



wind-tolerant plants. It's where caimans bask and birds of passage find sanctuary. And, of course, there are piranhas and stingrays in the shallows.

One of the best places for this is the island archipelago (Arquipélago das Anavilhanas), just upstream of the River Negro from Manaus, which is the biggest archipelago in the world, many miles wide with thousands of long islands. This amazing formation is one of those natural places that can be seen from outer space. From the comfort of your own home you can see these massive islands by searching the Internet for satellite maps of the Amazon centred on Manaus, and looking upstream from the confluence near Manaus of the Negro and the Amazon rivers. Where the Negro broadens out, the islands can be seen. They are also shown on good maps of the world.

When the water level falls, the pure white sand is exposed – the result of eroded material that has come down from the Andes over thousands of years. Under the unremitting sun the sand dries, drifts about, and small sand-dunes are created. When you anchor the boat a quarter of a mile away and visit one of these exposed areas you have to take a canoe, since the water is incredibly shallow. Shooing the stingrays away (the first one out of the canoe's responsibility – for the stingrays bask in little shallows), it is possible to inspect these desert habitats in more detail.

The greater the effect of El Niño, the lower the Amazon's waters and the larger the exposed deserts. In some years water levels can get very low and massive sandbars are exposed. The Amazon experienced the lowest level of waters in its system in 2005.

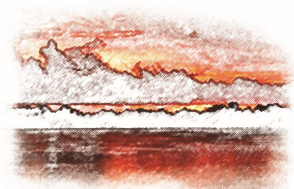
To go walk-about on one of the sandbars or dunes is quite an experience. It is terrifyingly hot, with no shade and sometimes no plants. It is one thing to get momentarily lost in the uniform rainforest, but out here, in a hollow between dunes, it is just as difficult to maintain contact, for in a moment you may be in one of the world's frying pans with nothing in sight for miles. The fine surface of the sand is broken only here and there by distorted tree trunks and branches that were once the fabric of the rainforest and have seen flood and ferment miles upstream.

Sandbars are always great places for nesting terns, and such is the case within the Amazon Basin. Walk too close and the birds become very chatty, but they do not go in for the dive-bombing that Arctic terns or skuas might undertake. In the Amazon they will let you walk across their patch, for their eggs, like those of many terns, are camouflaged against the sand and you, as the predator, may have passed them a few moments ago. Eggs left on the surface of this amazing frying pan are likely to get boiled within minutes, so the birds need to get back to the 'nest' as soon as possible – the 'nest' being the sand itself where the bird sits down. There are plenty of fish in the warm and shallow waters that surround these dune patches to keep the tern populations going for years. The extent of the dunes in some case amounts to several square miles, generally far too large an area to explore without water and a large sun-hat.

Coming to the rainforest you are always expecting something new, something very special to the rainforest. The disappointment sets in for a millisecond when you find trans-continental regulars.

More growth of vines at the expense of other plants with global warming.





More storms on
the horizon with
global warming.

Here on the dunes is found the familiar quick patter of feet and the small white and grey plumage of what looks like a plover, in fact the solitary sandpiper *Tringa solitaria* has chosen a quick stopover here, whilst transiting the country from North America. You can imagine it crossing the Amazon; patches of human activity as it crosses the Venezuelan coast, then over monotonous spreads of rainforest interspersed regularly with veins and arteries of rivers. The bird would find time, between bursts of flying further south, to stop off at one of these dunes as a refuelling stop. The bird I studied in some detail through the binoculars was actively feeding, running in bursts this way and that, chasing various insects.

One of the lessons you learn pretty early on in visiting the Amazon rainforest is that apart from the resident fascinating wealth of wildlife there is also a background of species that have much wider horizons – the osprey, turkey vulture, cattle egret and Muscovy duck. Without the vagaries of El Niño, it would be impossible to study the ecology of deserts in the heart of a rainforest.

Researchers have shown that 338 species of bird from North America, or 52% of the North American migrant bird species, fly to their wintering grounds in the autumn.¹² This is a staggering amount of birds that go to the Neotropics, most of them going to Central America, the rest going into South America. The birds go to all sorts of habitat including rainforest. Our sandpiper is one of the many and a tiny piece in the jigsaw of understanding where all the birds go. Limited research has shown that some bird species tend to be faithful to their wintering habitats, so much so that the same individual can be caught three years in a row on the same patch. So our sandpiper may well be more familiar with his patch than we think.

Some of the sandbars, as described above, are immense and nothing significant grows on them before they are flooded again. Of course, plant succession takes place, probably on those bars that are first to appear when the water is dropping and that are last to be covered in water. The wealth of minerals in the sand is conducive to plant growth and colonisation by such plants as willows (*Salix* spp.) and red-orange *Lantana* (a familiar conservatory plant in the West) are typical. If the vegetation can become stabilised to sustain some inundation, then in following years scrub and trees will dominate. Small islands with trees are commonplace along the waterways and may have arisen

Vines choking the virgin rainforest.





from sandbars. Researchers have shown that at least 125 species of plant may be found on these sandbars and they all contribute to the succession of plants that you may see there.

These dunes are purely seasonal; the more pronounced in years of El Niño. As the snowmelt comes down the tributaries from the east, and the rains start falling, the dunes drown out and are not seen again for 6 months. You can visit the same area and not see a single dune, and not thrill with the experience of desert ecology. A low-water adventure in the Amazon (in November) may be more preferable and throw up a range of different habitats than travelling during high water (May). It is a question of swings and roundabouts. At high water it is possible to canoe through the flooded forest that is impossible at low water, introducing totally new experiences.

For a river that once flowed west,¹³ we must not forget (taking the long view) that the whole area of the Amazon is, and has been, constantly influenced by local and regional climatic conditions. Nothing is new. In the Amazon you cannot rely on the rainy season. The flux we call weather can always bring surprises. The year I was in the Amazon Basin during 1998 the water level was particularly low, we grounded many times in mid-water, perhaps half a mile from one of these dunes that looked simply like a bright white horizon. We had to get out of the boat and push, it was that low. The sonar was showing a depth of 5 ft (1.5 m) of water although the boat was clearing just 4 ft (1.2 m). Many a time we had to stop progressing up a channel. This seemed completely mad, since the channel we were going up looked just like a perfectly navigable river. All the Amazon boats are flat-bottomed to make allowances for this low-water period. El Niño just serves to make it incredibly low in some years; and presumably incredibly high in others.

So what is El Niño and how is it related to global warming?

El Niño is a climatic effect that has been known for at least the last century. It is called El Niño since it occurs during December–January and has most of its principal effect on the west coast of the Americas. It strikes every 2–7 years. There are actually two effects that influence rainforests in this region (as well as many other regions around the world): El Niño – the unusually warm ocean–atmosphere system in the eastern and central Equatorial Pacific, and La Niña – the unusually cold ocean temperatures in the east and central Equatorial Pacific.

Historically, catastrophic changes in the Amazon climate appear to have taken place. Mega-Niños (a new phrase that describes bigger Niños than have ever been experienced) have occurred in the Amazon, since it appears from discontinuities in archaeological field data that there have been some calamitous events in recent history, for instance around 500, 1000, 1200 and 1500 AD.

The water dynamics are clearly very important in these hot and tropical climates, despite the vagaries of El Niño. Roughly 40% of the world's precipitation falls within 15 degrees of the Equator and most

As the water level drops along the River Negro in Amazonia drifts of bright white sand appear contrasting with the tea-like consistency of the river water. Increasing drought conditions have appeared in the Amazon basin in recent years.





within three main convergence zones, centred over the Amazon, Congo and western Pacific. These intertropical convergence zones are called ITCZ.

The trigger for the effect is a high-pressure complex that breaks away from the normal weather pattern in the Pacific and makes its way to the west coast of South America, displacing the trade winds for a while. Instead of the cold water lapping the Pacific coast, warm water wells up and influences the climate inland. The effect is unpredictable and causes either drought or flooding. There were twenty El Niño years in the twentieth century; and of these, 1982/83 was the worst. Others more recently included 1986/87 and 1994/95.

El Niño consequently has had a great effect on human migration within Brazil. During the 1877/78 El Niño, contributory factors saw 400,000 people leaving the terrible drought of north-east Brazil and joining the throngs of rubber-tappers along the Amazon. It was as late as 1884 that slavery was outlawed in the north-east and this migration, spurred on by the effects of El Niño, was the incentive for many to move. Following the drought in this part of Brazil, the interior and the south of Brazil looked a better place to find work, so major migrations of people left in 1888, 1915, 1931, 1942 and, to the new city of Brasília, in 1958. The impact upon the environment must have been huge in terms of timber lost and habitat cleared, much of it induced by these El Niño years.

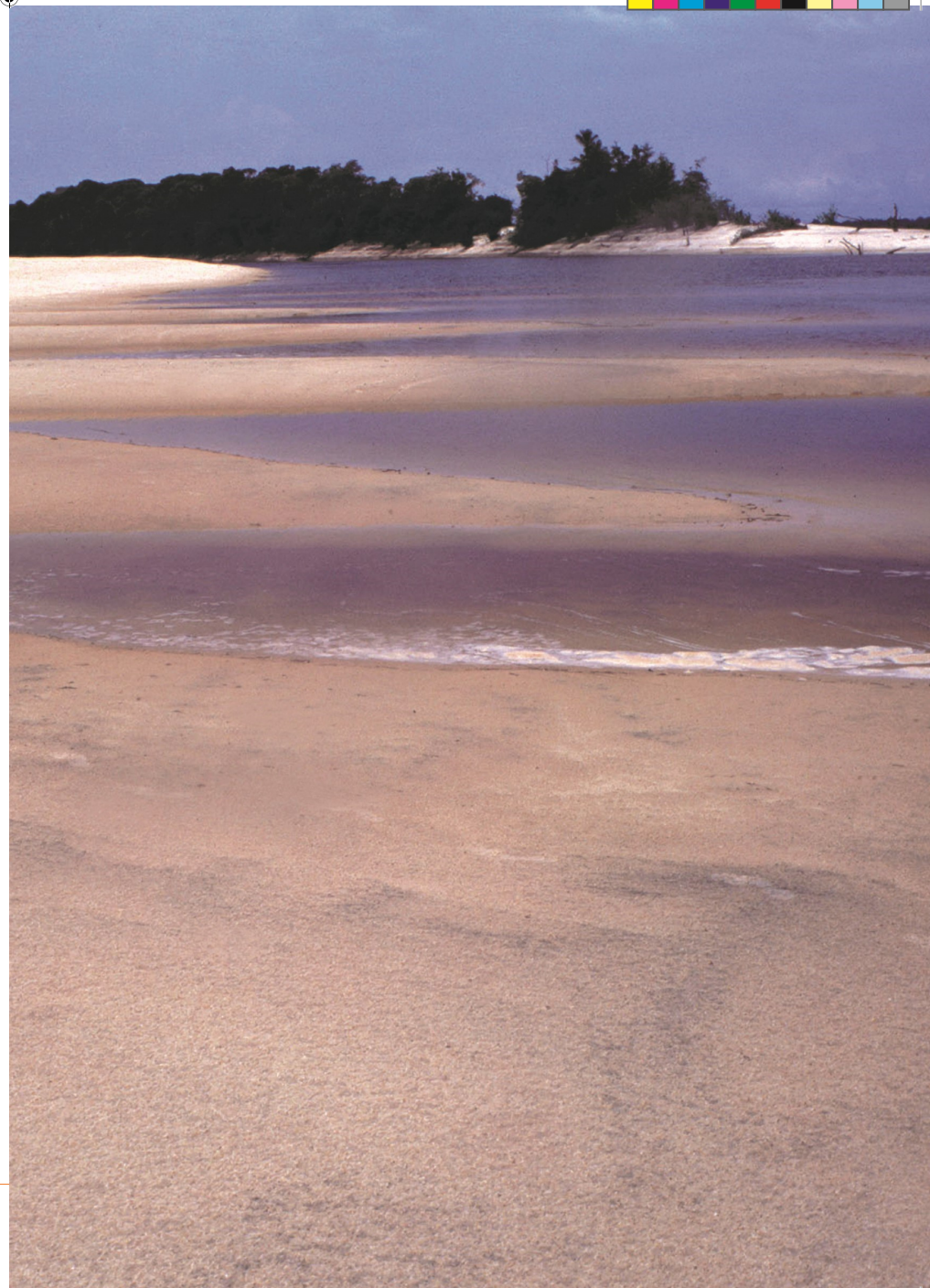
In 1912 an extended drought affected the Amazon, leading to a great fire, that burned out of control for several months, killing thousands of rubber-gatherers. More recently, in 1926, a major drought caused a fire to burn for a month in the River Negro catchment area – an area that most of the time is inundated with plenty of water and a place that you would not think could ever burn.

Again, during 1982/83, there was a lethal rise in ocean temperature in the Pacific waters off Panama, Costa Rica and Colombia. It was 2–3°C warmer than usual for several months, resulting in 99% mortality of corals in shallow water, and the inevitable result of bleaching. A re-occurrence happened in 1987 in the Caribbean coral reefs.

La Niña of 1988 was felt in the Amazon by flooding in El Salvador, Nicaragua, Colombia and also many other places around the world. Hurricanes wreaked havoc in Jamaica, Haiti and eastern Mexico, culminating in Hurricane Joan, and the western Amazon had its worst flooding for two decades.

If you believe in global warming, then the warming influence of El Niño along the South American coast in place of the normal cold currents and associated weather, then the effect of warm winds and precipitation moving westwards over the canopy of the Amazon Basin is an important factor. It is these vagaries of the weather pattern that provide the Amazon with its contrasting water levels that can sometimes be regarded as record-breakers.

As the rainwaters from the Andes dry up every year, the level of the water in the Amazon goes down significantly, and in some years much more than usual. This exposes lots of sand and makes for a kind of desert habitat, perhaps stimulated by global warming. Drought conditions then replace the hot and humid conditions.





The effects of El Niño are also found further afield than South America, for the warm winds are carried north and can wreak their effects as far north as the Californian coast, as in 1994/95. On their way they affect countries in Central America too, where a great deal of rainforest still abounds.

El Niño effects on wildlife

When the weather changes dramatically over a short period of time, it is too much to assume that wildlife will evolve to meet the new weather patterns. Some groups of animals can do it, but for others even a slight change can be fatal. Such is the case with some amphibians, but for more mobile species, such as birds, or more fecund species, such as corals, colonisation to new pastures is slightly easier within a short time-frame.

In Costa Rica, a small country that has more national parks than any other country on Earth, the effects of El Niño have been documented in at least two amphibian species. It was argued in 1994 that the extinction of the golden toad *Bufo perigrinus* and the harlequin frog *Atelopus varius* was strongly influenced by El Niño. I have visited the site where these frogs have disappeared. It is the Monteverde Cloud Forest reserve, a few hours drive from the capital of Costa Rica, San Jose. Most of the inbound big jets from around the world are routed over these tropical highlands and some good views of the cloudforest can often be had on arrival. It is one of the most visited of all the reserves in the country and a driveable trail takes you to its entrance. From there on you continue on foot. The uniqueness of the cloudforest is that it harbours a lively suite of species from exotic butterflies to hummingbirds, monkeys and amphibians.

On the question of butterflies it may seem incongruous to visit a butterfly farm in one of the world's paradises of butterflies, such as Monteverde, but it demonstrates one feature of rainforest biodiversity – that species can sometimes be thin on the ground if you are time-limited, as eco-tourists are – you have to cover a lot of ground to see a great many species, or to return at a different time. This immediate and relative paucity of species, especially in the Amazon Basin (away from the mountains) has not gone unnoticed by naturalists in the past.

All the butterflies are there somewhere in the rainforests, but enveloping a section of the rainforest in nets and collecting and breeding the butterflies in this enclosed place is the only way a tourist, with a limited time at disposal, can witness these species at close quarters. This is often how wildlife is exposed to the public. Elsewhere in Costa Rica you can visit hummingbird areas and caiman farms. The alternative is to plod through rainforest trails and see a small fraction of the wildlife. Most tourists are not into that. So most visitors to Monteverde miss the star attraction, the quetzal, which has a colourful long tail, and is best seen along a long rainforest trail.

Coral reefs are threatened both by the effects of man and by global warming. The threatened areas in Latin America are the warm waters from Florida south to encompass the whole of Cuba, all along

More damage to coral reefs with global warming.

