Climate change and biodiversity

by Richard McKellar and Ian Abbott

Climate change is recognised as a major global issue and is a growing challenge for all nations, most industries and many communities. Because climate has a fundamental influence on the distribution and abundance of plants and animals and the composition of ecosystems, changes to climate conditions will have significant implications for our environment.

In places where there are clear visual signs of a warming world, such as melting mountain glaciers, icefields or sea ice, the scale and significance of climate change are evident. But how is climate change affecting Western Australia and what can we do about it?

Temperatures throughout Western Australia have risen during the twentieth century (see the graph below), mainly due to warmer nights rather than hotter days.

Since the 1970s, average annual rainfall in many parts of the south-west region has fallen significantly (see map on page 57). Research by the Indian Ocean Climate Initiative (IOCI) partnership has revealed that this reduction has almost entirely resulted from a loss of rainfall in the late autumn and early winter months. The Bureau of Meteorology and CSIRO have advised that this change is at least partly due to global climate change.

Warmer weather and drier winters are great for hikers and campers, and for some sports and recreational activities. Agriculture also seems to have benefited from fewer waterlogged areas. But these changes have also generated significant economic and environmental costs.

Lower rainfall has already required new sources of water to be developed, with new infrastructure such as dams, pipelines and a desalination plant being constructed. Even with increased investments in water infrastructure and a stronger focus on using water efficiently, harvesting further water resources such as the Yarragadee aquifer is being considered.

This increased competition for limited water resources requires water planners and the broader community to determine how much water should be allocated to local communities and industries, how much to the regional centres, how much to the Perth metropolitan region and how much to the environment. When an already limited resource is reduced, competition becomes fierce.

It appears that reduced rainfall and increased water harvesting from the Gnangara aquifer (in the northern Perth region) have resulted in lower water levels in the caves of Yanchep National Park, threatening species found only in those caves. To maintain the environment these species require, the Department of Environment and Conservation (DEC) has pumped water into the caves for the past five years (see 'Threatened wildlife of the Yanchep caves', *LANDSCOPE*, Winter 2002). However, the region's wetlands and associated vegetation have also been affected and these environmental values are harder to maintain.

What about the future? How long can water pumping be maintained in the Yanchep caves and the rare species protected? How many ecosystems and habitats can be maintained artificially in this way, as living museums, if climate change continues to affect WA and forces society to make necessary but difficult decisions about responding to its impacts?

To understand these issues and be ready for the challenges they present we need to have reasonable projections of future climate conditions and a sound understanding of the relationship between climate and biodiversity values (species, ecosystem structure and ecological processes).

Climate projections for WA

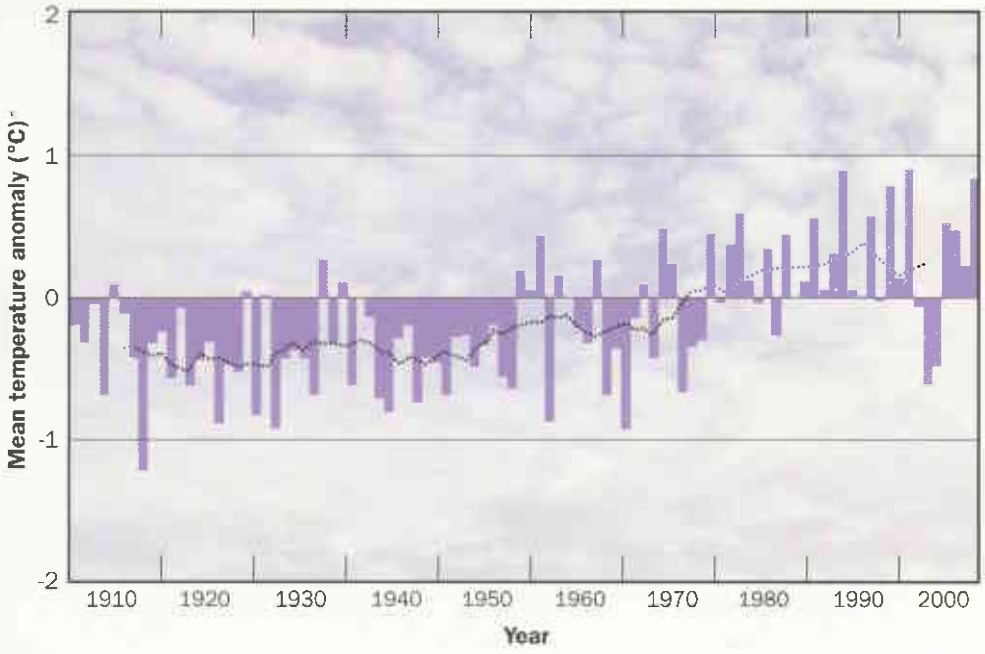
Climate projections, developed from computer models, suggest how the Earth's atmospheric processes are likely to change under specified conditions. Such projections are our best indication of future climates.

Previous page
Main Climate change will affect rainfall patterns and storm intensity.
Photo – Len Stewart/Lochman Transparencies
Inset Birds are a key indicator of environmental impacts resulting from climate change.
Photo – Jan van de Kam

Left Lower water levels in caves at Yanchep National Park threaten critically endangered invertebrate communities.
Photo – Michael James/DEC

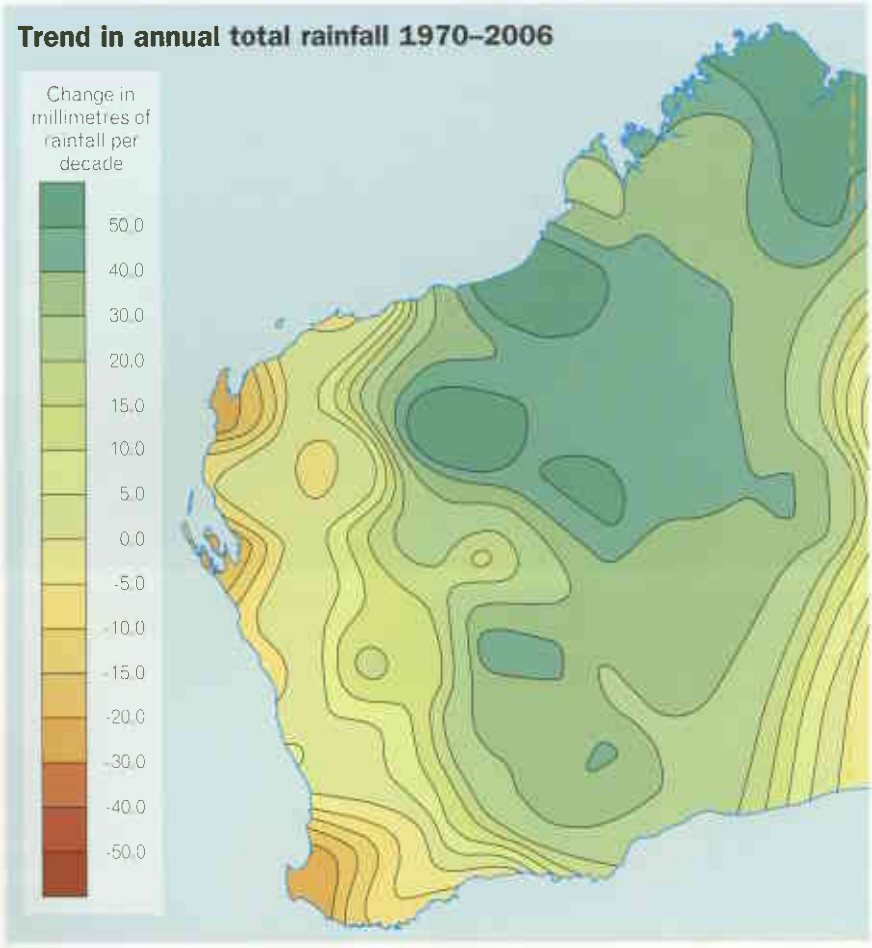
Below left Western Australia's annual mean temperatures increased during the twentieth century.
Courtesy Bureau of Meteorology

Western Australia's annual mean temperature (base 1961–1990)



Above Coastal wetlands such as Herdsman Lake could become smaller or disappear with lower rainfall and higher temperatures.
Photo – Michael James/DEC

Right Several coastal areas in WA—including the south-west—have had less rainfall while parts of the north-west have become much wetter over recent decades.
Courtesy Bureau of Meteorology



'Dangerous climate change' is a term used in the United Nations Framework Convention on Climate Change to indicate the level of change that should be avoided by international action. Analysis of the likely impacts of temperature increases suggests that dangerous climate change would occur if global average temperatures rose more than 2°C above the prevailing global average temperatures before widespread use of fossil fuels and land clearing started in about 1780. As temperatures have already risen by about 0.6°C since 1780, a further rise of only 1.4°C could bring dangerous climate change to the world.

Climate projections recently published by the CSIRO indicate that average annual temperatures are likely to continue to rise in WA. Even the relatively small temperature increases projected for the south-west approach 'dangerous' levels, but the temperature changes projected for the Pilbara far exceed dangerous levels. CSIRO projections of rainfall change in WA show that while average annual rainfall is likely to be reduced in the south-west region—a global biodiversity hotspot—it could increase in other parts of the State. However, the key climate events that affect our communities and the ecosystems with which we are familiar are likely to be more specific and local, such as hot dry periods, extended droughts, storms or floods. Global climate models are less capable of providing projections for

these parameters, so a risk management approach is required to analyse the potential impacts of climate changes of this type.

Climate and biodiversity

Climate is a fundamental determinant of where plants and other living species can establish themselves, survive and reproduce, and is a factor in the evolution of species. Therefore, when a region's climate changes, the region's biodiversity values—the species found in the region and the ecosystems they form—will also change.

Climate changes are having both direct and indirect influences on biodiversity values. Changes to climate directly affect species and the ecosystems they comprise, through changes to ambient temperature, rainfall, winds and extreme events. Climate changes also indirectly affect species and ecosystems by altering important factors such as fire frequency and behaviour, the spread and intensity of salinity and diseases such as dieback (caused by the introduced pathogen *Phytophthora cinnamomi*), competition and predation, and altering water flows and resources.

Other impacts will result from factors associated with climate change. For example, higher levels of carbon dioxide are likely to affect plant processes such as photosynthesis and are already increasing ocean acidity, with significant impacts on corals. Higher sea levels and more intense storm events will also affect highly diverse intertidal zones and wetlands.

Top left Climate change is expected to affect the spread of salinity, which is already a major threat to hundreds of species in the State's south-west.
Photo – Sallyanne Cousans

Above left Low-lying coastal areas are highly vulnerable to increased storm intensity and rising sea levels.
Photo – Clay Bryce/Lochman Transparencies

Left Scientists are yet to understand how climate change may affect the size and frequency of bushfires.
Photo – Len Stewart/Lochman Transparencies

Right Cracked earth caused by drought.
Photo – Marie Lochman

Below right White-striped freetail bat.
Photo – Babs and Bert Wells/DEC

Why is this animal moving home?

An animal's habitat comprises shelter and sources of food and water, all of which can be affected or even determined by weather and climate. When climate changes, so does habitat. The key question is whether thresholds of habitat change are crossed that result in habitat no longer being suitable for an animal. For instance, a drier climate may not support key seasonal food sources on which a species may depend.

While the range of most animals appears to be largely determined only partially and indirectly by climate, the range of a few animals appears to be directly affected by climate. For instance, the white-striped freetail bat (*Tadarida australis*) appears to have a climatic range determined by a combination of temperature and humidity threshold conditions. The bat migrates annually to stay within these conditions as seasons change and weather varies.

Ecological principles can provide guidance about many of these impacts. For instance, these principles would suggest that, as an area becomes warmer, species currently found there would migrate to a new location with their preferred environmental conditions. The new location would most likely be in an inherently cooler place, such as further from the equator, closer to a moderating influence such as an ocean or higher in the landscape, such as further up a mountainside. However, the situation doesn't appear to be as simple as this in WA.

Because the south-west has experienced repeated periodic climate changes over millions of years, many species indigenous to the region may have a very broad tolerance of extreme climate conditions. However, our understanding of how such episodic climate variation has affected the climatic dependence of the region's plant and animal species is limited. In other words, we are not sure what the climate thresholds might be for plants and animals in the south-west. This brings into sharp focus the need for effective and responsible risk management strategies.

Climate and soil are not the only factors that determine where plants and animals are found. Ecological processes, such as competition, are an important local factor in the distribution of plants and animals. Evolutionary history or local extinction from fire or predation also affect where species are found or are absent. To manage climate change, scientists need to know the extent to which climate is determining where a species is found; and whether climate change will favour rare or vulnerable plants and animals or the stresses and forces that may endanger them. In addition, little is known about the impacts of higher carbon dioxide concentrations on Australia's land and marine species.

Managing the risks of climate change

Because there are so many complex biological variables, it is hard to confidently project future climate conditions and the role of climate in determining the survival and reproduction of species. Observations of birds are frequently used, because they are well studied, highly visible and very mobile. Some observations indicate WA's ecosystems are already being affected by changes to climate. These include reduced productivity of some birds in the south-west, a southerly spread in the range of some tropical seabirds, and changes to the time of arrival and departure of some bird species in semi-arid regions.

What can we do in the face of this climate uncertainty and biological complexity? There are four key responses: firstly, to reduce the causes of climate change; secondly, to increase our understanding of the impacts of climate change on the State's ecosystems; thirdly, to limit the impacts of climate change as much as possible; and, finally, to safeguard the most vulnerable species.

Reducing the causes of climate change

Greenhouse gas concentrations need to be limited to levels that would not be dangerous. This will require reductions in global net emissions of 50 per cent or more by the middle of this century. Halting climate change will only be accomplished through concerted global action to increase energy efficiency, adopt renewable energy options, reduce greenhouse gas emissions through a range of technological innovations and minimise land clearing. However, biodiversity protection and land management can play an important role in lowering atmospheric concentrations of carbon dioxide by increasing vegetation. DEC is directly involved in developing and implementing revegetation options such as oil mallees and biodiversity plantings which help to

reduce salinity and erosion and protect biodiversity, while reducing atmospheric carbon dioxide. Similarly, removing stock and feral herbivores from pastoral areas and allowing vegetation to regenerate can increase carbon sequestration, protect biodiversity values and stabilise landscapes.

Better information

Understanding the role of climate in ecosystem composition and functioning will enable us to better prepare for the impacts of future climate change.

We need to identify the areas, species and ecosystems most at risk from projected changes in climate. Modelling climate change impacts requires good information about a large number of factors, including the distribution of species, the role of climate in determining this distribution, and climate thresholds species might have. Other required information includes the capacity of a species to migrate, the potential influence of climate change on pests, diseases, predators and other threats, and possible influences of higher atmospheric concentrations of carbon dioxide on plants and animals.

While changes to WA's climate have been measured using long-term specialised weather stations, there is no equivalent ecological monitoring system, apart from the FORESTCHECK system (see 'Keeping our forests in check', *LANDSCOPE*, Autumn 2004). Dedicated ecological monitoring stations in highly vulnerable ecosystems would enable scientists and managers to identify ecological changes and to develop and implement timely responses to them.

Refuges are likely to play a significant role in harbouring plant and animal species under changed climate conditions. It is important that the characteristics of future refuges be identified to support effective conservation initiatives such as national parks and conservation reserves. The implications of climate change for the design of WA's reserve system must be understood, and the role of regional links studied.

The indirect impacts of climate change also need to be well understood. For instance, lower rainfall will normally reduce the number and size of leaves, which in turn would reduce litter on the ground. But when lower rainfall is associated with a longer dry summer season and warmer temperatures are also experienced, the fire season is extended. In this circumstance, it is unclear how fire frequency, intensity and scale will be affected: more frequent, hotter and bigger fires or less frequent, cooler and smaller fires seem equally plausible using our current understanding of how climate change might affect fire behaviour.

Limiting the impacts of climate change

WA's ecological systems are already significantly affected by clearing, grazing, predation by introduced species such as the cat and fox, salinity, diseases such as *Phytophthora*-caused dieback and inappropriate fire regimes. Hence, one of the best ways to directly reduce the vulnerability of WA's ecological systems to climate change is to reduce the impacts and damage they already experience. We therefore need to replant or revegetate many cleared areas; reduce or exclude grazing and feral animals from areas having high biodiversity values; reduce cat and fox predation; reduce the spread of salinity and dieback; stop the introduction of new predators, pests and diseases; and take account of climate change when using fire as a management tool.

Protecting or establishing corridors that allow plants and animals to

Above left Insects and other rapidly reproducing highly mobile species can take advantage of changing climate conditions.
Photo – Dennis Sarson/Lochman Transparencies

Left Sea level rises could affect mangroves which stabilise many of WA's northern coasts.
Photo – Jan van de Kam

Right Beneath the Busselton Jetty. Low-lying coastal infrastructure and wetlands in the Busselton region are likely to be affected by rising sea levels and increased storm surges.
Photo – Ann Storrie

migrate as climate changes alter their environmental conditions and habitats is also a key strategy, both within the reserve system and across regional landscapes.

Identifying core climate refuges and providing them with specific protection will be an increasingly important option as climate change becomes more widespread. Where such refuges lie outside the reserve system, partnerships with landowners or extension of the reserve system will be crucial.

Safeguarding vulnerable species

Where climate change is likely to result in some species becoming locally extinct, seed collection and storage or protection in a zoo or a garden will be required. Protecting species in this way is an essential element of a comprehensive biodiversity conservation program, and will be an increasingly important option as climate change proceeds.

Our greatest threat

Climate change is increasingly described as the greatest threat facing the Earth and its ecosystems. WA is already being affected by climate change, with reduced rainfall becoming normal over much of the south-west. The impacts of this are already evident.

Maintaining WA's species and ecosystems will demand greater knowledge, increased efforts to reduce greenhouse gas emissions and actions to reduce environmental stresses such as salinity, diseases, introduced pests (see 'War against weeds' on pages 39-43) and predators and inappropriate fire regimes. In addition, climate refuges and links will need to be identified and protected.

Initiatives of this type already form the basis of DEC's nature conservation programs, but much more will be required to protect WA's biodiversity values if climate change alters the processes which underpin the State's ecological systems.

Causes of climate change

Scientists have long sought to understand the causes of climate change, including variations in the energy received from the sun, smoke from erupting volcanoes, the emergence of mountain ranges or islands, continental drift and changes in the chemical composition of the atmosphere.

While all these factors can affect climate, there are two broad causes of long-term climate changes. Variations in the amount of solar radiation and energy received by Earth—resulting from minor alterations in the Earth's orbit around the sun, the tilt of the Earth's axis and a wobble in the Earth's axis—could combine to alter the amount of solar energy received on the Earth's surface. These long-term influences on the Earth's climate, now termed the 'Milankovitch Cycles', have influenced the development of glaciations and warmer periods for millions of years. Milankovitch Cycles are independent of human activity.

The second long-term cause of climate change is altered composition of the Earth's atmosphere resulting from human activities, especially fossil fuel use and land clearing. Climate changes resulting from human-induced changes to atmospheric composition are popularly termed 'the greenhouse effect'. Society is challenged in 2006 both to reduce atmospheric changes and to successfully adapt to climate changes that are already unavoidable.

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In writing this article, the authors referred to a review article in the *Bulletin of the American Meteorological Society*, February 2006, by Lynda Chambers entitled 'Associations between climate change and natural systems in Australia'.

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