC produces a report with the latest data and information. These reports help to guide the decisions that world leaders must make, and consequently the choices that we as global citizens must make to tackle the problem of climate change. They also include scenarios in their reports, based on the data and possible future trends in our greenhouse gas emissions (growing, stable or declining emissions). A scenario is like a 'what if' - it tells us what else is likely to be affected if a certain thing happens. These scenarios provide us with an idea of what changes we might expect in the future and how these will likely affect different regions of the world, including Bermuda.



HOW DO YOU STUDY CLIMATE CHANGE?

WEATHER STATIONS **WEATHER BALLOONS** **OCEAN BUOYS** **SATELLITES**	provide a picture of the earth's temperature today
ICE CORES **TREE RINGS** **SEDIMENT LAYERS**	give clues about the climate and levels of greenhouse gases in the past

COMPUTER MODELS estimate how the climate will respond to changes in greenhouse gas concentrations, as well solar output and volcanoes. When natural factors alone are considered, computer models do not reproduce the climate warming we have observed. This can only be explained when greenhouse gases are included.

WHAT IS A CARBON FOOTPRINT?

When you walk along the beach, you leave footprints which show your impact on the sand. If you look carefully, you can also see whether your footprint was the same size or deeper, or bigger than that of your friend.

We can consider our impact on the climate in a similar way by measuring our **CARBON FOOTPRINT.** Our carbon footprint is the sum of the greenhouse gases (mainly carbon dioxide) that we produce in our daily lives. It is usually measured in tonnes or kilograms. This includes direct emissions, for example from burning fossil fuels to produce the electricity we use, and fuel for our cars and bikes, as well as the indirect emissions that result from the manufacture and use of all the food and products we use. Do you think the size of the carbon footprint made from the things you buy is your responsibility? Or is it the manufacturer's responsibility? Do you think you could reduce your footprint by choosing to buy different products?

Knowing our carbon footprint is important because it allows us to set a goal for improvement. By thinking about the choices we make each day, we can significantly reduce our footprint.

UNFORTUNATELY, BERMUDIANS TEND TO HAVE A VERY LARGE CARBON FOOTPRINT – ABOUT 11 TONNES OF CARBON PER PERSON, PER YEAR.

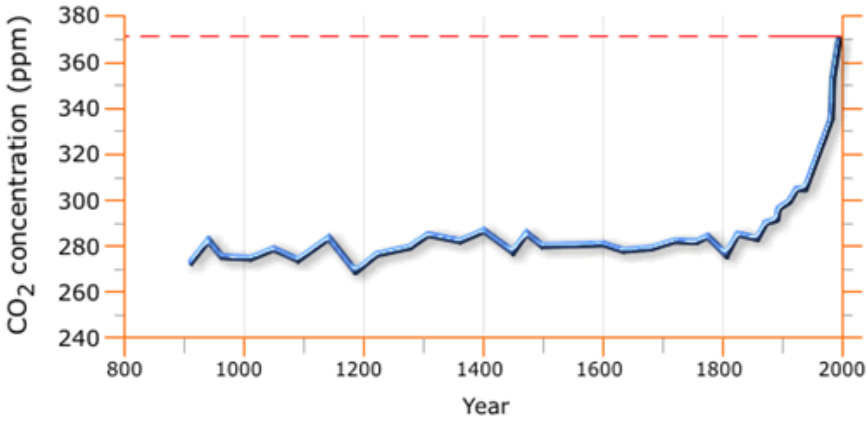
WHAT IS BEING DONE ABOUT CLIMATE CHANGE?

World leaders and scientists have been trying to map out a plan of action in order to tackle the climate change issue. They have negotiated a global agreement, the **KYOTO PROTOCOL**, which seeks to prevent greenhouse gases from rising above dangerous levels (450 ppm of carbon dioxide). Through this agreement, countries agreed to reduce their greenhouse gas emissions by 2012 to 8% below 1990 emission levels. If this is achieved within a few decades, then carbon dioxide levels could be prevented from rising above 450 ppm and the earth could be prevented from becoming dangerously warm.

However, there are many challenges to doing this. It is the wealthier countries of the world that have largely been responsible for the current level of greenhouse gases. Many poorer countries are now playing '**CATCH UP**' to the wealthier nations of the world in terms of their development. For example, in China and India which are the two most populated countries in the world, many more people now want to drive cars than a few years ago. This means that their greenhouse gas emissions are rising quickly but they do not feel it is fair to have the same emissions limits placed on them as on the more developed countries, where so many of us have been driving cars for years!

Despite this, governments in countries all over the world are setting up **POLICIES** to reduce their own emissions, or their 'carbon footprint'. These policies include ways to increase energy conservation (or decrease energy use), and increase the use of **RENEWABLE ENERGY** sources. Can you think of ways to do this in your own home? Governments are also making other changes necessary to cope with the climate change.

In order to meet the 2050 global emissions targets, the carbon footprint of the average global citizen must be no more than one tonne of carbon dioxide.[7] This is important when we realize that in Bermuda, each resident has an average carbon footprint of 11 tonnes per year! So by how many tonnes will we have to reduce our carbon footprint?



This graph shows how the levels of carbon dioxide started to increase more quickly when carbon dioxide emissions started to rise in the late 19th century during the Industrial Revolution.

www.landcareresearch.co.nz/research/globalchange/climate_change.asp#TempChange

Source: UNEP/GRID-Arenda

This graph shows the average carbon emissions per person for different countries in the world. Despite our small size, Bermuda has one of the highest carbon footprints. This is a sign of our wealthy lifestyle which is also shown on the graph by our high **GROSS DOMESTIC PRODUCT** (GDP).

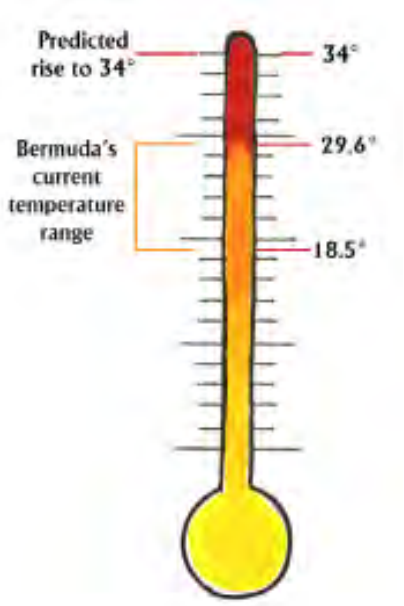
SECTION 2:
What Climate Change means for Bermuda

SO HOW WILL BERMUDA'S CLIMATE CHANGE?

1. RISING TEMPERATURES

The IPCC's calculations suggest that the average global temperature will continue to increase with an average range of 1.8 to 4.0°C by the year 2100. (The exact amount will depend on how quickly greenhouse emissions are reduced). A 2°C temperature rise would be at least equivalent to the warmest global climate conditions of the last 2 million years.

Bermuda's climate is sub-tropical thanks to the impact of the Gulf Stream and the Bermuda-Azores high-pressure system. Our mean temperatures range from 18.5°C (65.3°F) in February to 29.6°C (85°F) in August. According to the IPCC models, we might expect the yearly temperature in Bermuda to rise between 2.8 – 4.3°C (or an average of 3.6°C) by the end of the century.



2. SEA LEVEL RISE

Bermuda has actually experienced a yo-yo effect of rising and falling sea levels over its geological history, from as much as 130 metres below the present level to as high as 21 metres above, but that was a long time ago (about 400,00 years).[8] How many places can you find around Bermuda that are 21 metres above the present sea level? We know from research on the Island that in the past 131 years, the sea has been rising by 3 mm/year or a total of 0.4 metres.[9] We can calculate this by comparing old photographs taken in 1876, which show the level of the tide line on the seawall built in the Naval Dockyard in 1835, to the tide line today.

There are two factors which contribute to sea level rise: first, the water in the oceans swells or expands as the temperature rises, and second, the world's glaciers and ice caps are melting, and all the water that was stored up as ice becomes liquid and adds to the amount of water in the oceans. A few years ago, scientists were predicting that the Arctic Ocean could be free of ice in the summertime by 2030 or 2040, but recent research now suggests that this condition could occur as early as 2015. Consider this: between 2005 and 2007, summertime ice in the Arctic dropped by 23%.

In this book we are using two predictions for sea level rise in Bermuda. The first, 0.59 metres (just under two feet) by the end of the century takes account only of the expansion of the oceans due to warmer temperatures;[1] this would result in about 462 acres (187 hectares) of Bermuda being submerged with water. If we add to this the rapid rate of melting polar ice we could be looking at a sea level rise of as much as 2 metres (just over 6½ feet) by the end of the century.[10] If this were to occur, we would be looking at a loss of about 2,026 acres (820 hectares) of land to the sea. This would be a loss of 14% of Bermuda's land area. Fortunately, our shoreline rises quite steeply around much of the Island, but nevertheless rising seas will definitely impact our lives.

Dr. Steve Blasco of the Canadian Geological Survey using the Naval Dockyard wall to show how much sea level has risen (40.6cm) since 1876. (Photo courtesy Dr. P. Rouja).

A SEA LEVEL RISE OF 2M WOULD MEAN
LOSING AS MUCH LAND AS IS FOUND
IN DEVONSHIRE PARISH PLUS
2/3 THE AREA OF SMITH'S PARISH.

Credit: M. Shailer, Department of Conservation Services

3. HEAVIER RAINFALL

There is likely to be more rain overall across the Earth as greenhouse gas emissions rise, but it is likely to become much more erratic in different parts of the world. Scientists suggest that in tropical climates there will be less rainfall but at mid latitudes, where Bermuda lies, there will be more. Our average yearly rainfall is 150cm but this may increase by between 5-10% (7.5 -15cm). This doesn't mean it will rain more often. In fact, it is more likely that it will not rain as often, but when it does rain, the downpours will be heavier. This could lead to flash floods because the ground won't be able to soak up all the rain fast enough.

4. MORE SEVERE TROPICAL STORMS

It is believed that climate change may result in fewer hurricanes in Bermuda; however those that do form would probably be bigger as well as stronger. We might also get more winter storms.

In addition to these major changes, increasing carbon dioxide and ozone, and possible shifting of ocean currents will also directly affect us.

ENERGY

Like most small islands, Bermuda gets its energy from imported fossil fuels (oil). Approximately one million barrels of oil are **IMPORTED** to Bermuda each year and used by BELCO to produce electricity. As well as all the greenhouse gases burning this oil produces, Bermuda's need for imported oil also means that we pay a high price for electricity and if the supply of oil to the Island is cut off, we have a major problem!

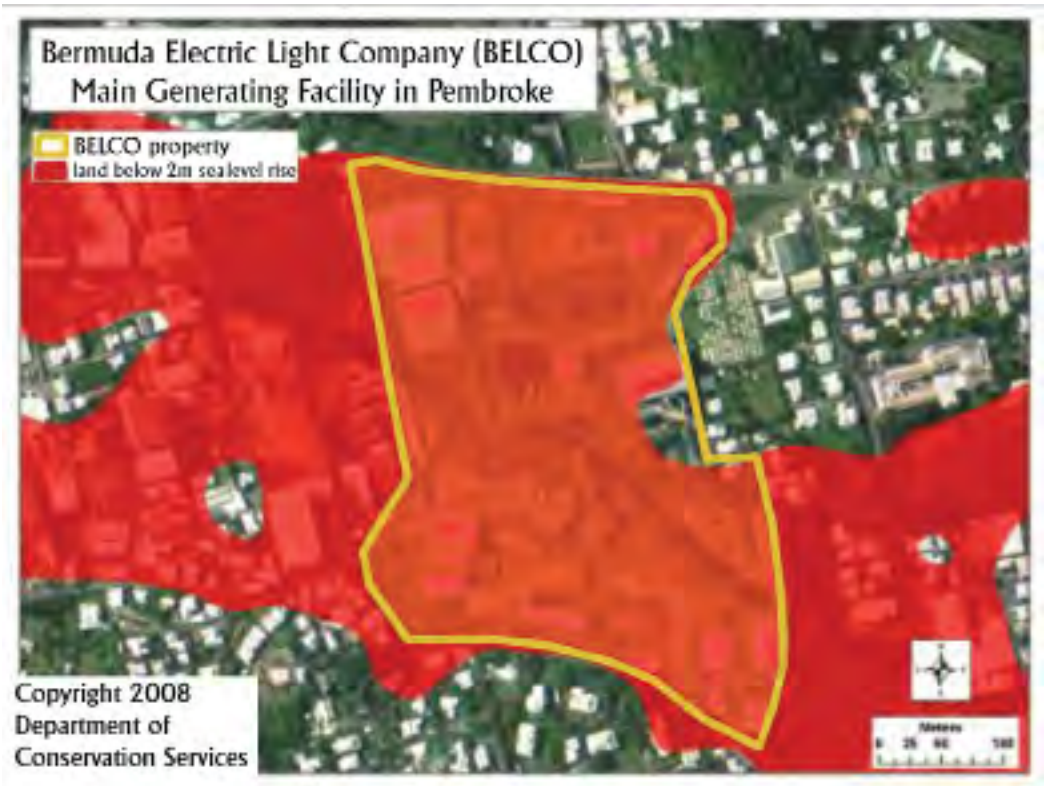
Electricity travels at nearly the speed of light, which means that it arrives at our homes at almost the same moment it is produced. Pretty cool! Unlike oil or natural gas in a pipeline, electricity cannot easily be stored. It must be generated and delivered exactly when it is needed. Bermuda's electricity grid delivers power from the main BELCO power plant, through 31 substations, 400 km of underground cables and 1,472 km of overhead lines, to all parts of the island.

Bermuda currently uses on average about 80 MW (megawatts) of power and peaks at about 120 MW. BELCO has the capacity to produce 169 MW. A further 1.2 MW is provided from the Tynes Bay Waste Incinerator. It is expected that by 2020, Bermuda will need an average of 145 MW of electricity to supply our needs.

We have mentioned that the typical Bermuda resident is responsible for emissions of 11 tonnes of carbon per year. This is one of the highest carbon footprints in the world. Over half of this is from our energy use. Under the Kyoto Protocol, Bermuda has committed to reducing its carbon emissions by being more careful about how much energy we use and reducing our need for oil. Remember, to meet Kyoto targets, we, along with every global citizen, will need to reduce our emissions to just one tonne/year by the year 2050.

Energy conservation is the solution to so many problems: it saves money, reduces our carbon footprint and protects the natural environment.

How much electricity does your house use? Is there any way your family could use less?



The area outlined in yellow is the main BELCO facility in Pembroke. The red area shows land that would be underwater if the sea level were to rise two metres. As you can see, if that were to happen, BELCO's main generating facility would be almost completely under water.

HOW WILL CLIMATE CHANGE AFFECT OUR ENERGY SUPPLY?

RISING SEA LEVEL

The main BELCO plant in Pembroke and many of its substations and lines are on low-lying land where rising sea levels could flood them. Saltwater flooding of BELCO would be disastrous, cutting off our electricity supply and disrupting our whole way of life.

HIGHER TEMPERATURES

With rising temperatures our use of electricity will also rise. We will want to spend more time indoors to avoid the heat and will therefore use more air conditioning. Higher temperatures can also affect the electricity transmission in power lines, causing more blackouts.

MORE RAINFALL

Heavier rain could result in flooding of the main BELCO plant as well as the substations and underground cabling.

STRONGER STORMS

Stronger storms and hurricanes may damage power lines and substations as well as weaken the actual power generation equipment. Storms may also affect the shipping supply of oil to Bermuda to run the power plant.

WHAT'S UP WITH WATTS?

Electricity production is measured in 'watts'. A watt measures the rate of energy conversion. For example, when a light bulb with a power rating of 100 watts is turned on for one hour, the energy used is 100 watt-hours. This same amount of energy would light a 40-watt bulb for 2.5 hours, or a 50-watt bulb for 2 hours. One kilowatt (kW) is equal to 1000 watts. A power station would be rated in multiples of watts, but its annual energy sales would be described in multiples of watt-hours. A kilowatt-hour (kWh) is the amount of energy equivalent to a steady power of 1 kilowatt running for 1 hour.

Reducing Bermuda's ENERGY FOOTPRINT

As citizens we are counting on Government and BELCO to be aware of the liklihood of flooding and to take steps to secure our energy infrastructure. But that only addresses part of the issue. What we really need to do is to develop alternative ways of generating electricity using new technologies such as solar, wind and ocean energy. As long as Bermuda is totally dependant on imported oil for our electricity, we are vulnerable.

WHAT CAN WE DO? TEN WAYS TO CONSERVE ENERGY!

Take a look at your monthly electricity bill and find out how much electricity you and your family actually use. Your bill will tell you how many kilowatt hours (kWh) you use each month, as well as how much electricity you used in the previous month and in the same month the year before. Set yourself a target to reduce the amount of electricity your household uses - there are many easy ways to do this:

- Switch off lights, TVs, computers – anything that has an on/off switch! – when not needed.
- Open windows instead of using air conditioning in summer; wear more clothes instead of using heaters during winter months.
- Buy energy saving appliances. Refrigerators account for about 20% of household electricity use, so use a thermometer to set your refrigerator temperature as close to 37 °C and your freezer as close to 3 °C as possible
- Set your washing machine to cold water – that uses much less electricity than a hot wash.
- Set your water heater no higher than 48 °C (120 °F). Each 5.5 °C (10 °F) reduction saves over 0.25 tonnes of carbon per year. Wrap your household water heater in an insulating jacket to save 0.5 tonnes of carbon dioxide per year.
- Run your dishwasher only when it is full. Put on the energy saving setting to air dry the dishes – this reduces its electricity use by 20%.
- Select the most energy-efficient models when you replace appliances. Look for the Energy Star Label and buy the product that is sized to your actual needs – not the biggest one available.
- Buy energy-efficient compact fluorescent bulbs. Although they cost more initially, they save money in the long run by using only 1/4 the energy of an ordinary incandescent bulb and lasting 8 -12 times longer. In a typical home, one compact fluorescent bulb can save 0.125 tonnes of carbon dioxide per year.
- As an island, we must start using other sources of energy that do not emit carbon dioxide. Investing in a solar water heater can save 4.9 tonnes of carbon dioxide annually. We should also look at generating power from wind turbines, solar farms, biofuel and from ocean swell and currents.
- We need to think about energy conservation in the global context and the amount of energy needed to manufacture many of the products we import from overseas. For example, vast amounts of energy are needed to mine bauxite, from which aluminium is made. By using recycled aluminium, we can make a 95% energy savings. Similar savings apply to using recycled glass.

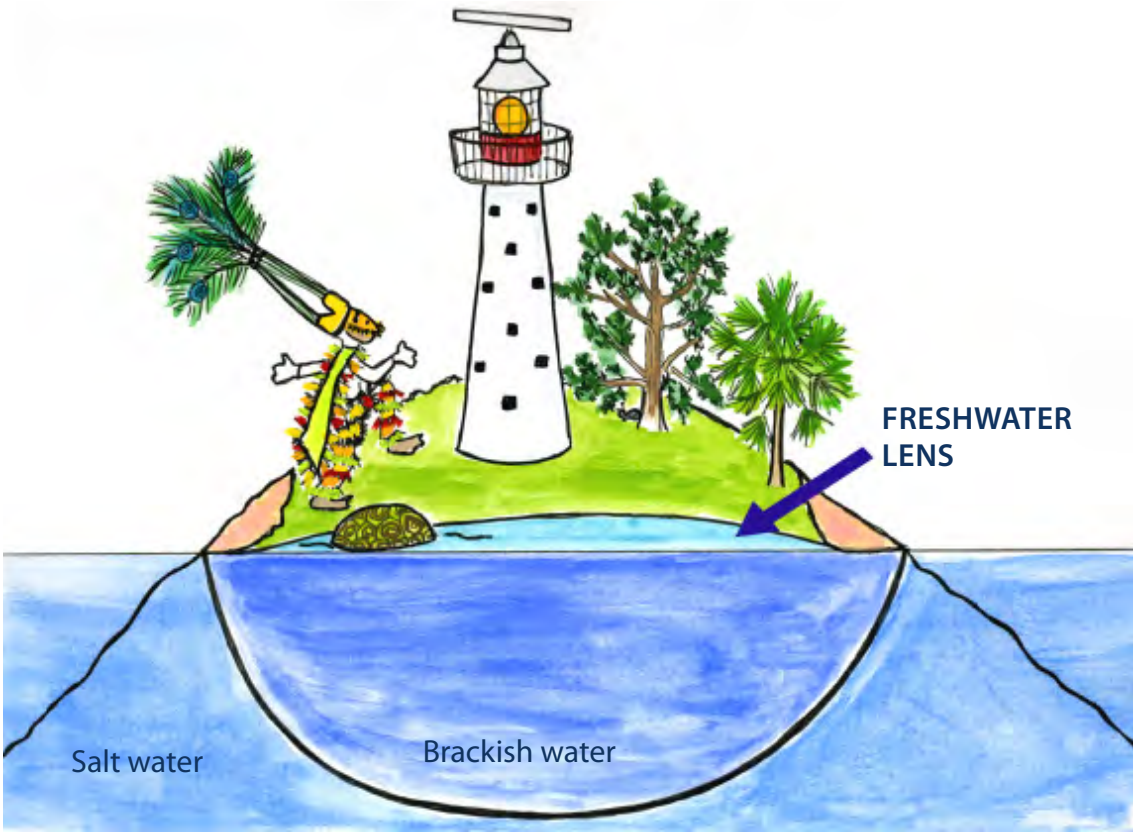
FRESH WATER

Without freshwater we cannot survive. We need clean, freshwater for drinking, cooking and washing. Bermudians have always been fairly careful with water: we average 136 litres (about 36 gallons) per person per day mainly for drinking and washing, compared to 340 litres (nearly 90 gallons) for the average American citizen. But that's only a small part of the water we actually use. Everything we import - food, clothes, cars, toys, furniture, everything - is grown or made using water. So we have a far larger impact on the world's water supply than you would think, and what happens to the world's water supply affects us here in Bermuda.

WHERE DO WE GET OUR WATER IN BERMUDA?

Most of us rely on 'rainwater harvesting' from our roofs for our freshwater needs. Bermuda's white roofs are specially designed so that rainwater can be collected on them and then stored in tanks underneath the houses. This system of harvesting works because rain usually falls fairly evenly throughout the year in Bermuda, bringing us that wonderful Bermuda phenomenon - 'tank rain'. This is one way Bermuda can set a good example of **SUSTAINABLE PRACTICES** for other countries.

We **SUPPLEMENT** rainwater with water from wells. Bermuda is a limestone island sitting on top of an extinct volcano. Limestone is like a sponge; when it rains, the fresh rainwater doesn't pool on the surface, but soaks into the ground out of sight. In four areas of Bermuda, this 'groundwater' has collected into large areas known as water lenses. These lenses are in Somerset, Port Royal, St. George's and Pembroke/Devonshire. The groundwater in these lenses floats on top of the seawater because freshwater is less dense and lighter. Many larger buildings such as hotels, businesses and the hospital, as well as some homes, depend on this groundwater, which can supply up to 9.1 million litres/day. It is delivered either through a system of pipes or water trucks, or from wells drilled in gardens.



Bermuda can also 'produce' freshwater by **EXTRACTING** it from seawater through a process known as **REVERSE OSMOSIS.** Bermuda Waterworks produces 2.275 million litres (about 60 million gallons) of fresh water per day from seawater and the Bermuda Government produces a further 2.275 million litres/day in its reverse osmosis plant next to the Tynes Bay incinerator.[11] A number of homes also have their own reverse osmosis plants. But we need to remember that all of these plants use considerable amounts of electricity and therefore fossil fuels to produce water.

This map shows the four main freshwater lenses in Bermuda.

HOW WILL CLIMATE CHANGE AFFECT OUR FRESHWATER?

RISING SEA LEVEL

As Bermuda's freshwater lenses float on top of seawater, it is likely that our groundwater will simply float upwards as the sea level rises and will not be affected too much by small rises. But with rising seawater we will lose land area for freshwater collection and drainage.

MORE RAINFALL

Under the IPCC predictions, Bermuda is expected to get more rain. This would be good for our water supplies. However, there may also be heavier flash floods, which could lead to more oil and pesticides running off our roads into our groundwater supplies.

HIGHER TEMPERATURES

Higher temperatures will mean that our freshwater evaporates more quickly. This means that the same amount of water won't go as far as it does today. Bacteria also thrive in higher temperatures so our water could become more easily **CONTAMINATED.**

STRONGER STORMS

Bigger storms and hurricanes are expected which tend to blow salt and leaves onto our roofs and into our water tanks, contaminating them.

WHAT CAN WE DO TO PROTECT OUR FRESHWATER SUPPLY?

- Use less water in our daily lives by:
  - --running our taps less
  - --fixing leaks
  - --running our washing machines with full loads of laundry
  - --taking shorter showers and fewer baths
  - --using 'dirty' water to water our gardens.
- Install water meters to monitor usage, and encourage more use of well water For flushing water.
- We could also build larger water tanks under all new homes being constructed.
- We can prevent contamination of our freshwater by keeping our roofs and tanks clean.
- We can reduce the amount of contaminants that get washed into our ground-water during heavy rain by keeping our cars, bikes and trucks well maintained to prevent oil leaking onto our roads.
- And we need to reduce the amount of insecticides and pesticides used around our homes and on our land as these all get washed into the groundwater.

Reducing Bermuda's WATER FOOTPRINT

HOW MUCH OF THE WORLD'S WATER DO WE USE?

Everything we buy that has been imported has drained the freshwater supply of another country. Some people call this 'virtual' water. Keeping in mind that in a typical bath, we use 150 litres (40 gallons) of water, take a look at the amount of water needed to make...

...ONE MICROCHIP FOR A COMPUTER: 32 LITRES (8 GALLONS)

...ONE SERVING OF POTATO CHIPS: 185 LITRES (49 GALLONS)

...ONE CUP OF COFFEE: 280 LITRES (74 GALLONS)

...ONE HUNDRED SHEETS OF PAPER: 1,000 LITRES (264 GALLONS)

...ONE HAMBURGER: 2,400 LITRES (634 GALLONS)

...ONE MEDIUM SIZED COTTON T-SHIRT: 2,700 LITRES (713 GALLONS)[12]

So, we really need to think about what we are buying and to buy locally, wherever possible. This includes making sure that if we are going to buy drinking water, we buy local water, not water that has been harvested and bottled from another country's water supply and shipped to Bermuda. Climate change will affect the whole worlds' water supply.

How can it possibly take 2,400 litres (634 gallons) of water to produce one hamburger?

On average it takes three years before a farmed animal is slaughtered to produce about 200 kg of boneless beef. During this time, the cow consumes nearly 1,300 kg of grains (wheat, oats, barley etc), 7,200 kg of roughages (pasture, dry hay etc), 24,000 litres of water for drinking. Another 7,000 litres of water are used for servicing the animal. This means that to produce one kilogram of boneless beef, we use about 6.5 kg of grain, 36 kg of roughages, and 155 litres of water. However, growing all that feed requires an additional 15,300 litres of water.

That brings the average water footprint to 15,455 litres of water per kg of beef, or 2,320 litres per 150g beef patty. Add 40 litres for the slice of cheese and 40 litres of water for the bun and you're up to just over 2,400 litres (634 gallons) before you even think about the mayo and ketchup!

TRANSPORT: Land, Air and Sea

How we get around is an important part of our lifestyle. Bermuda's transport system includes land transport, marine transport and air transport, and all will be affected by global warming. It is important to remember almost all of the vehicles in Bermuda (boat, car, bus, airplane) rely on fossil fuels, which have to be imported, to power them. The more we use them, the more carbon emissions we produce. As we have already said, half of our carbon footprint is from our electricity use - the other half comes from the transport we use.

LAND

Our land transport **INFRASTRUCTURE** includes roads and bridges. Bermuda has about 209 km of public roadway and 248 km of private roads. Several bridges link the main islands. There were 48,661 registered road vehicles in 2010.[13] Most run on fossil fuels but some electric vehicles are now available on the Island.

Did you know that 100 return trips between St. George's and Dockyard produce 1 tonne of carbon emissions in a small car (up to 1.2 litre engine)? A large car produces the same emissions in just 50 trips. Every 20 gallons of gasoline you use creates approximately 0.176 tonnes of carbon emissions. A scooter on the other hand produces about six times less carbon dioxide than the average car.

AIR

Bermuda's airport, the LF Wade International Airport, lies on 561 acres (227 hectares) of land. There is one operational runway, and several taxiways. In 2002, there were nearly 14,000 aircraft arrivals and departures, almost 850,000 passengers and 7 million kg of mail and cargo.

Did you know that a return flight from London to Bermuda results in 1.8 tonnes of carbon emissions per passenger? New York to Bermuda produces 0.2 tonnes.[14] In order to meet current emissions reductions, emissions per global citizen need to be reduced to one tonne per year by 2050. This would not even allow for one return trip to the UK per year, and this doesn't even take into account the rest of our carbon budget that we need for daily living.

SEA

Bermuda has three ports - Hamilton, St. George's and Dockyard. In 2001, 1,566 boats from overseas docked in Bermuda. Cruise ships currently berth in Dockyard, Hamilton and St. George's; only Dockyard can take the newer, larger ships capable of carrying up to 2,500 passengers and 800 crew.

Many of the tourists, as well as Bermuda's residents, also use ferries, particularly between Hamilton and Somerset/ Dockyard and Hamilton and St. George's.

Did you know that on a large cruise liner such as the Queen Elizabeth II, sailing from the UK to New York and back, every passenger is responsible for 6.2 tonnes of carbon emissions for fuel and a further 2.9 tonnes for food and water consumption, etc. This is over five times as much as flying. On a typical cruise ship travelling from New York to Bermuda and back, carbon emissions per passenger would be 0.33 tonnes.[14]

HOW WILL CLIMATE CHANGE AFFECT OUR TRANSPORT SYSTEM?

RISING SEA LEVEL

Sea level rise may affect our port facilities, as well as the airport; a 2 metre rise would flood the runway. Low-lying roads may become submerged and bridges may be weakened.

HIGHER TEMPERATURES

Higher temperatures may cause cracks in our roads and airport runway, meaning more frequent maintenance will be needed. This will also put more stress on our bridges connecting the islands.

MORE RAINFALL

Heavier rainfall may flood our roads and the airport runway and facilities. Airport storm water currently drains into Castle Harbour through drains running under the runway. Drains on our roads also remove rainwater from the roads, but often these get blocked with debris adding to the problem of flooding.

STRONGER STORMS

Recent hurricanes have shown us how vulnerable our roads, bridges, ports and airport are to storm damage. The force of the wind and waves can literally rip them apart and this can disrupt our travel plans. It affects our economy as tourists and business visitors may not be able to arrive or depart. Shipments of food, the fuel BELCO uses to generate our electricity and other supplies would also be affected.

INCREASING CARBON DIOXIDE

Rising greenhouse gas levels may affect the way we travel in the future. For example, the European Union has now placed a limit on the carbon emissions allowed by airlines that make international flights into or out of Europe. If the airlines exceed these, they either have to find a way to reduce their emissions, or pay to increase their allowance.

This is an aerial view of our airport. The red area shows the parts of the airport that would be underwater if the sea level were to rise two metres - practically all of it! You can see the terminal in the lower left area and the runways.

Reducing Bermuda's TRANSPORT FOOTPRINT

WHAT CAN WE DO?

Protecting our transport infrastructure is really something which must be tackled by Government. As citizens we can make sure they know that we are counting on them to think ahead and find ways to protect it.

You might think Bermudians already do one good thing by riding scooters instead of driving a car, especially a large car. That's true as far as carbon emissions are concerned, but the story is not straightforward because scooters produce a lot more other pollutants (carbon monoxide, hydrocarbons and nitrous oxides) than cars! Still, whether driving a bike or a car, we can make sure we drive 'smarter'. Making sure our tyres are pumped up to the correct pressure, avoiding carrying extra weight in our car, reading the road ahead so that we drive smoothly and do not keep speeding up then slowing down, not leaving the engine running unnecessarily and not running the air conditioning in our cars are all ways we can reduce how much gas we use and therefore our emissions.

But those measures won't get all the carbon savings we need - that has to come simply from travelling less, using public transport (buses and ferries) which is more fuel-efficient, walking, cycling, rowing or kayaking, car-pooling, and making fewer unnecessary trips. Business leaders might look at using videoconferencing for business meetings, rather than travelling overseas.

Increasingly, new vehicle designs are emerging and there are several electric bikes and cars already on the island that do not use fossil fuel. However, these vehicles still need to be plugged in to a power outlet to charge them, so until we start producing electricity from renewable energy sources (sun, wind, ocean, biofuel) they are still relying on fossil fuels.

HOW CAN WE PUT OUR TRANSPORT CONSUMPTION ON A 'CARBON DIET'?

Half the carbon we generate comes from energy used for transport. If we each generate 11 tonnes carbon in total each year, 5.5 of those tonnes are generated though our travels. To meet global targets we will need to cut that by 5 tonnes. That's not as hard as you might think…….

Car pool (4 people) to work each day for 48 weeks on a 15 mile round trip in car doing 30 m/gallon	**6.30 tonnes**
Hold one video conference instead of flying to New York	**0.33 tonnes**
Walk 10 miles per week instead of driving your car (48 weeks)	**0.50 tonnes**
Total reduction of carbon generated	**7.13 tonnes**

See? It's easy!

Impacts on Bermuda's Buildings
INCLUDING OUR ARCHITECTURAL HERITAGE

Bermuda's traditional architecture is unique. The climate was an important consideration in the design of the early Bermuda homes. Built from stone, most Bermuda homes are very strong and largely hurricane-proof. Over time, as more modern construction materials and household appliances have become available, construction methods have also changed. Larger buildings such as offices are built using more modern designs able to withstand hurricanes.

Many older buildings are an important part of our cultural heritage. Over 700 individual buildings of special architectural or historical interest are listed for protection under Bermuda law. These include forts, churches, houses and gateposts. There are 58 historic areas around the Island, including Naval Dockyard and the Town of St. George, the oldest town in the New World and a designated World Heritage Site.[12] Bermuda also has quite a rich archaeological heritage.

A permit is needed from the Department of Planning to build on any piece of land in Bermuda and all buildings must meet certain standards. All of Bermuda's land is zoned so that different types of building are allowed in different areas (for example, for residential, industrial or tourism uses). Some conservation areas are completely protected from any building in order to safeguard our wildlife. An area zoned **COASTAL RESERVE** stops people from building too close to the shore where storms or rising sea level might damage them. We have a good structure in place to safeguard our natural and cultural heritage and we must stick to it.

HOW WILL CLIMATE CHANGE AFFECT OUR BUILDINGS?

RISING SEA LEVEL

Seawater is highly **CORROSIVE** which means that rising sea level may corrode the concrete and steel in our buildings, as well as lead to flooding of low-lying buildings including historic ones, which are very vulnerable to **SALT WEATHERING.** If sea level rises 0.59 metres, 534 buildings will be affected. 1,977 buildings will be affected by a 2 metre rise. Sea level rise will also lead to changes in soil chemistry, which may affect archaeological sites and destroy **ARTEFACTS**.

WATERVILLE... UNDER WATER!

MORE RAINFALL

More flash floods will lead to building damage. Historic buildings in particular absorb water more easily and moulds and fungi often thrive in such conditions.

HIGHER TEMPERATURES

Higher temperatures will place greater stress on our buildings by causing expansion of materials including concrete joints, steel, sealants, wood and masonry. This will cause cracking, splitting and flaking and reduce their life. Increased temperatures may also change the soil composition, which can affect the foundations of historic buildings. Changing temperatures may also bring new **PEST INFESTATIONS**, which could attack wood in our buildings.

STRONGER STORMS

Despite the high building standards in Bermuda, strong hurricanes can damage our homes and offices. Sometimes the wind alone can cause structural damage. But buildings near to the shoreline may also be damaged by waves during storms. In Hurricane Fabian, 56 historic buildings were damaged in the St. George's World Heritage Site compared with 25 of the more modern buildings.

HOW CAN WE DEAL WITH THESE IMPACTS?

We need to make sure that we continue to build to the highest standard and look at designs and construction methods that are most suited to the changing climate. Making sure that we do not build in zones likely to flood or too close to the shoreline will also be important, and this may mean having to build upwards rather than on undeveloped land. The new Coastal Reserve Zone should help this. We might also want to protect our sand dunes and vegetation, as they protect the land (and our homes) from the sea. Many native and endemic trees create effective wind barriers. Planting trees and bushes and not concreting every surface will also allow better drainage during heavy rains, preventing flooding and keeping us cooler!

As far as our historic buildings are concerned, we need to remove existing threats that weaken their structure including invasive plant species such as the casuarina, Indian laurel and Mexican pepper trees, all of which have root structures that can weaken the foundations of these buildings, as well as grow through roofs and walls.

Impacts on Bermuda's PUBLIC HEALTH

Our quality of life and how happy we are depends to a large degree how healthy we are. We have relatively high standards of health in Bermuda. Most people who become sick and die here do so from illnesses such as circulatory diseases (e.g. heart disease) and cancer, which cause over 60% of deaths, and diabetes and respiratory diseases which lead to another 7% of deaths.[15] However, in the past, infectious diseases such as yellow fever and dengue fever caused most deaths and one of the major concerns about climate change is that these infectious diseases may become more of a problem again in Bermuda. When people get sick, there is a '**KNOCK-ON**' effect to the whole community. If people cannot work there is a loss of income and productivity, which often leads to social unrest as well as reduced quality of life and increased health care costs.

HOW WILL CLIMATE CHANGE AFFECT OUR HEALTH?

RISING TEMPERATURES

Heat exhaustion, heat rash, cramps and swelling, as well as heatstroke may all be caused by a warmer climate. These could lead to death or **CHRONIC ILLNESS**, but may also simply affect our ability to work as hard. Children, the elderly and people who are already in poor health will be most affected. However, most people should be able to adapt to gradual warming of our climate.

A warmer climate will also cause a shift in the geographical range of insects and birds that carry diseases, perhaps leading to the introduction of new diseases to Bermuda. Warmer weather also speeds up the larval stage of mosquitoes, meaning they can breed faster, and if our winters warm up, we may find mosquitoes here all year round and not just in the summer. Warm weather also makes flies, cockroaches and rodents more active, which means food-borne diseases such as diarrhoea, food poisoning and typhoid may also become more of a problem. Food poisoning already tends to increase in Bermuda after hurricanes when there are power outages and problems keeping food chilled, and this could become a greater problem in future.

HEAVIER RAINFALL

Heavier rainfall can cause flooding which may lead to contamination of our groundwater with harmful chemicals, oils, heavy metals or other hazardous substances from road runoff. More standing water around our homes as a result of heavier rain may also encourage breeding of disease-carrying mosquitoes.

STRONGER STORMS

Big storms often bring dust from the African desert, which can carry particles, fungal spores and bacteria that can all affect our health. Therefore, asthma, bronchitis and respiratory allergies and infections may all increase if we get more intense storms. Contamination of our fresh water with salt water and debris, washed off our roofs and into our storage tanks during hurricanes, may also mean that more people get **GASTROINTESTINAL** problems. Storms can cause injuries and stress-related health issues.

INCREASING UV RADIATION

Climate change will increase our exposure to UV radiation from the sun. This may lead to eye damage, skin cancer and sunburn. Skin cancer is the fastest growing type of cancer.

RISING CARBON DIOXIDE

Studies on poison ivy have shown that higher carbon dioxide levels make it more toxic, as well as encouraging its growth. Bad news for people who react to poison ivy!

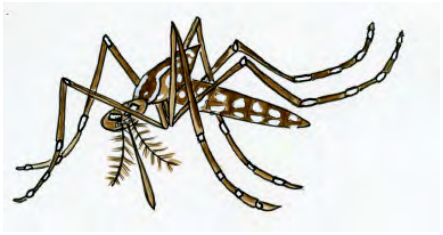
MORE OZONE

Climate change could cause greater air pollution triggering pneumonia, asthma, allergies and other respiratory diseases. Ozone levels are expected to increase. Ozone as a greenhouse gas occurs as result of a reaction between vehicle emissions and sunlight and high temperatures. Whilst not usually a problem in Bermuda, warmer temperatures may cause it to build up and become a health problem.

SEA LEVEL RISE

Sea level rise will inevitably mean that some homes will be flooded and destroyed, and for the people living in them, the health impacts will include stress, anxiety and depression. Displaced Bermudians may end up living in crowded and less healthy accommodation.

PUBLIC ENEMY: THE MOSQUITO



Throughout Bermuda's history, mosquitoes have presented one of the most significant and deadly human health problems, transmitting yellow fever and dengue fever in **EPIDEMIC** outbreaks. The 1940s dengue fever outbreak affected thousands of residents, and prompted a successful island-wide mosquito **ERADICATION** programme of the dengue mosquito. Unfortunately, the mosquito was accidentally re-introduced in 1998 and has now re-established itself. The Asian Tiger mosquito, which was first reported in Bermuda in 2000 also carries dengue fever, as well as West Nile Virus, and like the dengue mosquito is now found island wide. The common mosquito, which is the main vector for West Nile Virus in the USA is also found here, whilst the fourth locally found mosquito species, the salt marsh mosquito, carries **ENCEPHALITIS** and dog heartworm.

WHAT CAN WE DO TO PROTECT PUBLIC HEALTH?

- The first thing we must do is to make every effort to keep ourselves fit and healthy. The healthier we are, the better we will be able to deal with any of these challenges.
- Make smart choices about our clothing and lifestyles to adjust to changing temperatures.
- Design and build our homes to provide more shade and withstand hurricanes.
- Plug roof gutters before storms to prevent freshwater contamination and clean tanks regularly.
- Clear poison ivy from residential areas and public trails.
- Well practiced emergency management plans are already in place in Bermuda to deal with weather-related hazards. The construction of new satellite clinics at each end of the island has strengthened the island's ability to deal with such events.
- Longer term measures aimed at reducing heat across the island might consider large- scale use of light-coloured, reflective 'cool' surfaces or planting more trees to provide shade.
- Ongoing monitoring for new diseases as well as public education programmes that provide information on reducing the risk of **EXPOSURE** and **TRANSMISSION** will help to limit the threat of infectious diseases. Rigorous ongoing mosquito ('House Index' and 'Fight the bite') and vermin control by the Health Department are critical to this, whilst the Government of Bermuda's 'Well Bermuda' programme is a key initiative to promote island-wide health that in itself will help us to cope with the impacts of climate change.

Impacts on Bermuda's TOURISM INDUSTRY

Tourism has been one of the pillars of Bermuda's economy for over a century. In 2010, the total number of tourists visiting Bermuda was 580,193 or nearly 10 times the population of the island. In 2010, the average number of tourists on the island on any day was 3,944.[13] Tourist spending was just under $384 million in 2010, or 6.5% of Bermuda's Gross Domestic Product. Several thousand people in Bermuda have jobs either directly related (hoteliers, tour operators, taxi drivers) or indirectly related (through **WHOLESALE** and **RETAIL** businesses, transportation, trades and professions) to tourism.

Climate change will definitely affect tourism in Bermuda. Climate defines the length and quality of our tourist season and local climate is a factor most tourists consider when choosing where to vacation. However, the most serious impacts of climate change on tourism in Bermuda may well be due to global greenhouse gas reduction policies (e.g. introduction of carbon quotas by governments), which could affect the amount of travelling we can do.

HOW WILL CLIMATE CHANGE AFFECT TOURISM?

RISING SEA LEVEL

With most of our tourist resorts and favourite beaches located on the more exposed South Shore, rising sea levels could be a problem. With a 0.59 metre sea level rise at least 31% of Bermuda's beach and dune habitat would be covered. A 2 metre rise would result in 54% of our beaches and dunes being lost. Beach structures and amenities, hotels and restaurants will also lose **REAL ESTATE** through rising seas. Rising sea level will also affect the airport, which will affect tourism.

HIGHER TEMPERATURES

Warmer temperatures might encourage tourists to come to Bermuda. However, increasing sea surface temperatures may harm one of our most valuable natural assets: our coral reef. Surveys of tourists in the Caribbean suggest that many of them would not be so keen to visit if the coral reefs were not so beautiful and healthy.

MORE RAINFALL

Whilst heavy downpours may be an inconvenience to tourists to Bermuda, it is unlikely that tourists would be put off from visiting just because of this. However, flooding may temporarily affect their ability to travel around the Island. More flooding may also damage our cultural heritage, which draws tourists to the island.

STRONGER STORMS

Stronger hurricanes may disrupt tourists' vacation plans to Bermuda but the bigger effect may be more **BEACH EROSION** and damage to hotels near the beaches. Stronger storms may also do more damage to the coral reef, which is a key attraction for visitors, whilst storm damage may force the airport to close, which would seriously affect tourism.

INCREASING CARBON DIOXIDE

This may be the biggest threat to our tourism industry as governments try to reduce our greenhouse gas emissions, which in turn may affect how much we can travel and how much it will cost. This could affect where people choose to vacation.

HOW CAN WE DEAL WITH THESE IMPACTS ON OUR TOURISM INDUSTRY?

Tourism is important to our economy, so we must try to get a handle on the real risks, prevent or **MITIGATE** these risks where possible and adapt where we must. That means we need a strategy which **DECOUPLES** tourism from increasing energy use and greenhouse gas emissions, and that protects our key tourism assets.

We need to make sure our infrastructure remains strong and that we do not build too close to the shoreline.

Protecting the airport and our ports from storms and rising seas will be necessary. And being creative in terms of how we market tourism and what we offer tourists will be important to keep us competitive as a tourist destination.

Making sure we adopt green technologies to attract tourists may also be important.

Impacts on Bermuda's FOOD SECURITY

FOOD SECURITY is all about our ability to feed ourselves with nutritious, safe and affordable food. Global food security is going to become more of a problem in the future. Not only is the world's population growing so that we have more people to feed, but climate change is also impacting agricultural land and our crops, meaning that we are struggling to provide enough food for the world. In Bermuda nearly all of our food is imported, so the impact of climate change on transport, energy and freshwater could have a very real effect on our food security. Local agriculture and fisheries are vital to our future food security. We should be thinking about how to encourage and manage essential home grown sources of food.

AGRICULTURE

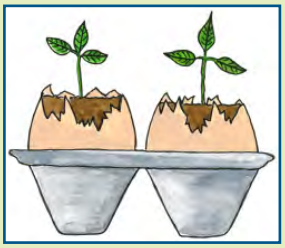
In the past, Bermuda had an important agricultural industry that supported the local economy. But this has changed over the last 100 years and now most of our food is imported from overseas. Only about 20% of our **FRESH PRODUCE** is locally produced. Less and less land is set aside for agriculture. At one point 1,214 hectares of land were farmed; nowadays it is just 154 hectares (380 acres). **EMBARGOES** (or bans) are established on foreign imports of some crops to protect the market for the local farmers and to protect the local crops from introduced pests. About 39% of us are also growing some of our own fruit and vegetables in our gardens.

Bermuda's weather can be **UNPREDICTABLE** and this makes farming difficult. Farmers often risk losing whole stands of crops planted either too early or late in the season. Water is also a big concern and some farms use an **IRRIGATION SYSTEM**, using water from reverse osmosis or extracted from wells. However, generally the groundwater from the wells is too salty.

In addition to providing us with some food security, local farming also improves our quality of life by keeping undeveloped open spaces. It is also an important part of our cultural heritage.

GROWING ORGANIC?

It seems ironic, but conventional farming does add to greenhouse gas emissions - the impact is tiny compared to that created by energy production and transportation, but it is real.



Animals such as dairy cows produce methane when they digest grass and fodder. And nitrous oxide is released from conventionally farmed agricultural soils. This is where **ORGANIC FARMING** comes in; organically farmed soil actually captures carbon dioxide and serves as a **CARBON SINK**. And organic agriculture reduces the use of fertilisers. So supporting our Bermuda farmers who have 'gone organic' is good for all of us.

HOW WILL CLIMATE CHANGE AFFECT OUR AGRICULTURE?

RISING SEA LEVEL

Crops cannot grow in salty water and as the sea level rises, some of our agricultural land is being flooded with saltwater. If the sea level rises 0.59 metres, 16 agricultural plots will be flooded. A 2 metre sea level rise will mean that 133 plots and about 30 hectares would be affected.

HIGHER TEMPERATURES

Already the summer months are too warm for many crops to grow here and even milk production is lower from June to September as a result of heat stress in the cows. Future climate predictions suggest that temperatures will rise, which will make these conditions worse. Warmer weather may encourage **INVASIVE** weeds, pests and diseases. However, warmer temperatures in winter months may mean other crops will be able to grow here.

MORE RAINFALL

Heavy rainfall can affect the soil and crop production and can also affect the production of honey on the island.

STRONGER STORMS

Hurricanes can have a devastating effect on crops and dairy herds. Hurricane Fabian put several local farmers out of business. Tropical storms also affect planting; September and October is the main planting season and this coincides with the peak of the hurricane season. This is also the time of one of the year's major nectar flows, so honey production can also be affected by hurricanes. The loss of electrical power in storms can mean that cows cannot be milked and this can make them sick and affect their milk production.

HOW CAN WE DEAL WITH THESE IMPACTS?

Our isolation in the middle of the Atlantic Ocean and need for imported food makes Bermuda very vulnerable. Producing more local food is likely to become more important. We need to protect our **ARABLE LAND** from development and set aside more land for crops to **COMPENSATE** for agricultural plots being flooded by seawater. An additional 128 hectares (316 acres) have been zoned for agricultural protection under the **BERMUDA PLAN** but are not currently farmed; we need to get them into active production.

We also need to provide **INCENTIVES** for people to become farmers. Farming is hard work and not very **PROFITABLE** so very few Bermudians want to become farmers. We need to find ways to encourage young people, perhaps through an apprenticeship programme. Encouraging more people to grow their own fruit and vegetables in their backyards or through community farming programmes also makes sense. We should also try to ensure that we buy local produce, as this will encourage more local farming.

Better planning and coordination for disasters such as hurricanes and support for the farmers to make sure they have continued electricity supply for irrigation and animal husbandry is also important. We also need to consider planting other crops that might be more suitable to the changing conditions, or new technologies that can help us meet the challenges of a changing climate on our current crops.

FISHERIES

Fish is one of the last remaining 'wild foods' in our diets and is not only a rich source of important **NUTRIENTS** but also forms an important part of our cultural identity. With steady fishing over its 400-year history, Bermuda's fish stocks have suffered. Certain species are **ECONOMICALLY EXTINCT**, whilst others have become locally extinct (**EXTIRPATED**). In 1990, the use of fish pots was banned locally in order to try to protect the remaining stocks.

The main fish caught in the Bermuda fishery today are the offshore **PELAGIC** species: yellowfin tuna, blackfin tuna, wahoo and dolphinfish. Bait, jacks and little tunny are caught in seine nets, and there is a commercial lobster fishery using specially designed traps. There are 331 licensed fishermen who catch about 418 tonnes of fish each year.[13] Of this, about 100 tonnes of reef fish (primarily groupers, snappers, grunts and coneys) are caught by hand line. Sportfishing, which targets the offshore pelagics rather than the reef fish is popular with both Bermudians and tourists. There are 26 licensed charter fishing vessels.

HOW WILL CLIMATE CHANGE AFFECT OUR FISHERIES?

Climate change may have both direct and indirect impacts on our fish stocks, including impacts on their habitats, the numbers of fish, fishing patterns, and the fishermen and their fishing gear.

RISING SEA LEVEL

Sea level rise will affect fish **NURSERY AREAS** (where fish grow up) in seagrass and mangrove habitats. Further, if corals cannot keep pace with rising seas and start dying off, then the reef fish will suffer.

HIGHER TEMPERATURES

Fish are **POIKILOTHERMIC**, meaning that their body temperatures vary according to the surrounding water temperatures. Any change in the temperature of the ocean will therefore affect their **METABOLISM**, how fast they grow, their breeding, where they live and their vulnerability to diseases and toxins. Fish species that migrate may adapt to climate change by changing their migratory routes. In Bermuda, most of the yellowfin and blackfin tunas and dolphinfish are caught when the water is warmest and it is possible that if waters get too warm in the Caribbean, fish would migrate further north to join Bermuda's fishery.

Bermuda is the northern limit for many reef fish species. This may be the reason we don't have as many species here as you can see in the Caribbean, because our waters are too cold for some of them. However, if our waters becomes warmer, more species might be able to survive.

Changing temperatures will have other effects. Many fish spawn (reproduce) when the temperature is 'right'. Warmer water could mean that fish spawn earlier and for longer. This could be good; however, it could cause a '**MISMATCH**' with the availability of their food source, meaning there isn't enough for them to eat. Warmer waters have been known to lead to big **DIE-OFFS** in some marine animals. Increasing seawater temperatures may also lead to the increased incidence of **TOXIC RED TIDES**.

MORE RAINFALL

Flooding may increase the amount of pollutants and sediment running off the land into the water and this may trigger fish 'die-offs' by reducing the amount of oxygen available to the fish. Oxygen levels are generally low in our inshore waters during the summer months anyway because of warmer temperatures, so flooding would make things worse.

STRONGER STORMS

Storms can damage the reef, which will of course affect the reef fish that live within it. Hurricanes may also push fish ashore causing them to be stranded on our beaches and even roads. Hurricane Fabian left fish high and dry on the airport runway and on the walking trail at Spittal Pond. Fish nursery areas in mangroves and seagrasses can also be damaged by hurricanes.

Storms also affect fishing activity. Often during storm surges, fish and lobsters leave their hiding places in the reef and may be more easily caught. However, fishing is much harder when the weather is bad and fishing equipment including boats may be damaged during storms, making it costly and dangerous.

HOW CAN WE DEAL WITH THESE IMPACTS?

This is one of the few areas where there is good news as well as bad for Bermuda. Climate change could harm our fish stocks, so reducing other pressures such as overfishing, loss of habitat and pollution will protect Bermuda's fish stocks and fishing industry and help them cope better with climate change.

Fishing is already quite well regulated in Bermuda, but continuing to monitor the amount of fish caught (fish landings) will help fisheries managers keep an eye on any changes in the health of the fish stocks. Changes can then be made to the level of **FISHING EFFORT** or the species of fish allowed if there are concerns about the stocks.

But climate change may actually increase some of our fish stocks if species that like warmer water are able to migrate north to join our fishery. So continuing to carefully manage our local fisheries may be an important tool in the fight for food security in the future.

Impacts on Bermuda's BIODIVERSITY

Just as it's important to have a variety of people in your group of friends, it's important for the natural environment to include a wide variety of plants and animals. Everyone or every species brings different skills, characteristics or roles and this strengthens the group. This diversity in nature is called **BIODIVERSITY**. Unfortunately, climate change is already starting to affect biodiversity.

Although species have adapted to environmental change over millions of years, scientists fear that the way the current global climate is changing (too fast!) will mean that plants and animals will need to adapt far faster and over much larger areas than ever before. Those that cannot adapt may not survive and will risk extinction. As different species depend on each other, for example through **FOOD WEBS**, the loss of even a single species can be a big problem.

An **ECOSYSTEM** is made up of plants, animals, and microorganisms interacting with one another and with the air, water and soil around them. As humans, we depend on ecosystems for sustaining our overall quality of life as they provide us with food, medicines, and many other products. But they also play an important role in purifying water, providing oxygen for us to breathe and moderating our climate, some important parts of life that we don't see and may not notice.

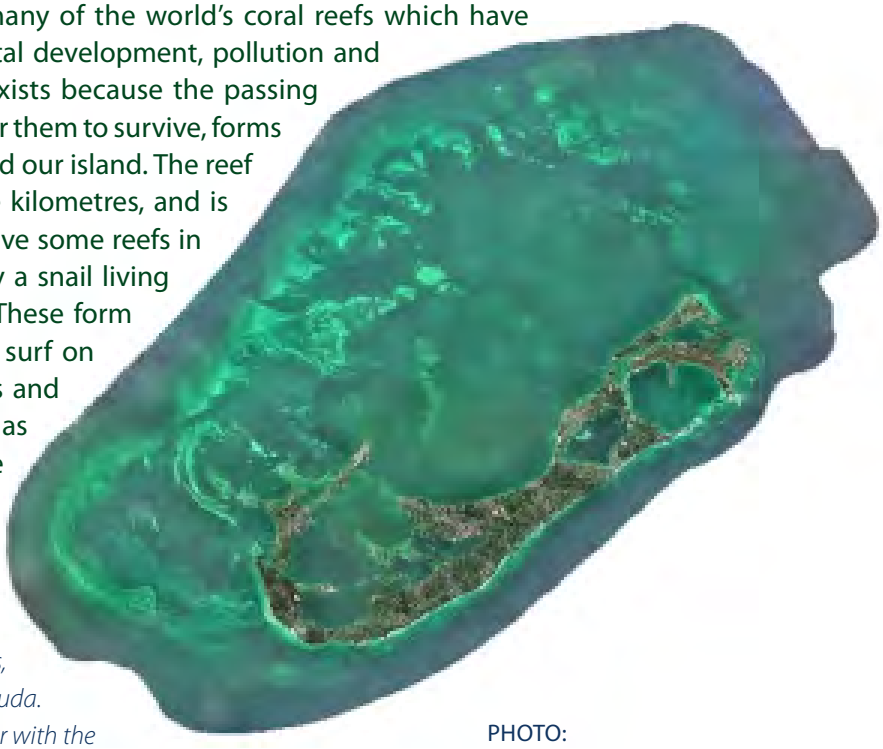
Within an ecosystem, plants and animals tend to live in habitats with more specific conditions that often show a delicate balance. For example, there are three main habitats in Bermuda's shallow marine ecosystem: the coral reefs themselves, seagrass meadows and mangrove swamps. Together these habitats are teeming with life, and climate change will affect both the habitats themselves and the different species that live within them.

BERMUDA'S MARINE ECOSYSTEM

CORAL REEFS

Coral reefs are the most diverse of all marine ecosystems. They are made of calcium carbonate (limestone), which is produced by the coral animal to form a skeleton. Single celled algae live within the bodies of the corals in a special, **SYMBIOTIC RELATIONSHIP:** the algae photosynthesise like all plants and provide food for the coral. In return, the algae feed on the waste nutrients released by the coral. This vast coral framework provides the home for hundreds of species of fish, crabs, lobsters, shrimp, snails, sponges as well as many other species.

Bermuda's reefs are very healthy, unlike many of the world's coral reefs which have been destroyed through over-fishing, coastal development, pollution and invasive species. Our reef system, which exists because the passing **GULF STREAM** warms our waters enough for them to survive, forms an important protective barrier for us around our island. The reef system covers an area of about 550 square kilometres, and is the most northerly in the world. We also have some reefs in Bermuda that are not built by coral, but by a snail living in partnership with a **CALCAREOUS** alga. These form the cup or boiler reefs we see in breaking surf on the South Shore. Temperature, light, waves and suspended sediments (sand or mud that has been stirred up in the water) all affect the health of our reefs.



Aerial view of Bermuda and its surrounding reefs. The Bermuda platform is the area incorporating the islands, the lagoon, the rim and the main reef terrace of Bermuda. The various shades of blue indicate the depth of water with the lightest colour the shallowest water

PHOTO:
BERMUDA ZOOLOGICAL SOCIETY

HOW WE PUT A VALUE ON AN ECOSYSTEM

Ecosystems provide us with many different services which we would never be able to afford to replace. For example, our coral reefs directly support the livelihoods of local fishermen to an estimated value of $4.9 million each year. They also provide recreational and cultural value to the estimated tune of $37 million per year. Our reefs also provide an important defence against hurricanes. This coastal protection service has been valued at a staggering $266 million annually. But this pales by comparison with the estimated $405 million annual service they provide to support tourism! And we shouldn't forget the value they add to education and research (about $2.3 million annually), nor to real estate prices ($6.8 million).[16]

Likewise on land, it has been estimated that a single tree provides services to us of about $664,000 over the course of its average 50-year lifespan. That's $6,000/year of oxygen production; $5,000/year controlling soil erosion and maintaining soil fertility; $5,000/year filtering dust and harmful gases; $350/year controlling temperature and humidity; and $930/year sheltering wildlife and providing us with food.[17]

SEAGRASSES

Seagrasses are marine flowering plants that live in the sea and use the sun's energy to photosynthesise, just like plants on land. They form large meadows, which are often teeming with life. Green turtles feed on seagrass and many fish swim to the seagrass meadows at night from nearby coral reefs and mangrove swamps to feed on the rich food that lives there. Seagrasses are also an important **REFUGE**, or safe area for **JUVENILE** fish, as well as creatures like sea urchins and conch. These meadows also protect Bermuda's shoreline from erosion, by dampening the waves, and helping to stabilise the sand to make sure it does not smother and kill the corals growing nearby. They also keep the water clean so that the light needed by the coral to grow can shine through. There are four species of seagrass in Bermuda. They are turtle grass, manatee grass, shoal grass and paddle grass. Together these species cover a total area of 1,625 hectares (4,015 acres). That's almost one quarter the size of Bermuda's land area. Most of these seagrass meadows are in the lagoon on the sheltered, north side of the island. Since 1995, scientists have noticed that quite large areas of seagrass have disappeared, particularly further offshore.[18] They do not know why but they do know that seagrasses will die quickly when disturbed or placed under a lot of stress. If they do manage to recover, it is much more slowly.

Like corals, seagrass growth is controlled mainly by light. What affects the amount of light? Day length, water depth, turbidity, and waves. Other things that affect seagrass growth are temperature and **SALINITY** as well as how much food there is. Bermuda is as far north as the seagrass can live and our cooler water temperatures and short day lengths in winter, as well as the limited nutrients in the surrounding **SARGASSO SEA**, mean that they grow very slowly at the best of times. Bermuda's green turtle relies entirely on seagrass for food, so if the seagrass dies the turtles will starve.

MANGROVES

Mangrove trees are unique as they have specially-adapted roots so that they can live in muddy and salty sediments. Mangroves are known for the large quantities of **PEAT** that are produced from their fallen leaves (leaf litter) and roots, which decay and form the base of a large food web. Mangroves provide an important habitat for fish (especially juvenile fish), crustaceans, molluscs, insects and birds. They also serve as a '**BIOSHIELD**' helping to filter and stabilize coastal areas by trapping sediment and protecting the shoreline against storm damage.

Bermuda's mangrove swamps, which nowadays cover just 17.5 hectares (43 acres), are the most northerly in the world. Only two species of mangrove tree live here: the red mangrove, which lives on the seaward edge of coastal swamps, and the black mangrove which lives further inland. Buttonwoods, which are not proper mangroves, often grow in a strip behind the black mangroves.

There are three distinct types of mangrove swamps in Bermuda, each with a different structure. These are:

- Coastal or bay mangrove swamps (e.g. Hungry Bay);
- Fringing mangrove swamps (e.g. Mullet Bay);
- The marine pond mangrove swamps such as those in Lovers Lake which usually only have one species of mangrove.

HOW WILL CLIMATE CHANGE AFFECT OUR MARINE HABITATS AND SPECIES?

Climate change will affect both the reef building species (corals, algae and snails), the seagrasses and mangroves, as well as the organisms living within them.

RISING SEA LEVEL

Reefs are known as '**KEEP-UP**', '**CATCH-UP**' and '**GIVE-UP**' reefs when it comes to sea level rise. Provided that the sea rises slowly enough, healthy reefs should be able to grow upwards fast enough and keep up with this rise. However, sea level is not likely to rise smoothly but rather quickly at times, and slowly at others. Patch reefs, which are so abundant in Bermuda in the North Lagoon, are typically 'catch-up' reefs whose growth may be delayed until sea level has stopped rising for a bit.

Likewise for mangrove swamps, if there is space on the landward side of the swamp, mangroves can retreat backwards and upwards as the sea level rises, as long as it rises slowly and gently. However, Bermuda's mangroves are considered extremely vulnerable to sea level rise because they are only adapted to a small **TIDAL RANGE** and there isn't much sediment or space for them to **RETREAT** into.

Hungry Bay represents Bermuda's largest mangrove swamp and is about 6,000 years old. However, scientists have discovered that its leaf litter is not building up fast enough to allow it to keep up with rate of sea level rise and the seaward edge of the swamp has retreated about 80 m in recent years.[19] Further calculations show:

- If the sea level rises another 0.59 m, then 18.8% of Bermuda's remaining mangroves would be lost.
- If it rises 2m, then 61.4% of our mangroves would disappear.

This would include the fringing mangroves along Ferry Reach and Mullet Bay. Some of the pond mangroves are more likely to be able to retreat.

Seagrasses face a tough challenge too. Less light will reach the seagrasses as the water gets deeper and most of the meadows hugging our shoreline are backed either by natural or man-made walls, which means they cannot retreat shorewards. Changes in currents, circulation, and tidal range brought about by rising seas may also stir up sediment, which makes the water murky and harder for the sunlight to shine through.

Let's do some math - some calculations have shown that mangroves can keep pace if the sea rises no faster than 8cm in 100 years. Measure out 8cm. Now, if it speeds up to more than 59 cm over 100 years, as predicted, then what will happen? Clue: will they still be above water? Right, they will likely drown.

HIGHER TEMPERATURES

The fact that Bermuda's corals, seagrasses and mangroves live at their most northern limit here because they cannot survive in colder temperatures further north, means that they might actually be better able to survive the rising temperatures better than these same habitats further south in the Caribbean.

However, we do know that warmer water causes coral bleaching, even in Bermuda. Corals bleach when the coral animal is stressed and 'throws out' the algae living within it. It is these algae, which give the coral colony its colour. Without these, the coral structure is just white or '**BLEACHED**' and the coral is at risk from starvation. If temperatures decrease, the algae may **RE-COLONISE** the coral but if it stays hot, the coral will starve and die.

Bleaching of a brain coral amid healthy corals on a Bermuda reef. Photo by Ron Lucas

Boulder-shaped corals such as the brain and star corals so typical in Bermuda tend to be more resistant to bleaching than the branching corals more common in the Caribbean. However, warming temperatures have also been linked to diseases in corals. Various diseases such as black band disease, white plague and yellow blotch disease already affect Bermuda's corals, but they could become worse.

Warmer temperatures may actually improve the growth rate in our seagrasses and mangroves which would be good. For mangroves this will allow faster build up of the leaf litter, which will help them adapt to the rising sea level. However, if the sea gets too hot, the mangroves could become stressed.

Marine turtles are also affected by changing temperatures, as the temperature of the sand in which they lay their eggs determines the sex of their **OFFSPRING**. In green turtles for example, higher temperatures lead to more females. Thus any change in temperature on turtle nesting beaches will affect the number of male versus female turtles, which could have a big impact on the population.

HEAVY RAINFALL

Heavier rainfall will bring more '**RUN-OFF**' of sediments (soils, sand and pollutants) from the land into the ocean. What do you think that would do to the corals and seagrasses? More sediments would smother and suffocate them and lower the saltiness of the ocean, stressing them. However, more rain may actually encourage mangroves to grow.

Temperature affects the development of turtle eggs and higher temperatures lead to more females.

STRONGER STORMS

Hurricanes can damage all our marine habitats, especially in shallower water where there is a lot of wave action. Seagrasses are particularly easily dislodged or buried by storms, However, recent hurricanes do not appear to have damaged our reefs too badly. In fact, hurricanes may actually be helpful by lowering the temperatures by 1-2°C, and reducing the impact of heat stress in the summer months.

Storms also stir up the sand and sediments, which can smother the corals and seagrasses, and reduce water clarity and the light levels required for photosynthesis.

Storms can have an equally devastating impact on mangroves. Hurricanes Emily in 1987 and Dean in 1989 caused about a 35-40% destruction of the Hungry Bay mangroves.

INCREASING CARBON DIOXIDE

Too much carbon dioxide changes the chemistry of the ocean, which is bad news. To try and understand this, let's think about a can of soda. The gas bubbles in a soda can are carbon dioxide and they mix with the water in the can to form carbonic acid. In the same way, the more carbon dioxide there is in the air, the more carbonic acid forms in the sea. This process is known as **ACIDIFICATION** and corrodes the calcium carbonate (limestone) skeletons of corals and shells of other marine animals and slows growth. Bermuda's reefs already grow 10 times slower than the reefs in the Caribbean because our colder winter temperatures mean we have a shorter growing season. Brain corals in Bermuda only grow about 2.5 mm per year, which is slower than the current rate of sea level rise.

Acidification will also slow growth in the organisms that live at the bottom of the **FOODCHAIN (PLANKTON)**, which will have a knock-on effect on the whole marine ecosystem. If something affected your food, it would affect you too! Changing water chemistry will also affect seagrasses and mangroves as well as the plants and animals that live in them.

WHAT CAN WE DO?

Just as the fitter and healthier we are, the less likely we are to become sick, so it is with our marine ecosystem. The healthier it is to begin with, the more likely it will be able to deal with the added stress of climate change. This means that keeping the ocean clean and free of pollutants and sediments, and protecting our fish populations and their nursery habitats, is very important. We need to:

- Make sure we stop sediment, soil, fertilizers and pesticides running-off from the land into the sea;
- Reduce boat anchoring and moorings in seagrasses and on the reef (as these damage them) and install environmentally-friendly moorings instead;
- Continue to monitor changes in the seagrass, mangrove and coral communities;
- Identify connections between seagrass meadows, mangroves and coral reefs, to better manage the whole system and establish Marine Protected Areas (MPAs) as these are widely considered to be the best management tool for conserving marine habitats;
- Identify and fully protect healthy mangrove and seagrass communities which could serve as **REFUGIA** to help seed the recovery of damaged areas;
- Restore critical seagrass and mangrove areas either by improving the conditions (e.g. water quality) to encourage natural regeneration or by seeding or **TRANSPLANTING** seagrass plants or mangrove **PROPAGULES** from other areas.
- Create a **BUFFER ZONE** behind the mangroves to allow for retreat where possible.

TERRESTRIAL HABITATS

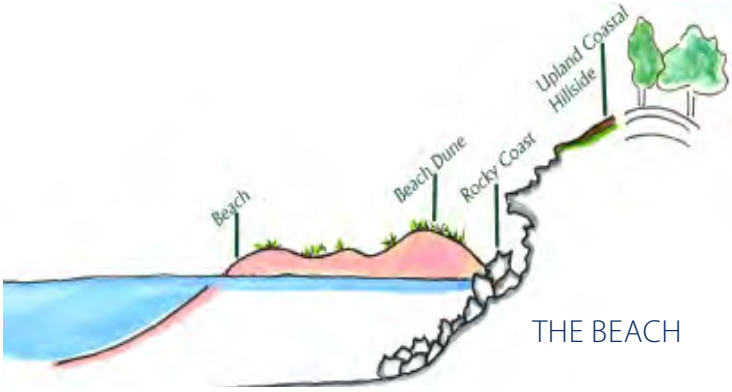
Plants are perhaps the single most important group of organisms on land, as they help to create the actual physical structure of most of Bermuda's terrestrial habitats, as well as store carbon.

Before humans arrived, Bermuda's low, hilly landscape and freshwater marshes were densely wooded with 15 species of **ENDEMIC** evergreen plants such as the Bermuda cedar, Bermuda palmetto, olivewood bark and about 150 native plants. With colonisation the landscape changed, as these trees were felled for fuel and building materials, and hundreds of **EXOTIC SPECIES** and crops were introduced for food. One of the most devastating impacts on the native flora was the accidental introduction of two invasive insects in the 1940s, which resulted in the loss of nearly 94% of our cedar trees. This led to a big tree planting effort but unfortunately, many of the trees planted turned out to be invasive, including casuarina, Brazil pepper and Indian laurel. Recent island-wide vegetation surveys have shown the extent of the changes to the island's native vegetation, with 22 invasive plant species now dominating 33% of Bermuda's remaining undeveloped land.[20]

Let's consider some of Bermuda's main terrestrial habitats before we explore the impact of climate change on these, working our way up from the shoreline.

BEACHES AND ROCKY SHORES

Most of Bermuda's 290 km of shoreline is either rocky shore or beach and dune. Many of the species living here are adapted to both the salty ocean environment as well as life on dry land, but plant life is relatively sparse.

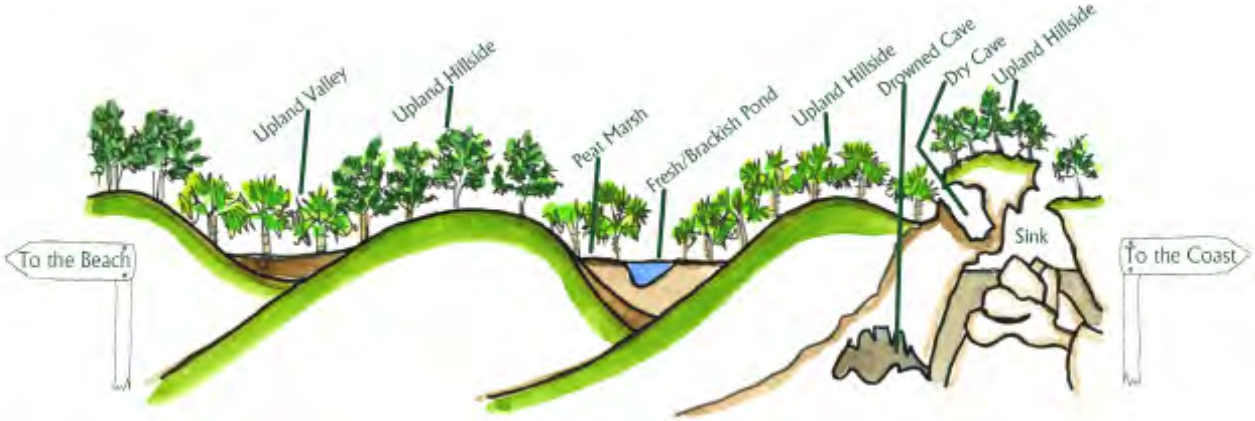


THE BEACH

BEACHES AND DUNES

Sandy beaches and dunes are found where there is a lot of wave action and where enough sand is produced. Beaches comprise 6% of Bermuda's coastline. Most are on the South Shore, which is more exposed to wind and waves. There are only a few animals such as ghost crabs and beach fleas that can survive the constant changes that occur on beaches although many shorebirds **FORAGE** amongst the stranded seaweed.

Behind the beaches, sand dunes serve as natural reserves for beaches and as a barrier to storm waves. They are very important in preventing long-term erosion of beaches and inland areas. There are now fewer and smaller sand dunes in Bermuda than ever before recorded. Today, the only dunes are between Horseshoe Bay and Chaplin Bay. These are fairly stable and almost entirely covered with specially adapted plants such as the tassel plant, sea lavender, beach lobelia, and Spanish bayonet and vines such as the morning glories and bay bean. The land crab is the most common animal found on the dunes. Our beaches also used to support nesting marine turtles; however due to their over-harvesting for food in days gone by the turtles do not nest here anymore (with the occasional exception). However, with recent conservation efforts it is hoped that they might do so again one day!



ROCKY SHORE

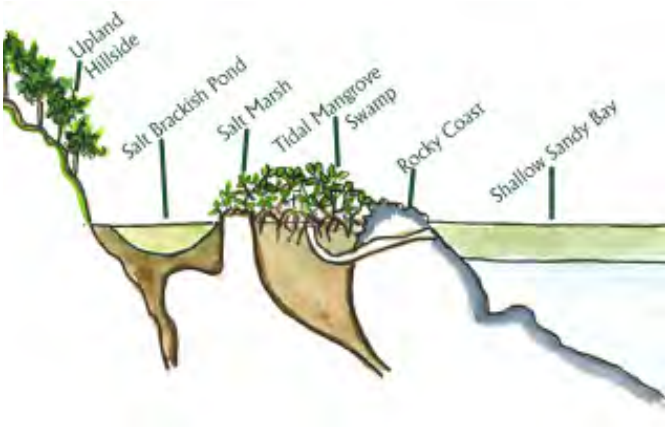
Bermuda's rocky shores are home to an interesting community of animals which are well adapted to the harsh daily changes that occur between high and low tide in the **INTERTIDAL** area. They go from being completely submerged by water, to being fully exposed to the air and hot mid day sun just a few hours later. They have adapted to these changes in salinity, temperature, oxygen, **PH** and exposure to UV radiation. Different species live at various heights up the shore according to their ability to withstand these conditions and clear species **ZONATION** patterns have been identified. Rocky shore species include barnacles, snails or nerites, the re-introduced West Indian topshell and various limpets, mussels, oyster species and periwinkles. At the top of the rocks, there are also plant species such as coast spurge, sea oxeye, seaside goldenrod, sea purslane, buttonwood, tamarisk as well as the invasive casuarina. Most animals in this habitat do not move (are **SESSILE**) which means we can study them to see the impacts of climate change. Two resident birds, the white-tailed tropicbird or longtail and the common tern also inhabit the rocky shore habitat. We know from looking at Bermuda's **FOSSIL RECORDS** that several other bird species used to breed here, but no longer do so. This includes the endangered short-tailed albatross, which scientists believe was wiped out in Bermuda about 450,000 years ago when the sea level was 20 m higher than it is today. The Island would have only been one tenth of the size that it is today so it is likely that there wasn't enough land left for them to find safe nesting areas.

COASTAL AND UPLAND HILLSIDES

Bermuda's upland coastal habitat extends from the top of the rocky coastal to the top of the old foredune and covers an area of about 855 acres (346 hectares). Plants living in this habitat are well adapted to salt spray and to rooting in the shallow soil. Typical **CANOPY SPECIES** include Bermuda cedar and palmetto, bay grape, buttonwood and forestiera, whilst the **UNDERSTOREY** is dominated by Darrell's fleabane, cape weed, common sage bush, inkberry and poison ivy. Animals include the landcrab, land hermit crab, skink and orb web spider .

The coastal hillsides (and rocky shore) also provide breeding habitat for Bermuda's most famous endemic seabird, the cahow, whilst migrant birds take up temporary residence in the coastal hillsides. The endemic Bermuda rock lizard or skink is also an inhabitant of the coastal hillside.

The coastal hillside gives way to the upland hillside habitat which covers a larger total area of 2,244 acres (908 hectares). With its deeper soil and more sheltered location, the Bermuda cedar, palmetto and olivewood, as well as forestiera, white stopper and Jamaica dogwood would have grown here before humans developed this land. Bermuda snowberry and bedstraw, shrubby fleabane, doc-bush, poison ivy, Virginia creeper and St. Andrew's cross would have been typical understorey species. Nowadays most of the upland hillside habitats are dominated by invasives such as Brazil pepper, allspice and Surinam cherry. 19 resident birds such as the endemic white-eyed vireo (otherwise known as the 'chick of the village'), the catbird, European goldfinch and northern cardinal inhabit these areas.



THE COAST

MARSHES

Bermuda's peat-filled marshes are confined to low-lying inland areas and have already been heavily impacted by human development. Historically they have been used as areas to dump garbage or cleared for lowland agricultural areas. There are only about 165.5 acres (67 hectares) of peat marsh left, of which Paget Marsh is the largest. These marshes have a very high diversity of native and endemic species, dominated by the Bermuda palmetto and Bermuda cedar. Fern species such as giant fern, royal fern, southern bracken fern, Virginia chain fern are typical and the rarer ten day fern and Bermuda sedge can also be found here. Various migrant birds, including warblers, herons, egrets, ducks and other waterfowl also inhabit them. The diamondback terrapin is a native species found in Bermuda's 'landlocked' marine ponds (Mangrove Lake and Trotts Pond).

HOW WILL CLIMATE CHANGE AFFECT OUR TERRESTRIAL HABITATS AND SPECIES?

As many as 25% of the world's terrestrial plant species are thought to be under threat from climate change and by the end of the century as many as half of them may become extinct. In responding to climate change, plants and animals have two options: they can shift their distribution and settle in a more suitable environment, or they can stay and adapt to the changing conditions. If they can't do either of these, they will likely become extinct. On an island with limited space, finding new areas to inhabit can be a real problem. Also, introduced species often **OUT-COMPETE** our native species because they grow and reproduce more quickly so can adapt faster to the changes. Any changes to the plant community directly affect all the other terrestrial species.

SEA LEVEL RISE

As sea level rises, our coastline will be eroded faster. If a beach cannot retreat inland because the land behind has been developed or cliffs prevent it, the beach may simply disappear. If the sea rises 0.59 m, we could lose 41% of our beaches and dunes. A 2 m rise may mean we lose 54% of them. Although none of our marine turtles breed here now, loss of our beaches and dunes, will hinder any chance of turtle breeding populations becoming re-established. For the rocky shore habitat such sea level rises would result in a loss of 32% and 52% of the habitat respectively. However, if the sea level rises gradually, the animals living there should be able to keep pace and retreat further up the shore, provided the land has not been developed.

Sea level rise will also coastal birds, flooding their nests. Bermuda's resident seabirds, the cahow and longtail, both return to the same nesting sites in coastal crevices to breed each year, whilst the common tern nests on small rocky islets. There is particular concern for the cahow because most of its current nest sites lie on very low-lying islands. Meanwhile rising sea level may drown the nests of the Bermuda skink, or it may force them to migrate inland to less suitable habitat with more **PREDATORS**.

Rising seas will also force plants to migrate higher. A sea level rise of 0.59 m will not really impact upland coastal and hillside habitats, but a 2 m rise, will submerge 13.8% of our upland coastal and 4.7% of the upland hillside. Perhaps the most threatened plants are those in inland areas such as marshes, which will be particularly vulnerable to sea level rise. A 2 m rise would impact 92% of these areas. In November 2003 an unusually high sea level stand caused the death of many cedars in Paget Marsh; some of which were over 100 years old.

HIGHER TEMPERATURES

In very hot conditions, sandy shore animals can burrow and escape from the heat. For animals living on the rocky shore it is less easy to hide. Molluscs (snail species) are the largest group of animals found on Bermuda's rocky shores and are very vulnerable to changes in water temperature and UV radiation. However, Bermuda currently represents the northern–most limits of many coastal species (it's too cold further north), so warming temperatures may actually encourage more species to live here.

Warmer temperatures could help plants grow faster and have longer growing seasons leading to more organic matter in soils and more nitrogen, which in turn is important for plant growth. However, on hotter, drier days plants tend to **PHOTORESPIRE** rather than photosynthesise (use oxygen rather than carbon dioxide) to reduce water loss which slows their growth. Warmer temperatures may also lead to more pests and plant diseases.

Birds are **HOMEOTHERMIC** animals, keeping their body temperature roughly constant regardless of the surrounding temperature. This means that if the temperature changes, they have to spend to more energy **REGULATE** their own temperature! Birds also go through several phases in their annual cycle, often in different places (breeding, **MOULTING, AUTUMN MIGRATION, WINTERING, SPRING MIGRATION**), which means that they not only have to adapt to climate change in one area, but also to changes occurring in different areas. Some bird populations have declined up to 90% as a result. However birds are also very adaptable and as long as they can find a suitable habitat, they may shift their habitat range if necessary. With expected temperature changes, most scientists expect this shift to occur northwards. This makes birds good **INDICATORS** of climate change. However, scientists also believe that because humans have destroyed so much natural habitat, many birds have nowhere to move to!

Scientists fear that 20-30% of all bird species may become extinct if average global temperatures increase by more than 2.5°C. Temperature changes are already affecting the timing of breeding and migration. In Bermuda, warmer temperatures led to earlier breeding in longtails and bluebirds in 2008. However, a sudden cold spell meant that most of the chicks that hatched early died. This resulted in a second nesting, which by then was late and extended into the start of the hurricane season. An early hurricane could have seriously affected nesting success. (Fortunately it didn't happen!)

Reptiles are **ECTOTHERMIC** which means that their body temperature is the same as the surrounding environment, and they are therefore very sensitive to changes in air and water temperature. Like other animals, temperature plays an important role in their activities, including breeding, **DISPERSAL**, and migration. If shifts occur in these activities that place them out of step with other ecological events (e.g. the emergence of their insect prey), it may affect their survival. Also, in many reptiles, the temperature at which the eggs are **INCUBATED** determines the sex of the hatchlings. The only native breeding turtle population in Bermuda is the diamondback turtle; whether it is driven by temperature-dependent sex is not yet known.

MORE RAINFALL

Heavier rainfall may result in sudden cliff collapse along the shoreline destroying habitat and presenting a danger to beachgoers. Bird and skink nests may flood or be destroyed in cliff collapse due to **WATERLOGGING.** Our soil may also become waterlogged decreasing the air spaces and depriving plant roots of oxygen and preventing carbon dioxide being diffused away. With too much water, plants are unable to draw up soil moisture, leaves will wilt, roots will rot and the plant will 'drown'. However, this may not be too much of a threat in Bermuda, because water drains away so quickly through the limestone.

Like temperature, rainfall also acts as a **CUE** for bird breeding and migration and affects the timing of breeding, **METAMORPHOSIS,** dispersal and migration in amphibians and reptiles. Species such as the diamondback terrapin, which live in or use shallow ponds, may be particularly vulnerable to changing rainfall patterns.

STRONGER STORMS

Coastal erosion will get worse with stronger storms. Along the cliffs, wave damage can occur as high as 14 m during hurricanes and great chunks of rock face can break off. Meanwhile, the sand on the island's beaches can completely disappear although it doesn't seem to take too long for it to build up again afterwards. Strong storms and hurricanes can obviously topple trees but endemic and native trees are much better adapted to storms than introduced trees such as the shallow-rooting casuarinas. Unfortunately, any space left by fallen trees is more likely to be filled by an invasive tree species than a native species.

Stronger storms and hurricanes can impact Bermuda's birds and reptiles. Between 1995 and 1999, **STORM-SURGE** from two passing hurricanes completely swamped two of the cahow nesting islands, destroying 40% of the (then empty) nest sites each time. If these storms had been later in the year during the breeding season, they could have wiped out a lot of the cahow population. Migrating bird

species are also at risk. If they run into a hurricane during their migration, they can get 'caught' in the **EYE** and may die if they cannot find a way out.

INCREASING CARBON DIOXIDE

We've already learnt about the concerns of ocean acidification caused by higher levels of carbon dioxide. More acidic water will cause the shells of animals living on the rocky shore to dissolve or at least become thinner and weaker. This will also mean that there is less material available as sand. (Most sand comes from the broken down shells of marine animals).

Increasing carbon dioxide in the atmosphere can increase plant growth. However, in high carbon dioxide environments, plants tend to **TRANSPIRE** less so that they lose less water. This will reduce plant growth and limit their ability to store carbon, which is so important in reducing the greenhouse effect. Additionally, transpiration in our trees and plants is important in helping to cool the Island!

INCREASING OZONE

Ozone (O_3) is a both a greenhouse gas and a pollutant; it is formed when nitrogen oxides, carbon monoxide and **VOLATILE ORGANIC COMPOUNDS (VOCS)** produced from things like car exhaust fumes, react with water and sunlight. Ozone levels will rise with climate change, which could be a problem for plants as it can interfere with photosynthesis.

WHAT CAN WE DO?

The best way of protecting our terrestrial habitats from climate change is to remove other stresses on them.

Loss of natural habitat for development and invasive species is the biggest local threat to these habitats, so safeguarding open space by creating nature reserves, LAND CORRIDORS or backyard gardens is important, as is the continued CULLING of invasive species. We also need to plant more native and endemic plants and trees.

Our beaches and dunes will need to be protected from development in order to allow them space to adapt and retreat as necessary. Much of our rocky coastal shoreline has invasive casuarina trees growing along it. With their shallow roots, they often cause large chunks of rock around our coastline to break away, so we need to remove these trees.

Protecting Bermuda's known bird habitats and open space and making sure that we keep natural corridors between them will be one of the best ways to help birds adapt to the impacts of climate change. Continuing to provide ARTIFICIAL NESTS for cahows and longtails will also help. We can also make sure we provide bluebird boxes in our gardens and plant trees to support bird life.

The best thing we can do to protect our reptiles is to prevent habitat loss, pollution and toxins and protect them from predation by invasive species. This will allow them to be better able to adapt to the challenges of climate change.

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GLOSSARY

ACCELERATE – to go faster or speed up

ACID – a chemical substance, which when it dissolves in water produces a hydrogen ion (H+). The more acidic a substance is, the more hydrogen ions are produced

ACIDIFICATION – becoming acidic

ADAPT – to adjust to new conditions

ALGAE – simple organisms often called seaweeds, which live in water and photosynthesise like plants

ARABLE LAND – land that is suitable for growing crops

ARTEFACT – an object made by humans such as a tool or piece of art and often representing a culture or period in history

ARTIFICIAL NESTS – a nest made by humans for a certain animal e.g. longtail igloos

ATMOSPHERE – the envelope of gases surrounding the earth (or any other planet)

AUTUMN MIGRATION – a seasonal journey taken by birds during which they move to another area to find more food and warmer conditions over the winter months

BEACH EROSION – the wearing away of the land or sand by wave action

BERMUDA PLAN – a specific document that details the rules and regulations by which we must abide when we build our homes or develop our island

BIODIVERSITY – the variety of plants and animals and the habitats in which they live

BIOSHIELD – a natural habitat such as a coral reef or mangrove that forms a barrier to protect the land from damage, e.g. during a storm

BLEACHED – something that has turned colourless. Corals will bleach when they lose the colourful algae that live within them

BUFFER ZONE – an area that is set aside to protect homes from natural disasters such as sea level rise

CALCAREOUS – made of calcium carbonate, often known as limestone

CANOPY SPECIES – the taller tree and plant species that provide shade cover for other species in a habitat

CARBON FOOTPRINT – the amount of greenhouse gases that we produce in our daily lives, often summed up over a year, or calculated for a specific event

CARBON SINK – areas of vegetation, forest or ocean which soak up or absorb carbon dioxide in the atmosphere

CATCH UP – to make up for lost ground, or speed up, e.g. coral reefs that speed up their growth rate to keep up with sea level rise

CHRONIC ILLNESS – an illness that keeps reoccurring or lasts for a long time

COASTAL RESERVE ZONE – a defined area in the Bermuda Plan to stop people building too close to the coast where their homes might be harmed by storms or sea level rise

COMPENSATE – to make up for a loss of some sort

COMPOUND – a substance formed by two or more chemicals

CONTAMINATED – something which is polluted and often harmful to living things

CORROSIVE – to destroy something through a chemical reaction

CUE – something that serves as a signal and usually triggers a response

CULL – to reduce or control the size of a group such as unwanted weeds or rats

DECOUPLE – to separate or disconnect

DESERTIFICATION – change of productive land into desert-like wasteland

DIE-OFF – to die one after another, usually quite suddenly and often in large numbers

DISPERSAL – the spread of plants, animals, seeds or larvae to new areas

ECONOMICALLY EXTINCT – when a species becomes so rare that there are not enough left to harvest commercially

ECOSYSTEM – the interaction between the living

organisms in an area and the non-living environment

ECTOTHERMIC – an animal that cannot regulate its own body temperature, so that its body temperature changes with the outside temperature

EL NIÑO – unusually warm temperatures in the eastern Pacific Ocean, which affect the weather in the tropics

EMBARGO – to legally stop or prohibit something from being traded, e.g. stopping certain vegetables from being imported to Bermuda

EMISSIONS – something that is released or discharged, such as harmful fumes

ENCEPHALITIS – swelling of the brain

ENDEMIC – a species that originates and is often still only found in one particular area or region

EPIDEMIC – rapid spread of a disease

ERADICATE – to remove or wipe out something

ERRATIC – uneven, unusual or unpredictable behaviour or pattern

EXOTIC SPECIES – from a foreign country, often tropical, with a particular quality or beauty

EXPEL – to eject or force out

EXPOSURE – lack of protection or shelter from something, e.g. the weather

EXTINCTION – when a plant or animal species has been completely wiped out so that there are none left

EXTIRPATED – removed, destroyed or wiped out

EXTRACTING – removing or taking something

EYE – a circular area in the middle of a hurricane where the winds are very light and it is relatively calm

FISHING EFFORT – the number of boats, man hours and gear that it takes to haul a certain amount of fish

FOOD CHAIN – a sequence of plants and animals in which each species is the food of the next member of the chain

FOOD SECURITY – the availability, access to and nutritional value of food

FOOD WEB – what eats what in an ecosystem

FORAGE – to search for something, e.g. food

FOSSIL FUEL – made from decomposing plant and animal matter, e.g. oil, coal and natural gas

FOSSIL RECORD – provides snapshots of the past through relic or representation of an organism

FRESH PRODUCE – food which has not been frozen, typically fruit and vegetables. Often locally grown

GASTROINTESTINAL – anything to do with the stomach and intestines

GIVE UP – to be unable to keep going, e.g. coral reefs that cannot grow fast enough to keep up with rising sea level

GROSS DOMESTIC PRODUCT – the value of all the goods and services produced within a country in a year

GULF STREAM – a warm ocean current flowing northeast past Bermuda from the Gulf of Mexico to northern Europe

HOMEOTHERMIC – an animal that is able to regulate and maintain a stable body temperature regardless of the temperature of its surroundings

IMPORTED – to bring goods into a country from another country, usually to sell them

INCENTIVE – something that makes a person try or work hard or harder; a reward

INCUBATED – to keep something (e.g. eggs) at a certain temperature (so that they develop and hatch)

INDICATOR – something that guides you or points something out

INDUSTRIAL REVOLUTION – The period from the mid 1700s to mid 1800s when manufacturing and industry developed; helped by inventions such as steam power, fuelled by coal and oil.

INFRASTRUCTURE – the services and facilities necessary for our community to function, e.g. roads, bridges, public transport, schools, hospital, electricity supply

INTERTIDAL – the part of the shoreline that is above water at low tide and below water at high tide

INVASIVE – a plant or animal which is introduced to a new area and outcompetes the native species

IRRIGATION – supply with water

JUVENILE – a young, immature person, animal, or plant

KEEP UP – able to keep going, e.g. coral reefs that can grow at the same rate as rising sea level

KNOCK-ON – something that happens as a result of something else

KYOTO PROTOCOL – an international treaty (agreement) in which the countries that signed it promise to reduce their greenhouse gas emissions

LAND CORRIDOR – a strip of land, usually in the middle of a very developed area with little open space, that allows wildlife in one area to stay connected with wildlife in another.

LIVELIHOOD – a way of making a living to survive; a job

MANUFACTURING – to make something from raw materials using machinery

METABOLISM – the sum of all the chemical reactions going on inside an animal or plant that allow it to grow, reproduce, get rid of its waste products and respond to its environment

METAMORPHOSIS – changing from one form to another or one stage of development to another, such as a caterpillar which changes into a pupa before becoming an adult butterfly

MISMATCH – many species aim to reproduce at times where there is most food available to them. If this does not happen, it is termed a mis-match

MICROBIAL ACTION – the activity of organisms like bacteria and fungi which help in processes such as decomposition, transforming certain chemical compounds and various biological interactions

MIGRATION – to move from one area to another. In animals, this is often at specific times of the year

MITIGATE – an action to make the impact of something less serious or severe

MOULTING – when an animal sheds its feathers or skin in order to be able to grow

NURSERY – an area specifically where young plants or animals tend to live in order to grow

NUTRIENTS – food substances that plants and animals need in order to live and grow

OFFSPRING – the young or descendents resulting from reproduction or mating

ORGANIC FARMING – farming without the use of chemical fertilizers or pesticides

OUT-COMPETE – to do better than, e.g. one species may be better at finding food and will therefore grow faster or out-compete another

OZONE LAYER – a region outside our atmosphere with a high amount of ozone gas which absorbs ultra-violet radiation from the sun and helps protect life on earth

PEAT – partly decomposed plant matter that has been compacted in wetland habitats

PELAGIC – living in the open ocean and not attached to the sea floor

pH – a measure of how acidic or alkali (non-acidic) a substance is. Water has a pH of 7.0

PERMAFROST – ground that is permanently frozen

PEST INFESTATION – to be over-run by unwanted organisms e.g. cockroaches

PHOTORESPIRE – the process that occurs when plants stop photosynthesising because carbon dioxide levels are too low, and they take up oxygen instead. However, it does not produce the same useful energy that photosynthesis does for the plant

PHOTOSYNTHESIS – the process by which plants make carbohydrates from carbon dioxide and water using energy from sunlight and chlorophyll in their cells

PLANKTON – drifting organisms that live in the ocean and often form the base of the food chain

POIKILOTHERMIC – an animal (typically a reptile or fish) whose body temperature varies with the temperature of its surroundings

POLICIES – plans of action developed by Governments or businesses, often to tackle a particular set of issues

POSITIVE FEEDBACK MECHANISM – when a change in the size of one impact can affect the size of a second impact, which in turn can increase the size of the first impact

PROPAGULES – seeds or spores produced by plants or animals to help them spread and colonise new areas

PREDATOR – an animal which hunts, kills and eats another animal, its prey

PREDATION – the relationship between the predator and its prey

PRODUCTIVITY – the amount of productivity (e.g. energy produced) in an ecosystem in a known area over a known period of time

PROFITABLE – a gain or benefit from something

RADIATION – the way energy waves travel

REAL ESTATE – property

RE-COLONISE – to re-settle into an area

REFUGE/REFUGIA – a safe haven for a particular species which may be threatened elsewhere

REGULATE – to control or adjust something

RENEWABLE ENERGY – energy produced from natural sources such as sunlight, wind, or waves, and without using fossil fuels

RETAIL – the sale of products from a fixed location such as a shop

RETREAT – moving away, often from something difficult or dangerous

REVERSE OSMOSIS – the process by which sea water is forced through a semi permeable membrane so removing the salt and producing fresh water

RUN-OFF – excess water than cannot be absorbed into the ground which flows from the land into the sea often carrying pollutants with it

SAFE GUARDING – a way of protecting something against danger

SALINITY – a measure of how salty water is

SALT WEATHERING – damage caused by salt to rock, stone or buildings

SARGASSO SEA – a large part of the ocean in the middle of the North Atlantic surrounded by currents. Bermuda sits on the western edge of the Sargasso Sea

SESSILE – an animal which is attached to the ground and does not move very far from one place to another (eg. a suck rock)

SPRING MIGRATION –a seasonal journey often taken by birds when they move to another area to find better conditions over the summer months

STORM-SURGE – the rise in sea level that occurs during a storm and often causes flooding

SUB-TROPICAL – a climactic region which lies between 23.5 and 40 degrees of latitude

SUPPLEMENT – a needed addition to something

SUSTAINABLE PRACTICES – behaviour that makes efficient use of resources, to allow for future generations

SYMBIOTIC RELATIONSHIP – a relationship between two organisms from which they both benefit

TIDAL RANGE – the height between low tide and high tide caused by the gravitational forces of the moon and sun and the rotation of the earth. In Bermuda, this height is about 3 feet

TOXIC RED TIDE – when algae living in the sea suddenly increase in number they can change the colour of the water (often to red), and sometimes also produce toxic substances which may kills other animals

TRACE GASES - a gas which occurs in very small amounts (less than 1% by volume) in the earth's atmosphere

TRANSMISSION – the spread of something, e.g. a disease

TRANSPIRE – the process by which plants pass water vapour through the stomata in their leaves

TRANSPIRATION – the process by which plants pass or give off water vapour through the stomata in their leaves

TRANSPLANTING – moving a plant from one location to another

UNDERSTOREY – the trees and plants that form the lowest canopy in a woodland. These are usually tree seedlings or saplings or shrubs

UNPREDICTABLE – unexpected

VOLATILE ORGANIC COMPOUNDS (VOC) – compounds that change from liquid to gas at room temperature and which are usually harmful to humans

VULNERABLE – at risk

WATERLOGGED – filled or soaked with water so that no air can get in

WHOLESALE – goods that are sold in bulk to retailers (who then sell to the public)

WINTERING – a region where animals go to spend the winter

ZONATION – distinct bands or zones found at different heights up a shoreline or up a mountain in which particular species are found

I hope as you followed through the pages of this publication that you have learned a bit about climate change, but more importantly, about what you can do about it.

As young people, you have a unique stake in facing the climate change challenge. This may seem unfair; after all, you did not create the problem! But your individual and collective decisions and actions over the next few years will shape the world you live in for the rest of your lives, not to mention that of your children. Young people around the world just like you are making their voices heard, standing up to politicians and polluters and even family and friends, helping change peoples' behaviours today and taking their future into their own hands.

It is a big challenge, but one that none of us can afford to shy away from. The good news is that we know what to do. In communities and schools, here and abroad, we have the knowledge and tools to take action to face the climate change challenge. Remember, small steps can make a big difference. And, as technology advances, this will make it even easier to respond.

But we must not wait. Choose to be a part of the solution and encourage those in your life to do the same.

You are not only the leaders of tomorrow but you can be the leaders of today!

The Bermuda NATIONAL TRUST