

**What are the
drivers and
pressures on our
environment?**

Mountain Spiny Crayfish – *Euastacus crassus*. This crayfish species is located in creeks and small waterways between 600 m and 1000 m elevation in Namadgi National Park and other areas. Its habitat is thought to be restricted to the cooler upper reaches of drainages in the ACT, NSW and Victoria, and the species is considered fragmented across its range, due to the isolating effects of unsuitable warmer lowland habitat. No population data are available for *Euastacus crassus* in the ACT and little is known about its biology. It is not listed as endangered or vulnerable under the *Nature Conservation Act 2014*. It is, however, on the IUCN Red List of threatened species and listed in Victoria. A current project is under way to survey for this species to determine its distribution in the ACT.

Photo: Mark Jekabsons, ACT Government



2 Climate change

2.1 Main findings



The evidence for climate change is overwhelming. Levels of greenhouse gases in the atmosphere are rising.

Temperatures are going up. Spring is arriving earlier, and summers in both hemispheres are hotter. Ice sheets are melting. Sea level is rising. The patterns of rainfall and drought are changing. Heatwaves are getting worse, as are extreme storm events. The oceans are acidifying. These environmental changes have impacts on humans – hunger, disease, drought and flooding are likely to worsen, as are the resulting conflicts and refugee crises.

The Australian Capital Territory (ACT) is already seeing the effects of climate change, and further impacts are predicted. In particular, we expect:

- lower rainfall, which will affect water availability and quality, water-dependent ecosystems, agriculture and recreational amenity
- higher temperatures and increased fire risk, which will affect human health and property, and vulnerable ecosystems
- more extreme weather events, which will affect property and ecosystems.

However, the impact of climate change on the population will depend on the degree to which we can mitigate the degree of change and increase our resilience to change that now cannot be avoided.

Climate change action must be tackled at local, regional and national levels, but cities may be best placed to take serious action and play a leadership role in the reduction of greenhouse gases. In taking this path, they can realise the opportunities inherent in the task of transforming economic activity. Both mitigation and adaptation are needed. Mitigation is required to reduce carbon pollution to limit the degree of climate change, and adaptation is needed to limit the impacts of climate change.

The ACT Government, with strong community support, is responding robustly and constructively to the challenge. It has developed and is implementing mitigation strategies and is working on an adaptation strategy.

It has legislated greenhouse gas emissions reduction targets that are not only consistent with the recommendations of the Intergovernmental Panel on Climate Change, but are also the most ambitious targets in Australia. The ACT Government has also legislated an actions plan for achieving these targets. Current projections



show that the ACT is on track to achieve its target commitment. This demonstrates that we, as a community working together, can make a positive contribution to the global climate change mitigation effort by demonstrating that the move to a less carbon-intensive society is feasible.

Adaptation is well supported politically, and progress has been made on collaborative work to build knowledge and develop responses. A coordinated action plan is still to be released.

2.2 Introduction

Earth's climate has been changing during the past century. The atmosphere and oceans have warmed, glaciers and ice sheets have decreased in size, sea levels have risen, and there has been an increase in extreme weather events. There is strong scientific evidence that human activities that result in greenhouse gases being emitted – such as burning fossil fuels and large-scale land-use change – have been the main cause of these climatic changes. It is also anticipated that there will be further climatic changes as a result of human society's continuing release of greenhouse gases.

This chapter will:

- define climate change
- explain why climate change is important
- explain how climate change is measured using
 - climate change indicators
 - greenhouse gas emissions
- describe and assess the magnitude of climate change impacts in the Australian Capital Territory (ACT) on
 - humans
 - the natural environment
- summarise the relationship between climate change and resilience
- summarise Government and community responses to climate change by way of
 - adaptation
 - mitigation.

2.2.1 What is climate change?

The United Nations Framework Convention on Climate Change^a defines climate change as:

... a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

The definition of climate change from the Intergovernmental Panel on Climate Change (IPCC) recognises any measurable persistent change in climate that lasts for a decade or longer, whether due to natural variability or as a result of human activity. Both definitions are relevant in the discussion of climate change as a pressure on our environment.

The Australian Capital Territory (ACT) Commissioner for Sustainability and the Environment accepts the definitive assessment of the evidence for climate change comprehensively presented by the IPCC in its Fifth Assessment Report, released in November 2014. This group of more than 3000 scientists from 85 countries concludes that:¹

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.

a http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf; the convention entered into force on 21 March 1994.



This is the moment when we must come together to save this planet. Let us resolve that we will not leave our children a world where the oceans rise and famine spreads and terrible storms devastate our lands.

-Barack Obama

The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

This assessment is supported by the Australian Academy of Science, which concludes that:²

Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems.

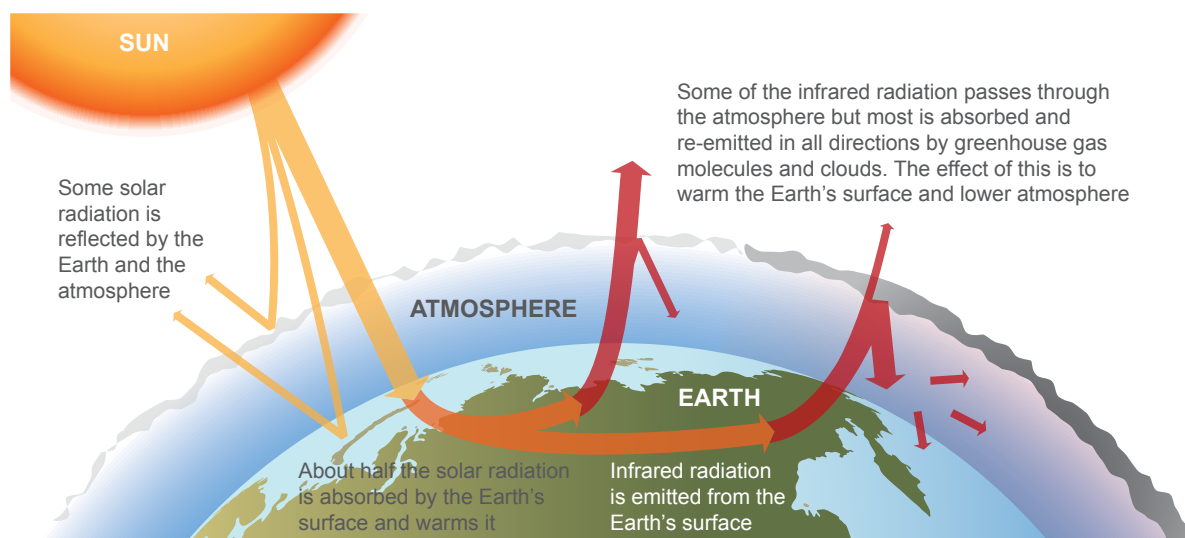


Snow falls in the ACT are predicted to decrease as our climate changes

Photo: Penny Bradfield, Fairfax Syndication

The science behind these statements is supported by extensive studies based on four main areas of evidence:

- **Physical principles** established more than a century ago tell us that certain trace gases in the atmosphere, such as carbon dioxide and water vapour, restrict the radiant flow of heat from Earth to space. This mechanism, known as the 'greenhouse effect', keeps Earth's surface and lower atmosphere considerably warmer than they would otherwise be (Figure 2.1). The gases involved are called 'greenhouse gases'. An increase in greenhouse gas concentrations raises the temperature of the surface. The burning of fossil fuels releases carbon dioxide. Because of this, since the start of the industrial era (about 1750), the effect of human activities on climate has, overall, been a warming influence.
- **The record of the distant past** (millions of years) tells us that climate has varied greatly through Earth's history. It has, for example, gone through 10 major ice-age cycles during about the past million years. During the past few thousand years of this period, during which civilisations developed, climate was unusually stable. Evidence from the past confirms that climate can be sensitive to small persistent changes, such as variations in Earth's orbit.
- **Measurements from the recent past** (the past 150 years) tell us that Earth's surface has warmed as atmospheric concentrations of greenhouse gases have increased through human activities, and that this warming has led to other environmental changes. Although climate varies from decade to decade, the overall upward trend of average global surface temperature during the past century is clear.
- **Climate models** allow us to understand the causes of past climate changes and to project climate change into the future. Together with physical principles and knowledge of past variations, models provide compelling evidence that recent changes are due to increased greenhouse gas concentrations in the atmosphere. They tell us that, unless greenhouse gas emissions are reduced greatly and greenhouse gas concentrations are stabilised, greenhouse warming will continue to increase.



Source: Intergovernmental Panel on Climate Change³

Figure 2.1 The greenhouse effect

Some of the key changes noted by the IPCC report are:³

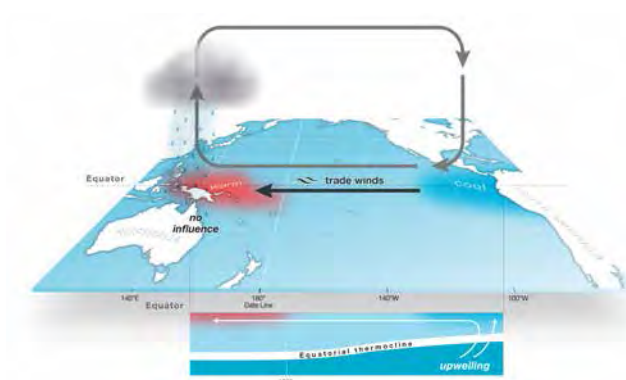
- Each of the past three decades has been successively warmer at Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the past 1400 years.
- Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010. It is virtually certain that the upper ocean (0–700 m) warmed from 1971 to 2010, and it is likely that it warmed between the 1870s and 1971.
- During the past two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.

Climate variability

It should be noted that Australia's climate has large natural variations, and human-induced climate change is therefore superimposed on natural variability. This variability has existed for many thousands of years, and poses challenges for recording and analysing changes in climate extremes, not just in Australia, but across the whole world.

For the Australian region, the main drivers of natural variability are the:

- El Niño–Southern Oscillation (ENSO; Figure 2.2)
- Indian Ocean Dipole
- Madden–Julien Oscillation
- Southern Annular Mode.



Source: Bureau of Meteorology, www.bom.gov.au/climate/enso/history/In-2010-12/three-phases-of-ENSO.shtml

Figure 2.2 El Niño–Southern Oscillation

Of these, ENSO has the most significant influence on Australia's – and most likely the global – climate. In particular, it affects south-eastern Australia, including the ACT and surrounding region. ENSO refers to shifts in ocean and atmospheric conditions. There are three phases of ENSO: El Niño, La Niña and the neutral (or 'normal') phase. An El Niño phase is associated with abnormally warm central and east equatorial Pacific Ocean surface temperatures, while the La Niña phase is associated with cool ocean temperatures in this region. Both extremes are associated with a characteristic spatial pattern of droughts and floods. An El Niño episode is usually accompanied by drought in south-eastern Australia, Asia, India, south-eastern Africa, Amazonia and north-east Brazil, with fewer than normal tropical cyclones around Australia and in the north Atlantic Ocean.

The frequency and duration of these phases are highly variable. For example, the El Niño phase typically occurs every 3–8 years. Each event evolves and decays on seasonal timescales (ie months), and reaches a peak in intensity before conditions start to return to a near-normal state. However, historically, successive events over several years can and do occur. Two successive La Niña events occurred in 2010–11 and 2011–12, causing the wettest two-year period on record for Australia as a whole. The typical ENSO

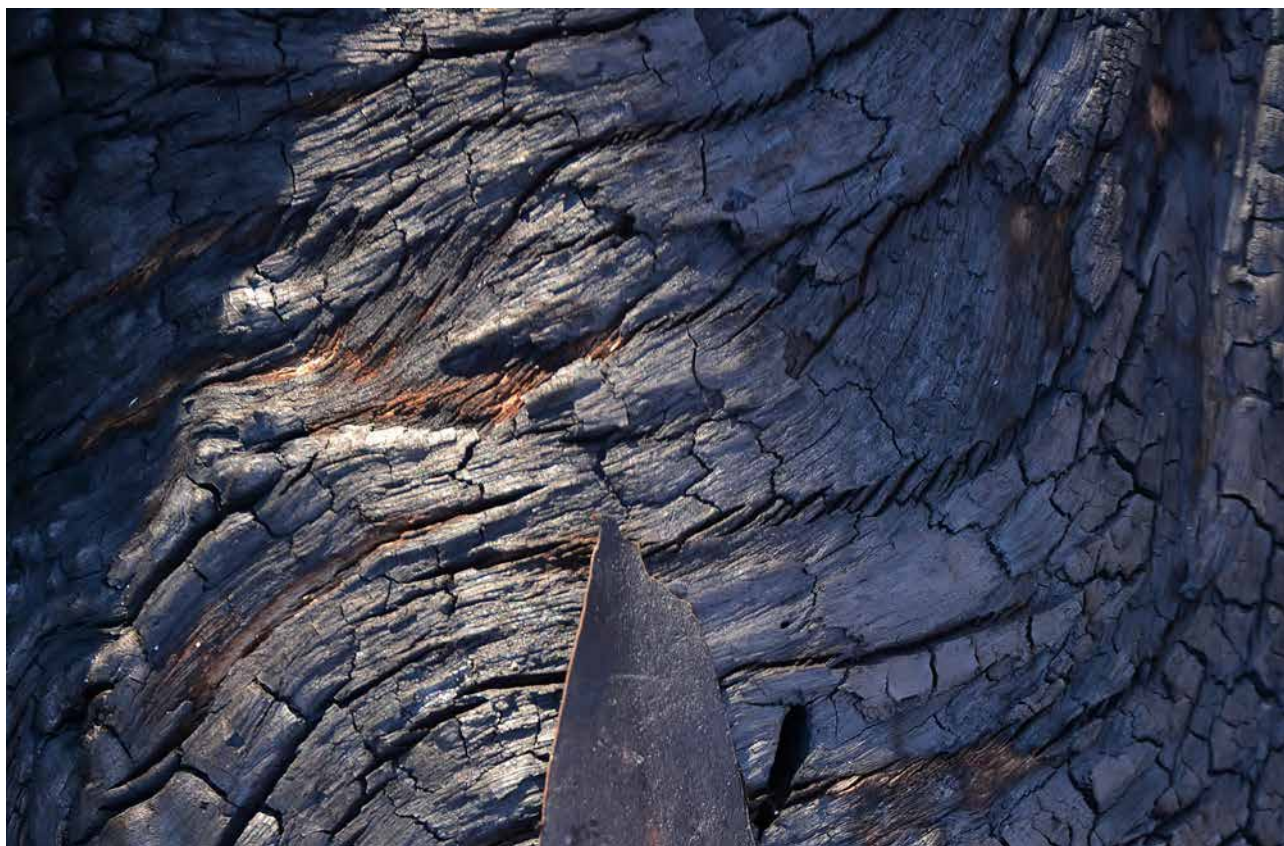
cycle includes a gradual build-up of ENSO conditions beginning in late Southern Hemisphere autumn or early Southern Hemisphere winter. ENSO typically peaks in late spring or early summer (near the end of the calendar year) and then wanes in late summer or early autumn. Although every El Niño has behaved differently, generally the ENSO cycle spans the course of a year, with autumn being the transitional period. Successive events are more common with La Niña than with El Niño.

The IPCC's 5th Assessment Report concluded that there is high confidence that ENSO will very likely remain as the dominant mode of interannual variability in the future and, due to increased moisture availability, the associated precipitation variability on regional scales will likely intensify.

2.2.2 Why is climate change important?

Climate change has emerged during the past three decades as the most significant challenge to our environment. It is certain that climate change will affect not only us, but our children and grandchildren as well. Climate change and its impacts therefore pose a serious challenge for governments and communities around the world.^{2,3}

The ACT faces a number of serious challenges related to climate change, including decreased rainfall, and increased temperatures and fire danger.⁴ It is important to understand the drivers and impacts of climate change to develop strategies that address the risks they pose to human wellbeing. Building resilience in the social and environmental systems of the ACT is a core part of achieving this, as it allows us to focus on maintaining the desired values of the ACT's environment despite the effects of climate change.



Predicted impacts of climate change in the ACT include higher temperatures and an increased risk of fire

Photo: Mark Jekabsons

Climate change and humans

Modern societies are highly dependent on a stable climate. Human civilisations emerged mostly during the past 10 000 years, a timespan that coincides with the geological epoch known as the Holocene, characterised by relatively stable climate conditions. The development of agriculture, the formation of settled towns and cities, and the associated cultural changes may not have been possible without the onset of the Holocene.⁵⁻⁷ Under projected changes to Earth's climate in the coming decades and centuries, there is significant risk that the conditions that have supported human wellbeing during the past millennia will be disturbed.⁸ Australia is expected to experience an increase in average temperatures, extreme weather events and fire danger; a change in

rainfall patterns; and a decrease in soil moisture and run-off.⁹ A changing climate also leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather events.¹⁰

Humans are likely to be affected by climate change in multiple ways, such as through:^{9,11-14}

- negative consequences for water supply and agricultural productivity
- direct and indirect threats to human health
- risks and damage to infrastructure and associated costs
- negative impacts on natural environments and ecosystems.



Climate change and the natural environment

Natural ecosystems are vulnerable to climate change. It is therefore likely that the delivery of ecosystem services will be substantially altered under future scenarios of climate change.¹⁵⁻¹⁷

In the ACT, the combined effect of decreased rainfall, increased temperatures and increased fire incidents is likely to substantially alter the function, composition and structure of ecosystems.¹⁸ As a result of these various climate change impacts, the capacity of ecosystems to provide benefits such as clean air, food and water may be hampered, and the cultural values of ecosystems may be diminished.

2.2.3 How do we measure climate change?

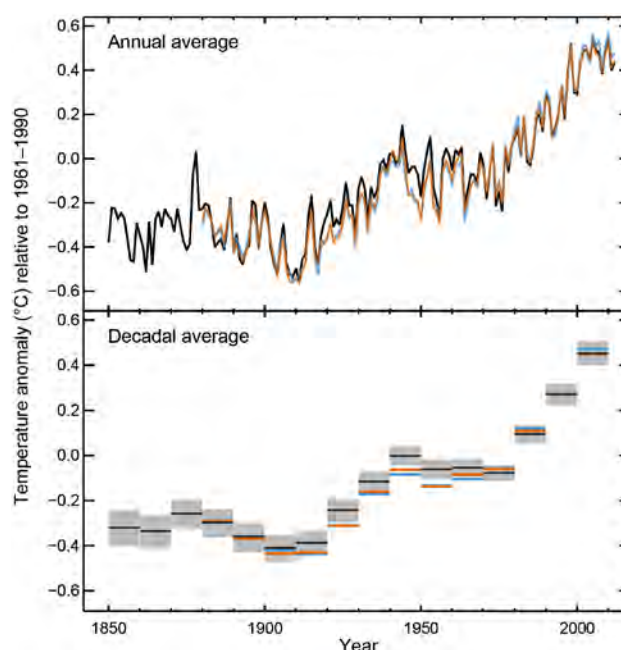
Measuring climate change involves the use of indicators that establish the current state of the climate, trends or changes in climate, pressures causing the change and the impacts caused by the change.

The ACT State of the Environment Report has adopted, and modified as necessary, indicators developed by the IPCC:¹⁹

- state and trend indicators (evidence of climate change)
 - changes in local and regional mean temperatures
 - changes in local and regional climate variables
 - changes in the intensity or frequency of extreme events
- pressure indicators (causes of climate change)
 - greenhouse gas emissions levels.

Mean temperatures

Each of the past three decades has been successively warmer at Earth's surface than any preceding decade since 1850 (Figure 2.3). In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the past 1400 years.

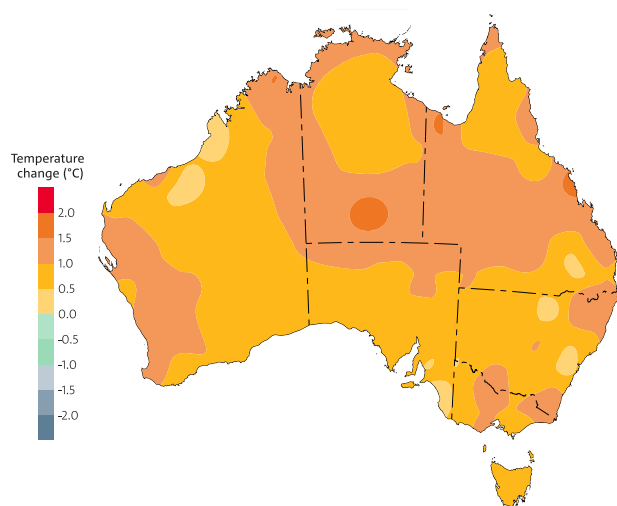
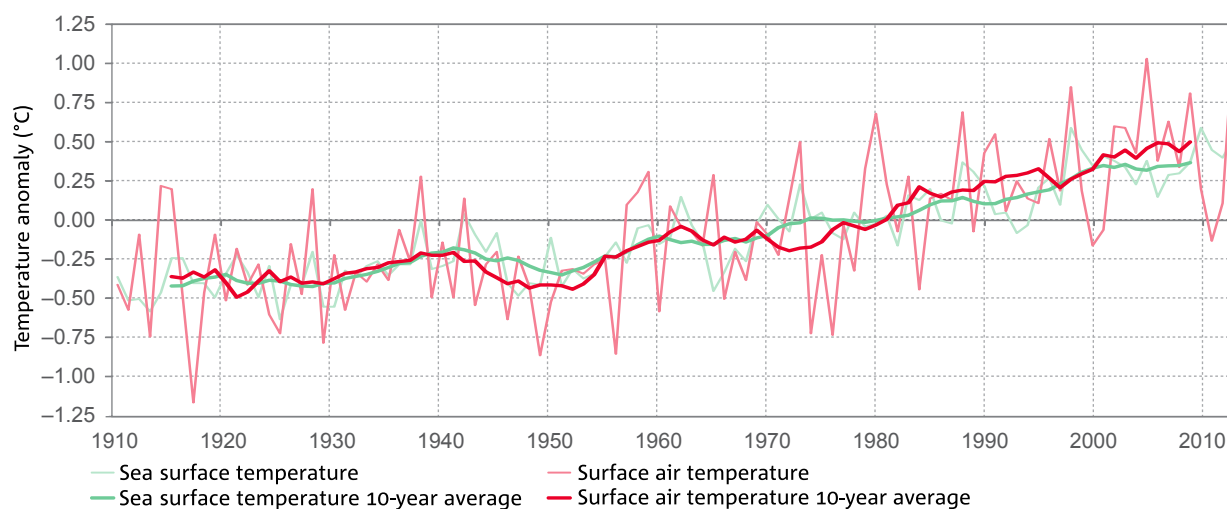


Top: Annual mean values from three datasets. Bottom: Decadal mean values from three datasets, including the estimate of uncertainty for one dataset (black). Anomalies are relative to the mean of 1961–1990.

Source: Intergovernmental Panel on Climate Change²⁰

Figure 2.3 Observed global mean combined land and ocean surface temperature anomalies, 1850–2012

Temperature has risen across Australia and in the surrounding oceans since the beginning of the 20th century, although there are regional differences (Figure 2.4). Australian temperatures are expected to rise by approximately half a degree or more by 2030 relative to 1990, bringing more hot days and nights.²¹



Top: Deviations from the 1961–1990 average of sea surface temperature and temperatures across land in the Australian region.

Bottom: Distribution of annual average temperature change across Australia since 1910.

Source: Adapted from the Bureau of Meteorology & CSIRO,²¹ pp 4–5

Figure 2.4 Sea surface temperature and temperatures across land in the Australian region since 1910



An Erickson Air Crane drops water on a bushfire near the eastern edge of the Brindabella Ranges. With a warming climate the ACT will experience increased severe fire danger.

Photo: Nick Moir, Fairfax Syndication

The ACT region

The NSW/ACT Regional Climate Modelling (NARClIM) project developed climate change projections for the ACT and region under a range of possible future climates. NARClIM is a multiagency research partnership between the New South Wales (NSW) and ACT Governments, and the Climate Change Research Centre at the University of NSW.^b

The long-term mean annual daily maximum temperature trend indicates that temperatures in the region have been increasing since around 1950. The most recent decades have experienced the largest increases in three temperature variables (ie average, maximum and minimum). The ACT is expected to experience an increase in all three annual temperature variables in the near future (2020–2039) and the far future (2060–2079) (Figure 2.5).

Maximum temperatures are projected to increase by 0.7 °C in the near future and by 2 °C in the far future. Spring will experience the greatest changes in seasonal mean maximum temperatures, increasing by 2.5 °C in the far future. Minimum temperatures are projected to increase by 0.6 °C in the near future and by 2 °C in the far future.

Currently, the ACT experiences an average of around six hot days each year (ie temperatures above 35 °C). The region is projected to experience an additional two hot days in the near future and six hot days in the far future. These increases will be seen mainly in spring and summer, although, in the far future, hot days will also likely extend into autumn.⁴

^b For an overview and references to the key technical documents, see www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARClIM.

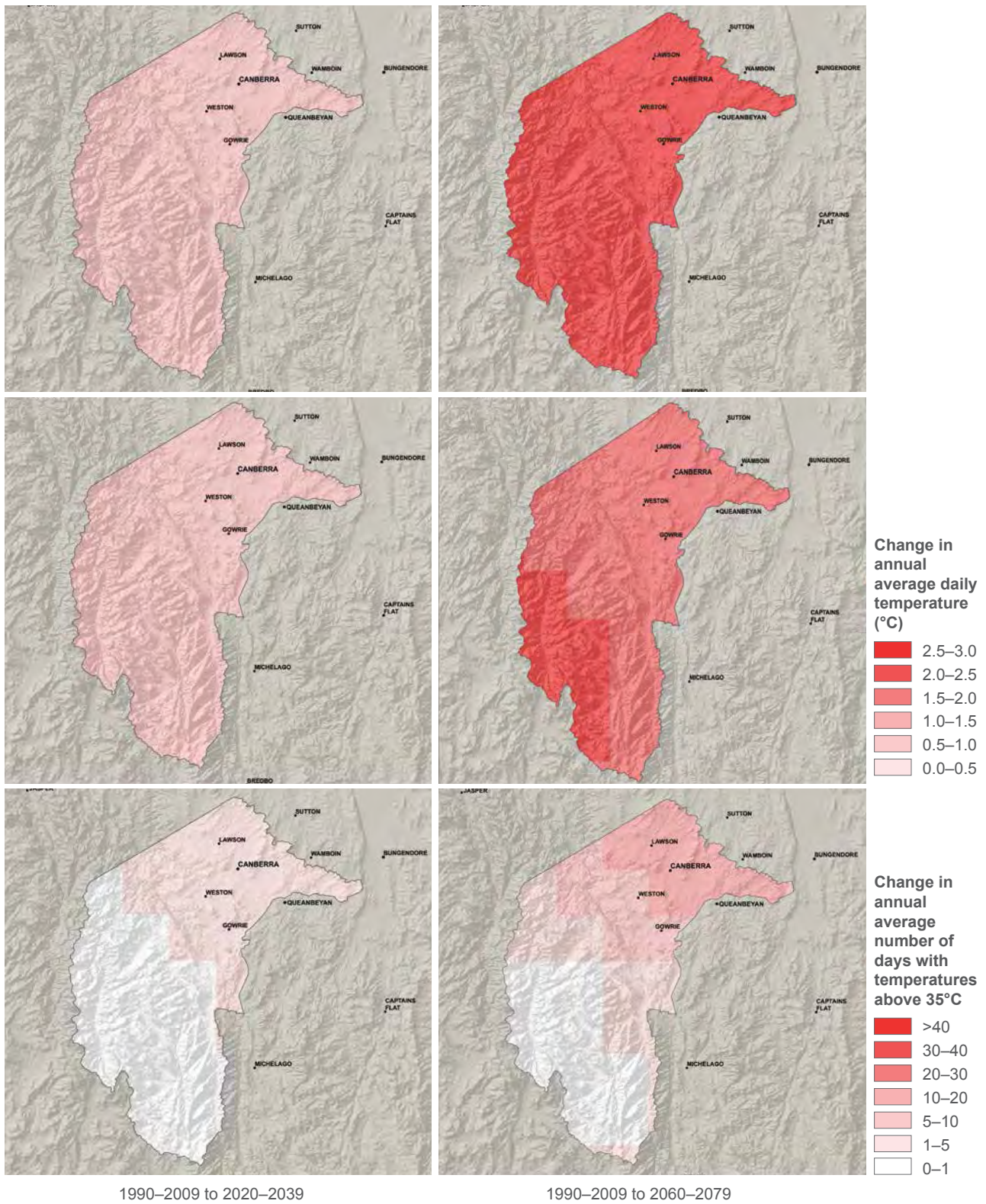


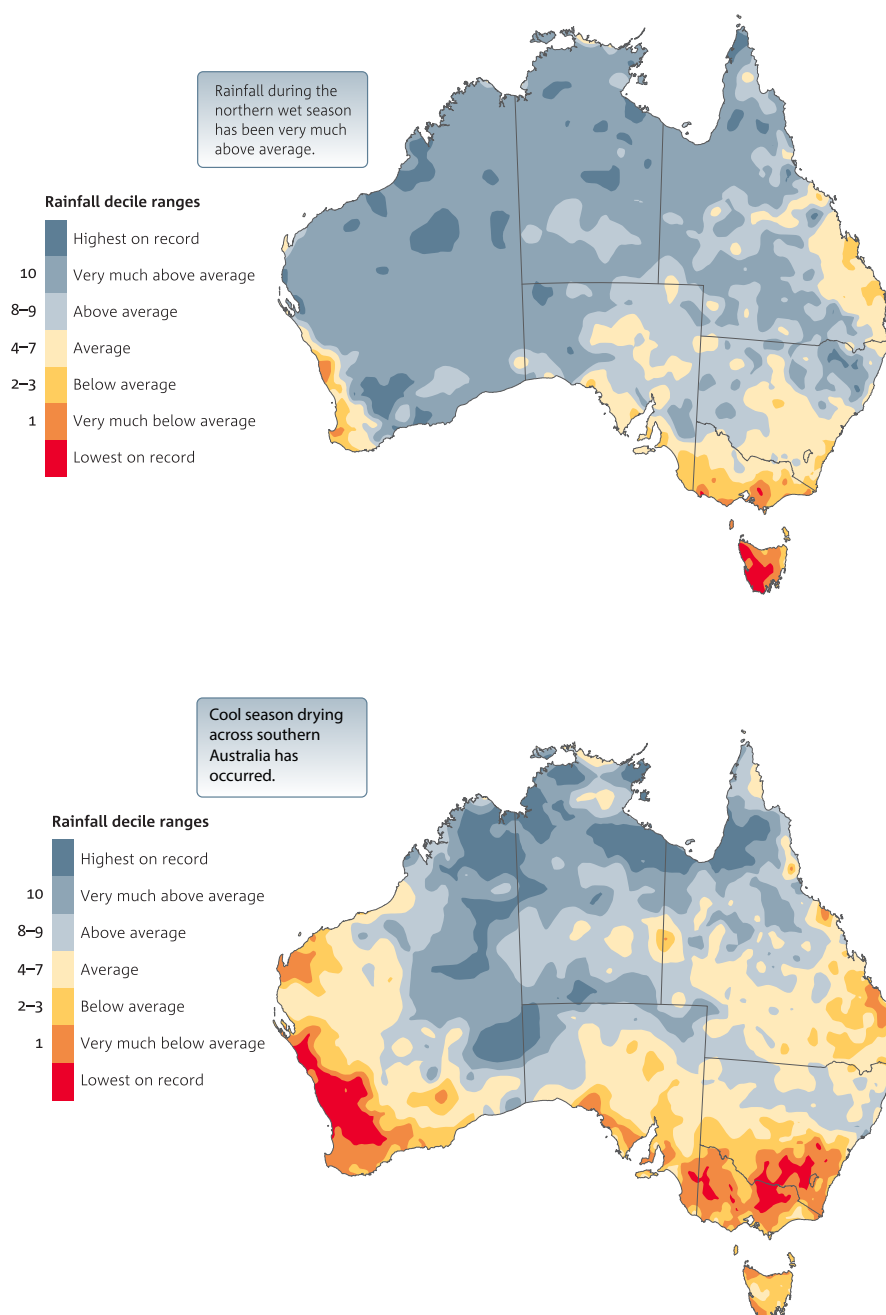
Figure 2.5 Mean annual temperature projections for the ACT, 2020–2039 and 2060–2079

2 Climate change



Climate variables

In northern Australia, recent rainfall has been higher than average, and in southern Australia, it has been lower than average (Figure 2.6).



The maps show the relative ranking (in 10% increments) of rainfall from July 1995 to June 2014 compared with the average since 1900 for (top) northern Australian wet season (October–April) and (bottom) southern Australian wet season (April–November).

Source: Adapted from the Bureau of Meteorology & CSIRO,²¹ pp 6–7

Figure 2.6 Rainfall across Australia, July 1995 to June 2014



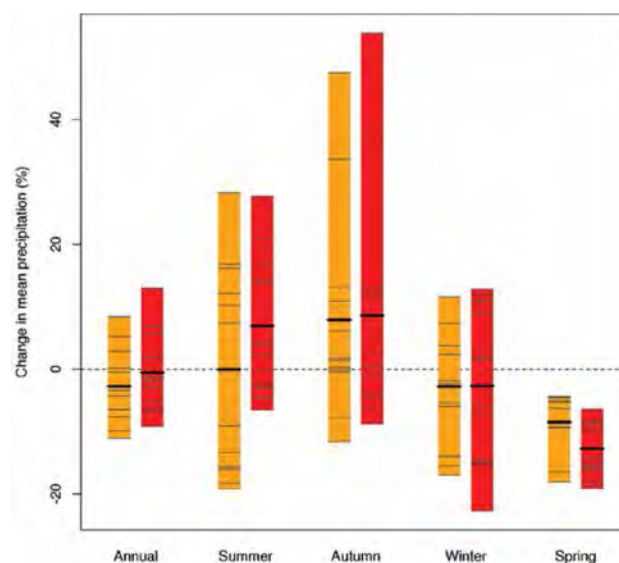
Australian average annual rainfall has increased since national records began in 1900, largely due to marked increases in rainfall across the north-west from October to April. In recent decades, declines in rainfall have been observed in the south-west and south-east of the continent, with a 17% decline in average winter rainfall since 1970 in the south-west and a 15% decline in the south-east. The cool-season drying across southern Australia in recent decades, and evidence of increased rainfall across the Southern Ocean, is associated with changes in atmospheric circulation. Although natural variability likely plays a role, a range of studies suggest that ozone depletion and global warming are contributing to circulation and pressure changes, most clearly affecting the south-west. However, uncertainties remain, and this is an area of ongoing research.

The reduction in rainfall is amplified in stream flow in our rivers and streams. In the far south-west, stream flow has declined by more than 50% since the mid-1970s. In the far south-east, stream flow during the 1997–2009 drought (referred to as the millennium drought) was around half the long-term average.²¹

The ACT region

Projections for the region's annual average rainfall range from a decrease (drying) of 11% to an increase (wetting) of 8% by 2030, and projections still span both drying and wetting scenarios (–9% to +13%) by 2070. The ACT currently experiences considerable rainfall variability across the region, and from season to season and from year to year, and this variability is also reflected in the projections.

All models agree that spring rainfall will decrease in the ACT in the near and far future, but the size of the decrease varies between models for both the near future (–18% to –4%) and the far future (–6% to –19%). Seasonal rainfall projections for the near future span both drying and wetting scenarios for summer (–19% to +28%), autumn (–12% to +48%) and winter (–17% to +12%). In the far future, there are projected changes for summer (–7% to +28%), autumn (–9% to +54%) and winter (–23% to +13%) (Figure 2.7).⁴



Notes:

1. Yellow bars represent the near future (2020–2039).
2. Red bars represent the far future (2060–2079).
3. Thin grey lines represent the individual models; there are 12 thin lines or models for each bar.
4. The thick line represents the average of all 12 models for the region.
5. The length of the bar shows the spread of the 12 model values for the region.
6. Each line is the average for the region. They do not represent a single location in the region.

Source: NSW Office of Environment and Heritage & ACT Government,⁴ p 12

Figure 2.7 Projected changes in average rainfall for the ACT, annually and by season, in the near future and far future

Extreme events

Changes in many extreme weather and climate events have been observed since about 1950:²²

- In a warming climate, extremely cold days occur less often and very hot days occur more often. It is very likely that the number of cold days and nights has decreased, and the number of warm days and nights has increased on the global scale.
- It is likely that the frequency of heatwaves has increased in large parts of Europe, Asia and Australia. Since records began, trends in the frequency, duration and intensity of heatwaves have increased across much of Australia, with these trends accelerating since 1970.

2 Climate change



- It is likely that there are more land regions where the number of heavy precipitation events has increased than where it has decreased.
- It is very likely that human influence has contributed to the observed global-scale changes in the frequency and intensity of daily temperature extremes since the mid-20th century.

In Australia, human-induced climate change is superimposed on natural variability. Some changes in Australia's climate extremes stand out from the background variability. As a whole, the average sea level around Australia is expected to be about 15 cm higher by 2030 relative to 1990. Some models project that tropical cyclones will become less frequent – but more severe in peak rainfall intensity – as the world warms. Bushfires are more likely as the average fire danger index increases, particularly in the south-east and south-west part of the continent.²³

The ACT region

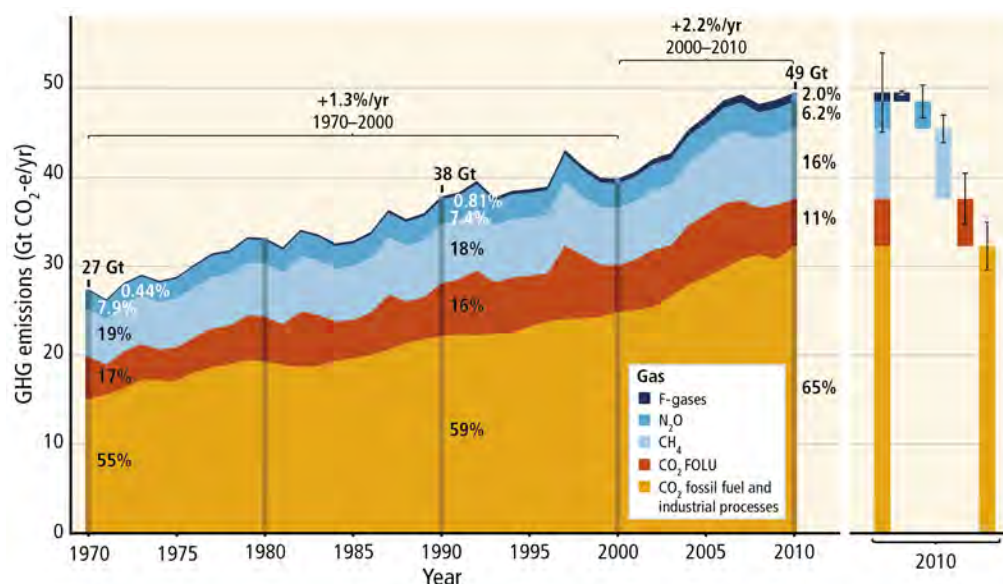
Severe and average fire weather is projected to increase. The ACT is projected to experience an increase in average and severe Forest Fire Danger Index in the near and far future. Although these

changes are relatively small in magnitude (three more days every decade), they are projected to occur in prescribed burning periods (spring) and the peak fire-risk season (summer). The northern ACT will have the greatest increases, and these increases occur across all seasons.

Autumn is projected to have a decreased severe fire risk in the near future due to the projected increase in autumn rainfall across the region, but there is less confidence in the projections for the far future.

Greenhouse gas emissions

Anthropogenic (human-influenced) greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever (Figure 2.8). This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that have been unprecedented in at least the past 800 000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.³



CH₄ = methane; CO₂ = carbon dioxide; CO₂-e = carbon dioxide equivalent; F-gases = fluorinated gases; FOLU = forestry and other land use; GHG = greenhouse gas; Gt = gigatonne; N₂O = nitrous oxide; yr = year
Source: Intergovernmental Panel on Climate Change,¹ p 5

Figure 2.8 Total annual anthropogenic greenhouse gas emissions, by groups of gases, 1970–2010



The ACT Government uses some electric vehicles in an effort to reduce emissions from transport

Photo: ACT Government

Greenhouse gases emitted by human activities and measured in the ACT are:

- carbon dioxide, which enters the atmosphere by burning fossil fuels (coal, natural gas and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (eg manufacture of cement)
- methane, which is emitted during the production and transport of coal, natural gas and oil. Methane emissions also result from livestock and other agricultural practices, and from organic waste decay in municipal solid-waste landfills
- nitrous oxide, which is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste
- fluorinated gases, including hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride, which are synthetic gases that are emitted from a variety of industrial processes. These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as high global-warming potential gases.

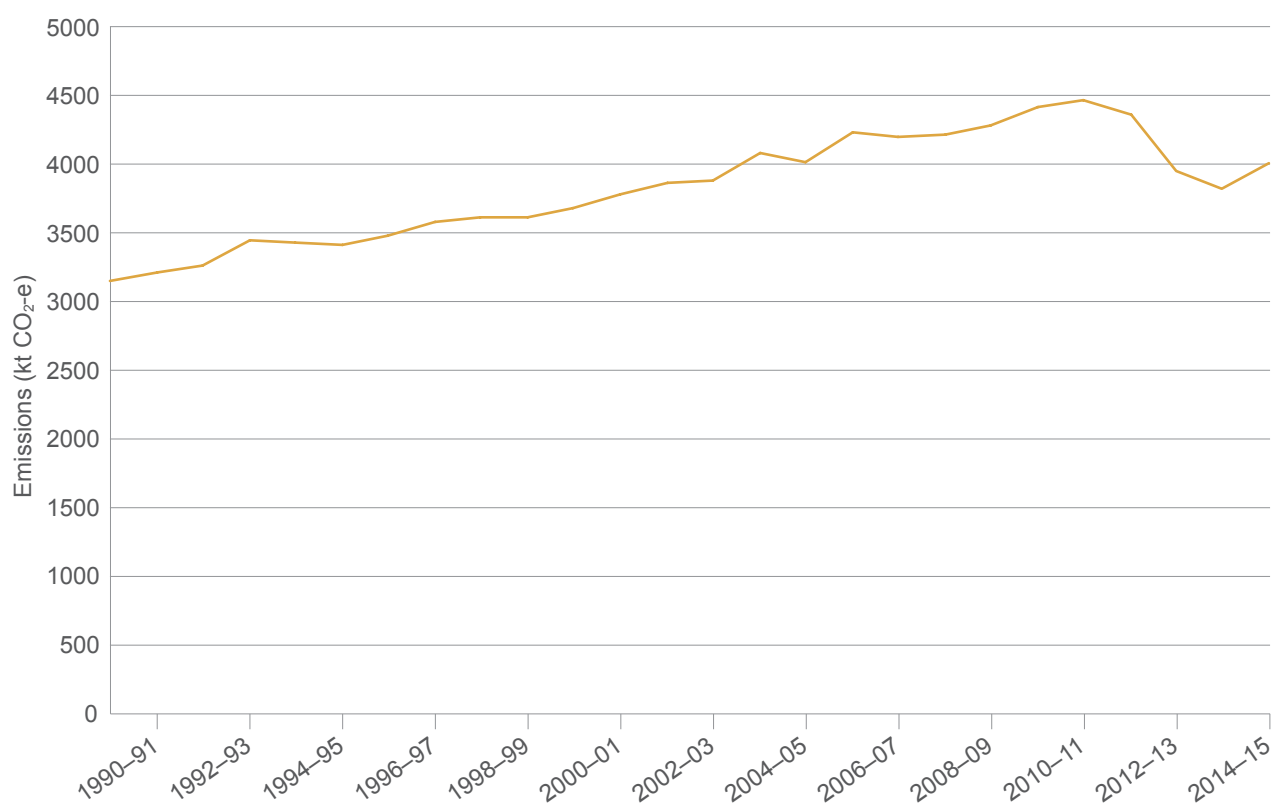
The ACT region

Total ACT greenhouse gas emissions

It should be noted that the ACT Greenhouse Gas Inventory includes emissions for electricity consumed in the ACT but produced outside the Territory. These are called scope 2 emissions. The National Inventory Report, prepared by the Australian Government, does not account for scope 2 emissions. Instead, it assigns emissions to the jurisdictions where the emissions are actually generated. The ACT Government has chosen to include scope 2 emissions to recognise and take responsibility for all emissions associated with the consumption of energy, whether or not they occur inside or outside of the Territory.

ACT greenhouse gas emissions rose steadily during the years until 2010 (Figure 2.9), when the ACT Government prescribed a legislative greenhouse gas emissions reduction target (the *Climate Change and Greenhouse Gas Reduction Act 2010*). The target is a reduction in greenhouse gas emissions of 40% below the 1989–90 level of emissions by 2020. This target is consistent with the IPCC's recommendations and the most ambitious target in Australia. As a consequence of the legislation and various supporting initiatives (for an example, see Case study 2.1 on page 37), emissions have steadily fallen since 2010–11 (Figure 2.9 and Table 2.1).

2 Climate change



kt CO₂-e = kilotonnes of carbon dioxide equivalent

Note: The trends in total ACT emissions are correct; however, methods used in the greenhouse gas inventory have changed over the period.

Source: Pitt&Sherry²⁴

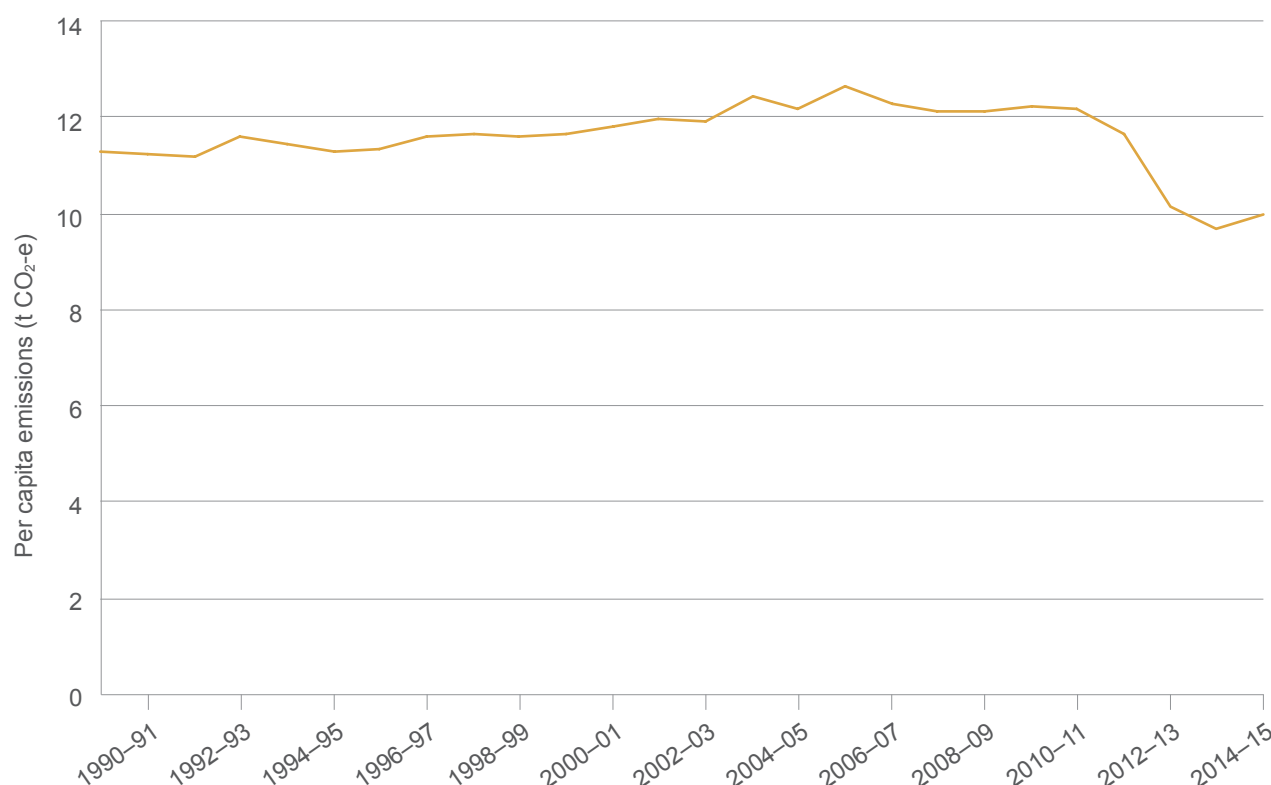
Figure 2.9 Total ACT greenhouse gas emissions, 1990–2014

Table 2.1 ACT greenhouse gas emissions, 2010–2015

	1989–90	2010–11	2011–12	2012–13	2013–14	2014–15	2020 target
Total emissions including LULUCF (kt CO ₂ -e)	3185.5	4459.7	4352.1	3869.2	3759.8	3934.1	1911
Total emissions excluding LULUCF (kt CO ₂ -e)		4471.6	4364.3	3939.0	3829.6	4004.0	

kt CO₂-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use changes and forestry

Per-capita emissions for the ACT peaked earlier (in 2005–06) than the total Territory emissions and dropped below the 1989–90 level in 2012–13 (Figure 2.10).



t CO₂-e = tonnes of carbon dioxide equivalent

Note: The trends in total ACT emissions are correct; however, methods used in the greenhouse gas inventory have changed over the period.

Source: Pitt&Sherry²⁴

Figure 2.10 ACT per-capita greenhouse gas emissions, 1990–2014

Emissions by source

Stationary energy is the dominant source of emissions in the ACT, and produced more than two-thirds of the carbon dioxide equivalent emissions that were attributable to the ACT in 2014–15, as in all previous years.

The transport sector is also very important, with one-quarter of emissions coming from petroleum-based fuels used in transport vehicles. Industrial processes, waste, and fugitive emissions related to the energy sector account for the remainder of emissions. The net effect in 2014–15 of land use, land-use changes and forestry was a reduction in emissions of 69.8 kt of carbon dioxide equivalent.

Figure 2.11 provides the broad breakdown of ACT emissions based on results for the years 2012–2015.

Emissions relating to some form of energy use accounted for around 93% of emissions in 2014–15. This is the combined emissions of stationary energy, energy for transport and fugitive emissions (which, in the case of the ACT, is the leakage of natural gas). Stationary energy emissions are predominantly attributable to the generation of electricity used in the ACT, but also include emissions from use of natural gas, non-transport use of petroleum fuels, including LPG, heating oil and fuel oil, and use of fuel wood. Emissions attributed to non transport petroleum fuels and fuel wood are very small.

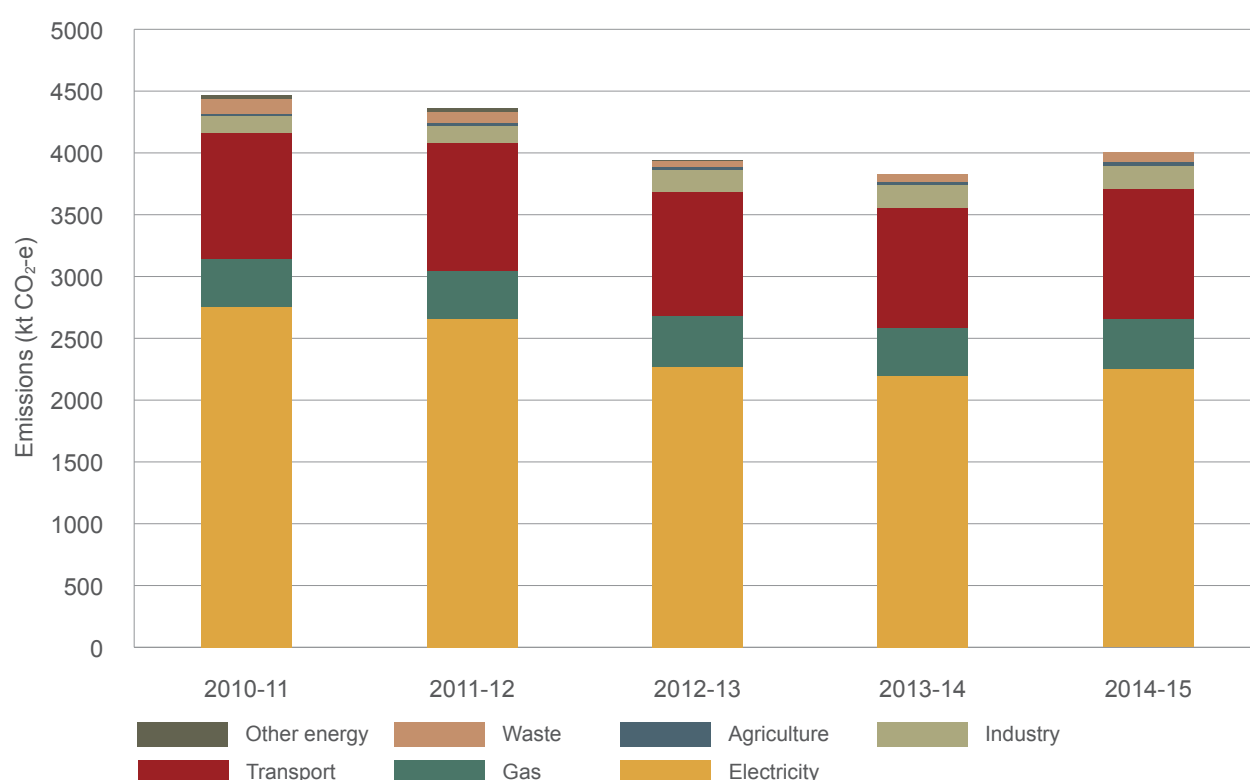
2 Climate change



Although electricity production still accounts for the highest proportion of emissions, the overall reduction in ACT emissions since 2010 has been mainly from decreases in stationary energy emissions (Figure 2.11).

Emissions from energy are determined by two factors: total demand and emissions intensity. The reduction in electricity emissions in the ACT is due to a steady fall in total demand for electricity since around 2010. In addition, since 2010, the emissions

intensity of electricity supplied through the National Electricity Market (NEM) has decreased. This holds true up to 2014–15. In 2014–15, a decrease in NEM renewable energy caused an increase in emissions. Roof-top photovoltaic installations have emerged as a significant, zero-emissions source of electricity supply, displacing some purchases of NEM electricity, and thereby further reducing the weighted average emissions intensity of electricity used by ACT consumers. (See Case study 2.1 on page 37.)



kt CO₂-e = kilotonnes of carbon dioxide equivalent

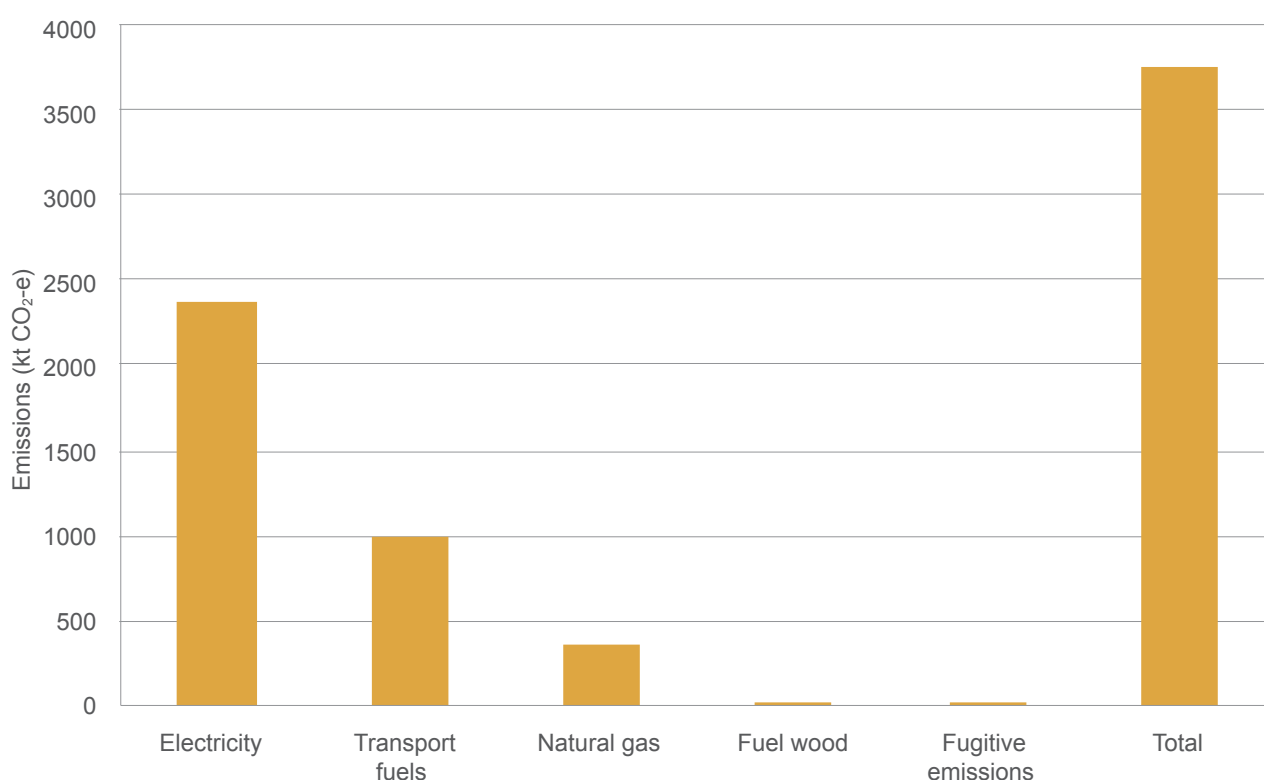
Note: This figure incorporates data from Pitt & Sherry (2015) *ACT Greenhouse Gas Inventory for 2014–15: with recalculations for 2012–13 and 2013–14*, prepared for the Environment and Planning Directorate ACT Government, Canberra, and from the Independent Competition and Regulatory Commission (2014) *ACT Greenhouse Gas Inventory Report 2011–12*, ICRC, Canberra. The datasets in the two reports are based on different methods, including updates to emissions factors for methane and nitrous oxide.

Figure 2.11 Annual ACT greenhouse gas emissions, by source, 1989–2014



Emissions relating to some form of energy use accounted for around 94% of total emissions (excluding land use, land-use changes and forestry) in 2013–14. This is the combined emissions of stationary energy (electricity, natural gas and fuel wood), energy for transport and fugitive emissions (leakage of natural gas) (Figure 2.12). The use of electricity from fossil-fuelled power stations is by far the biggest single source of emissions in the ACT. The combustion of petroleum-based fuels for transport purposes is

the second largest source of emissions, significantly outweighing the third largest emissions source – the use of natural gas for stationary energy purposes (eg home space and water heating). Natural gas leaks (where natural gas escapes before combustion) and the burning of wood for the space heating of ACT homes are relatively small emissions sources. There has also been a small fall in fugitive emissions from natural gas leakage, in line with the small fall in total demand for natural gas.



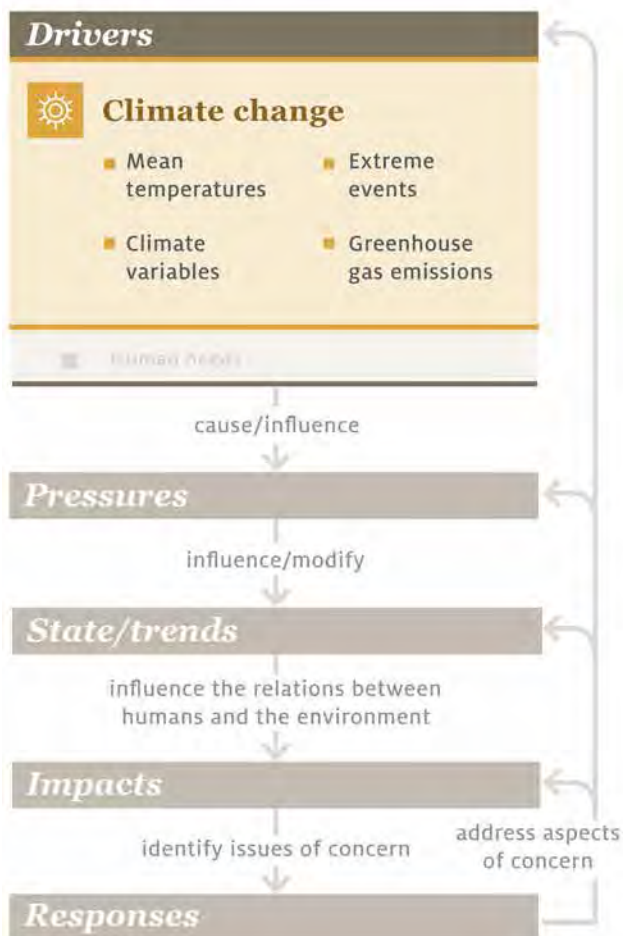
kt CO₂-e = kilotonnes of carbon dioxide equivalent

Figure 2.12 ACT greenhouse gas emissions from energy use, 2013–14



Links and influences

The *Driver–Pressure–State–Impact–Response* model as used in the ACT State of the Environment Report



Windfarms contribute to a reduction in emissions from energy production feeding into the national electricity market and used by ACT consumers

Photo: ACT Government



Case study 2.1 The Energy Efficiency Improvement Scheme

The Energy Efficiency Improvement Scheme (EEIS) started on 1 January 2013. It sets an Australian Capital Territory (ACT)–wide energy savings target, legislated obligations and options for ACT electricity retailers to meet an individual ‘retailer energy savings obligation’. These activities are determined by the Minister for the Environment and must be carried out in accordance with codes of practice approved by the EEIS Administrator. Retailers incur penalties if they do not meet their targets.

A 2014 review of the EEIS found that it had achieved its four objectives:

- to encourage the efficient use of energy
- to reduce greenhouse gas emissions associated with stationary energy use
- to reduce household and business energy use and costs
- to increase opportunities for priority (low-income) households in the ACT to reduce energy use and costs.

By mid-2015, the EEIS had:

- delivered energy savings in more than 50 000 Canberra households, of which nearly 30% are priority households
- delivered an average savings of \$1600 in participating households during the life of energy-saving items, or \$318 per year
- installed more than 550 000 energy-saving items, saving about 440 000 tonnes of carbon dioxide equivalent emissions; this includes the replacement and recycling of more than 465 000 incandescent light globes with energy-efficient light globes

- installed more than 43 000 door seals to keep hot air inside during winter and out during summer
- installed more than 85 000 stand-by power controllers, preventing power wastage by equipment left on when not in use
- retired and recycled more than 1500 old, inefficient refrigerators and freezers
- created 35 full-time equivalent private sector jobs, with this number expected to grow.

The ACT Government has extended the EEIS to run until 2020. This recognises the significant success of the EEIS to date, and the potential that remains to implement cost-effective energy savings in ACT households and businesses. The key elements of the EEIS extension are to:

- maintain momentum on ambitious, but achievable, targets for low-cost electricity and gas; households and businesses should see a decrease in their energy bills as a result of energy efficiency improvements
- deliver economic benefits of around \$40 million to the ACT economy, and \$106 million to householders
- give even greater certainty to energy retailers about their obligations under the scheme
- support competition and business opportunities by harmonising the ACT system with those of other jurisdictions.

Source: www.environment.act.gov.au/energy/energy_efficiency_improvement_scheme_eeis



2.3 Measuring the effects of climate change

Although scientists can predict the broad pressures that are likely to emerge from projected climate change, there remains uncertainty about the exact effects of climate change, particularly at small scales. The vulnerability of any particular region at any particular point in time will be influenced by the extent of exposure to changes in the climate system, the degree of sensitivity of the region to these exposures and the capacity of the region to adapt.¹²

The ACT is already seeing the effects of climate change. However, the impact of change on the population will depend on how much we can mitigate the degree of change and increase our resilience to inevitable change.

This section first looks briefly at the weather and climate experienced by the ACT during 2011–2015. It then examines the existing and likely effects of climate change on humans and the natural environment.

2.3.1 ACT weather and climate, 2011–2015

As we have noted previously, Australia's climate is naturally variable. However, it is still useful to look at weather during the reporting period, especially in relation to the usual drivers of variability.

During 2011–2015, the weather in the ACT was generally warmer in the daytime than the long-term climatological average (1961–1990). Night-time temperatures during the four years were near average or below average. The ACT experienced some of its hottest daytime temperatures during the reporting period (Figure 2.13). In 2014, there were three days when temperatures reached at least 40 °C, equalling the 2009 record, and 19 days reached at least 35 °C – nearly four times the average of five days each year.

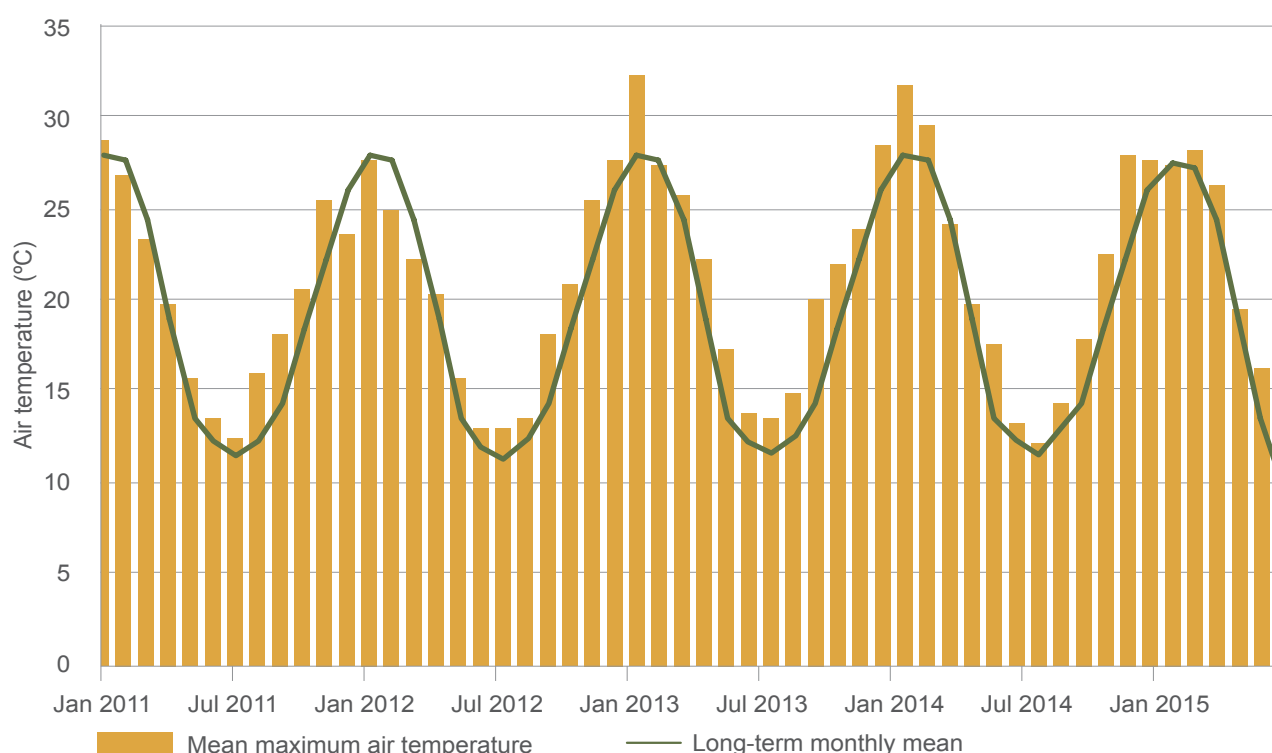


Figure 2.13 Comparison of monthly observed maximum ACT temperatures with the long-term average (1961–1990), July 2011 – June 2015



The ACT region, particularly during winter and spring, can be influenced by the ENSO (see 'Climate variability'). The conditions throughout 2011 and 2012 were influenced by the 2010–2012 La Niña, which brought heavy rains and cooler temperatures to much of Australia's south-east (Figure 2.14). A near El Niño in 2014 brought warmer temperatures to the region.

Although 2013 was a neutral ENSO year, it was the second warmest year on record. January, July and September of 2013 all broke their long-term monthly records, and winter was the equal warmest on record; 2013 followed 2006 as the warmest year on record. Since 2012, rainfall has been below the long-term average in the autumn and winter months.

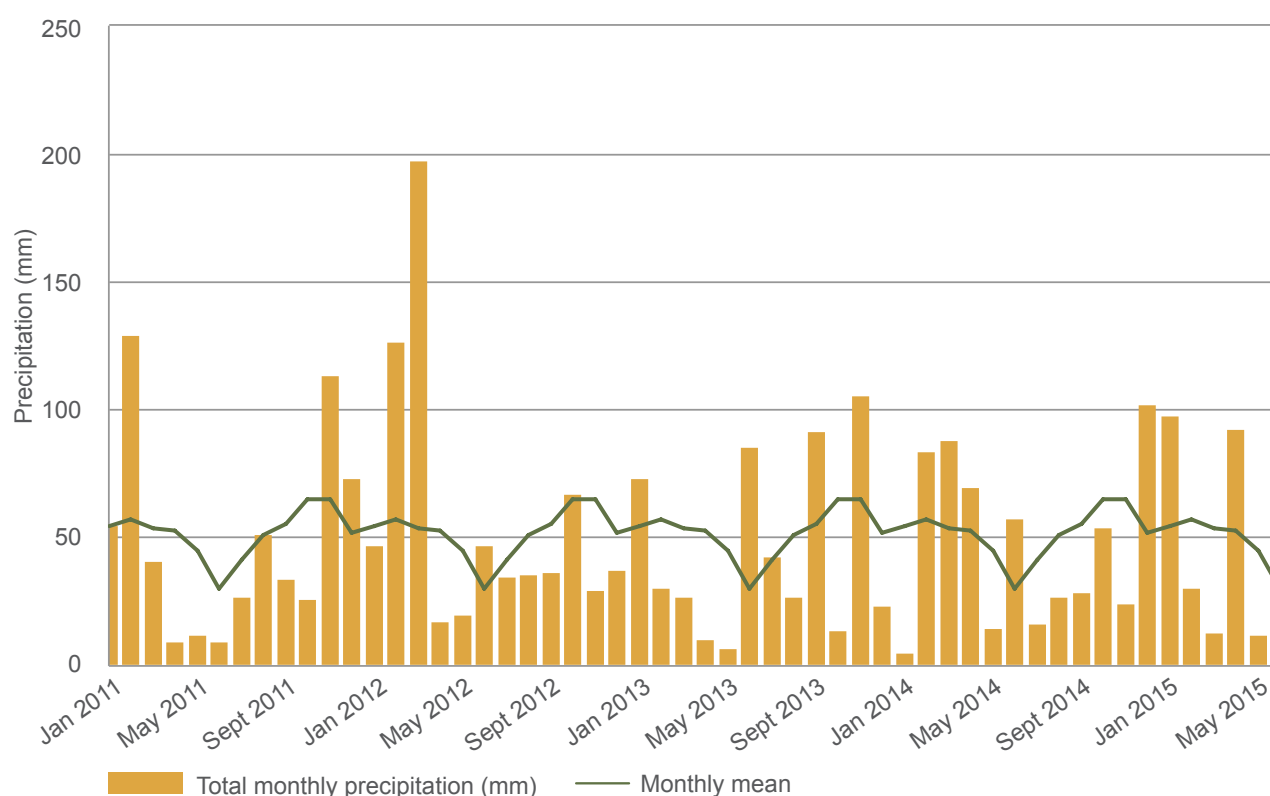


Figure 2.14 Comparison of actual monthly ACT rainfall with the long-term monthly average (1961–1990), July 2011 – June 2015



2.3.2 Impacts on humans

The ACT community faces a number of serious challenges related to climate change, including decreased rainfall, and increased temperatures and fire danger:

- **Water supply.** It is expected that there will be reduced rainfall and run-off in the ACT, leading to reduced water in our catchments and dams. This is likely to compound the pressure on water supply from population growth. Water quality in the ACT's lakes, dams and waterways may also decline with reduced flows and increased temperatures. Reductions in water quantity and quality typically affect human wellbeing through
 - restrictions on residential and commercial water use
 - health hazards associated with toxic algae outbreaks
 - a decline in recreation, amenity and aesthetic values, including challenges in maintaining green space.
- **Human health.** Climate change has both direct and indirect health impacts. The adverse health impacts of climate change will be greatest among people on lower incomes, older people and the sick. Impacts include
 - an increase in heat-related illness and death. The number of heat-related illnesses and deaths in the ACT is likely to rise as a consequence of an increase in the number of very hot days above 35 °C. The number of illnesses and heat-related deaths in the ACT could more than double, with older people particularly vulnerable. Currently, an estimated 14 people aged 65 and over die each year in Canberra from heat-related deaths (1997–1999 average). This could potentially rise to 37–41 deaths each year by 2020, and 62–92 deaths each year by 2050
 - a decrease in cold-related illness and death. The population of the ACT is also susceptible to cold-related deaths, with three people each year currently dying from the cold. The proportion of people dying from the cold is expected to decrease as temperatures increase; however, as population growth is also expected,

the total number of cold-related deaths is projected to be between 4 and 9 deaths in 2050^c

- bushfire impacts. The increased incidence of bushfires also poses significant risks to human health, through death and injury, smoke pollution and negative impacts on water quality
 - disease. There may also be a greater risk of vector-borne infectious diseases, as insects carrying disease find new ranges as a result of changing temperatures, including malaria, dengue fever and Ross River virus disease. There is also evidence of an expected increase in some foodborne illnesses.
- **Human wellbeing.** Indirectly, the effects of climate change on things like the amenity value of the landscape, the ability to recreate outdoors and the number of extreme events has impacts on both physical and mental health.



Flooding at the Googong Dam spillway

Photo: ACT Government

^c As reported in Loughnan et al,²⁵ Bambrick et al²⁶ identified an upper mortality threshold of 33 °C daily maximum temperature for Canberra.



- **Extreme events.** The anticipated increase in temperatures and evaporation is likely to result in more frequent and more intense heatwaves and bushfires in the ACT, with significant economic, social and environmental consequences. An increase in fire weather will increase the chances of direct injury and death, as well as health problems associated with a decline in air quality, which is particularly significant for those with asthma and chronic lung disease. There are also significant costs associated with property damage from fire. In rural areas of the ACT, fire can result in the loss of stock and farm infrastructure.
- **Agriculture.** The agricultural sector in the ACT and surrounding regions is particularly vulnerable to climate change impacts. Grazing, cropping, horticulture and viticulture could all be negatively affected by reduced rainfall and run-off, increased fire risk, and increased average temperatures and hot days. These pressures are likely to have an impact on the mental and physical health of farmers, as well as reducing the financial benefits to the ACT economy.²⁷

2.3.3 Impacts on the natural environment

Climate change is already altering the biophysical environment – plant and animal species, and their relationships and habitats are transforming. These changes rarely result in improvement and are likely to continue.

Changes in rainfall and temperature, and increases in extreme events, are likely to affect the natural environment in and around the ACT. The function, composition and structure of both water- and land-based ecosystems are likely to be affected. The changing conditions may be favourable to the spread of weeds and pests. Species reliant on special habitat, such as the Corroboree Frog, may face extinction. The lack of connectivity of ecosystems in the ACT could limit the ability of species to adapt to the changes. An increase in the number of fire events is also likely to put further pressure on particular plants and animals.

Ecosystems

For the biophysical environment of the ACT, the following climate change impacts are likely:²⁸

- changed patterns of run-off and stream flows
- reduced soil moisture and nutrients
- increased erosion and soil salinity
- increased drought severity, and bushfire frequency and intensity.

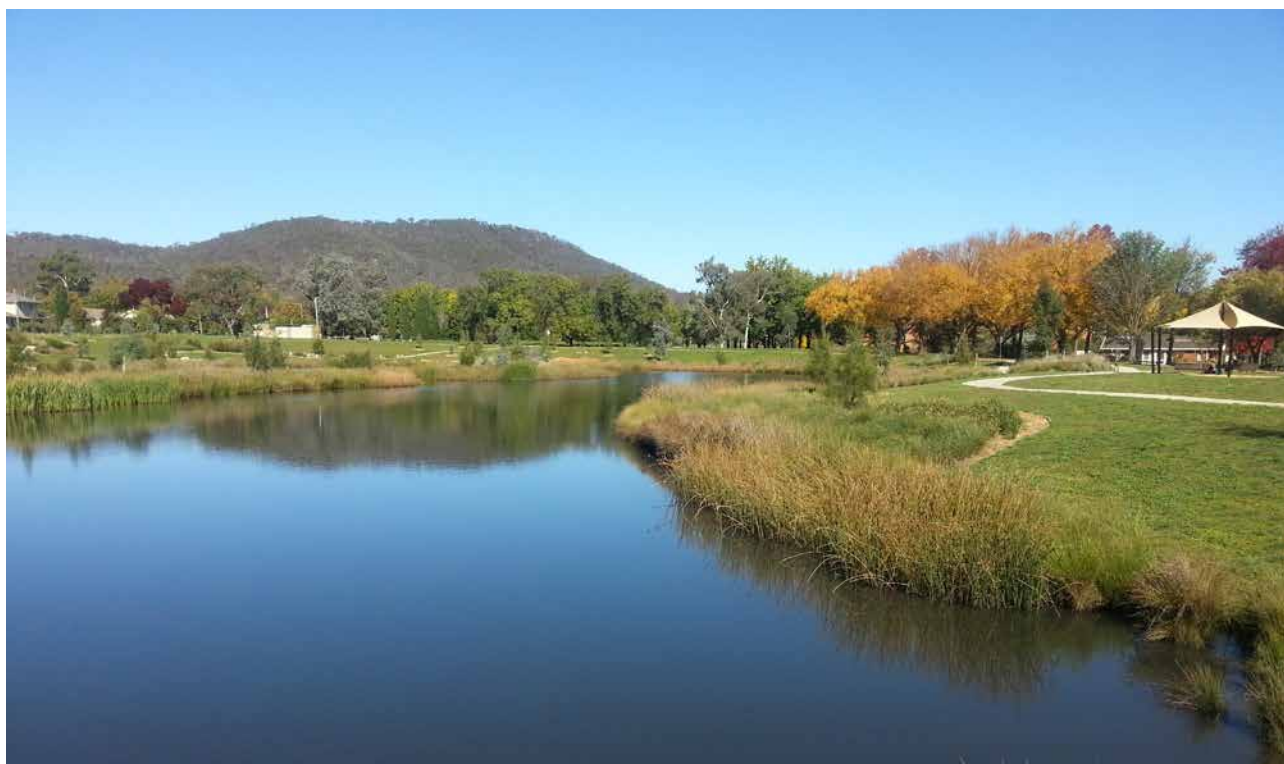
Specific threats have also been also identified for a number of ACT ecosystems:

- Alpine and subalpine ecosystems
 - increased threat to cold climate–adapted and narrow temperature–range species such as those in feldmarks, short alpine herbfields, and sphagnum bogs and fens; Southern Corroboree Frog and Mountain Pygmy Possum
 - increased fire risk to groundcover and fire-sensitive species such as those in sphagnum bogs and alpine herbfields; Alpine Ash and Mountain Plum Pine
 - invasion of more temperature- and fire-tolerant species, including certain tree, heathland, shrubland and weed species (eg Ribbon Gum, grevillea, Wild Parsnip).
- Subalpine grassy woodlands
 - reduction in snow, groundcover and grasses, which will threaten some fauna (eg Broad-Toothed Rat, Alpine Skink, frogs, echidnas)
 - more invasive species (eg rabbits, hares, cats) and increased grazing pressure (eg kangaroos, wallabies, horses, hares)
 - changed seed germination, regeneration and recruitment periods (eg less cool time available for Alpine Ash and Snow Gum)
 - earlier flowering of annuals and shrubs, which will disturb synchronicity for migratory birds (eg Flame Robin, Pink Robin)
 - spring breeding season shortened (eg for Richard's Pipit, some honeyeaters)

2 Climate change



- increased loss of microhabitats (eg tree hollows for Yellow-Bellied Gliders, leaf litter for ground-dwelling fauna)
- increased frost heave, which may decrease organic decomposition and soil nutrients
- effects on nutrient cycling by invertebrates and soil fauna.
- Tablelands – woodlands
 - stresses on fragmented and less storm-buffered woodland trees (eg Box–Gum Woodland, Blakely’s Red Gum, Snow Gum), including water pests, insects and diseases, which make this community more threatened than subalpine woodlands
 - increased fire frequency, which will reduce the range and abundance of some fire-sensitive species (eg Blueberry Ash)
 - increased risk to fauna from further woodland habitat and microhabitat loss, reduced plant and grass growth, and reduced or changed timing of flowering, nectar, pollen, foliage or seed, including
 - nectivorous and insectivorous woodland birds (eg Hooded Robin, Diamond Firetail, Regent Honeyeater, Superb Parrot)
 - small mammals (eg possums, Sugar Glider, Squirrel Glider)
 - ground dwellers (eg antechinus, Smoky Mouse)
 - increased opportunity for invasive species (eg Indian Myna, Noisy Miner)
 - reduced woodland habitat available for seasonal migratory birds from subalpine regions (eg Gang-Gang Cockatoo, robins in winter) and from the north (eg Rainbow Bee-Eater, Dollarbird in spring), as well as for native refugee species from further west (eg Galah and Crested Pigeon)
 - asynchrony in arrival of migratory species if responding to temperature cues
 - increased impacts on already stressed grasslands through invasive species such as summer-growing C4 grasses (eg Kangaroo Grass) and weeds (eg Scotch Broom, Blackberry, Serrated Tussock, St John’s Wort, Chilean Needlegrass, African Lovegrass), replacing winter-growing native C3 grasses and tussocks (eg Poa), spring annuals and perennials
- higher carbon dioxide and some increase in growth season from higher temperatures and reduced frosts, which may promote some extra overall growth (including shrubs); reduced rain and increased grazing could potentially offset this effect
- increased impacts on threatened grassland fauna (eg Grassland Earless Dragon, Striped Legless Lizard, Golden Sun Moth) because of the decreased productivity of temperate grasslands, as well as changes in species composition and weeds. The decreased grass cover also increases susceptibility to predation by birds (eg kookaburras, Brown Falcon) and feral species (eg foxes, cats)
- extra vulnerability through reduced habitat for already stressed species (eg Spotted Tree Frog), and for autumn and winter breeders dependent on moisture (eg Common Toadlet, Bibret’s Toadlet)
- loss of damp grassland cover and habitats, which threatens fauna requiring wetter environments (eg Green Bell Frog, Golden Bell Frog).
- Tablelands – dry sclerophyll forests
 - dry sclerophyll forests in tableland ridge tops and hill slopes are less vulnerable than other forests or woodlands because they are less modified, but extra heat and dryness could mean lower ground-level productivity (eg grasses), and a more open structure could affect fauna (invertebrates and granivorous species) and lead to more grazing impacts
 - some eucalypts may be displaced by arid-adapted acacias
 - changed flowering frequency and timing, especially in eucalypts (eg White Box, Mugga Ironbark), will affect insectivorous species (eg Regent Honeyeater, Superb Parrot, mammals, bats), including those with synchronised spring breeding
 - fewer resources will be available for winter-breeding fauna such as dasyurids (eg antechinus)
 - more fire may not advantage shrubs because of poor soils and nutrients, but will reduce hollows (eg for bats, arboreals, birds), and log and leaf litter protection for small mammals from predators (eg cats, foxes).



Dickson urban wetland

Photo: ACT Government

Soil

Projected climate change has the potential to have severe, but variable, impacts on soils, depending on the bioclimatic zone and the intrinsic vulnerability of the soils in that zone.²⁹⁻³¹

The major impacts expected on soils in the south-eastern region as a result of projected climate change are:

- a major increase in sheet, rill, gully and streambank erosion caused by increased rainfall and run-off events
- exacerbation of dryland salinity – which is currently a problem in areas of the Southern Tablelands that already experience lower-than-average rainfall – caused by any modification to groundwater hydrology.

Improvements in organic matter accumulation and overall carbon levels may occur, but these may be offset by a decrease in biomass protein, leading to changed soil biodegrader activity, increased soil erosion and increased evaporation.

Changes to rainfall erosivity in summer will most severely affect many of the region's sodic soils. The reduction in winter precipitation is likely to have severe implications for alpine areas, where alpine humus soils (Tenosols and Organosols) dominate. In addition, increased soil biodegrader activity in subalpine areas caused by increased temperatures will lead to significant loss of organic matter in areas of alpine humus soils.

Water

Projected changes to rainfall and, hence, water availability have the potential to affect both the quantity and quality of our water resources. (See Chapter 6: Water for further details.) Government and community action will be needed to protect our water resources, and the habitats and species that depend on them (see Case study 2.2 on page 44).



Case study 2.2 River rehabilitation



Artificial log jams were constructed on the Cotter River as part of the Tharwa Fish Habitat Project

Photo: ACT Government

Climate change is likely to cause decreased flows in the Murrumbidgee River, which will reduce the availability of, and access to, good river habitat for fish. The Tharwa Fish Habitat Project has installed structures that will help fish survive stressful climatic conditions by increasing the depth of the river channel and providing habitat. These structures have been placed in a degraded stretch of river that is the corridor between two good river sections.

Engineered log jams near Tharwa are a rehabilitation activity undertaken as part of the Upper Murrumbidgee Demonstration Reach (UMDR) initiative. The UMDR is a 100-kilometre stretch of river from Bredbo to Casuarina Sands. The log jams, which are made of interlocking hardwood logs and rock, will benefit native aquatic species including threatened Murray Cod, Trout Cod, Macquarie Perch and Murray Crayfish. Water flowing past the log jams is scouring away a century of sand

build-up from human-induced erosion, deepening the channel to help fish move between good habitat and breeding zones.

The Tharwa Fish Habitat Project has received funding of approximately \$300 000 and is supported by organisations including the Australian Government, the ACT Government, ACTEW and the Southern ACT Catchment Group.

The river corridor will be further improved and stabilised with tree planting, weed control and site rehabilitation under the ACT Million Trees Program. This revegetation will improve bank stability, thus reducing the risk of erosion and further deposition of sediment into the river.

Despite the short amount of time since completion, channel deepening in the UMDR has already been observed.

continued



Case study 2.2 continued



Completed log jams in the Cotter River

Photo: ACT Government

2.3.4 Resilience to pressures

A resilience assessment involves looking at the systems, networks, human resources and feedback loops involved in maintaining environmental values (see Chapter 9).

It is important to understand the drivers and impacts of climate change in order to develop strategies to address the risks they pose to human wellbeing and the natural environment. Building resilience in the social and environmental systems of the ACT is a core part of these strategies, as building resilience enables a focus on maintaining the desired values of the ACT's environment despite the effects of climate change.

Natural ecosystems have been identified as one of the sectors most vulnerable to climate change in Australia. It is therefore likely that the delivery of ecosystem services will be substantially altered under future scenarios of climate change.¹⁵⁻¹⁷ To date, there

have been few studies that have specifically looked at climate change impacts on ecosystem services on the Australian continent,^{15,17} but research from Europe and North America has identified key effects that are likely to occur in many regions.³²⁻³⁶

In the ACT region, the combined effect of decreased rainfall, increased temperatures and increased fire incidents is likely to substantially alter the function, composition and structure of ecosystems.¹⁸ Existing threats to biodiversity may be exacerbated.^{32,37} As a result of these various climate change impacts, the capacity of ecosystems to provide benefits such as clean air, food and water may be hampered, and the cultural values of ecosystems may be diminished.



2.4 Response

Climate change is a system response to increasing population, increasing consumption and, therefore, the type of economic development that our societies are pursuing. The response to climate change therefore requires collaborative and focused efforts at the international, national and local levels.

Responding effectively to climate change requires both mitigation and adaptation:

- **Mitigation** is tackling the causes of climate change – in other words, reducing the human-influenced emissions of greenhouse gases to the atmosphere. Although some climate change is now inevitable, mitigation is designed to limit the degree of climate change.
- **Adaptation** is action to cope with the impacts of climate change on our human settlements and our natural environment. Adaptation increases our resilience, and allows us to live with and limit the impacts of climate change.

Building the resilience of the ACT's socioecological systems to cope with climate change impacts is a key challenge for the years ahead. It is important to consider how the ACT can be resilient in the face of specific and anticipated threats, such as increased bushfires and droughts. We must also think about how to build general resilience of the ACT to be able to deal with unforeseen climate change impacts. Increasing the diversity of water sources for Canberra, encouraging and supporting strong social networks in families and neighbourhoods, and ensuring that Government agencies are able to adapt and learn from extreme events are just some examples of the broad range of ways that the ACT can become more resilient to ongoing climate challenges.

2.4.1 Mitigation

In 2013, the IPCC detailed, for the first time, the maximum amount of carbon emissions that can enter the atmosphere worldwide to limit temperature change. This global 'carbon budget' is around 1000 billion tonnes of carbon dioxide equivalents.

Around the world, governments, individuals, businesses and industries are taking action against carbon pollution through a variety of measures. Many governments have agreed to limit carbon pollution in an effort to ensure that the average global temperature rise can be held below 2 °C above pre-industrial levels. The aim is to limit global concentrations of carbon dioxide to 450 parts per million (ppm). Pre-industrial levels were 280 ppm; recent data from the Mauna Loa observatory in Hawaii have shown that global carbon dioxide recently passed 400 ppm. There is therefore a need for urgent and critical action, and, reflecting this, some international investments in renewable energy alternatives have overtaken conventional high-pollution energy generation.³⁸

Against a background of various discussions, negotiations and agreements, the United Nations is currently developing a new international climate change agreement that will cover all countries. The new agreement will be adopted at the Paris climate summit in December 2015 and implemented from 2020. It will take the form of a protocol, another legal instrument or 'an agreed outcome with legal force', and will be applicable to all parties.

In the lead-up to this global summit, parties have been encouraged to declare their targets and commitments, called their 'intended nationally determined contribution'. There have been some hopeful signs of progress – 55 parties to the United Nations Framework Convention on Climate Change (UNFCCC) have now made significant commitments. For example:

- the United States will cut its emissions by 26–28%, compared with 2005 levels, by 2025
- China will agree that its emissions will peak by 2030



- the European Union's contribution to the new agreement will be a binding, economy-wide, domestic greenhouse gas emissions reduction target of at least 40% by 2030.

The UNFCCC Secretariat will publish these contributions and prepare, by 1 November 2015, a synthesis report to assess whether they put us on track to keep global warming below 2 °C.

In developing its targets, the Australian Government sought advice from the Climate Change Authority. In a report released in July 2015,³⁹ the Authority recommended:

- a 2025 target of 30% below 2000 levels
- further reductions by 2030 of 40–60% below 2000 levels.

Overall, the Authority considers that:

- the recommended targets are consistent with climate science
- the targets are comparable to the targets of similar countries
- the costs of achieving targets, and the distribution of those costs, are best considered in the design of policies
- the costs must be considered against the economic, social and environmental benefits of avoiding dangerous climate change.

The Australian Government has now submitted its commitment to the UNFCCC. Australia's commitment of 26–28% reduction in 2005 emissions levels by 2030 falls short of the targets that the IPCC considered necessary to limit warming to 2 °C. The target is also set against 2005 levels rather than 2000 levels, because 2005 was a year with higher emissions than 2000.

National governments are not the only players that can potentially affect greenhouse gas emissions. Individual cities are well positioned to play a leadership role in driving local action to address climate change. Cities consume two-thirds of the world's energy and create more than 70% of global carbon emissions. National governments are often focused on geopolitical issues, which can hamper cooperation. In contrast, cities – individually and collectively – are often in a better position to cooperate, and are often more effective at identifying

and acting on the needs of residents. With closer proximity to the public, cities tend to be more pragmatic and concerned about the sustainability of day-to-day services than higher levels of government.

Depending on the unique circumstances of each city – including local climate risks, political environments, resources and capacity constraints – different types of plans, policies and programs may be used. Some cities have stand-alone climate action plans in place, whereas others have mainstreamed climate change information into existing plans and policies. In some cases, cities have an emissions reduction target in place.

ACT response

The ACT community has supported strong targets and action by our Government so that we are playing our part in the global climate change challenge. We have set targets that are consistent with those that IPCC experts tell us are required to limit change to the critical 2 °C warming and, indeed, are ambitious enough to help tackle warming at the higher end of the range – up to 6 °C. The ACT is therefore beginning the process of transformational change to our economy that the IPCC considers is required to slow climate change.

The ACT's greenhouse gas emissions reduction targets have been established through the Climate Change Act, and the ACT Government has also developed two action plans – the ACT climate change strategy: *Weathering the Change*⁴⁰ and AP2: *A new climate change strategy and action plan for the Australian Capital Territory*⁴¹ – to implement the Climate Change Act.

The Climate Change Act was enacted by the ACT Legislative Assembly on 5 November 2010. The Climate Change Act sets targets for reducing greenhouse gas emissions in the ACT, provides for monitoring and reporting in relation to targets and functions performed by the Minister for the Environment, and promotes community and business engagement in climate change mitigation and adaptation through the establishment of the Climate Change Council and sector agreements.

The Climate Change Act prescribes the following:

- The principal target is to reduce greenhouse gas emissions in the ACT to achieve zero net emissions by 30 June 2060.

2 Climate change



- The interim targets are to reduce greenhouse gas emissions in the ACT to achieve
 - 40% less than 1990 emissions by 30 June 2020
 - 80% less than 1990 emissions by 30 June 2050.
- The average amount of greenhouse gas emissions produced per person in the ACT each year is to peak by 30 June 2013.

The second action plan (AP2), released in September 2012, was designed as the ACT's guide to meeting the targets prescribed by the Climate Change Act. AP2 identifies and targets emissions reductions across the ACT community, with actions in five key sectors, which correspond to the major emissions sources in our community:

- residential sector energy use
- non-residential sector energy use
- transport sector
- waste sector
- energy supply sector.

In 2020, around 553 000 tonnes of carbon dioxide equivalent savings is targeted through electricity, gas and transport fuel savings, and through reductions in emissions from the ACT's landfill sites. The remaining reductions are expected to be achieved through changing the generation mix of electricity supplied to the ACT.

The key actions are:

- reducing residential sector emissions (Energy Efficiency Improvement Scheme [EEIS], see Case study 2.1 on page 37; Actsmart Home Energy Efficiency program)
- reducing non-residential sector emissions (EEIS; Actsmart Business Energy and Water program)
- transitioning to large-scale renewable energy sector (solar and wind auctions)
- reducing transport sector emissions (Transport for Canberra policy; Low Emission Vehicle Strategy)
- reducing waste sector emissions (*ACT Waste Management Strategy 2011–2025*)
- reducing emissions from government operations (Carbon Neutral Government Framework, see Case study 2.3 on page 49).

The ACT community has also contributed to the reduction in greenhouse gas emissions (see Community case study 2.4 on page 50) by:

- installing roof-top solar panels with the encouragement of the ACT Government feed-in tariff, but also increasingly on their own initiative
- retrofitting older houses or designing new ones with energy efficiency in mind
- joining the increasing numbers of people who use active transport through riding and walking
- recycling, reusing and reducing waste.

How are we going?

AP2 provides for the Office of the Commissioner for Sustainability and the Environment to assess every three years whether the ACT Government is reducing greenhouse gas emissions, adapting to climate change and leading a sustainable future. The first assessment, an Implementation Status Report, was published in 2014 and found that AP2, combined with the greenhouse gas reduction targets prescribed by the *Climate Change and Greenhouse Gas Reduction Act 2010*, positions the ACT among the world's most progressive jurisdictions in terms of mitigating the impacts of climate change.

When compared with 14 Australian and 10 international cities, the ACT's climate change policies and actions are at least on par with, and in some cases leading, other Australian and international cities in mitigating and adapting to climate change.

Against national and international targets, Canberra compares well with its proposed greenhouse gas emissions reduction target of 40% below 1990 levels by 2020. In comparison, the Australian Government has committed to a new target of 26–28% reduction in 2005 emissions levels by 2030, replacing a previous unconditional 5% reduction in emissions on 2000 levels by 2020. Canberra's target aligns closely with a number of international cities.

Canberra is one of the few cities that has a target of being carbon neutral. Of the cities used in the Implementation Status Report comparison, Canberra's target is set the furthest into the future (2060). However, the Carbon Neutral Government Framework requires the ACT Government to be carbon neutral in its own operations by 2020.⁴²



Case study 2.3 The Carbon Neutral Government Framework

The ACT Government is leading by example to achieve carbon neutrality in its own operations by 2020 through the implementation of the Carbon Neutral Government Framework. Endorsed in August 2012, the framework provides a whole-of-government approach to achieving sustained emissions reductions and energy savings to become carbon neutral in a cost-effective manner.

The 2012–13 ACT Budget provided \$5 million to establish the Carbon Neutral Government Fund, which can provide loans to ACT Government agencies to invest in efficiency projects that will reduce energy consumption and greenhouse gas emissions, and minimise the impact of rising energy costs. Energy savings are used to repay the loan, making these funds available for new projects.

Since 2010, 18 ACT Government projects have been established, with a total of \$6.5 million in loans provided under the fund; \$2.4 million worth of loans have already been repaid and those funds loaned for further projects. In 2014–15, these projects made an estimated saving of at least 7400 tonnes of greenhouse gas emissions. Large-scale LED lighting projects

installing internal lighting to more than 90 government buildings and schools have an estimated cost saving (once fully implemented) of \$1.3 million per year, reducing electricity use by 20–30% at most sites.

The recently announced \$3.3 million loan to the Health Directorate is for a combined project that includes an energy-efficient lighting upgrade throughout Canberra Hospital. This will reduce electricity consumed by the hospital by approximately 9%. Reducing electricity consumption also means a financial saving by decreasing the electrical load of the site. To further supplement the electricity reduction at the site, the Health Directorate will tender for a 500 kW solar photovoltaic system to be installed. The combined electricity savings from the lighting retrofit and solar photovoltaic system will produce annual savings of \$490 000 each year. The loan will be fully repaid into the Carbon Neutral Government Fund during the coming years, to be made available for other energy efficiency projects.

The progress on AP2 since its implementation in 2013 is as follows:

- **The ACT is on track to reach its 90% by 2020 renewable energy target.** In 2013–14, 18.6% of the ACT's electricity supply came from renewable sources. This is being realised through a number of large-scale renewable projects procured by an innovative reverse auction process, which won a gold Banksia Award in 2014. In 2014–15, there were 45 megawatts (MW) of small- and medium-scale solar electricity systems installed in the ACT.
- **By 2018, the ACT will have secured renewable energy supply equal to 80% of its forecast 2020 electricity demand.** This includes the 20 MW Royalla solar farm, which has been operational since August 2014; a further 20 MW of large-scale solar installation expected to become operational in 2016; and three successful proponents of the 200 MW wind auction announced on 6 February 2015.
- **Further development of renewables is also in train.** A second 200 MW wind auction is planned for late 2015, and there is potential for 1 MW community solar and 50 MW next-generation solar.
- **Renewable energy jobs in the ACT have increased more than 400% in the past five years.** This is a rate of growth four times higher than any other Australian state or territory. The Renewable Energy Industry Development Strategy, announced on 1 May 2015, brings together a range of existing government renewable energy initiatives (eg the \$1.2 million Renewable Energy Innovation Fund and the \$50 million next-generation solar initiative) with new initiatives (eg the development of a physical business–research precinct with the Australian National University, and renewable energy test-berth facilities) to accelerate the expansion of the renewable energy industry in the ACT.

2 Climate change



- **Transport for Canberra actions are designed to improve vehicle efficiency, and increase use of walking, cycling and public transport use.**
The Low Emission Vehicle Strategy will build on the ACT Government's Green Vehicle Duty Scheme to further encourage the uptake of low-emissions vehicles.
- **Work towards the Zero Emissions Building Policy has started, with a review of the ACT Building Act 2004 and the building regulation system.** This will consider, as part of a broad policy review, improving building energy performance, including consideration of new or amended building standards.
- **The ACT Government has brought forward the annual inventory of ACT greenhouse gas emissions that is required under the *Climate Change and Greenhouse Gas Reduction Act 2010*.** These will now be available in the months following the end of the reporting year. An interim inventory for 2012–13 and 2013–14 was released in April 2015.
- **Emissions reduction targets are being met.** The previous inventory found that the ACT has met its first legislated emissions reduction target of per-capita emissions, peaking by 2013. Territory emissions fell by 8% between 2011–12 and 2013–14, in line with the projections presented in AP2.



Community case study 2.4

350.org

350.org is a global climate movement that organises campaigns, grassroots events and mass public actions, coordinated by a global network that is active in more than 188 countries. In Australia, 350.org is a not-for-profit group funded from private donations and operated by volunteers. Canberra has an active 350.org team.

350.org uses mass mobilisations and people power to effect systemic change. The campaigns strive to hold government, business and industry leaders accountable to the realities of climate science, and to principles of justice for current and future generations.

350.org also uses 'divestment' as a key strategy in reducing carbon dioxide emissions by encouraging investors to shift funds away from fossil fuels. For example, locally, the Australian National University decided in 2014 to divest shareholdings

in seven resource and mining companies. As part of its ACT divestment strategy, the 350.org team has analysed quarterly ACT Government reports to draw attention to the role of investment choices in providing continuing support for the fossil fuel industry.

In August 2015, the ACT Government announced that it would 'responsibly divest over a five-year period from companies that are listed in the Carbon Underground Top 200 list published by Fossil Free Indexes'.^a

a The Carbon Underground 200 is an annually updated listing of the top 100 public coal companies globally and the top 100 public oil and gas companies globally, ranked by the potential carbon emissions content of their reported reserves. The list is available at <http://gofossilfree.org/top-200>.



View of Royalla Solar Farm

Photo: ACT Government

2.4.2 Adaptation

In contrast to climate change mitigation, which requires cooperation at a global level, most climate change adaptation occurs at a local level through the actions of individuals, businesses and communities in response to locally specific climate change impacts.

The level of adaptation needed will depend, to some extent, on the success of mitigation. If mitigation is successful in limiting climate change, less adaptation will be needed. However, even with mitigation, some climate change is inevitable, and adaptation responses are required by all communities. By increasing our community's and our environment's resilience to the diverse challenges we may face, we can minimise the impacts of climate change, and realise other significant social and economic benefits of sustainable and equitable development.

ACT response

The ACT's approach to adaptation is consistent with the national *Climate Adaptation Outlook: A proposed national adaptation assessment framework* (2013). The strategies in this framework aim to build understanding and adaptive capacity, and reduce sectoral and regional vulnerability to climate change impacts.

AP2 addresses adaptation to the consequences of climate change through:

- a new ACT-wide risk assessment to inform future health system planning, and natural disaster and emergency risk management and planning
- a ministerial statement on how the built environment and urban open spaces will be developed to respond to climate change
- a review of the development codes and design standards in the Territory Plan 2008 to incorporate the ACT's long-term mitigation objectives



- an assessment of impacts on ecological systems in the ACT and the surrounding region, and integration of this knowledge into environmental management and development planning decisions to ensure that our natural environment is conserved and improved.

The ACT Government is developing a draft adaptation strategy, which will build on the work already done through the risk assessment and ministerial statement. The draft strategy is being developed through ‘Enabling adaptation in the ACT’ meetings and workshops. These have been conducted with the ACT Climate Change Council, our community’s academic and local peak bodies, the NSW Government and ACT Government agencies. The key focus is to improve the resilience of our community to deal with unavoidable climate change impacts, particularly on those who are vulnerable and less able to make adjustments.

How are we going?

In the implementation Status Report, the Office of the Commissioner for Sustainability and the Environment investigated and assessed the ACT’s adaptation policies and strategies using a methodology based on the one described in *Australia State of the Environment 2011*.⁴³ The assessment looked at both general adaptation needs, which represent a series of key requirements to facilitate successful adaptation strategies, and specific adaptation needs, which address specific identified vulnerabilities for the ACT.

The assessment found that, for general adaptation needs:

- political commitment was very effective
- funding, strategy and action plans, and knowledge management and data were effective
- governance, and communication and awareness were partially effective.

Specific adaptation needs were also assessed. Plans for:

- water, heat management and bushfires were considered very effective
- urban planning, emergency management, the health system, social and mental health services, and environmental management were considered effective
- government services and infrastructure were considered partially effective.

The assessment found that many of the ACT’s climate change adaptation mechanisms are currently addressed somewhat incidentally, and within policies or plans that have other, non-adaptation goals. However, this is being redressed through the first stage of the Government’s *Adapting to a changing climate: Directions for the ACT*.⁴⁴ This will provide new opportunities to incorporate adaptation responses into all relevant policies or programs, and to coordinate approaches across the Government.

The ACT’s mitigation responses are beginning to address our emissions requirements. At the same time, we could be realising other significant social and economic benefits of sustainable and equitable development, and recognising the benefits of an effective strategy to increase our community’s and our environment’s resilience to the diverse climate challenges we may face.



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