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Australian Species and Climate Change



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Waved albatross © WWF-Canon/James Frankham



Spotted tail quoll © WWF/Frédéric Mercay



Green turtle © Richard Ling

Climate Change: What does it mean for Australia's species?

Australia already has the worst rate of mammal extinction in the world. Almost 40 per cent of mammal extinctions globally in the last 200 years have occurred in Australia. This incredible continent is losing species at an unprecedented rate and, as most species found here aren't found anywhere else, the loss of Australian species is a loss for the whole world. The habitat destruction and alteration, invasive species and altered fire regimes, that have occurred as a result of our use of the land, are the major factors in driving Australia's shocking extinction record.

What does climate change mean for Australia's environment and its precious species?

Rapid climate change of more than 2°C can be considered dangerous. If this is to be avoided, global greenhouse gas emissions will have to peak in the next couple of decades. Even if greenhouse gas emissions were to suddenly drop to zero, the Earth is still committed to approximately 0.4 °C of warming by 2050. This new climate will be hotter, and different to what we experience today, just as Australian average temperatures are now around 0.9°C higher than they were 100 years ago.

It's not just the obvious impacts of climate change like rising temperatures and declining rainfall that are important. The early signs are that climate change is likely to make all of the existing threats to species worse. Climate change may mean more frequent and hotter wild fires, reduced connectivity between already fragmented habitats and the expansion of invasive species like cane toads. As humans respond to changes in climate, agricultural expansion into parts of Australia, such as the northern savannahs, that are predicted to have more rainfall, will mean old threats to species in new places.

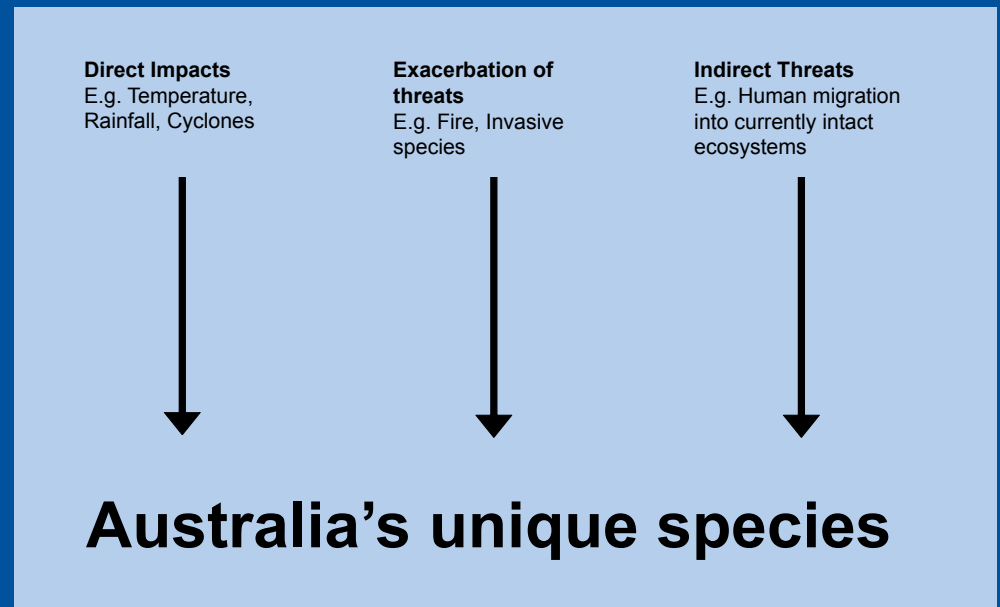
The climatic changes that have occurred over the 20th Century have already had impacts on biodiversity. Australian species are not immune from climate change and many are already experiencing its effects.

How will climate change affect the key threats to Australia's species?

The threat posed by invasive species could increase with climate change, with direct repercussions for species like bilbies and rock wallabies. Many weeds and pest animals are favoured by changing conditions, as they can colonise new habitats rapidly. Pests such as the cane toad will thrive in warmer conditions and move into new areas. Weeds are often more effective than native plants at dispersal, in part because they are often transported unintentionally by people.

Threatened species like Gouldian finches have already declined as a result of changed fire regimes and climate change is likely to exacerbate this threat. In south-east Australia, the home of black cockatoos and quolls, the frequency of very high and extreme fire danger days is likely to rise up to 70 per cent by 2050 with impacts on these species.

There are still many unknowns as to how species will be impacted by climate change but the early warning signs are already there for some threatened species like marine turtles. As temperatures at nesting beaches increase, so does the proportion of females produced (in turtles sex is determined by temperature). A highly skewed sex-ratio could pose problems for turtle populations. At some beaches, the lethal temperature (34°C) is already being regularly exceeded.



What can I do to halt the perilous decline of Australian species?

Resilient ecosystems are best able to cope with change. One of the fundamental ways of maintaining resilience in an ecosystem is to remove the existing threats to biodiversity, such as invasive pests and weeds, water extraction, and inappropriate fire management. By tackling these threats to wildlife and protecting and connecting their habitat, we are giving them the room to adapt to climatic changes.

Australia's current protected area network (national parks and nature reserves) is currently not large or connected enough to protect our threatened species. Climate change will render some habitats unsuitable for species that used them before. If species have any chance of persisting in an environment that is already severely degraded, we have to make sure they have homes to go to and this means a comprehensive, adequate and representative reserve system.

Everyone can and must do their bit to reduce their carbon emissions and stop global warming. Small actions taken in your everyday life is all it takes to make a big difference. It's as simple as switching off your lights.

What you can do to help:

- 1) Switch off unused lights
- 2) Switch off appliances on standby
- 3) Change to energy efficient light globes
- 4) Take shorter showers
- 5) Install a triple A rated shower head
- 6) Pump up your tyres to the correct tyre pressure
- 7) Switch to Greenpower
- 8) Install a solar hot water system
- 9) Walk, cycle or catch public transport
- 10) Support WWF so we can continue our work on critical environmental issues such as climate change



Albatross and Climate Change



Waved albatross © WWF-Canon/James Frankham

The albatrosses are a group of majestic, long-lived oceanic birds. They are the largest seabirds, with some species having a wingspan up to 3.5 metres.

Of the 24 species of albatross worldwide, at least 19 occur within the Australian fishing zone. The Australian fishing zone is nearly nine million square kilometers and includes a 200 nautical mile band around the mainland and waters around all external territories. Most albatrosses spend more than 95 per cent of their time traversing the Southern Ocean in search of prey, returning to land to breed.

Albatrosses mate for life and are slow breeders, producing only one egg at a time. Nesting usually occurs on small, remote islands scattered throughout the Southern Ocean such as Macquarie Island, Heard Island, McDonald Island, Campbell Island, the Crozets, Albatross Island, Pedra Branca and the Mewstone. Five albatross species breed on islands within Australian waters. The shy albatross is an endemic breeding species to Australia meaning it only breeds within the Australian territory.

Albatrosses were often shot at sea for the amusement of 19th century sailors and their feathers sold. More recently, albatross are threatened by a variety of human

activities particularly longline, squid and driftnet fisheries. Their natural prey is squid and fish, both of which are commonly used as bait in long-line fishing.

The threat of climate change

Historically, bycatch from the longline fishing industry has been a major threat to albatrosses. While the fishing industry has made significant improvements in reducing this threat, illegal, unregulated and unreported fishing remains the cause of thousands of albatross mortalities every year. Rabbits, that are destroying albatross habitat on sub-Antarctic Macquarie Island, have exploded in numbers due to a few key factors including climate change and resistance to the myxoma virus. Because of slightly warmer winters, rabbits are now able to breed all year round, contributing to their growing numbers.

With already reduced populations, climate change is likely to make things even worse for the world's albatrosses, especially those species with restricted populations. In fact, birds are a good indicator of climate change as their life cycles are often reliant on weather and climatic conditions. This is especially true of birds that migrate or that travel long distances whilst foraging, such as the albatross. While no one knows for sure what the impact of climate change will be on albatrosses and how they will adapt, some worrying trends are apparent.

Albatrosses that breed at a single location are the most at risk from climate change as their populations are not buffered against environmental change. Six of Australia's albatross species breed on only one or two geographically close islands. Albatross are extremely faithful to breeding sites and unlikely to breed elsewhere. At this time there is not enough research to indicate how these species will fare, or how the vegetation of these islands will respond to climate change. It is possible that warmer temperatures will foster improved conditions for invasive species like rats and rabbits at nesting sites, leading to conditions that are unfavorable to albatross recruitment.

Air temperatures over the Southern Ocean have been increasing steadily since the 1960s, and this has coincided with a decrease in the abundance of the wandering and black-browed albatross, both of which breed in Australian waters. Warmer waters are more nutrient poor than cooler waters and the success of seabird feeding has been correlated with instances where a high degree of mixing between colder deeper nutrient rich water and warmer nutrient poor surface water occurs. In 2002, there were unusually high sea surface temperatures (SSTs), associated with reductions in food availability. Many chicks died as a result.

The prevalence of storms is also an important consideration; adults may literally

be blown off their nests, or, as happened in November 1994 to a Chatham Island albatross population, eggs may be damaged or destroyed.

Since 1970, the climate has become warmer and drier at all sites where the northern wandering albatross breeds in New Zealand. This may be stressful for the adults as they rear chicks because they can not leave the nest and risk heat exhaustion. Hot conditions also promote the growth and reproduction of blowflies, which attack and kill chicks. As breeding grounds are adversely affected, for example by storms eroding habitat, albatross may be forced to compete for less space and higher densities could in turn lead to an increase in blowfly attack and parasite outbreaks.

The best outcome for albatrosses in the face of climate change is to build population resilience by ameliorating all other threats. A recovery plan was developed in 2001, but in recent years has been largely replaced as a conservation framework by the Agreement on the Conservation of Albatross and Petrels (ACAP), an international agreement which provides a focus for international cooperation and exchange of information and expertise towards the conservation of these declining seabirds. ACAP's goals include control of non-native animals on breeding islands, implementing measures to reduce by catch and protecting breeding habitat.



Black-browed albatross © WWF-Canon/Sylvia Rubli

Greater Bilby and Climate Change



Greater bilbies are nocturnal animals that feed on a wide range of seeds, fruits and bulbs, as well as fungi and insects. They can be found living in deep burrows among the grasslands and woodlands of Australia's sandy deserts.

The distribution of the greater bilby once spanned much of mainland Australia. Since European settlement and the introduction of foxes, rabbits and feral cats, the species is now restricted to smaller patches across western and central Australia and is classified as vulnerable by the Australian Government and the World Conservation Union. Bilbies have to compete with rabbits for food and are preyed upon by feral cats and foxes. Periodic 'booms' in rabbit populations may facilitate increases in predator numbers which, when rabbit populations collapse, turn to preying upon native species such as bilbies. Other predators include dingoes, pythons, birds of prey and monitor lizards. It is believed that feral camel populations are also imposing a significant threat to bilby populations by trampling suitable grassland habitat.

The threat of climate change

Fire is an important natural component of the ecology of many Australian terrestrial ecosystems, including those inhabited by bilbies. A primary source of food for the bilby comes from plants that rely on occasional burning to thrive. The traditional use of fire for landscape management by Indigenous Australians maintains habitats that consist of a mosaic of plant communities at varying successional stages. This type of habitat allows bilbies to exploit an abundance of varied food sources. The close relationship between food sources and fire regimes suggests that appropriate fire management of arid grasslands could be used to promote bilby populations.

Studies have predicted changes to fire regimes in many Australian ecosystems as a result of climate change. It is not known how the fire regimes resulting from climate change will affect remaining bilby populations. Increased fuel load, due to greater plant growth under higher CO₂ levels, as well as increased temperatures and lower humidity in some areas could alter the frequency and intensity of wildfires in many Australian ecosystems. Under certain circumstances it is possible that fire frequency may decrease where increased rainfall regulates any greater fire potential and nutrient limitation prevents increased plant growth.

More frequent fires may initially increase some types of food resources for bilbies but there are, however, many other complicating factors. Intense and widespread wildfires will create a uniformly burnt habitat rather than a variable mosaic habitat as is achieved by patch burning. This may reduce the suitability of these landscapes for bilbies. Conversely, a reduction in fire frequency may lead to a reduction in important, fire-dependent food resources for bilbies.

Increased periods of reduced groundcover following wildfires may make bilbies more vulnerable to attack by predators such as cats and foxes. They may also need to search further for food following intense fires making them even more prone to predation whilst outside their burrows.

It is also likely that climate change will alter the species composition of the grasslands and woodlands that bilbies inhabit. Disturbances such as wildfires are known to provide opportunities for invasion by exotic plant species. Increases in fire intensity and/or severity will therefore create more opportunities for invasion by introduced grass species, which will compete with the native species that bilbies rely on for food and shelter. Changes in the species composition of grasslands may also affect the susceptibility of these areas to fire with certain exotic species such as mission grass and gamba grass producing much greater amounts of flammable material than native species.

Under favourable environmental conditions bilbies can reproduce quickly and populations may thrive. However, the ability of populations to adapt to sudden unfavourable environmental changes is hampered by their already reduced and fragmented populations. This increases the risk of localised extinctions of bilby populations in the future. A certain amount of climate change is inevitable, and the only option many species have is to adapt to these changes. The best way to save vulnerable species is to ensure they are given the best fighting chance against these environmental upheavals. Working hard to instigate proper fire management while removing other factors that continue to threaten the greater bilby, such as predation and habitat destruction by feral animals, will give bilbies the best chance of surviving the added pressures of climate change.

Switch off appliances
on standby



Black Cockatoo and Climate Change



Carnaby's black cockatoo © John Lauri

Carnaby's black cockatoo is endemic to southwest Australia with a range stretching from the Murchison River in the north, inland to Coorow, Kellerberrin and Lake Cronin, and south to Esperance.

It is classified as endangered according to the criteria of the World Conservation Union (IUCN) and Australian Government and 'Rare or likely to become extinct' by the Western Australian Government.

Carnaby's black cockatoo is large with a white patch on its cheek and white bands on its tail. It has a strong, short bill designed to cope with the hard nuts and seeds that form its diet. It feeds on seeds and insect larvae from species of banksia, dryandra, hakea, grevillea, eucalyptus, and introduced pinus species.

Carnaby's black cockatoo depends on both breeding sites and nearby feeding habitat in the Western Australian wheatbelt, and other feeding habitats on the higher rainfall coastal plain where it spends the summer and autumn months. Most of its critical habitat in the wheatbelt has been cleared, and coastal plain feeding habitat continues to be cleared for urban and industrial development.

These breeding sites need to have large hollows in old eucalyptus trees where the birds raise a single chick per season. These breeding sites can be used for many years but as invasive species such as corellas, galahs and feral bees move into the area, there is increased competition for these sites. Additionally, trees can take up to 150-200 years to form suitable hollows, and clearing and lack of habitat regeneration can reduce the number of available hollows.

The threat of climate change

Cockatoos are unique birds and unfortunately, the Carnaby's black cockatoo is not the only threatened cockatoo species. Also considered endangered are the Kangaroo Island form of the glossy black cockatoo and the southeastern

subspecies of red-tailed black cockatoo. The Major Mitchell's cockatoo, Baudins black cockatoo, palm cockatoo and eastern glossy black cockatoo are also listed as 'near threatened', meaning they have a lower risk of extinction but are still in danger of becoming threatened. Relatively little is known about how climate change will affect these birds. In a study of the potential effects of climate change on the endangered red-tailed black cockatoo in Victoria, only one per cent of the current land area thought to be available to the birds is projected to remain unchanged after a 3°C rise in mean annual temperature.

The full array of climate change impacts on Carnaby's black cockatoo are unknown. The climate in south-western Western Australia has already become drier and is predicted to continue warming and drying. In a study of the glossy black cockatoo that lives in central New South Wales and feeds on allocasuarina cones, drought conditions were found to decrease the number of cones produced and therefore the food available to the cockatoos. The responses of vegetation communities to climate change in southwest Australia, particularly the vegetation communities on which the cockatoos are reliant, is unknown. However, increasing demand for water as the human population grows, accompanying increased groundwater abstraction, and the drying of the climate are already affecting vegetation communities. Species such as the Carnaby's black cockatoo, which has a restricted diet, lives in a restricted habitat, and/or requires different habitats at various times of the year, are thought to be more vulnerable to the effects of climate change.

A breeding population of Carnaby's black cockatoos that has been monitored in the northern part of south-west Western Australia has declined by 50 per cent since 1969. This decline has been mostly attributed to loss of habitat. If populations continue to decline because of habitat fragmentation, it is unlikely they will be robust enough to withstand the potential negative effects of climate change.



Flock Carnaby's black cockatoo © Dejan Stojanovic

Frogs and Climate Change



Green and gold bell frog © Viewfinder

As frogs generally have aquatic eggs and larvae, followed by terrestrial juvenile and adult stages, they are generally considered to be good indicators of environmental health.

Frogs have a permeable skin, so they can lose water easily when on land and are affected by chemicals in the air and water. Aspects of climate change that will have most impact on frogs will be increases in temperature, length of the dry season, and variability of rainfall and decreases in soil moisture.

In Australia there are three main native frog families – *Myobatrachidae* (or ground frogs), *Hylidae* (tree frogs), and the tropical *Microhylidae*. Australia is described as a significant centre of amphibian diversity, with more than 200 species of frogs already discovered and new species being found all the time. Frogs are the most threatened living species in the world, with more listed internationally as threatened than any other species. Globally, 21 per cent of the world's frogs are critically endangered.

The threat of climate change

Frogs are poikilothermic, which means that their internal temperature varies with the ambient temperature of the immediate environment. Therefore, ambient temperature has an effect on their physiology and behaviour.

Warming trends are thought to be contributing to the extinction of some populations, for example, in the cloud forests of Costa Rica, and may be influencing the breeding patterns of others. Amphibians are sensitive to climate change because their behaviour, physiology and ecology depend on environmental cues, such as temperature and rainfall. The two processes most likely to be affected by temperature changes are reproduction and development.

Temperature is the primary driver of seasonal patterns of emergence and reproduction in frogs. In England and west and north-eastern North America, amphibians are responding to climate change, specifically increasing temperatures, by breeding earlier. It has been found that frogs breeding earliest in the season had the strongest response to increasing temperatures, by calling earlier to attract mates, but other frogs showed no response to increasing temperatures, indeed one was found to start calling later.

21 Australian rainforest species have been identified as being vulnerable to losing greater than 50 per cent of their core climatic environment with a 1°C increase in temperature, of which seven are frogs. For example the Tangerine nursery frog is expected to disappear entirely with a 1°C average annual warming.

Climate modelling was done for the Australian Greenhouse Office to assess the impacts of climate change on three Western Australian frog species. The conclusions drawn from this study are straightforward: the climatic habitats of the white-bellied frog, yellow-bellied frog and sunset frog are predicted to disappear completely with an increase in annual temperatures of 0.5°C.

In warmer and drier habitats ponds may fill later in the season and hold water for less time, forcing more species to use a single pond at the same time and leading to competition for egg laying and calling sites. With so many different species of males calling in the same pond, calls will overlap, making it harder for females to find a mate. Furthermore, such a high concentration of frogs may attract predators and spread disease.

In pond-breeding frogs, the ability to accumulate nutrients and energy will be affected by climate change. Because of increased competition for prey at breeding sites, females may change egg and clutch sizes and time needed for egg development. Males may also have less energy for territorial defence and calling.

With increased evaporative stress (decreased rainfall and humidity and increased temperatures) ponds will dry faster, which could mean that tadpoles don't reach metamorphosis. Fast drying ponds may lead to some males not having the chance to breed. Increases in the length of the dry season and temperatures may also increase stress on eggs that are laid on land, which may lead to fewer hatchlings.

Leaf litter invertebrates in the neotropics have shown a negative response to dry conditions. With a future warmer, drier, less predictable environment it is expected that the abundance of leaf litter invertebrates will decrease, making it harder for frogs that live in the leaf litter to find prey.

Climate change is likely to act together with other threats such as increased acidification, pollution and UV radiation, leading to immune system damage and making amphibians more susceptible to pathogens.

Take shorter showers



Corroboree frog © Hal Cogger/ Australian Museum

Gouldian Finch and Climate Change



The Gouldian finch is endemic to northern Australia. The species occurs in scattered populations throughout Queensland with the population stronghold from Derby, Western Australia, to the western edge of the Gulf of Carpentaria, Northern Territory.

The Gouldian finch's small population size, restricted diet of grass seed, together with the impacts of altered fire regimes, grazing by introduced herbivores and competition, mean the species is now endangered.

Gouldian finches are specialist seed eaters. They rely on two different sources of grass seed in the dry season, when they breed, and only eat seeds that have fallen on the ground, while in the wet season they feed directly from the grass stems. There is a seasonal drop in seed availability early in the wet season as grass seeds germinate. Finches are known to breed in eucalypt hollows, which are often within two to four kilometres of waterholes or springs because the birds are reliant on surface water for drinking.

There are main threats faced by the Gouldian finch: grazing by both domestic and feral animals that may prevent grass going to seed or destroy it completely,

competition for tree hollows used for breeding and landscape changes due to altered fire regimes.

The threat of climate change

The average minimum temperature in the Northern Territory has already increased to just under 1°C over the last 90 years and is projected to rise by 0.9 to 1.2°C by 2030, depending on location. Rainfall changes are very important in understanding the effects of climate change on core habitats of species, yet there is much uncertainty surrounding changes in precipitation with global climate change. Thus, predicting the influences of climatic change on species distributions is subject to considerable uncertainty. Rainfall patterns over the wetter months (November to April) are predicted to change little from current conditions. Rainfall predictions for the drier months (May to October) are more variable. Any changes in average rainfall that do occur may also affect the intensity and frequency of extreme weather events such as heavy rains leading to flooding, or extended dry spells.

Such changes may have serious implications for finch habitat. For example dry season food, sorghum, requires high rainfall at the start of the wet season to allow it to grow large enough to set seed. Low rainfall in this critical period of sorghum growth led to a low seed yield during the 1990 breeding season. The Northern

Territory, like most arid regions, experiences a moisture balance deficit in the dry season, that is, there is more potential evaporation across the entire territory than there is rainfall. This deficit is predicted to increase even further by 2030 making the region drier still. The effects of this change may include increased competition for water resources and increased flammability of the vegetation.

Gouldian finches are reliant on early dry season fires to burn the undergrowth so that they can forage for seeds on the ground. In the wet season they prefer areas which have been previously burnt, as this promotes grass growth and thus seed production. A fire regime that creates a mosaic landscape is therefore critical for the maintenance of Gouldian finch populations. In addition to determining food availability, fire can also affect breeding habitats by affecting the availability of nesting sites within tree hollows.

Parts of the Northern Territory and Queensland have been invaded by introduced plant species such as buffel grass, mission grass and gamba grass. The potential area for it to invade is large, covering the entire northern region of Australia from Queensland to Western Australia. Fire patterns will be influenced by changes in temperature, rainfall, wind, fuel availability and patterns of ignition such as lightning strikes. This has serious implications for the finches

Gouldian finches, like most tropically distributed Australian birds, are not as heat tolerant as one might expect. In a study of captive finches it was found that the birds have limited physiological ability to deal with increasing heat, instead “hiding” from the heat by foraging during cool times of the day, early morning and late afternoon. Future temperature increases may lead to an increase in conditions during which the finches cannot forage, and if they are unable to meet their nutritional needs during this time they may suffer heat exhaustion or even starve.

Change to energy efficient light globes



Hare Wallabies and Climate Change



The hare wallabies were once a common macropod occurring throughout Australia, yet over the past 60 years the distribution of all six species has declined severely.

Hare wallabies are small, nocturnal macropods that received their name due to their resemblance to the European hare. Presently there are six surviving species in two genera, the banded hare wallaby, *Lagostrophus fasciatus* and the true hare wallabies within the genera *Lagorchestes*. Today, hare wallabies predominately live in the tropical woodlands or grasslands of Queensland and a few offshore islands of Western Australia, with reintroductions occurring in the Tanami Desert of the Northern Territory.

Over the last 100 years a combination of intensive settlement, drought, introduced predators and changed fire regimes has led to the extinction of four species of hare wallaby from the Australian mainland. Two of the four species extinct on the mainland survive on a few offshore islands and represent the sole remaining populations of their species. Today only one species is relatively common and survives on mainland Australia, albeit with a reduced distribution. The decline of the hare wallabies is likely to continue under climate change, given changes to and losses of habitat and food resources and the increasing occurrence of drought.

The threat of climate change

The distributions of flora and fauna are expected to shift in response to changing temperatures, and this is problematic for species like hare wallabies that are largely restricted in habitat and range, predominately being isolated on a few off-shore islands. Further, ecological specialisation is thought to increase the susceptibility of a species to population declines and extinction because more specialised species cope less well with environmental change. Climatic factors, especially extreme events such as droughts, are known to directly influence the demography of island populations of a number of endangered species.

Climate change will have an impact by increasing the probability of extreme events and therefore increasing population fluctuations with likely genetic and demographic consequences. The main threatening processes that have led to the decline and extinction of hare wallabies are a combination of native vegetation clearing which can increase aridity, introduced predators (foxes and cats), competitors (rabbits, house mice, feral pigs, livestock), drought and changes in fire regimes. Increased

pressure from predators, disease, pollution, habitat fragmentation and disturbance is likely to exacerbate the effects of climate change by reducing the health of species and their dispersal ability.

Variations in future climate may negatively or positively influence species distributions, which are predominately influenced by temperature and rainfall. Yet there is much uncertainty surrounding changes in precipitation due to climate change. For example, projected annual average rainfall ranges tend towards a decrease but is largely variable in the Shark Bay and Barrow Island regions of Western Australia. Any deficiencies in rainfall are suggested to lead to severe population crashes in hare wallabies as drought is known to interrupt their breeding cycle.

Temperature changes are clearer. By 2030, annual average temperatures are expected to increase by about 1 - 1.2°C within the Shark Bay and Barrow Island regions of Western Australia. Bioclimatic modelling suggests that the Shark Bay Islands and Barrow Island further to the north will become climatically unsuitable for the rufous and banded hare wallabies with temperature increases of as little as 0.5°C. Further, the impacts of climate change on islands also include changes in cyclone or storm activity and an increase in sea level. Changes in rainfall seasonality could lead to extremely wet seasons with flooding or greater dry spells leading to extreme and/or prolonged drought. Future differences in seasonality and extreme weather events (drought, flood or cyclone) may have drastic implications for those island species already living in a highly variable climate.

In contrast, predicted changes in rainfall patterns for the tropical north are difficult to disentangle from natural variability. Here the habitat of the spectacled hare wallaby may fare better under changing climatic conditions. However, as climate change is likely to further increase the variability of seasonal rainfall, the long-term future of these species is not assured.

As changes in fire regimes have been held partly responsible for the decline and extinction of hare wallabies, climate change is likely to have negative consequences for hare wallabies in areas where increased frequency and severity of wildfires is expected.

The impact of climate change on the distribution of introduced species like foxes, rabbits and cats is unknown at present. Yet given their wide distribution, mobility and opportunistic behaviour, climate change is likely to increase their impact on rare and endangered species.

Switch off lights



Rufous hare wallaby © WWF-Canon/Martin Harvey

Marine Turtles and Climate Change



Loggerhead turtle © WWF-Canon/Michel Gunther

Marine turtles have been swimming in the world's oceans for over 100 million years, but are now recognised globally as a species of conservation concern.

Marine turtles have coped with considerable climatic changes over time. However, it is the accelerated rate of global warming, in addition to the multitude of human induced impacts that already threaten marine turtle populations, that has led to concern's over the marine turtle's ability to adapt.

Presently, there are seven living species of marine turtles. Australian waters are home to six of these species, with one species nesting exclusively on Australian shores. Life history characteristics are reasonably similar in all marine turtle species. Mating occurs in waters near the shore while nests are laid on tropical, subtropical or warm-temperate beaches. There is minimal parental care but several clutches are laid per nesting season with up to 50-200 eggs per clutch. Females do not breed every year but can breed over several decades. Hatchlings usually emerge at night when temperatures are cooler, using the moon as a guide to find the water. Growth is very slow and sexual maturity is not attained for many years. Mortality is high in the young and all stages of their life history are profoundly affected by temperature.

The threat of climate change

The sex of marine turtles is determined by the incubation temperature of eggs nesting within the sand of beaches. As higher temperatures lead to female hatchlings and lower temperatures lead to more males, warm dark sand produces more females and lighter sand gives rise to more males. Small increases in temperature due to global warming can skew the sex ratio of hatchlings in favour of females. Future increases in temperature will only amplify the warming that has currently begun and many nesting beaches already have a strong female bias.

Low and high temperatures are a significant source of mortality in several marine turtle species. Low hatchling success has been linked to temperatures exceeding the maximum for successful embryonic development, leading to heat stress and embryo mortality. Higher nest temperatures have also been attributed to the production of smaller or debilitated turtles. Marine turtle eggs usually require incubation temperatures of 25 - 32°C. Some nesting beaches are seeing temperatures rise above 34°C, which is often lethal. Some well studied marine turtle beaches in the Great Barrier Reef are already recording sand temperatures at nesting depth of up to 36°C. In contrast, 'cold stunning' occurs in young turtles when they are taken out of the normal ocean currents due to adverse weather conditions. At around 20°C young turtles cease to feed while at 15°C locomotion is reduced and at 10°C coma is soon followed by death.

Higher sea surface temperatures and increased frequency and severity of storms leading to increased flooding may directly and indirectly affect the survival of marine turtles. Higher sea surface temperatures have contributed to a loss of important foraging grounds for marine turtles through coral bleaching and seagrass burning. Increased severity of storms can lead to the loss of critical nesting beaches through erosion, suitability of sites and direct nest and egg destruction. Increased flooding from storms can lead to loss of critical seagrass habitat and has been implicated in reduced growth and breeding rates of green turtles in parts of Queensland.

As sea surface temperatures warm, large poleward movements of tropical and temperate species are expected. Indeed, evidence of range shifts has been seen through higher numbers of green turtles nesting on the Great Barrier Reef in Queensland which has been attributed to climate-induced food availability from strong El Niño-Southern Oscillation (ENSO) anomalies. Similarly, an increased number of turtles have been recently recorded in the United Kingdom. There is further evidence that loggerhead turtles are nesting earlier in response to warming in Florida, USA.

Marine turtles have responded to climate change in the past. Adaptation to different climatic conditions has occurred over many generations and hundreds of years.

However, marine turtle populations are already rapidly declining, with many being perilously close to extinction due to human induced threats. Combined with the added pressure of accelerated global warming, many marine turtle populations are unlikely to avoid extinction long enough to adapt.

We need to reduce all processes threatening marine turtle survival today, to increase the chance of more generations surviving and eventually adapting to changed conditions. We need to retain coastal vegetation that provides shade and protects nesting beaches from erosion, and we may need to explore innovative ways to protect critical nesting beaches. We need to protect all important habitat today as well as potential habitat for tomorrow. Cooler beaches that may not yet be the most productive rookeries must be available to the next generation of females, in case the beach they hatched from becomes too hot for their young to survive.

Install a triple A rated
shower head



Quolls and Climate Change



There are four species of quoll in Australia and another two in New Guinea, all of which are classed as either vulnerable or near threatened by the World Conservation Union.

Quolls are small marsupial carnivores that den amongst rocky outcrops, crevices, hollow logs and in the abandoned burrows of other animals in a range of habitat types from rainforest to open woodlands. Many species have suffered severe reductions in geographical range with population numbers continuing to decline due to a number of ongoing threats.

Some quolls species are often prey for feral cats and foxes and also have to compete for resources with these introduced carnivores. There is some evidence to suggest that poison baits set for foxes may be eaten by quolls. The rapid spread of the cane toad throughout northern Australia continues to threaten quoll populations. The toxins produced by cane toads are highly poisonous to quolls. These toxins are ingested when quolls prey upon cane toads mistaking them for a viable food source.

Some species of quolls, along with many other Australian animals, are known to have evolved under circumstances where they have benefited from the land use practices of Indigenous Australians. Patchy burning of grasslands by Indigenous people creates landscapes that are a 'mosaic' of plant communities at varying successional stages. This is known to support a wider diversity of plants and animals than a more uniform habitat. It has become apparent that this effect is important for the success of quoll populations as localised extinctions of quolls have occurred where traditional burning practices have ceased following European settlement.

Other threats include habitat loss and fragmentation, which may restrict the ability of species to move and adapt to climate change. Forestry practices are also a threat which continues to remove and fragment habitat. As part of this, prescription burning has the potential to impact on some quoll species through reducing prey availability. Other threats unlikely to be influenced by climate change include road mortality.

The threat of climate change

It is possible for the geographical range of the cane toad to spread dramatically across the northern and eastern coasts of Australia as a result of increasing

temperatures. This will bring cane toad populations into contact with quolls that have as yet remained separated from the threats posed by these pests with adverse impacts on quoll populations. This would affect the viability of some quoll populations.

Given the importance of a suitable fire regime to the success of some quoll populations, future changes to fire frequency and intensity in Australia are likely to have negative impacts on quolls. Higher variability in fire regimes is likely to occur across Australia as a result of climate change. Many ecosystems may experience more frequent or intense wildfires due to increased fuel loads, higher temperatures and dryer conditions. Other ecosystems may experience the opposite with increased humidity and rainfall leading to a decrease in fire potential. More frequent and widespread wildfires are likely to create a uniformly burnt habitat rather than a mosaic landscape, reducing the available resources for small mammals such as quolls. Intense fires can also kill quolls directly and lead to loss of important habitat structures such as fallen or hollowed logs. In areas where fire occurrence decreases and traditional burning practices no longer occur, there is the risk of additional localised extinctions of quoll populations.

In addition, climate change could increase the impacts of feral animals, which is likely to have repercussions for quolls through predatory and/or competitive interactions.

Walk, cycle or
catch public
transport



Rat Kangaroos and Climate Change



Long-nosed potoroo © WWF Canon/Martin Harvey

The rat kangaroos were once common marsupials throughout Australia. Since European settlement, habitat fragmentation, clearing, predation, and changed fire regimes have contributed to the extinction of four of the ten rat kangaroo species from mainland Australia.

Two of the four species that are extinct on the mainland survive today on a few offshore islands. This trend of extinction and isolation may continue as a result of climate change. The loss of this endangered group of relatively obscure animals would have an impact on the wider ecosystem, as rat kangaroos are not only important for native plants as dispersers of spores from mycorrhizal fungi, but also assist in the decomposition process, thereby enhancing the water holding capacity and fertility of the soil. Rat kangaroos therefore play a role in maintaining the health of the ecosystems they inhabit.

The threat of climate change

Climate change may cause losses of or large shifts in the distribution of species, predominately due to changes to their core habitats. Unlike species with broad

geographic ranges that tend to have a degree of climatic tolerance, species of rat kangaroo are narrowly distributed and acutely influenced by their immediate surroundings, including the diversity and abundance of truffles which are a major part of their diet.

The burrowing bettong, a species of rat kangaroo, is extinct from mainland Australia and is currently limited to the off-shore islands of Western Australia (Barrow, Bernier, and Dorre islands). These remnant populations are small and readily fluctuate due to weather. Although certain model scenarios suggest that the burrowing bettong may increase in its distribution, its core habitat on the offshore islands of Western Australia is predicted to disappear with an increase in temperature of 0.5°C. Indeed, by 2030 the best estimate for annual average temperatures across Australia is 0.7 to 1.2°C, and this may increase to 1.8-3.4°C by 2070.

Climatic factors, especially extreme events such as droughts, are known to directly influence the demography of island populations of a number of endangered species. The impacts of climate change on islands also include changes in cyclone or storm activity and an increase in sea level. Changes in rainfall patterns could lead to extremely wet seasons resulting in flooding, or greater dry spells leading to extreme and/or prolonged drought. Future differences in seasonality and extreme weather events (drought, flood or cyclone) may have drastic

implications for those island species already living in a highly variable climate. Moreover, climate change will affect these extremely restricted populations unless widespread reintroductions on the mainland occur with the removal of their main introduced predator, the fox.

Understanding future rainfall changes will be very important for predicting the effects of climate change on the core habitats of species, yet there is much uncertainty surrounding changes in precipitation. For example, the northern bettong is restricted to the tall open forest and woodlands (wet sclerophyll) in some of the wet tropics of northeast Australia, which are predicted to decline in area if warming (+ 1°C) is accompanied by greater precipitation (+ 10%). Alternately, the northern bettong is predicted to increase in geographic range if rainfall decreases (-10% with + 1°C), due to the contraction of rainforest and the expansion of open forest and woodland. Similar restrictions under various climate change scenarios may also be applied to the musky rat kangaroo, which lives in the tropical rainforests of northern Queensland.

Southeast Australia is also predicted to undergo severe drought with climate change. It is suggested that a temperature rise of up to 3°C and anything less than a 10 per cent rise in rainfall will result in increased dryness. Along with many other species, the long-footed potoroo would undergo a loss in bioclimatic

range if southeast Australia becomes drier, although the exact extent of this change remains uncertain. As climate change is likely to further increase the variability of seasonal rainfall, the long-term future of rat kangaroos in general is not assured.

Southeast Australia is already recognised as one of the most fire prone regions of the world with wildfire and prescribed fire being common events. Any increase in the frequency and intensity of fire would be likely to have negative consequences for rat kangaroos through a loss of habitat. For example, potoroo abundance has been shown to increase in sites that haven't been burnt for a long time, probably because fire causes loss of key microhabitats in terms of food (fungi and truffles) and shelter (groundcover). Further, potoroos are known to eat a large diversity of truffles (up to 50 species), which have been found to be reduced with frequent burning. As peaks in rat kangaroo reproduction and fitness have coincided with peaks in truffle production, any increase in the frequency and intensity of fires may have serious implications for the health and fitness of potoroos and will likely have negative impacts on other species of rat kangaroo.

Switch to Greenpower



Burrowing bettong © WWF/Klein & Hubert

Rock Wallabies and Climate Change



Yellow footed rock wallaby © WWF-Canon/Martin Harvey

Rock wallabies are endemic to Australia and form the largest group of macropods, kangaroos and wallabies and their relatives, representing 31 per cent of macropod species alive today.

Rock wallabies have been severely impacted upon since European settlement and are highly endangered as a group. Numerous populations have disappeared from Australia because of land clearing, changed fire regimes, competition for food with introduced herbivores and predation by introduced species.

Rock wallabies are found in scattered localities on the Australian mainland and on offshore islands. Presently there are 15 species and an additional eight subspecies of rock wallaby. They live in rocky habitats, which provide shelter and home sites, and may be found in colonies of up to several hundred animals.

The decline of rock wallabies is likely to continue as a consequence of global climate change, with changes to and losses of habitat and food resources and the increasing occurrence and severity of drought.

The threat of climate change

The distribution of flora and fauna is expected to shift in response to climate change and is problematic for species like rock wallabies that are largely restricted in habitat and range, with several species being isolated to a few off-shore islands. Further, ecological specialisation is thought to increase the susceptibility of a species to population declines and extinction because more specialised species cope less well with environmental change. Climatic factors, especially extreme events such as droughts, are known to directly influence the demography of rock wallabies. Climate change will have an impact by increasing the probability of extreme events and therefore increasing population fluctuations with likely genetic and demographic consequences. The main threatening processes that have led to the decline and extinction of rock wallabies are a combination of native vegetation clearing, which can increase aridity, introduced predators (foxes and cats), competitors (rabbits and goats), drought and changes in fire regime. The terrestrial vertebrate fauna of Australia has already undergone profound changes as a consequence of European settlement; climate change is likely to compound the problem.

Variations in future climate may negatively or positively affect species distributions

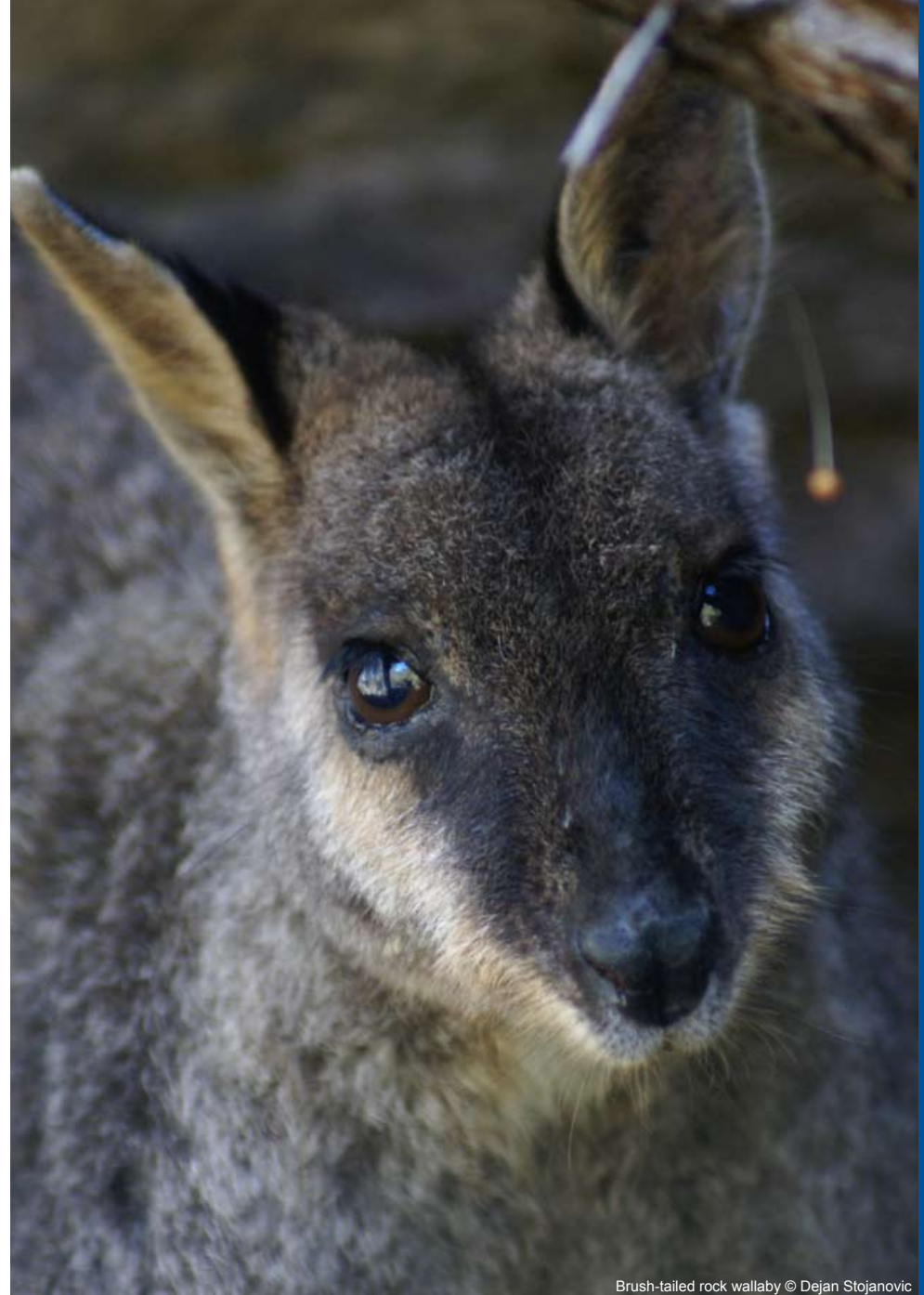
by influencing their associated habitat. Most rock wallabies tolerate a fairly broad range of habitats surrounding their rocky refuge habitat and generally cover a wide range of climatic conditions over Australia. Presently they are constrained by their habitat requirements and predator pressure rather than by climate. Yet if the vegetation in which they feed was to change under climate change and become too much like dry scrub or rainforest, the appropriate food would no longer be produced. Further, there is cause for concern as the populations are isolated and are extremely sensitive to local extinctions, particularly those restricted to offshore islands.

Bioclimatic modelling suggests that the Recherche Archipelago, the Western Australian Wheatbelt and Barrow Island further north will become climatically inadequate for the black-footed rock wallaby with temperature increases as small as 0.5°C. Moreover, impacts of climate change on islands also include changes in cyclone or storm activity and an increase in sea level. Changes in rainfall seasonality could lead to extremely wet seasons with flooding or greater dry spells leading to extreme and/or prolonged drought. Future differences in seasonality and extreme weather events (drought, flood or cyclone) may have drastic implications for those island species already living in a highly variable climate.

Southeast Australia is also predicted to undergo drought with climate change. It is suggested that a temperature rise of up to 3°C and anything less than a 10 per cent rise in rainfall will result in increased dryness. This may have serious implications for the brush-tailed rock wallaby, as their predicted range is suggested to contract with increasing global temperature. The recent contraction in the species is thought to be due to lower rainfall and a decline in rainforest vegetation. Further research into this little known species is required to assess the extent of its current populations.

In contrast, predicted changes in rainfall patterns for the tropical north of Australia are highly uncertain. As climate change is likely to further increase the variability of seasonal rainfall, the long-term future of these species is not assured.

Install a solar hot water system



Brush-tailed rock wallaby © Dejan Stojanovic

Tree Kangaroos and Climate Change



Lumholtz tree kangaroo © Viewfinder

Tree kangaroos are only found in Australia and New Guinea. Two species live in the tropical rainforests of Far North Queensland and another 10 species are distributed throughout the islands of New Guinea.

As their name suggests, tree kangaroos are arboreal relatives of the better-known ground-dwelling kangaroos that live throughout Australia. Compared with terrestrial kangaroos, tree kangaroos have furrier tails, powerful gripping forefeet, short wide hindfeet and much smaller ears. They are herbivores, feeding on a variety of leaves, fruits and flowers in their rainforest environment.

Tree kangaroos are sparsely distributed throughout forests with restricted home ranges. The size of these home ranges can vary depending on the species; however our understanding of their extent is still limited. Estimates of the home range of Matschie's tree kangaroo, for example, have varied between 0.7 and 25 hectares.

The threat of climate change

Australian species of tree kangaroo appear to be restricted to high elevation rainforests. These mountainous areas provide a cool environment allowing tree kangaroos to keep their body temperatures down and to get moisture from dew and mist forming under the rainforest canopy. Global warming, by increasing atmospheric temperatures, will greatly reduce the size of these important mountaintop habitats. Tree kangaroo populations will be pushed higher up mountains, restricting them to the highest peaks and therefore further reducing and fragmenting their already threatened populations. There is still little known about the habitat requirements of New Guinean tree kangaroos, so it is unknown as to whether they are also restricted to high altitude forests.

There are fears that increased atmospheric carbon dioxide could render plant material less nutritious for tree kangaroos. Animals will be subjected to higher levels of natural plant toxins if they are forced to eat greater amounts of less nutritious leaves. This may pose a further threat to the future survival of tree kangaroos.

Tropical cyclones are naturally occurring phenomena that have played a role in shaping the ecology and evolution of tropical rainforests. It is possible, however, that global warming will cause an increase in the frequency, severity and geographical range of tropical cyclones.

This change in cyclone regime poses a threat to animal species which are unable to adapt to such sudden changes in their environment. Animals can be easily killed by strong winds, rain, storm surges and falling debris during the passage of a cyclone. For those animals that survive the cyclone there is still a high risk of mortality in the following months due to the loss and destruction of important food and habitat resources. Tree kangaroos appear to be able to feed on a wide variety of food sources, which may allow them to survive following cyclones by changing their foraging habits. Certain studies however have shown that they rely quite heavily on their home range habitats and will not migrate to new forest patches even after their home range has been destroyed. This can lead to further mortality and may make them more prone to predation. The loss of dense foliage following cyclones has been found to make other small mammals more vulnerable to hunters. An increase in cyclone activity in tree kangaroo habitat could increase the pressure on their populations.

Pump up your tyres



Matschie's tree kangaroo © Brent Stirton/Getty Images WWF-UK

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