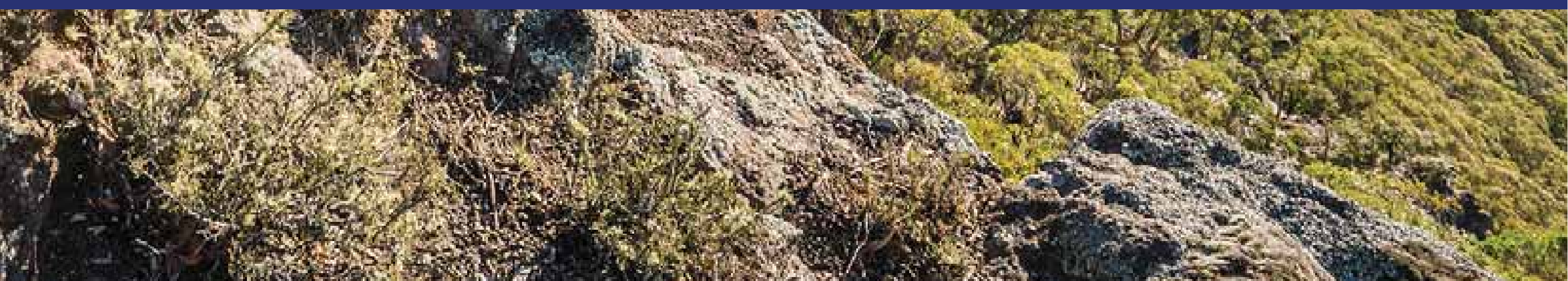
NSW State of the Environment 2018



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Purpose

New South Wales State of the Environment 2018 reports on the status of the main environmental issues facing NSW. The report has been prepared in accordance with the requirements of section 10 of the *Protection of the Environment Administration Act 1991*. This is the tenth State of the Environment report since 1993 and it was prepared by the NSW Environment Protection Authority (EPA).

The report's purpose is to provide credible, scientifically based environmental information at a statewide level to assist those involved in environmental policy and decision-making and managing the State's natural resources.

Preparation and use

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Contents

Foreword

The natural environment is essential to our daily lives in many ways - the air we breathe, the water we drink and the soil that sustains our land and agriculture. It provides raw materials for industry and economic growth. It provides natural beauty for public amenity and tourism. And it provides a home for us and the plants and animals that share our great state.

The condition of our environment has a profound effect on our quality of life and the health of our economy. Reporting on the state of the environment helps us to take stock of environmental conditions in our state, to identify emerging issues and to take effective action now, for future generations and for the environment.

I am pleased to present the New South Wales Environment Protection Authority's tenth *New South Wales State of the Environment*. This report supports the work of the EPA in protecting the environment by describing the status and trends in important environmental resources and their implications for environmental and human health.

The report is updated every three years and continues to build on the valuable time-series data of previous reports. It draws on the most up-to-date information from a range of government agencies and authorities as well as the latest peer-reviewed scientific research. For the first time, the State of the Environment Report is presented through an interactive on-line portal. This new online system will also allow us to update some environmental indicators more often.

Preparation of *New South Wales State of the Environment 2018* has relied on extensive contributions both from within the Environment Protection Authority and from many other NSW Government agencies. The data and information provided was appraised and validated by the contributing organisations and a range of independent experts, through an extensive process of review. My sincere thanks to everyone who contributed.

So, what does the report tell us about our environment?

New South Wales State of the Environment 2018 identifies that many aspects of the environment are in good condition.

Air quality continues to be generally good, with low concentrations of lead, carbon monoxide and sulphur dioxide, although ozone and particle pollution levels require ongoing attention in some situations.

Industry and household waste disposed in landfill is decreasing and garden and food waste recycling is increasing. The NSW Government is combating illegal dumping and supporting emergency clean-ups of pollution such as illegally dumped asbestos.

There are also many opportunities for innovative solutions that benefit both the environment and the economy. An example of this is the **container deposit scheme** *Return and Earn*, which was established in December 2017. Drink container rubbish makes up almost half of the total litter volume in NSW. By the first anniversary of the Scheme more than one billion discarded drink containers had been returned via the more than 660 return points across the state, and the litter of eligible drink containers by volume had reduced by 44%.

Electricity generation has seen a strong increase in the use of renewable, low emissions sources, from around 11% in 2014 to 16% in 2017. In the three years to June 2016, total NSW and ACT energy consumption declined by almost 6%. The fact that the NSW economy grew by 9% reminds us that economic growth and a better environment can be mutual goals.

The report also shows that humans and their activities can have a profound effect on our environment - our landscapes, soils, air, vegetation, and natural areas. Some of the principal challenges identified in previous *NSW State of the Environment* reports remain.

Population growth continues to be a key driver of human-caused changes to the environment. The challenge is to effectively manage our growing population without compromising liveability or the condition of the environment.

Climate change continues to pose a significant threat to both the environment and population of NSW. Its effects are already being felt and are anticipated to become more severe over the coming decades. Counteracting these effects will require collaborative action at the global level to reduce greenhouse gas emissions.

The number of **threatened species** continues to rise. Over 1,000 native plant and animal species and 112 ecological communities are currently listed as threatened under NSW legislation. The main threats to these species are habitat loss due to the clearing and degradation of native vegetation and the spread of invasive pests and weeds.

I trust that this report will be a valuable resource for the general community and in guiding policymakers in their determination of future priorities and objectives that will lead to the best possible outcomes for the environment.

Mark Gifford PSM
Acting Chair and Chief Executive Officer
NSW Environment Protection Authority

How to use this report

The NSW State of the Environment 2018 (SoE 2018), prepared by the NSW Environment Protection Authority (EPA), reports on the status of the main environmental issues facing NSW. The report has been prepared in accordance with the requirements of section 10 of the *Protection of the Environment Administration Act 1991*. It is the tenth SoE since 1993.

SoE 2018 aims to provide credible, scientifically based environmental information at the statewide level to assist those involved in environmental policy and decision-making and managing the state's natural resources.

Preparation

Although SoE 2018 has been prepared by the EPA, the scope of the State of the Environment report is too broad to be covered by just one agency. SoE 2018 contains extensive input from a wide range of government agencies, other organisations and individual specialists, who provided data, information, analysis and interpretation, and reviewed the assembled content of the report. The EPA relies strongly on the support and contributions from these agencies, as well as an inter-agency SoE coordination committee.

The specialist input also includes reviews and advice from a panel of independent experts external to the NSW Government.

Structure and linkages

SoE 2018 is structured around six broad themes and 21 separate topics within those themes.

Environmental drivers

The first theme of the report describes the key drivers of human caused change in the environment: population growth and economic trends. While these drivers lead to a build-up of threats and pressures on the environment their effects are diffuse and manifested through a multitude of pathways so that it is difficult to directly attribute changes in the environment to their effects.

The population of NSW is continually growing and trends in population growth, settlement patterns and residential densities are described in the Population topic. Growth in population helps to drive economic growth and prosperity for the people of NSW. To respond effectively to the environmental challenges presented by a growing economy requires a more sophisticated understanding of how the economy and the environment interact. Trends in economic growth and the relationship to resource consumption and decision making are discussed in the topic Economic Activity and the Environment, as well as new economic instruments and accounting systems that can enhance environmental management and decision making.

Human Settlements

The Human Settlements theme addresses issues that arise in the urban environment in which most of the people of NSW live, including energy use, transport trends, greenhouse gas emissions, urban water use, management of contaminated sites and waste and recycling.

The growth in population and the economy described in the Drivers theme leads to the consumption of energy, water and land resources and the generation of waste. The production and use of energy has been identified as the largest source of greenhouse gas emissions in NSW, with electricity generation and transport responsible for the majority of these emissions. Energy production and use is described in the Energy Consumption topic, while trends in the use of public and private transport are described in the Transport topic.

Communities, industry, and agriculture all require access to reliable sources of water. Drinking water quality and patterns of potable water use are described in the Urban Water Supply topic. Trends in waste generation, recycling and litter prevention are described in the Waste and Recycling topic. Management of legacy pollution of land and groundwater is outlined in the Contaminated Sites topic.

Climate and Air

Energy generation, industrial and manufacturing processes and transport give rise to emissions of air pollutants and greenhouse gases. Ensuring that air quality remains at a high level is essential to provide a clean living environment and maintain the health of the NSW population. While air quality is generally good in NSW the levels of the major pollutants and the issues that can arise in some situations are discussed in the Air Quality topic.

The build-up of greenhouse gases in the atmosphere since the start of the industrial age is leading to changes in our climate. The overall levels and trends in greenhouse gas emissions in NSW are described the Greenhouse Gas Emissions topic. The changes in current temperature and weather patterns in NSW and future projections of change are discussed in the Climate Change topic, as well as the impacts of these changes on the environment more generally.

Land

The natural environment is subject to disturbance from human land-uses and land management practices. Managing the land sustainably and maintaining the quality of habitat for natural ecosystems and wildlife enhances their prospects for survival in the longer term.

Healthy soils provide essential ecosystem services and the primary productivity that supports natural ecosystems and the economic prosperity of the state. The health of soils in NSW and recent changes in condition are described in the Soil Condition topic. Changes in the extent and condition of native vegetation and the quality of habitat it provides, as well as recent trends in clearing rates, are discussed in the Native Vegetation topic. The preservation of ecosystems and habitats is described in the Protected Areas and Conservation topic.

Biodiversity

Ensuring the long-term survival of the species and ecosystems of NSW means that they will persist for the benefit and enjoyment of future generations. Many native species are considered to be threatened in NSW and current patterns in the status and trends for threatened species are discussed in the Threatened Species topic. However, many species are not threatened and the broader patterns of survival and trends in animal populations are described in the topic Native Fauna.

The main threats to the survival of species are habitat destruction through the clearing of native vegetation and competition and predation by invasive species, while climate change will become a major threat in the future. The impacts of invasive species on the survival of native species and ecosystems are discussed in the Invasive Species topic.

Water and Marine

One of the greatest challenges facing NSW is continued access to reliable sources of good quality water. Water use needs to be managed to provide an equitable balance between the numerous beneficial uses of water and maintaining the health of rivers and aquatic ecosystems. How water resources are allocated and the share of water available for the environment is described in the Water Resources topic for surface water and in the Groundwater topic for sub-surface water. The ecological health of rivers and the effects of water extraction and flow regulation are described in the River Health topic, and the relationship to wetlands health in the Wetlands topic.

Most rivers flow to the sea through estuaries and the Coastal, Estuarine and Marine Ecosystems topic covers the health and impacts of pressures on the estuarine, coastal and marine environments of NSW.

Indicator summaries

SoE 2018 assesses the current Status and Trends for each of 73 environmental indicators, and the reliability of the information used to make these assessments. These are generally judged over the reporting period, between the previous report (SoE 2015) and the current report.

Key to the indicator summaries

Indicator term	Information
Ratings of indicator Status	The rating of indicator Status refers to the environmental condition of the indicator.
	**Green –** Good: the data shows a positive or healthy environmental condition
	**Yellow –** Moderate: the data shows that the environmental condition is neither good nor poor, or results may be mixed across the state
	**Red –** Poor: the data indicates poor environmental condition or condition under significant stress
Unknown	Insufficient data is available to make an assessment
Rating term	**Information**
Ratings of indicator Trend	The environmental rating of indicator Trend describes the direction of significant change in environmental condition, where this can be differentiated from natural background variation. The trend is judged over the three years of the reporting period, but with a greater focus on the latest and most current data. Longer-term data is considered, where available, to help interpret the significance of any change. The trend reported, if maintained, may have an impact on the overall status of the indicator in the future.
Getting better	The trend in environmental condition for the indicator is improving (environmental impacts are decreasing)
Stable	No significant change in condition is evident, allowing for some variation due to background variability that occurs naturally

Rating term	Information
Getting worse	The trend in environmental condition for the indicator is deteriorating (environmental impacts are increasing)
Reliability indicator	**Information**
Information reliability	The information reliability rating signifies the level of confidence in the data and information used to make these assessments. It considers the statewide extent of data coverage, the accuracy and 'fitness for use' of the data in assessing the Status and Trend for the indicator. This is represented by the symbols below.
✓✓✓	Three ticks = **Good**
✓✓	Two ticks = **Reasonable**
✓	One tick = **Limited**

Acknowledgements

Acknowledgement of First People

In compiling this report the NSW Environment Protection Authority (EPA) acknowledges that Aboriginal spiritual and cultural values exist in the land, waters, sky and natural resources of New South Wales. The first custodians cared for Country and the natural environment of NSW for thousands of years. We acknowledge these custodians and pay respect to Elders both past and present and extend that respect to other Aboriginal people in NSW.

The entire landscape, including traditional lands and seas, has spiritual and cultural significance to Aboriginal people. By this understanding there is no separation of nature, wellbeing and culture. The health of the natural environment, land animals, marine animals and people are intimately connected.

Consistent with its vision the NSW EPA believes that healthy ecosystems are the foundation for healthy communities, for a healthy economy and for enhancing liveability.

Custodial rights, responsibilities and interests of Aboriginal people endure in our country. Partnerships between Aboriginal peoples, the EPA and other NSW land management agencies such as Office of Environment and Heritage (OEH), Forestry Corporation, the Marine Estate Management Authority, and Department of Industry Crown Lands and Water Division, lead to positive outcomes for all parties.

Contributors

Preparation of the *State of the Environment Report 2018* has relied on contributions, appraisal and validation from many NSW Government agencies and from within the EPA.

The EPA is grateful for the assistance of NSW agencies who contributed the majority of content for other topics, particularly:

- Department of Industry Crown Lands and Water Division
- Department of Planning and Environment
- Department of Primary Industries
- Hunter Water Corporation
- Local Land Services
- Office of Environment and Heritage
- Sydney Water Corporation
- Transport for NSW.

Review assistance was also provided by NSW Ministry of Health, Department of Premier and Cabinet, and NSW Treasury.

Independent expert reviewers

Independent expert review enhances the value and transparency of the report by ensuring that the most up to date and appropriate information is included, analysis and interpretation of the material is appropriate, and content adequately covers new and emerging issues.

The EPA acknowledges the contribution of 16 independent experts who reviewed content and data relevant to their expertise:

- Associate Professor Howard Bridgman, University of Newcastle
- Associate Professor Joanne Chong, Institute for Sustainable Futures
- Dr Mathew Crowther, University of Sydney
- Professor Chris Dickman, University of Sydney
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Theme pages

- Drivers: Sarah Ryan/EPA (2017). Wollongong waterfront. Accessed from EPA Image Library.
- Human Settlement: John Spencer/EPA (2017). Aerial view of Newcastle. Accessed from EPA Image Library.
- Climate and Air: John Spencer/OEH (2011). Grass trees (Xanthorrhoea species), Myall Lakes National Park. Accessed from OEH Image Library.
- Land: John Spencer/EPA (2017). Goulburn River and Bylong Valley Way – Winden. Accessed from EPA Image Library.
- Biodiversity: John Spencer/OEH (2014). Native boronia, Barren Grounds Nature Reserve. Accessed from OEH Image Library.
- Water and Marine: John Spencer/OEH (2012). Lake Burragorang, Warragamba Catchment, Nattai National Park. Accessed from OEH Image Library.

Drivers

The State of the Environment Report – 2018

NSW EPA

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Population

Population growth is a key driver of human-caused changes to the environment.

Summary

The NSW population grew by

111,400

people on average each year 2012 to 2017

Read more

NSW's population is expected to reach

9.9

million people by 2036

Read more

Greater Sydney's population was

4.8

million people as of 2017

Read more

People per sq. km in NSW

12%

increase between 2008 and 2017

Read more

The NSW population continues to increase; between 2012 and 2017 the annual average growth rate was 1.5%. Population growth is a key driver of human-caused changes to the environment.

By June 2017, there were 7.9 million people living in NSW, 61% of whom lived in Greater Sydney. NSW gained more than 550,000 people between June 2012 and June 2017.

Population density in NSW has also risen. In June 2017, there were an average of 9.8 people per square kilometre – a 12% rise since 2008. In Greater Sydney, there were almost 450 people per square kilometre – 65 more people than in 2008.

By 2036, the NSW population is expected to grow to 9.9 million. Most of this growth is anticipated to be in Greater Sydney. The challenge is to manage projected population growth alongside environmental protection, conservation and liveability.

The NSW Government has developed long-term plans for Greater Sydney and regional NSW. The plans aim to provide for sustainable and resilient development with a balanced approach to the use of land and water resources while enhancing liveability and protecting the natural environment.

Other strategies for reducing environmental impacts of urbanisation and a growing population include the NSW Waste Avoidance and Resource Recovery Strategy, the Sydney Green Grid framework for enhancement of open space, Future Transport 2056 and the 2017 Metropolitan Water Plan.

Related topics: Energy Consumption | Transport | Urban Water | Waste and Recycling

Context

Population growth is a significant driver of environmental impacts. Rising population and increasing urbanisation lead to greater demand for housing, energy, water, consumer products and transport services, as well as increased resource use and waste and emissions generation.

An understanding of the dynamics of the NSW population is critical when devising strategic planning processes that provide for:

- environmental protection
- enhanced liveability
- sustainable land use
- management of the impacts of population growth on the environment.

Status and Trends

Population growth

At 30 June 2017, there were almost 7.9 million people in NSW, of whom 4.8 million (61%) lived in Greater Sydney, 1.8 million (23%) lived in coastal areas and 1.2 million (16%) lived inland. The NSW population has grown by 111,400 people a year, on average, over the five years to 30 June 2017 (see **Table 1.1** and **Figure 1.1**). At a growth rate of 1.5% per year, this was the second largest increase in state population after Victoria.

In this topic, unless otherwise noted, all references to a particular year mean the 12 months ending 30 June of that year.

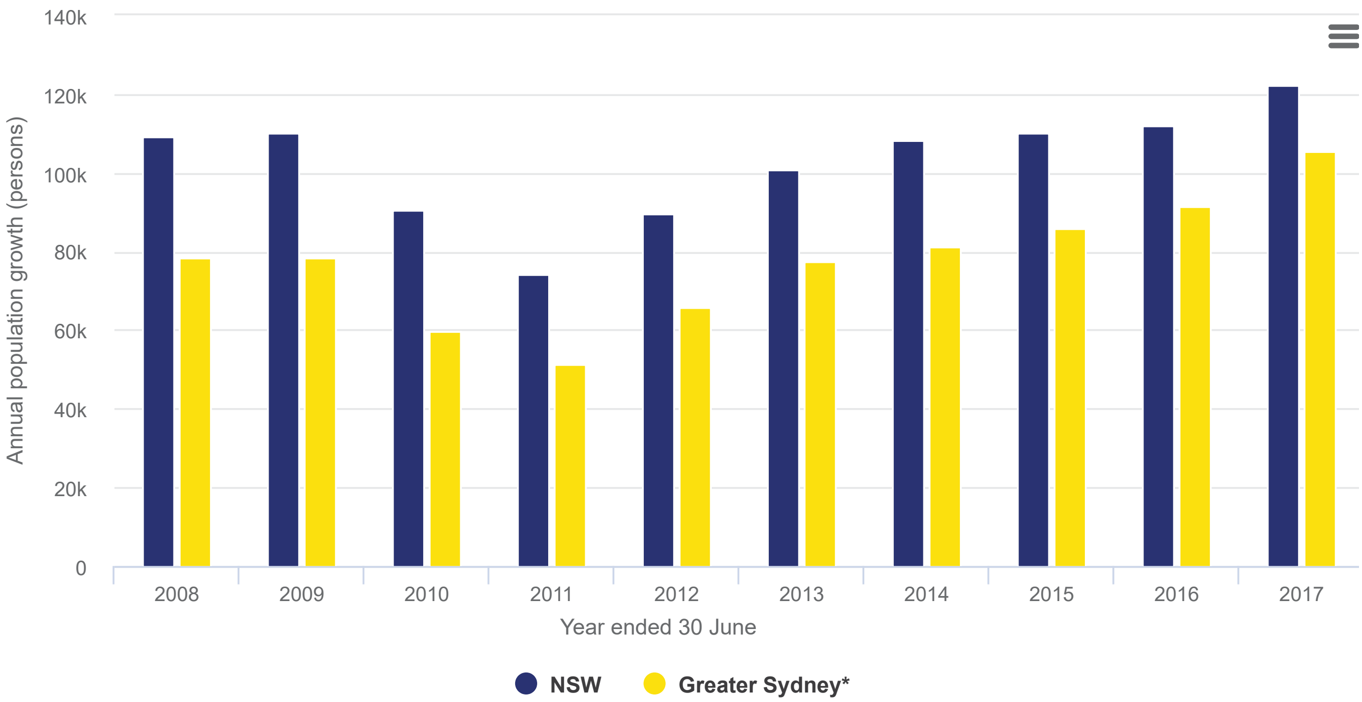
Table 1.1: Population of NSW and its regions, 2012 and 2017

Region	Population at 30 June		Population change 2012–17	
	2012	2017^{p}	Number	Annual growth rate (%)
Greater Sydney	4,351,990	4,793,691	441,701	2.0
Coastal NSW*	1,740,180	1,814,873	74,693	0.8
Inland NSW**	1,212,074	1,252,504	40,430	0.7
NSW	**7,304,244**	**7,861,068**	**556,824**	**1.5**

Notes:
^{p} preliminary; *Coastal NSW comprises all local government areas with coastal boundaries outside Greater Sydney; **Inland NSW comprises all areas not included in Greater Sydney or Coastal NSW.

Source:
ABS 2018

Figure 1.1: Population growth in Greater Sydney* and NSW, 2008–17

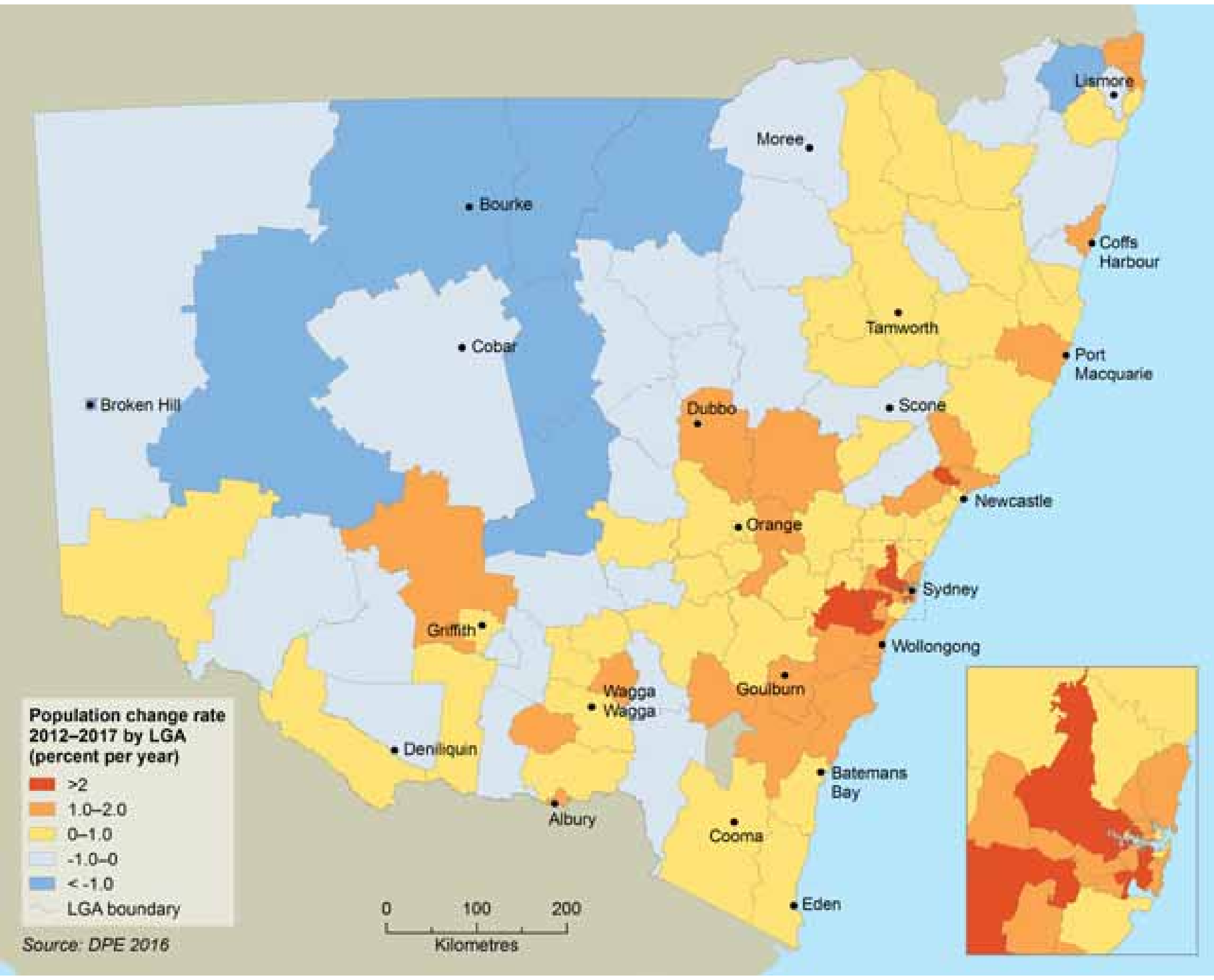


Notes:
* Greater Sydney extends from the Hawkesbury River in the north to the Royal National Park in the south; towards the west the region includes the Blue Mountains, Wollondilly and Hawkesbury local government areas.

Source:
ABS (2017, 2018); calculations by DPE

Between 2012 and 2017, population grew at a faster rate in parts of Greater Sydney, regional cities and popular coastal areas than in the rest of NSW (see **Map 1.1**).

Map 1.1: Population change in NSW, 2012 to 2017



Source:
ABS 2018

Greater Sydney

Over the five years to June 2017, Greater Sydney's population increased by almost 450,000 people, or 10%. Within Greater Sydney, the largest population increases were in the local government areas (LGAs) of Sydney (43,700), Blacktown (39,100) and Parramatta (35,300) (ABS 2018).

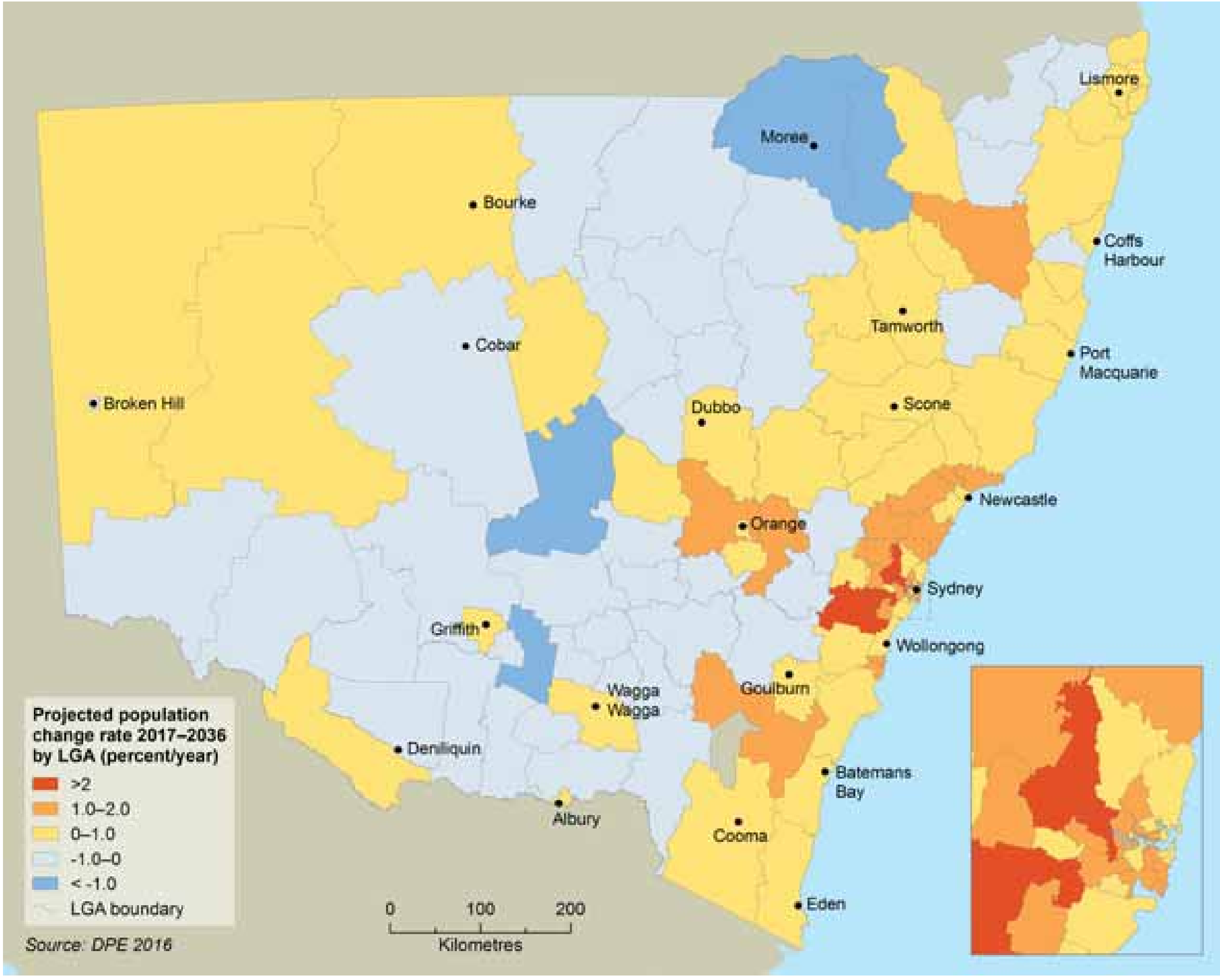
Regional NSW

Between 2012 and 2017, the population of regional NSW, which includes coastal NSW and inland NSW, increased by almost 4%. Substantial growth occurred in areas closer to Sydney (the Central Coast, Lower Hunter and Wollongong) and the state's larger regional centres (Tweed, Tamworth, Port Macquarie and Bathurst). The largest population declines occurred in areas that were already sparsely populated, such as Broken Hill and Moree Plains.

Growth projections

By 2036, the NSW population is projected to grow to 9.9 million people, with the majority – an additional 1.7 million people – living in Greater Sydney. **Map 1.2** shows projected population change across the state between 2017 and 2036. Further detail is available at the NSW Population Projections website (DPE 2016).

Map 1.2: Projected population change, 2017-2036



Source:
DPE population projections 2016

Population density and distribution

In June 2017, there were 9.8 people per square kilometre in NSW, a 12% increase from 8.7 in 2008. Differences in population density throughout the state have implications for provision of services and strategic planning.

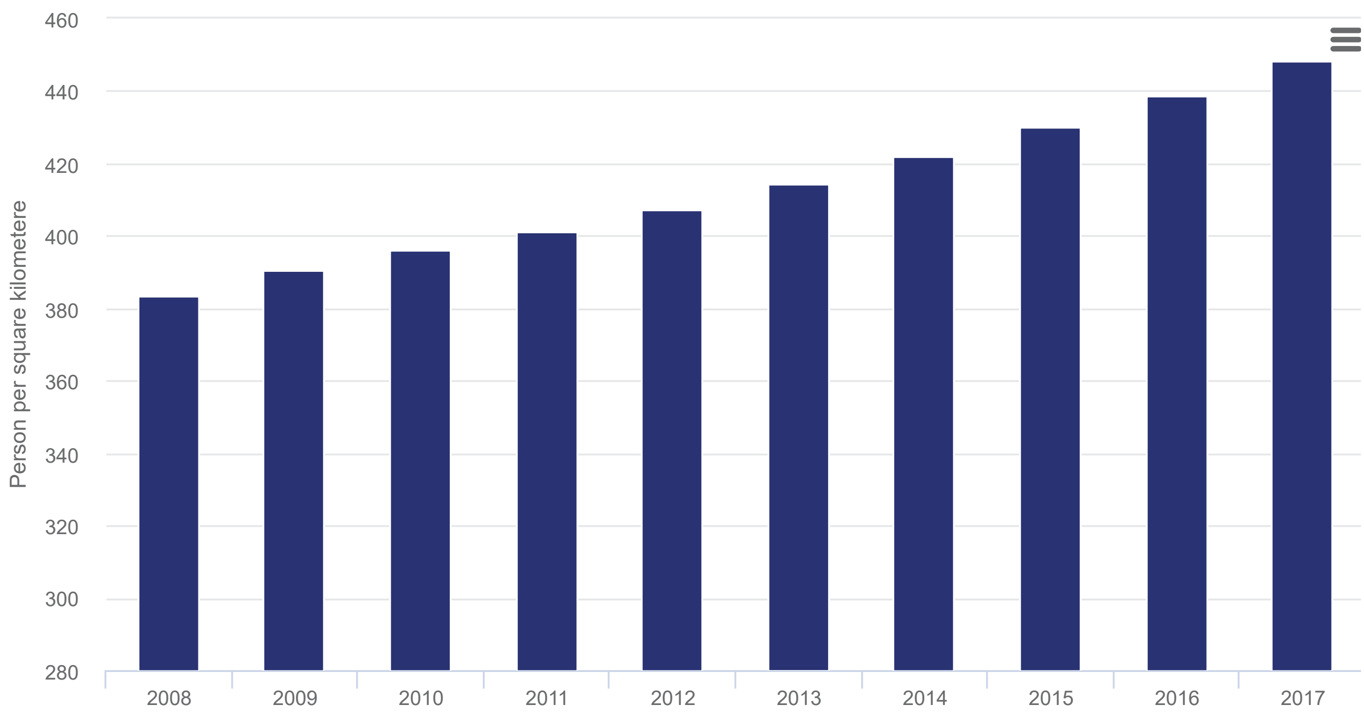
Higher densities require more energy, water and waste removal services to be provided within the existing urban footprint, but this can be offset by more efficient built environments and reduced demand for land on the urban fringe. It can reduce the impacts of transport and energy use by facilitating easier access to active transport (e.g. walking and cycling) and public transport. Well-designed urban areas with adequate green space also improve liveability and provide habitat for urban wildlife (Dexter et al. 2016, Hess at al. 2014).

See also Energy Consumption, Transport and Urban Water Supply topics

Population densities range from less than one person per square kilometre in the Far West region of NSW to more than 10,000 people per square kilometre in the inner-city suburbs of Darlinghurst, Potts Point, Pyrmont and Surry Hills.

Population density in Greater Sydney has grown steadily. With sustained population growth and management of urban fringe development, average population density in Greater Sydney has grown by 17% to almost 450 people per square kilometre since 2008 (see **Figure 1.2**). Even within Sydney there is a large variation in population density, which can be less than 50 people per square kilometre in some areas.

Figure 1.2: Population density of Greater Sydney, 2008–17



Source:
ABS 2018

Outside of Sydney, high population densities are found in parts of Newcastle and Wollongong, and the regional centres of Tweed Heads, Coffs Harbour and Port Macquarie. These are also areas with higher population growth.

Population trends

Populations grow due to:

- natural increase – the difference between births and deaths
- migration – the movement of people to and from other parts of Australia and overseas.

Over the past 40 years, overseas migration has been the most significant contributor to population growth in NSW, with natural increase remaining relatively stable (ABS 2017).

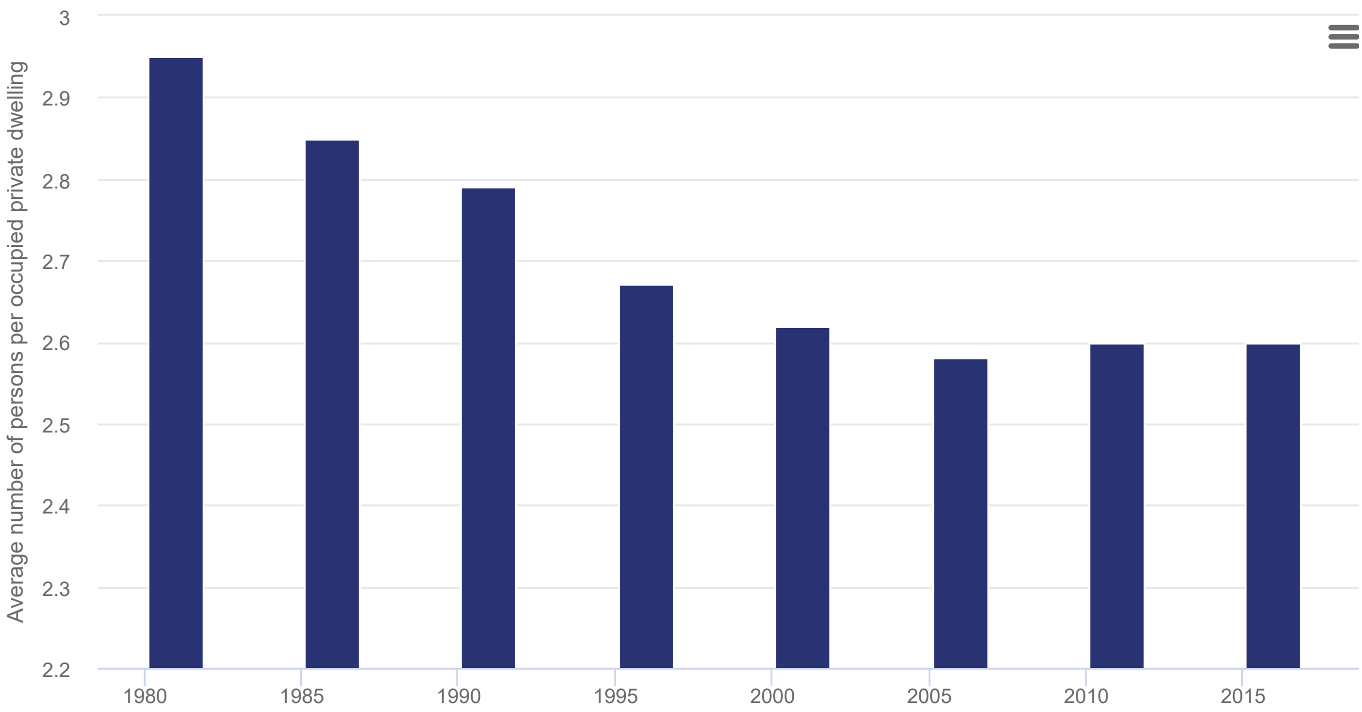
General trends related to population growth and distribution across the state include:

- movement from both rural areas and Sydney to regional centres
- young people moving from rural areas to the cities
- retirees ('tree changers' and 'sea changers') moving to popular areas on the coast, along the Murray River and locations within easy driving distance of metropolitan areas
- an ageing population – 16% of the NSW population is 65 years or older (ABS 2017).

Alongside increased housing costs and structural changes to employment, these trends influence living arrangements.

In NSW, especially metropolitan areas, there has been a slight increase recently in the average number of people per household (see **Figure 1.3**). This may represent a reversal of the trend of the previous three decades, where the average size of households in NSW had been getting gradually smaller, especially in regional areas. The key environmental implication of smaller households is that proportionally more housing stock is needed as the population grows, with flow-on impacts on land, energy, water, waste and resource use.

Figure 1.3: Average household size in NSW, 1980–2016



Source:
ABS, Census of Population and Housing, various years

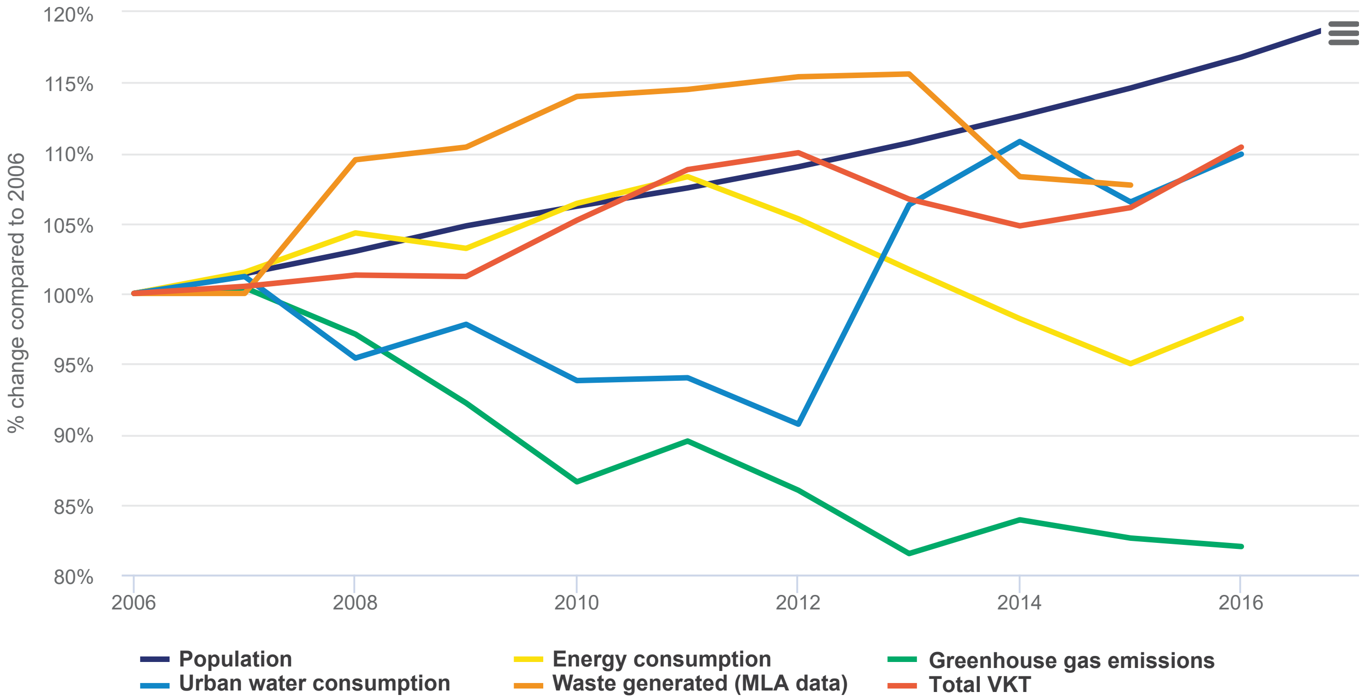
Pressures

Population and environmental trends

The State of the Environment (SoE) reporting framework is based on the pressure-state-response model of reporting. Within this framework the topics of Population and Economic activity and the environment are treated as drivers of environmental change. However, the actual effects of population increase and economic activity on environmental resources and ecosystems depend on how increased demand for transport, land, food, housing, energy and potable water, and increased waste generation is managed.

Figure 1.4 shows changes in population and a number of environmental indicators relative to their levels in 2006, with all values for each indicator adjusted to a baseline of 100% for that year. Between 2006 and 2016 there was a steady increase in population, while most of the environmental indicators grew at a lesser rate or decreased.

Figure 1.4: NSW population growth compared to trends in energy, greenhouse gas emissions, transport, water and waste, 2006–16



Notes:
Energy data includes ACT; greenhouse and urban water data are for all of NSW; VKT = vehicle kilometres travelled on an average weekday (in Household Travel Survey Sydney area, counting vehicles and drivers only); MLA = metropolitan waste levy area).

Source:
ABS 2017, EPA data 2018, NSW – various agencies 2008–17, TfNSW Household Travel Survey data 2018, Department of Environment and Energy 2018a, Department of Environment and Energy 2018b)

Specifically, **Figure 1.4** shows the following:

- Total energy use fluctuated during 2006–16, but by 2016 was at the same level as 2006, resulting in a reduction in energy consumption per capita. Emissions of greenhouse gases decreased during this period. Energy consumption has been dropping due to reduced demand from industry, increased uptake of renewable energy and greater efficiency of buildings and equipment. See Energy Consumption and Greenhouse Gas Emissions
- Overall household trips, measured by total vehicle kilometres travelled by drivers, increased, but at a lower rate than population growth because less trips are being made per household. The environmental impacts of increased traffic on roads include congestion, noise, air pollution and greenhouse gas emissions. See Transport and Air Quality
- Total waste generation, measured in the Sydney metropolitan waste levy area, reduced by 4% since it plateaued in 2012 and 2013 and waste generated per capita has declined since 2008. In populated areas, waste products (e.g. solid waste, sewage, hazardous waste and atmospheric emissions) need to be managed to avoid increased stress on natural ecosystems. See Waste and Recycling and Air Quality
- Overall urban water consumption dropped in response to water-saving policies and initiatives implemented during the millennium drought of 2003–2009 but has since started to rise again with population growth. A growing population requires more water for residential consumption and agriculture and puts pressure on the environmental health of river systems. See Urban Water Supply

The Australian State of the Environment Report 2016 includes a similar chart of selected socio-economic and environmental indicators to that shown in **Figure 1.4**. Broadly, this shows that NSW outcomes over the same time period are generally better than or similar to the national trend for common indicators.

Housing

A growing population, especially with a trend towards fewer people per dwelling, requires more housing. Based on current population projections, the NSW Government has identified that 725,000 additional homes will be needed by 2036 to meet demand.

Responses

Legislation and policies

While the NSW Government has firm population projections, it has not developed specific population targets, growth plans or limits to population growth.

In October 2018 the NSW Premier announced the appointment of an expert panel to develop a population policy for NSW. The panel will consider:

- the current rate of population growth and infrastructure pipeline
- how long it will take for infrastructure to catch up with population growth rates
- NSW's role at upcoming population discussions with the Commonwealth Government.

The Panel will also recommend next steps for more detailed work on the issue of population.

A number of plans have been developed to respond to the potential impacts of population change.

The Greater Sydney Region Plan

The Greater Sydney Region Plan: A Metropolis of Three Cities is the NSW Government's 40-year vision for the Greater Sydney Region.

The plan aims to re-balance growth and deliver benefits more equitably to residents across Greater Sydney. Prepared concurrently with Future Transport 2056 and the *State Infrastructure Strategy 2018–2038*, it aligns land use, transport and infrastructure planning to reshape Greater Sydney as three unique and connected cities: the Western Parkland City, the Central River City and the Eastern Harbour City.

It will boost productivity by bringing together good jobs and skilled workers; make Greater Sydney's suburbs more liveable as they grow through a place-based design approach; and make the three cities more sustainable by protecting the natural environment and open spaces.

Regional Plans

The NSW Government has 10 Regional Plans in place across the state that play a critical role in how natural resources are managed to ensure the prosperity and productivity of the NSW economy, as well as the health of local communities and the environment.

Regional Plans are long-term strategic planning documents that articulate a vision and plan for housing, jobs and community infrastructure to meet the needs of a changing population. Each Regional Plan also includes goals and actions to protect the environment and encourage sustainable use of resources, tailored to suit the region.

NSW Premier's Priorities

The Premier's Priority Delivering Infrastructure aims to deliver metropolitan, regional and local infrastructure projects to support an anticipated 113% increase in train trips, 30% increase in car trips (2018 State Infrastructure Strategy) and 40% more households (2016 NSW population and household projections) by 2036. These initiatives include new public transport developments.

See also the Responses sections in the Transport, Energy Consumption and Climate Change topics.

Waste

Waste management in NSW is guided by the Waste Avoidance and Resource Recovery (WARR) Strategy 2014–21 (EPA 2014), which, as noted in relation to **Figure 1.4**, has facilitated a decrease in per capita waste generation rates and total waste generation.

In 2017, a draft NSW Waste and Resource Recovery Infrastructure Strategy 2017–21 was released for consultation to assist the waste industry to understand expected increases in waste streams and to plan sufficient processing infrastructure capacity.

See also the Responses sections in the Waste and Recycling topic

Water

The 2017 Metropolitan Water Plan sets out strategies and programs for ensuring a sustainable water supply to meet the needs of the people and environment of Greater Sydney. The NSW Government has also developed initiatives for water and sewerage for towns in regional NSW, such as integrated water cycle management.

See also the Responses sections in the Urban Water Supply topic.

Programs

A range of NSW Government programs helps reduce the impacts of population growth. Many of these are discussed in the Energy Consumption, Waste and Recycling, Greenhouse Gas Emissions, Urban Water Supply and Transport topics. Some key programs addressing sustainability in urban environments are discussed below.

The Sydney Green Grid provides a framework for projects that will enhance liveability and biodiversity and increase ecological resilience by delivering an interconnecting network of open space throughout the city. This network includes parks, bush, creek corridors, transport routes, suburban streets, footpaths and cycleways.

The Metropolitan Greenspace Program (MGP) supports local councils in Greater Sydney and the Central Coast to improve regional open space by co-funding projects to deliver the Green Grid network. Since 1990, the program has awarded over $45 million to more than 620 projects.

The Building Sustainability Index (BASIX) is an integral part of the development assessment system in NSW. It sets energy and water saving targets, and minimum thermal comfort performance requirements for all new residential dwellings and significant renovations. Since the introduction of BASIX in 2004, the NSW Government estimates 460,000 homes have saved 202,000 megalitres of potable water and reduced carbon emissions by 6.3 million tonnes (DPE 2015).

Future opportunities

Reducing the environmental impacts of population growth can be achieved with careful management. The plans for Greater Sydney and regional areas outlined in this topic contain many elements that will improve sustainability outcomes.

In addition to these plans, the draft NSW Government Greener Places green infrastructure policy, when finalised, will guide urban planning, design and management to improve the network of green spaces. This will help reduce the urban heat island effect, improve biodiversity and increase access to walking and cycling pathways. The policy applies state-wide and links to the existing Sydney Green Grid program and sustainability objectives in the Greater Sydney Region Plan.

There are also opportunities to investigate each impact area at a strategic level and analyse the per capita reductions that would be needed to manage the impact of population growth. This will help define responses, including the possibility of setting new targets for key impact areas as part of the planning process.

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NSW EPA

Economic Activity and the Environment

The health of the economy is strongly linked to the condition of the environment and the natural resources it provides.
The NSW economy is shifting to become less resource intensive.

Summary

Service-based economy

~70%

of the NSW economy is service-based

Read more

Resource use by the economy

60%

The decoupling of CO_2 emissions from NSW Gross State Product since 1990

Read more

The NSW economy is shifting to a less resource-intensive, more service-based economy. A steady reduction in the resource and carbon emissions intensity of the NSW economy over time shows that economic growth does not necessarily have to be achieved at the expense of the environment.

Since 1990, the NSW economy has sustained positive annual growth of almost 2.6% per annum. Gross State Product has increased in real terms by close to $23,000 per capita over the same period.

The health of the NSW economy is strongly linked to the environment and the natural resources and ecosystem services it provides. However, over the past 30 years the NSW economy has been shifting from a more resource intensive industry base, to a service-based economy that has reduced environmental impacts.

Environmental-economic accounts which supplement conventional economic accounts are emerging as a focal point for the systematic collection of integrated environmental-economic information. These accounts can enhance decision-making by enabling environmental factors to be considered in decisions that traditionally have been based on economic factors alone.

The NSW Government employs a range of economic tools to manage its environmental resources, including cost-benefit analysis, market-based instruments and program evaluations.

Economic instruments such as levies or taxes, subsidies, tradeable permits and performance-based regulatory charges utilise market-based responses to offer a more flexible way to meet environmental quality objectives than traditional regulatory approaches. The recently-introduced container deposit scheme is a major initiative that relies on a market-based scheme.

Related topics: Population | Energy Consumption | Waste and Recycling | Urban Water Supply

Context

The economy is intrinsically related to the natural environment. This interaction is not simple, with different sectors of the economy having different levels and types of environmental impacts.

Economic growth (i.e. the increase in the production of goods and services in an economy over time) is influenced by various factors, including population growth, improved productivity, new technologies and growth in human capital (e.g. higher educational levels).

While population growth can affect the environment through increased consumption, resource use and waste production (see the Population topic), factors such as improved productivity and new technologies can reduce the resource intensity of goods and services (i.e. the same amount can be produced with fewer resources). Environmental impacts will also depend on whether an economy uses domestic or imported resources, and whether the goods and services that are produced are consumed locally or exported.

Environmental-economic accounts, which are still at an early stage of development and use, can potentially enhance the conventional system of economic accounts (the System of National Accounts) by extending them to apply to aspects of resource management from an environmental perspective. Changes in underlying natural resource wealth and environmental quality resulting from economic activity are excluded from conventional accounts, occurring outside the market, but can be included in environmental-economic accounts.

In 2018, a suite of national level environmental-economic accounts was released by the Australian Bureau of Statistics (ABS) which included:

- water consumption
- energy consumption
- greenhouse gas emissions
- waste generation.

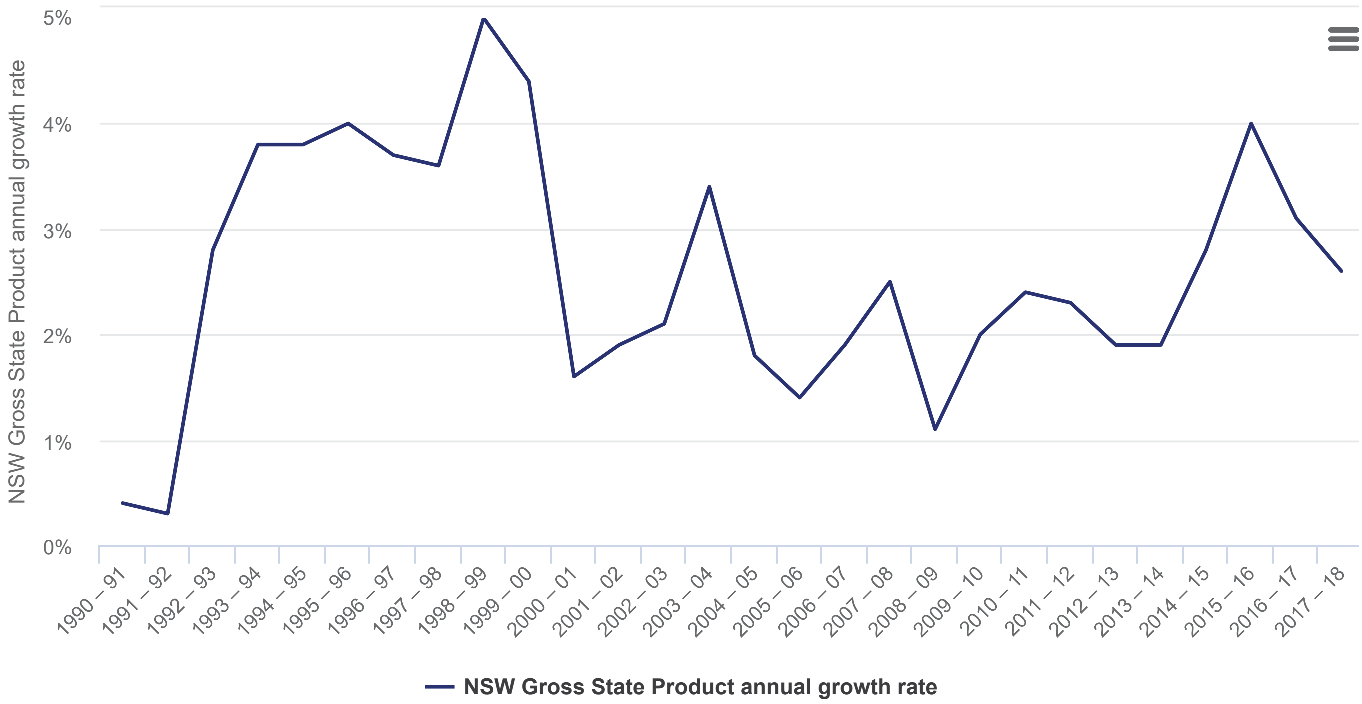
NSW information on these issues is described later in this topic, or in other topics of this report (see the topics Urban Water Supply, Energy Consumption, Greenhouse Gas Emissions and Waste and Recycling).

Status and Trends

Economic growth and structural change

NSW has the largest economy in Australia, contributing around one-third of national economic output in 2017. Between 1990–91 and 2017–18, the economic output of NSW doubled. Over that period the NSW economy has sustained positive growth of real Gross State Product (GSP) of around 2.6% per annum, on average (see **Figure 2.1**).

Figure 2.1: Economic growth (annual growth in real GSP), 1990–91 to 2017–18



Source:
ABS 2018a (cat. no. 5220.0)

GSP per capita increased by approximately $23,750 in real terms between 1990–91 and 2016–17, reaching $73,537 in 2017 (ABS 2018a, Table 1).

For the three year period covered by the latest State of the Environment reporting cycle, the average annual increase in economic growth was 3.3%, with business investment growing at 4.9% and employment at 2.7%, all recorded from July 2015 to June 2018 (ABS 2018a Table 1 & Table 2, ABS 2018a Table 4; ABS 2018b).

Structural change in the economy

NSW is primarily a service-based economy, with services contributing more than 70% of GSP in 2017–18 (ABS 2018a, Table 2).

Using chain volume measures to assess total industry gross value added (GVA), the five largest industries in NSW in 2018 were:

- finance and insurance (12.7%)
- professional, scientific and technical services (8.6%)
- construction (7.9%)
- health care and social assistance (6.5%)
- manufacturing (5.9%).

Over the past 30 years the NSW economy has been shifting from a resource intensive economy based on mining, manufacturing and agricultural production, towards the services and technological sectors. These sectors are less dependent on the use of natural resources and typically involve lower environmental impacts than primary and secondary industries.

While manufacturing remains a major sector in the NSW economy, it has not kept pace with the rest of the economy. Since 1990 it has remained relatively flat, with a recent up-turn inconsistent with a declining trend that started in about 2005.

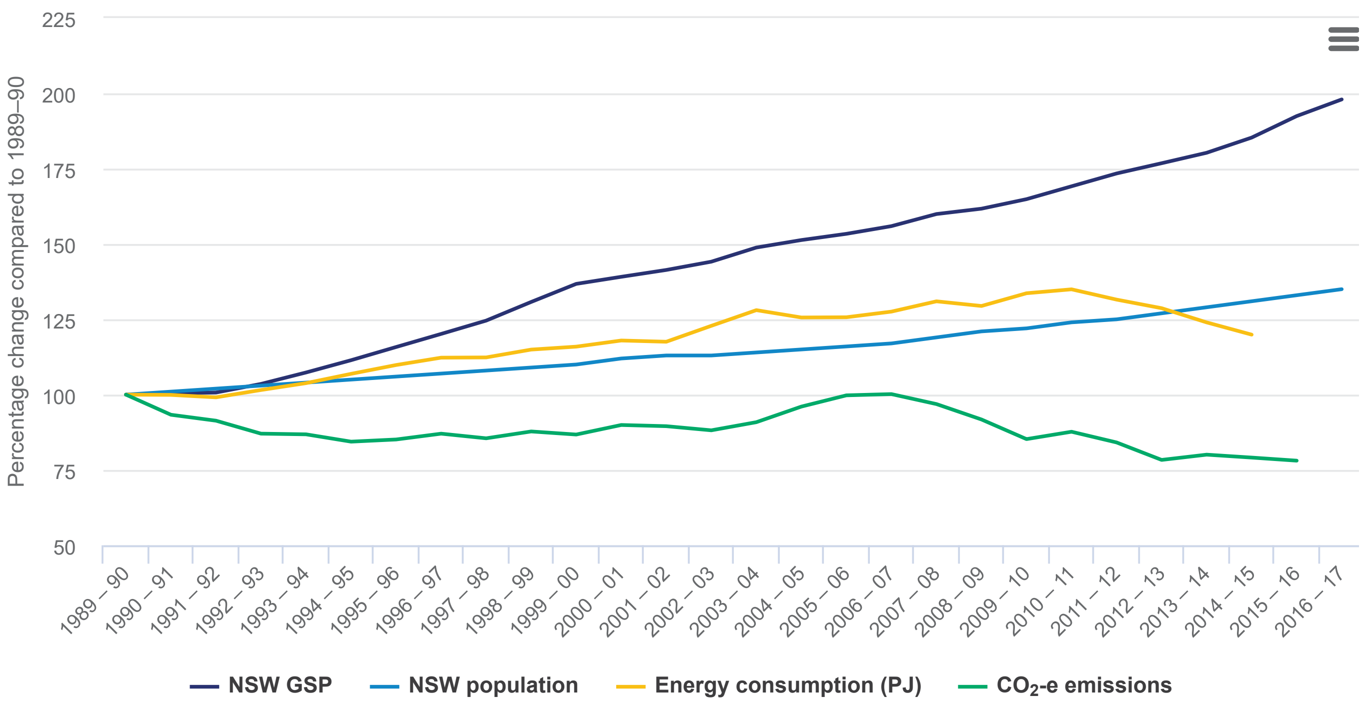
The next slowest growing sector is utilities, with electricity, gas and water services growing by only 22.3%. By contrast, over the same period the financial and insurance services sector grew by over 223%, overtaking manufacturing as the State's largest sector in the year 2000. Information, media and telecommunications is the fastest growing sector, with real growth of 262%. Agriculture, forestry and fishing grew by 65%, while mining grew by 181% (ABS 2018a, Table 2).

Emissions intensity of the economy

The way that economic growth affects greenhouse gas emissions and energy use over time is indicative of the changing relationship between economic activity and its environmental effects, including resource use. **Figure 2.2** contrasts the change relative to 1990 levels for a range of performance measures – economic performance (measured as GSP), population growth, greenhouse gas emissions and total energy use. Since 1990, real GSP has grown at an average annual rate of 2.6%, suggesting that the residents of NSW have become more affluent. Over the period until mid-2017, population growth has occurred at a substantially slower rate than economic growth, averaging 1.1% (ABS 2018a Table 4; 2018c).

While the key drivers of economic and population growth have both continued to grow steadily, total carbon emissions have been steadily declining (see **Figure 2.2**). The pattern is less regular for energy consumption which has largely grown at about the same rate as population, before declining from around the start of this decade.

Figure 2.2: Measures of economic performance and energy use in NSW 1989–90 to 2016–17

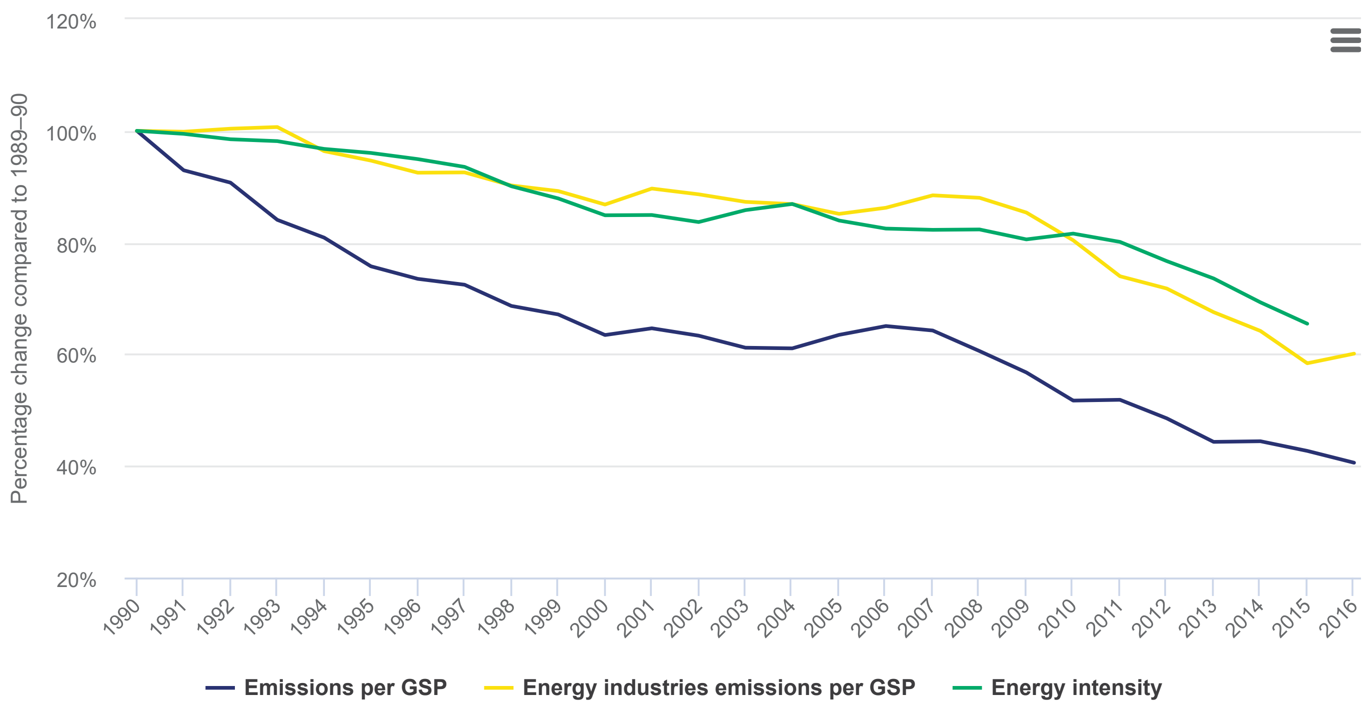


Source:
ABS 2018a (cat. no. 5220.0); ABS 2018c (cat. no. 3101.0); DEE 2017; DEE 2018

Figure 2.3 shows the change over time in the carbon emissions intensity and the energy intensity of the NSW economy; that is, the emissions produced, or the energy used for each dollar of GSP.

Relative to economic activity, both carbon emissions production and energy use have declined notably between 1990 and 2017. Carbon-equivalent emissions per dollar of GSP have fallen by about 60%, to about 40% of their 1990 levels. Energy use per dollar of GSP has fallen at a lesser rate to about 60% of 1990 levels. This suggests the NSW economy has been 'decoupling' from carbon emissions production, in particular, but also from energy use, so that less energy is required, and lower emissions are produced, for every dollar of economic activity.

Figure 2.3: Emissions and energy use relative to the economy 1990–2016



Source:
ABS 2018a (cat. no. 5220.0); DEE 2017; DEE 2018

Energy use and the economy

Sustained economic growth relies on energy for the production of goods and the delivery of services. While NSW's population and economy have grown, energy consumption has fallen (see the Population and Energy Consumption topics). Electricity consumption and generation has been and continues to be affected by a broad suite of factors, including:

- adoption of more energy efficient technologies (see above and the Energy Consumption topic)
- a significant, industry-led transition towards low-emissions, renewable energy sources in NSW to generate electricity (see the Energy Consumption topic)
- greater consumer engagement and attention to energy use and cost, including increasing the amount of generation for own use.

As noted above, the economy has been restructuring away from the production of goods towards the production of services, which typically requires less energy per dollar of value added. **Figure 2.3** above shows that emissions from the energy sector per dollar have also fallen since 1990, with this decline matching the reduction in energy intensity quite closely.

Additionally, the mix of energy sources continues to transition toward renewable sources, reducing emissions per unit of energy generated. Finally, energy prices are stabilising.

Figure 2.2 above shows that total energy use has fallen from the start of this decade, while **Figure 2.3** also shows that energy emissions dipped below energy intensity from about this time. This corresponds with a downturn in economic activity due to the global financial crisis, but more significantly the rapid uptake of energy from renewable resources in NSW, from about this time.

Energy pricing

Electricity prices are driven over time by several key factors including:

- changes in network costs
- wholesale costs (that is to say, the costs of generating electricity from an energy source)
- environmental costs (such as feed-in tariffs for solar panels)
- retail costs and margins.

In 2018, the Australian Competition and Consumer Commission released a report on electricity pricing, which found that the major factor contributing to rising prices over recent years has been the growth in network costs (ACCC, 2018). Specifically, between 2007–08 and 2017–18, growth in network costs contributed 38% of the total cost increase, while environmental costs contributed 15%.

New sources of energy

In the rapidly transitioning energy market (see the Energy Consumption) topic it is becoming increasingly apparent that when considering new sources of power supply, in most instances it would now be cheaper to build and supply electricity from renewable sources than from coal-fired generators. For example, the Australian Energy Market Operator has undertaken modelling for the Integrated System Plan, a cost-based engineering optimisation plan that forecasts system requirements for the National Energy Market over the next 20 years. The modelling is based on new generation capacity coming mainly from renewable sources backed up by gas for security of supply, with no role foreseen for new coal-powered generation (AEMO 2018).

Economic analysis to support environmental decision making

Current use of economic analysis

Economic analysis is used to support policies and to make decisions that either improve environmental outcomes at least cost, or provide the greatest net benefit to the NSW community. Such assessments help the NSW Government meet its commitments to industry and the community by:

- reducing the costs of regulation
- providing conditions that increase the competitiveness of doing business in NSW
- safeguarding the environment and the people of NSW.

By harnessing financial incentives, market-based economic instruments can provide policymakers with an alternative to conventional regulation for delivering environmental outcomes at minimal cost to business and the community.

Cost-benefit analysis: regulatory review and environmental evaluation

The process of cost-benefit analysis is used to enable the trade-offs between economic activity and environmental outcomes to be appropriately weighed. Cost-benefit analyses are required for all new policies and programs. This means that new environmental initiatives and regulations are properly evaluated so that the desired environmental goals are achieved through measures that provide net economic benefits to the community. Examples of environmental benefits included in cost-benefit analysis are greenhouse gas emissions reductions or savings and lower health costs from reduced air pollution.

In November 2016, the NSW **Climate Change Policy Framework** was released. In the Framework, the NSW Government committed to developing a benchmark value for emissions savings and applying this consistently in government economic appraisal. This means cost-benefit analysis for all new policies and programs will use the same value for any emissions savings benefit.

Use of economic instruments in environment protection

Economic instruments encourage behavioural responses to market forces, to help address the environmental concerns of the wider community in a more flexible way, with less cost and with less government intervention. Economic instruments include taxes, subsidies, offsets, tradeable permits and financial incentives.

The ultimate goal of economic instruments is to provide incentives for businesses and the community to consider the wider social impacts of their behaviour. This enables economic growth to occur while at the same time achieving more efficient allocation of resources.

In NSW a range of economic instruments are used to improve both economic efficiency and environmental outcomes. Examples include:

- the waste levy which provides financial incentives for residents and businesses to reduce the amount of waste they send to landfill
- solar feed-in tariffs provide an incentive for investing in household solar generation capacity
- the Biodiversity Offsets Scheme encourages prospective developments while conserving nature by ensuring that comparable areas are conserved elsewhere
- the Hunter River Salinity Trading Scheme allows industry participants to trade with each other for the right to discharge saline wastewater, without placing excessive pressure on the river's ecosystem
- the load-based licensing scheme imposes a charge on industrial facilities for each tonne of pollution they emit, encouraging these businesses to incorporate the wider social costs from pollution into their production decisions
- risk-based licensing matches the degree of regulatory oversight with the level of environmental risk posed by licensed operations in NSW, targeting poor performers and creating a financial incentive for facilities to improve their systems and performance
- the *Return and Earn* container deposit scheme uses financial incentives to encourage the return of used drink containers for recycling
- the NSW Energy Savings Scheme creates an incentive to reduce the consumption of electricity and gas by requiring electricity retailers and some large users to meet targets for energy savings certificates that are created on a voluntary basis by private sector service providers.

Environmental-economic accounting

Rationale and history

Environmental-economic accounting is a developing approach to the use of environmental data in economic analysis. It is designed to complement conventional national and State economic accounting.

The standard System of National Accounts (SNA) tracks the changes in an economy over time in terms of industry production, income, investment and household consumption, among other indicators. However, economic indicators only tell part of the story of how a society is progressing over time, excluding information on changes in environmental quality or resource conditions. By focusing only on changes in economic activity, conventional accounts can overlook pressures on land and other environmental assets, often called natural capital, which includes renewable and non-renewable resources, as well as ecosystem services.

Environmental accounts data typically link economic activity to various aspects of resource use, environmental impact and the generation of residuals (waste products). Such data can be used to explore trends in the use of natural resources, how these trends affect the level and condition of remaining stocks and patterns of pollution and waste discharged to the environment. This helps decision-makers explore relationships between the economy and the environment (UN 2012).

The system of environmental-economic accounts

Environmental-economic accounts provide an important extension to the national economic accounts framework (the System of National Accounts). The System of Environmental-Economic Accounting (SEEA) was developed by the United Nations and adopted as an international statistical standard in 2012.

The SEEA Central Framework uses a systems approach to environmental and economic information to describe the stocks and flows of natural resources. Individual accounts are relevant to the analysis of a specific resource or issue and a related set of environmental and economic questions.

Adoption of SEEA in Australia and NSW

At the national level, the Australian Bureau of Statistics (ABS) has taken the lead by establishing an Australian Environmental-Economic Accounts (AEEA) system that uses common standards and measures consistent with the SEEA. Initially, the AEEA will concentrate on monitoring the economic value of tradeable assets like timber and water, while following stages will expand the system to include the value of ecosystem services (ABS 2015b).

At various times over the past 10 years the ABS has produced ongoing or experimental accounts on a range of environmental topics that are SEEA-consistent extensions to the national economic accounts, for:

- land
- energy
- fish
- minerals
- water
- waste
- greenhouse gas emissions
- environmental expenditures and taxes.

In 2015, the ABS released the first national-level Australian Environmental-Economic Accounts report (ABS 2015) and this was updated in 2018 (ABS 2018d). These reports contain aggregate national statistics. Work is now underway to disaggregate and adapt this type of information to support decision-making in NSW.

Following meetings of the Commonwealth, State and Territory environment ministers, jurisdictions have agreed that their governments will collaborate to work towards a common national approach to environmental-economic accounting, including data-sharing between jurisdictions. This agreement led to the National Strategy for Environmental-Economic Accounting, which was endorsed by environment ministers in April 2018. The strategy sets out priority actions and timeframes to progress environmental-economic accounting at national and jurisdictional levels.

Pressures

Within the State of Environment (SoE) framework, based on the Pressure-State-Response model of reporting, the topics of Population and Economic Activity and the Environment are treated as drivers of environmental change. Unlike pressures, which have a direct impact on specific environmental outcomes, these drivers of environmental change are broader and more diffuse in their effect. These effects are mediated through a multitude of pathways and at a range of scales, facilitating:

- the processing and use of resources
- the production of goods and services
- the generation of waste.

Economic growth

A healthy environment provides ecosystem services and resources to underpin a thriving economy. Economic growth is widely regarded as critical for improving societal living standards, but it is debateable how much environmental damage or degradation is either inevitable or acceptable in order to generate improved material wellbeing. The decoupling demonstrated in this chapter between economic growth and environmental impacts, in particular carbon emissions, indicates that it is possible to reduce the environmental impacts of economic growth and that economic growth does not necessarily need to be achieved at the cost of significant environmental harm.

Moreover, slowdowns in economic growth do not necessarily generate accompanying improvements in environmental outcomes. Extended recessions can lead to environmental damage/degradation as business enterprises struggle to maintain viability. This may result in pressures for short-term exploitation of available natural resources, or less care and attention paid to the generation and management of waste.

Population

Population growth is often seen as a pathway to promote economic growth and has been identified as a key NSW Treasury economic indicator.

Population growth has a direct effect on the economy and the environment because bigger populations consume more goods and resources for food, clothing, housing, water, energy and transport, and they generate more waste.

However, not all economic performance and growth is necessarily dependent on the throughput of natural resources. Human capital is one of the most important inputs to the economy, converting labour into goods and increasingly services, with greater efficiency and productivity. Hence, population growth can stimulate economic growth through other pathways which have only an indirect or limited effect on the use of natural resources and the environment. The environmental impacts of growth will also vary depending on factors such as:

- policy settings
- technological progress and efficiencies
- improved management of natural resources
- changing social behaviours.

There is a stronger relationship between population growth and its environmental effects, than between economic growth and environmental effects. This is reflected in the observation that the economic growth rate is higher than the population growth rate. It is especially evident in comparing the per dollar trends to the per capita trends for emissions and energy use described earlier in this topic. The relationships between population and a range of other measures of environmental pressure such as use of transport and water and generation of waste are described in other topics of this report and summarised in **Figure 1.4** in the Population topic.

Climate change

Both mitigation and adaptation responses are required to address climate change. We need to act quickly to both reduce greenhouse gas emissions and adapt to climate impacts that are already occurring, and that are forecast to increase in frequency and severity. The earlier that mitigation action is taken, the less adaptation will be required later. However, for mitigation to be effective, concerted action is needed at the global level.

Major economic analyses commissioned by governments, Stern (2007) and Garnaut (2008), have recommended prompt action to mitigate emissions. Their work is supported by findings (Commonwealth of Australia 2008) that effective mitigation could be achieved at a cost that would be justified based on estimates of the future costs of climate impacts under business-as-usual scenarios, provided that mitigation action is part of coordinated international action.

The likely future, and potentially substantial, costs of climate change will include the costs of disaster relief, reconstruction and clean-up, and the rebuilding of infrastructure following extreme weather events, coastal erosion and bushfires. These are all likely to become more frequent and more intense in the future, due to the effects of climate change (see the Climate Change topic).

A report for the Australian Business Roundtable for Disaster Resilience and Safer Communities (Deloitte Access Economics 2017) estimates that the total cost of natural disasters to Australia will rise from just over $18 billion per year on average now, to an expected $39 billion by 2050. For NSW, the costs are $3.6 billion now, which will rise to $10.6 billion by 2050. As climate change has specifically been excluded from this analysis, these costs are likely to be higher, potentially substantially higher, when the future effects of climate change are taken into account.

Economic modelling undertaken by the Commonwealth Treasury for the original Carbon Pollution Reduction Scheme, based on emissions trading (Commonwealth of Australia 2008), compared a reference scenario with several alternative policy scenarios involving different emissions-reduction targets. Compared to annual per capita GDP growth averaging 1.4% from 2010–50, the modelled scenarios showed only modest impacts on growth, with annual growth rates predicted to be 1.2% to 1.3% across the various scenarios. Since that work was done, rapid developments in renewable energy are likely to have lowered the cost of moving away from reliance on fossil fuels.

Various researchers, including Wagner & Weitzman (2015), have stressed the uncertainty involved in predicting the nature and extent of the future effects of climate change. This means that estimates of the costs of emissions reductions are likely to be (significantly) more reliable than estimates of the damages from climate change and the costs of adaptation if emissions are not reduced significantly. Since worst-case outcomes would result in significantly harmful and costly outcomes to humanity and the environment, mitigation is seen from a risk-management perspective as comparable to taking out insurance against significant potential risks.

Insurance companies are already beginning to factor the effects of climate change into their risk profiles. In February 2017 the Australian Prudential Regulation Authority advised insurance companies that some climate risks are distinctly financial in nature and many of these risks are foreseeable, material and actionable now. Climate change is likely to have material, financial implications that should be carefully considered.

Responses

Legislation and policies

It is a legislative requirement of the *Subordinate Legislation Act 1989* that all new regulations in NSW must undergo a Regulatory Impact Assessment, including cost-benefit analysis. This is to ensure that the regulatory options adopted deliver the greatest net benefits to society. When environmental regulations and standards are developed they should have well-defined objectives and consider the cost of compliance and administration to industry and government as well as the economic, social and environmental benefits to the broader community.

Programs

NSW Environmental-Economic Accounts

Nationally, and in NSW, the development of harmonised waste accounts has been identified as a priority for environmental-economic accounts, and work has commenced to develop these accounts. Waste accounts will enable monitoring of flows of waste to landfill and recycling, helping to inform State management and planning for waste and resource recovery.

Market-based mechanisms

A range of economic instruments has been developed in NSW to provide market signals to achieve environmental outcomes, including:

- the Waste Levy
- the Biodiversity Offsets Scheme
- the Hunter River Salinity Trading Scheme
- load-based licensing
- risk-based licensing
- the NSW Energy Savings Scheme.

These are described in greater detail under Use of economic instruments in environment protection earlier in this topic.

Return and Earn container deposit scheme

The container deposit scheme *Return and Earn* was introduced on 1 December 2017 to reduce drink container litter. *Return and Earn* is the largest litter reduction initiative introduced in NSW.

The scheme addresses beverage container litter by providing an incentive to consumers to hold on to their empty container after finishing their drink and return it for a 10 cent refund. It also provides an incentive for others to pick up littered containers and obtain the refund for their efforts.

In December 2018, on the one year anniversary of the scheme's introduction more than one billion containers had been collected, reducing the number discarded into streets and waterways. Over the next 20 years, *Return and Earn* is expected to result in:

- 6 billion fewer beverage containers littered in NSW
- almost 11 billion fewer beverage containers ending up in landfill
- 6 billion more beverage containers being recycled.

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Human Settlement

The State of the Environment Report – 2018

NSW EPA

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NSW EPA

Energy Consumption

A reliable and affordable supply of energy underpins economic activity and our quality of life, but non-renewable sources create greenhouse gas emissions

Summary

Energy consumption in NSW & ACT has decreased by

6%

over the last three years

Read more

Transport is the biggest energy user, representing

45%

of NSW and ACT total energy use

Read more

Around 94% of the energy used in NSW comes from non-renewable sources such as oil, coal and gas.

However, electricity generation has seen a strong increase in the use of renewable, low emissions sources, from around 11% in 2014 to 16% in 2017.

In the three years to June 2016, total NSW and ACT energy consumption declined by almost 6%. Over the same period the NSW economy grew by 9%.

Almost half (45%) of the total energy use in NSW and ACT is by the transport sector, an increase of 6% over the last 12 years. The industrial sector accounts for 36%, with the residential and commercial sectors accounting for 11% and 9% respectively.

Related topics: Economic Activity and the Environment | Population | Greenhouse Gas Emissions | Climate Change

NSW indicators

Indicator and status		Environmental trend	Information reliability
Total NSW non-renewable energy consumption	POOR	Stable	✓✓✓
Transport sector use of non-renewable energy	POOR	Stable	✓✓✓
Renewable electricity generation in NSW	MODERATE	Getting better	✓✓✓
Per capita residential energy consumption	MODERATE	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

NSW is responsible for approximately one-quarter of Australia's total energy consumption and possesses large reserves of black coal and natural gas and significant wind, solar and hydro resources. Historically, NSW has used its coal and gas reserves to provide reliable and secure energy to the state, supporting economic stability and growth.

Coal and gas-fired power stations, combined with the petrol, diesel, gas and other fossil fuels used in the transport and industrial sectors, contribute significantly to NSW's greenhouse gas emissions. These power sources also impact local and regional air pollution (see Greenhouse Gas Emissions, Air Quality and Climate Change topics). To manage pollution and emission levels, and support sustainable economic development, NSW has introduced strong regulations for environmental controls and industry operations. These regulations are managed through mechanisms such as the *NSW Protection of the Environment Operations Act 1997*.

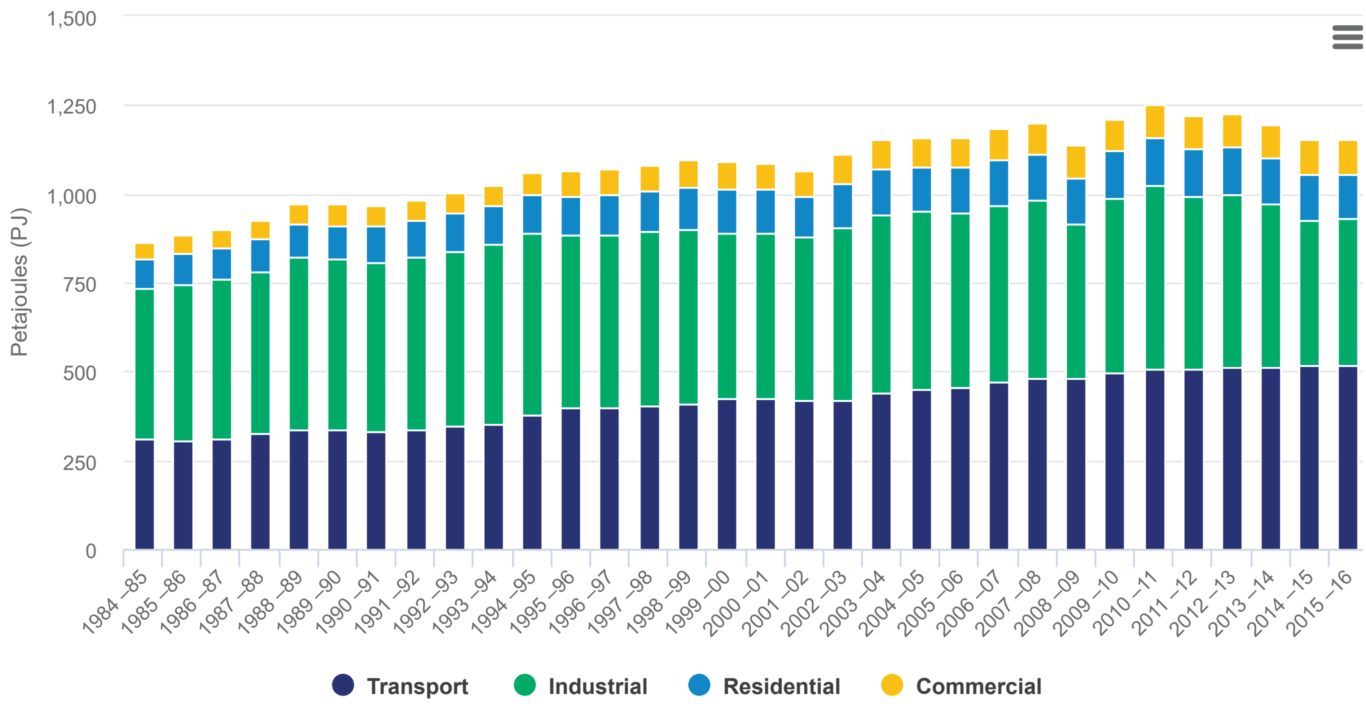
Status and Trends

Final energy consumption

'Final energy' is the energy supplied to the end user. Final energy consumption includes secondary energy, such as electricity, and therefore excludes the coal and gas used to generate electricity.

While the NSW economy has grown by around 9% between 2012–13 and 2015–16, total NSW and ACT energy consumption has declined by almost 6% over the same period. In 2015–16, final energy consumption in NSW and ACT was 1,156 petajoules (PJ), 69PJ less than in 2012–13. **Figure 3.1** shows the sectoral trends in final energy consumed for the NSW and ACT economies.

Figure 3.1: Final energy consumption by sector NSW and the ACT 1984–85 to 2015–16



Notes:
The data includes NSW and the ACT, as source data cannot be disaggregated.
Industrial sector includes agriculture, mining and manufacturing.
Commercial sector includes general commercial, construction and water, sewerage and drainage industries.

Source:
Derived from Department of Environment and Energy, Australian Energy Statistics, Table F, August 2017

The main reason for the decline in energy consumption is the lower consumption by the NSW industrial sector, particularly the manufacturing industry, since 2012–13. The closure of the Kurnell and Clyde petroleum refineries in October 2014 was the largest single cause of reduced consumption by the manufacturing industry.

The transport sector continues to be the highest user of energy (45% of energy use in 2015–16), compared to the industrial sector (36%), residential sector (11%) and commercial sector (8%). Transport's share of energy use has been steadily increasing, its share being 39% a decade ago (2005–06).

Energy use by fuel type and sector

Figure 3.2 shows final energy consumption by sector and fuel type (petroleum, electricity, gas, coal and renewable fuels) in NSW and the ACT in 2015–16.

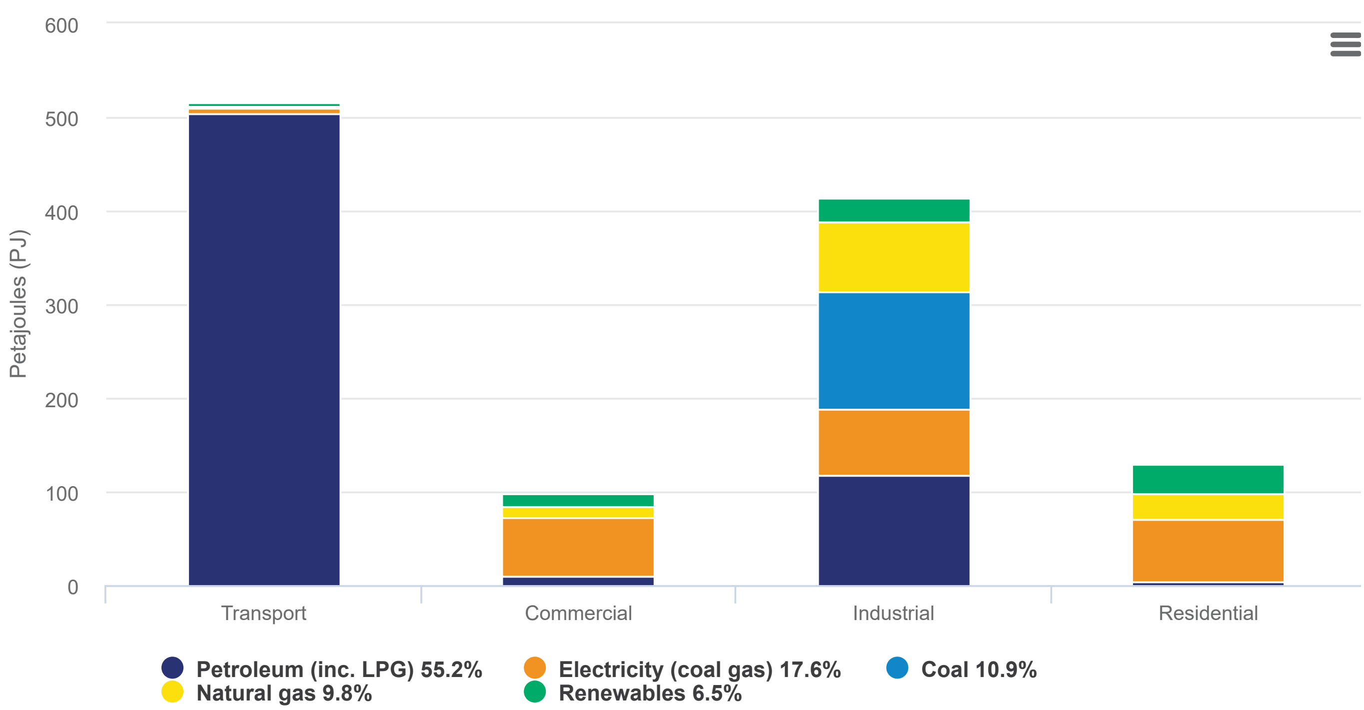
Petroleum was the largest component of final energy used in NSW and the ACT (around 55%). The transport sector was the major user of petroleum in 2015–16 (505PJ), followed by the industrial sector (118PJ). Industrial sector use of petroleum has declined, mainly due to the closure of the Kurnell refinery.

Electricity use was 18% of final energy used. Total electricity use has slightly declined (204PJ in 2015–16 compared to 210PJ in 2012–13), due to reduced consumption in the residential and industrial sectors.

Renewable energy use in final consumption decreased from 45PJ in 2013–14 to about 37PJ in 2015–16, due to reduced output from Snowy Hydro. This category predominantly represents the use of biomass (organic matter), solar and hydroelectricity energy.

Coal use accounted for around 11% of final consumption in 2015–16, and **gas use** 10% (this excludes coal and gas used for electricity generation). The industrial sector is the sole user of coal (other than for electricity generation), which is used to generate heat as part of the manufacturing process. The industrial sector is also the largest user of gas, mostly as a raw material input. Total coal use declined (126PJ in 2015–16 compared to 139PJ in 2012–13), while total use of gas increased slightly (114PJ in 2015–16, compared to 111PJ in 2012–13).

Figure 3.2: Final energy consumption for each sector by fuel type, NSW and the ACT, 2015–16



Notes:
Data re-analysed by NSW Department of Planning and Environment to avoid double-counting and better allocate energy use to sectors.
Final consumption figures exclude waste heat losses in power plant facilities, conversion losses in refineries, as well as network losses from the transmission of electricity over long distances. In 2015–16, for example, waste heat from power plants amounted to around 414PJ, equivalent to 35.8% of final energy consumption in NSW.
Consumption by the electricity generation sector is not shown.
Coal consumption figures exclude coal inputs to electricity generation.
Gas consumption figures exclude gas inputs to electricity generation.
Renewable energy figures quoted include biomass (including biofuels), solar and hydroelectricity.

Source:
Derived from Department of the Environment and Energy, Australian Energy Statistics, Table F, August 2017

Per capita energy consumption

Over the past decade, the population of NSW has increased by almost 13%, or nearly 1 million people. Over that same period, per capita energy consumption has decreased by around 13%. This is largely due to declining energy use in manufacturing and a slight decline in residential energy consumption since 2012–13.

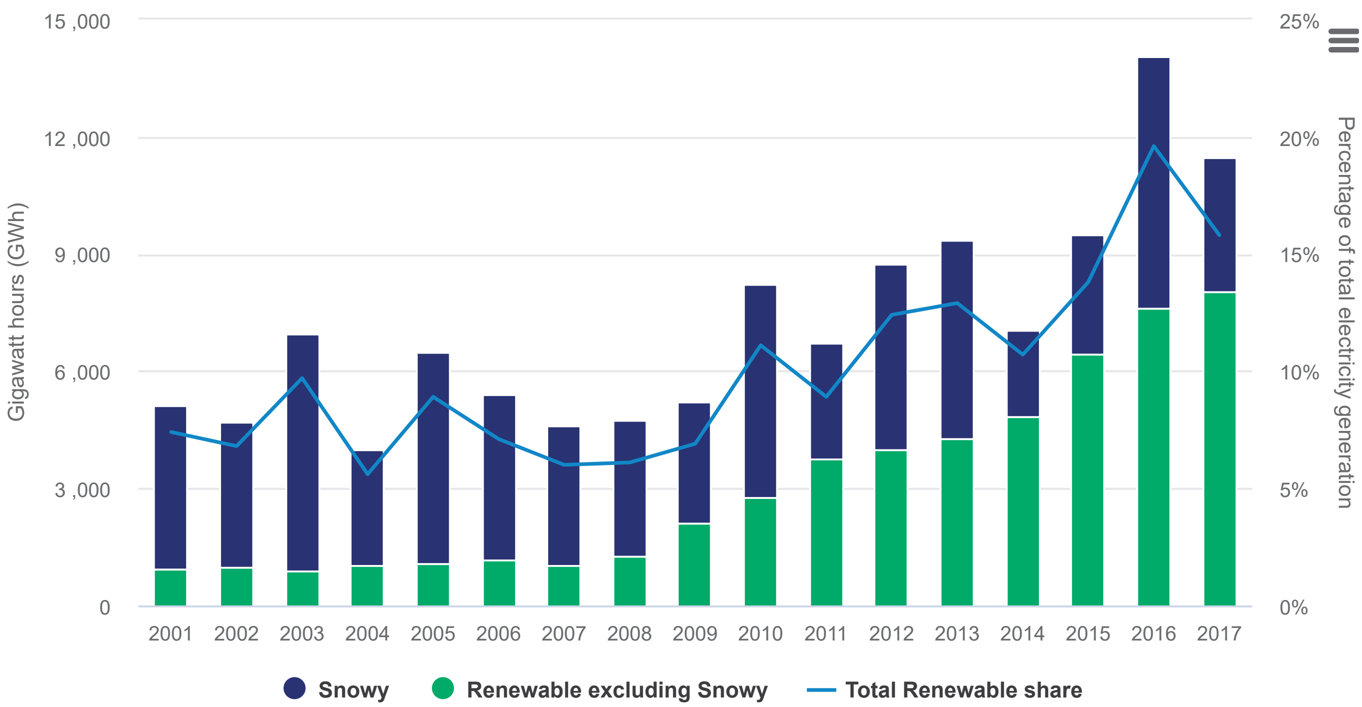
Table 3.1: Per capita energy consumption in NSW and the ACT, 1 July 2006 – 30 June 2016

	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Consumption (PJ)	1,182.7	1,199.1	1,135.6	1,211.9	1,252.1	1,220.1	1,225.2	1,192.5	1,154.2	1,156.0
Population NSW (Million)	6.9	6.9	7.1	7.1	7.2	7.3	7.4	7.5	7.6	7.7
Population ACT (Million)	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Population, combined (Million)	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1
Consumption (GJ/capita)	164.0	164.0	153.0	161.0	165.0	159.0	157.0	151.0	144.0	142.0
Residential Consumption (PJ)	126.8	127.6	130.8	134.0	137.0	135.5	135.3	129.3	128.8	129.2
Residential Consumption per capita (GJ/capita)	18.6	18.4	18.5	18.8	19.0	18.5	18.3	17.2	16.9	16.7

Energy generation

NSW is largely self-sufficient in relation to electricity supply, meeting about 92% of local demand. The remaining electricity is purchased from other states (particularly Victoria and Queensland) through the National Electricity Market (NEM). Electricity imports enable NSW to manage supply at lowest cost to consumers.

Figure 3.3: Renewable fuel sources for NSW electricity, 2001–2017



In 2017, renewable energy sources provided around 16% of the state's total electricity generation, which is more than double that provided in 2007 (6%). Of the renewable energy generated in 2017, Snowy Hydro accounted for almost 6% of total NSW electricity. Renewable electricity generation (excluding Snowy Hydro) continues to increase in NSW. This is being driven by an increase in wind and solar photovoltaic (PV) technologies, largely due to the Renewable Energy Target (RET).

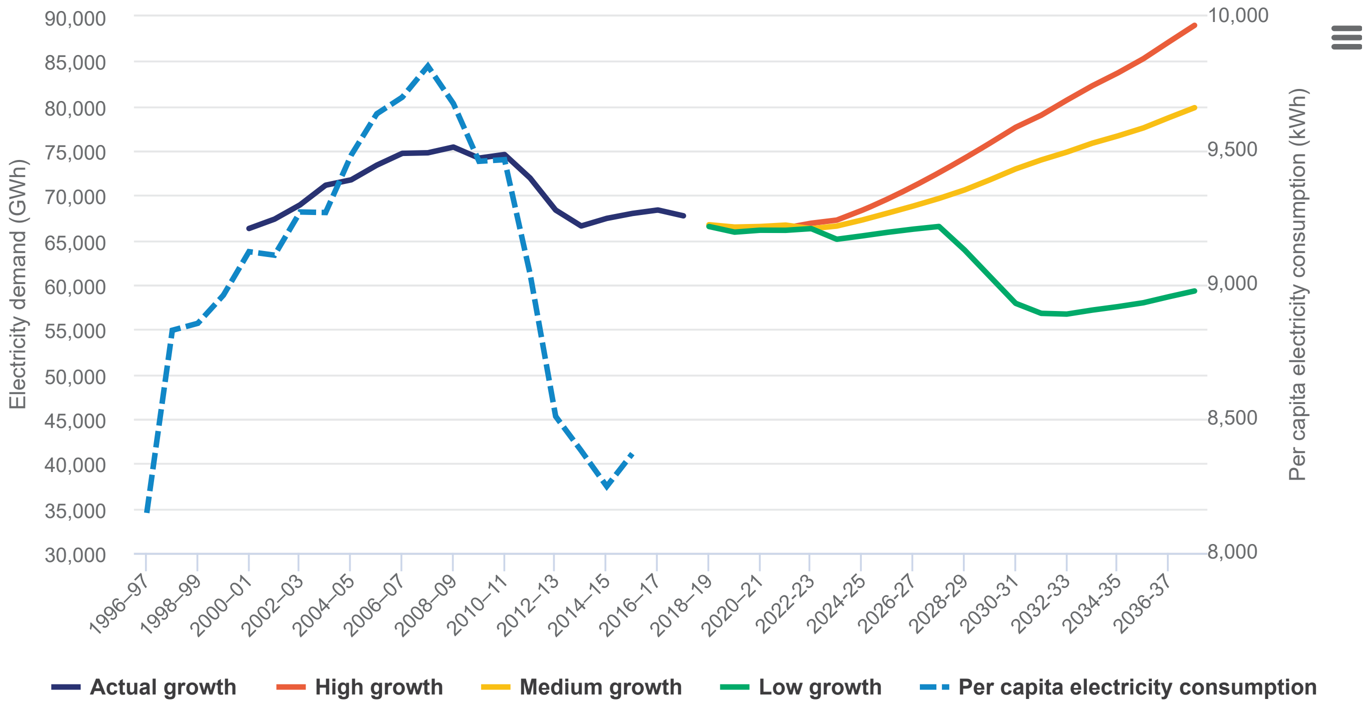
Since 2007, wind generation has increased 50-fold, and solar PV generation has increased 170-fold. In 2017, wind plants in NSW generated 1,944GWh of electricity, and solar PV systems generated 3,304GWh. Over 1,052GWh of electricity was generated from bagasse (sugar cane waste), landfill and other bioenergy sources.

Pressures

Electricity demand

Demand for electricity from NSW's grid is expected to remain flat over the next five years before increasing again (**Figure 3.4**). Demand resulting from population growth is estimated to be offset by improvements in the energy efficiency of appliances and machinery. Increasing adoption of rooftop solar and battery storage systems will further reduce residential demand from the electricity grid. Beyond the next five years, consumption is forecast to increase as electric vehicle charging begins to have a notable effect on electricity demand.

Figure 3.4: Electricity consumption and demand forecasts, NSW and the ACT



Notes:
The data includes NSW and the ACT.

Source:
TransGrid 2011; AEMO 2017; ABS 2017; Australian Energy Council and Energy Networks Australia data 2017

Transport fuel demand

Most vehicles in NSW are fuelled by either petrol or diesel. Transport is the second largest source of emissions, especially from vehicles, which are a major source of air pollution, particularly in urban areas. Standards for fuel efficiency of vehicles is the responsibility of the Federal Government. As noted in the Transport topic, the demand for transport has increased as population grows. NSW has targets of 6% of the total volume of petrol sold in NSW to be from ethanol, and 2% of diesel to be from biodiesel. In future, the increasing cost-efficiency and take-up of electric vehicles presents opportunities to improve the proportion of renewable energy used by the transport sector.

Climate Change

Stationary energy (which includes coal and gas fired power stations, petroleum refining and combustion of fossil fuels in manufacturing) is the main source of greenhouse gases in NSW, accounting for 51% of overall emissions. Coal and gas-fired power stations alone account for 39% of overall emissions (see Climate Change, Greenhouse Gas Emissions, and Air Quality topics). Greenhouse gases contribute to climate change, projected to cause higher temperatures, changing rainfall patterns, warming ocean temperatures, rising sea levels and more frequent extreme weather events.

Climate change also places an upwards pressure on energy demand. Increased climate variability and extremes may increase demand for heating and cooling and accelerate the need to replace infrastructure, power and manufacturing plants and other buildings to accommodate greater weather variability and extreme events (AEMO 2018). Climate variability will also increase the amount of electricity lost during transmission and distribution. Extreme weather events also present risks for energy security.

Responses

The NSW government's priority is to ensure NSW energy consumers have access to affordable, reliable and sustainable energy. The government has adopted a technology-neutral approach to achieve this goal, encouraging private sector-led energy investment.

Legislation and policy

NSW Climate Change Policy Framework

- The **NSW Climate Change Policy Framework** was released in November 2016. The framework sets two aspirational objectives for NSW to achieve net zero emissions by 2050 and to be more resilient to a changing climate. In the framework, the NSW Government endorses the Paris Agreement and commits to helping to achieve Australia's Paris Agreement commitments. It identifies boosting energy productivity as a key NSW Government policy direction that will assist in reducing greenhouse gas emissions and put downward pressure on household and business energy bills.

Increasing energy efficiency

- The **Greenhouse and Energy Minimum Standards (GEMS)** creates a national framework for product energy efficiency in Australia. Established in 2012 under Commonwealth legislation (*Greenhouse and Energy Minimum Standards Act 2012*), the program stops the importation of poorly performing electrical appliances and gives consumers information to help them choose more efficient appliances at the point of sale. Nationally, this program is expected to save households and businesses an estimated $60 billion between 2012 and 2030.
- The **Energy Savings Scheme (ESS)** is a state-wide program for improving energy efficiency. Established in 2009, the ESS creates financial incentives for businesses and households that improve their energy efficiency by requiring energy retailers to purchase energy savings from accredited energy efficiency service providers. Energy savings are

achieved by installing, improving, or replacing energy savings equipment. Since its establishment, the ESS has supported projects that will deliver around 22,000 gigawatt hours of energy savings and over $3 billion in bill savings over the projects' lifetimes.

- The **NSW Climate Change Fund** was established in 2007 under Part 6A of the *Energy and Utilities Administration Act 1987* to provide funding to reduce greenhouse gas emissions and the impacts of climate change associated with water and energy activities. The CCF has typically funded programs for energy efficiency, renewable energy and climate change adaptation. In September 2017 the NSW Government announced the Climate Change Fund supported Energy Affordability Package. This provided $112.5m in funding over five years to help small businesses and vulnerable households save energy and ease cost-of-living pressures. In August 2018 the NSW Government announced the Energy Efficiency Package, which provides a further $72m funding to support energy efficiency measures for households and businesses.
- The **Energy Efficiency Action Plan (EEAP)** was released in 2013 and ran to July 2017. Its 30 actions were designed to help NSW households, businesses and government to use energy more efficiently. The EEAP programs delivered electricity and gas savings of 6,310GWh, energy bill reductions of around $1.2 billion and reduced the peak load on the electricity network which helps reduce the need to invest in expanding electricity network infrastructure (OEH 2018).
- The **NSW Government Resource Efficiency Policy (GREP)**, released in July 2014, encourages the NSW Government to lead by example by implementing energy efficiency projects and adopting renewable energy across government facilities. In August 2018 the Government announced a new target to accelerate the roll-out of solar panels on government buildings, such as schools and hospitals. The target is to reach 25,000 megawatt hours of solar energy a year by 2021, increasing to 55,000 megawatt hours a year by 2024.
- In July 2017 the NSW Government increased **Building Sustainability Index (BASIX)** energy targets for residential developments. The new targets will typically improve the energy performance of new houses by 10%, and of multi-unit dwellings by 5%. The new targets are expected to contribute an additional 12GWh of annual energy savings per year by 2020.
- The **National Construction Code (NCC)** is a uniform set of technical guidelines for the design, construction and performance of buildings throughout Australia, comprising the Building Code of Australia (BCA) and the Plumbing Code of Australia. The BCA sets out minimum performance standards for buildings including energy efficiency. The BCA is referenced and given effect in NSW through the *Environmental Planning and Assessment Act 1979*. The NSW Government also sits on the Australian Building Codes Board (ABCB) which oversees the NCC. The ABCB is considering ways to increase the stringency of energy efficiency requirements for commercial buildings.
- The NSW Government's **National Australian Built Environment Rating System (NABERS)**, measures the environmental performance of Australian buildings using a star scale. Buildings that update their NABERS Energy ratings have reduced their energy consumption at some of the fastest rates in the world, saving over $400 million in power bills since 2010.

Diversifying energy supply

- NSW's **Renewable Energy Action Plan (REAP)** seeks to encourage the development of renewable energy projects that achieve the lowest possible costs and maximum overall benefits to the state economy. Since 2013, it has succeeded in delivering NSW's first large-scale solar farms, and doubling the share of renewables in the NSW energy mix.

Programs

Supporting renewable energy uptake

In August 2018, the Government announced five clean energy programs to help communities, the private sector and the government sector to develop and accelerate clean energy technology while also enhancing grid security and bill affordability.

- The **Emerging Energy Program** is a $55 million initiative to encourage private sector investment in new generation technology.
- $30 million **Regional Community Energy** is to help regional communities build and access the benefits of clean energy.
- **Solar for Low Income Households** trial is a $15 million initiative to deliver immediate energy savings through the installation of a solar system
- **Smart Energy Devices for Households and Businesses** is a $50 million program to provide incentives to households and businesses to enable up to 200MW of demand response capability through smart devices and their availability to the grid.
- **Smart Batteries for Government Buildings** is a $20 million program to install smart batteries in key government sites to optimise solar systems, to deliver electricity savings to Government and to increase security through additional demand response capacity to the grid.

NSW manages the **National GreenPower Accreditation Program**, which helps to drive investment in new solar and wind plants by enabling households and businesses to purchase renewable energy over and above mandated targets. In 2016, GreenPower sales stood at 759GWh, with over 270,000 customers.

Diversifying energy supply

- The **Hydro Energy and Storage Opportunities** initiative seeks to leverage WaterNSW's extensive infrastructure portfolio to improve the state's electricity grid flexibility and help meet future demand for energy.
- The **Coal Innovation NSW Fund (CINSW Fund)** supports the research, development, and demonstration of low-emission coal technologies. The Fund has invested directly in a number of initiatives supporting low-emission coal technologies, including the Delta Carbon Capture and Storage Demonstration Project and the NSW CO_2 Storage Assessment Project.

Supporting energy efficiency and demand management

- The NSW Government is partnering with the Australian Renewable Energy Agency (ARENA) in the delivery of the NSW Demand Response Program, using funds from the Climate Change Fund to manage electricity demand during extreme peaks. The program is providing funding of $14 million to four pilot projects. The Australian Energy Market Operator (AEMO) can activate the demand response in times of energy system emergencies. The three-year trial will provide the equivalent energy capacity of 16,000 rooftop solar systems.
- Under the Energy Affordability Package and Energy Efficiency Package, the NSW Government supports low income households in social and private housing to save energy. This includes:
  - the appliance replacement offer, which provides eligible households with the opportunity to replace their existing inefficient fridge or television with a new efficient appliance at a discounted cost
  - upgrades to more than 20,000 rental homes to enable low-income renters to benefit from energy efficient lighting, heating and hot water systems
  - partnering with social housing providers to install energy efficiency measures at social housing properties.
- The Household and Small Business Upgrades program helps households and small businesses to save energy and money by offering discounts on lighting upgrades and energy-efficient appliances. The program is part of the Energy Affordability Package announced in September 2017 and is delivered through contracted suppliers to increase its reach.
- The Manufacturing Efficiency Funding program was announced as part of the Energy Efficiency Package in August 2018. It provides funding assistance for around 250 manufacturing businesses to install energy efficient equipment. These upgrades to items such as boilers, refrigeration and metering technologies will help businesses better manage their energy use.
- Since December 2017, Energy Management Services has provided support for small businesses. This includes free online modules, webinars and tools and guidance designed to help small businesses understand the basics of managing their energy use. From November 2018, this includes blended learning, training, coaching and technical

support to businesses of any size to reduce their energy use. From 2019, eligible businesses in target sectors can access specific energy management support, including co-funding towards energy management diagnostics, opportunity analysis, sub-metering and technical support. This program is funded by the Energy Affordability Package and Energy Efficiency Package.

Supporting alternative transport fuels and new vehicle technology

- The NSW Government is supporting the development of a market for cleaner and alternative fuels. In 2007 the Government mandated that 6% of the total volume of petrol sold in NSW must be ethanol, and that 2% of diesel must be biodiesel. The NSW Government requires that the Independent Pricing and Regulatory Tribunal (IPART) regulate wholesale ethanol prices, and that a wider range of petrol stations sell E10 fuel, which is unleaded petrol with between 9 and 10% ethanol.
- The 2018 **Future Transport Strategy** encourages the Government to support the shift from private car use to public transport, promote low-emissions vehicles, work with industry partners on new fuel-efficient vehicle technologies and transition to a low emissions passenger vehicle fleet (NSW Government 2018).

Future opportunities

The NSW Government is also looking at the implications of longer-term energy trends and is positioning NSW to take advantage of these opportunities.

- **Digital meters:** In December 2017, the Australian Energy Market Commission (AEMC) introduced a National Electricity Rule requiring all new electricity meters to be digital. Digital meters will allow consumers to access new services from their retailers, including improved access to energy usage data and easier integration of solar and battery technologies.
- **Electric Vehicles:** Major changes in technology and fuel sources are required if NSW's vehicle fleet is to keep pace with global technology trends. There are significant opportunities to reduce fuel consumption by using electric and hydrogen fuel cell vehicles or adopting systems that improve the operational efficiency of passenger and freight transport. In 2016, just 0.1% of new vehicle sales in NSW were electric, but CSIRO forecasts suggest this could increase to up to 50% by 2030 (Campey et al 2017).
- **Pumped hydro storage:** New pumped hydro storage projects can help ensure that energy supply, security and reliability remain adequate for NSW's future needs. The Government is supporting private sector investment in complementary pumped hydro projects through actions such as the *Hydro Energy and Storage Opportunities* initiative.

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Transport

The demand for transport has increased as the population grows.

Summary

Average weekday vehicle driver trip length

9km

in Sydney in 2016–17, no change over last decade

Read more

Public transport trips accounted for

12%

of all weekday trips in Sydney in 2016–17, compared to about 11% in 2007–08

Read more

The demand for transport has increased as the population grows. Total vehicle kilometres travelled has increased but levels per person have dropped. The transport sector (road, rail, ship and air) is one of the major contributors to greenhouse gas emissions and air pollution in NSW.

The total distance travelled by motor vehicles in NSW increased by 12.6% between 2007 and 2016. But the average distance travelled reduced by 7.6% from 14,400 to 13,300km per vehicle per year.

In 2016–17, around 4.9 million Sydney residents made 18.7 million trips by all modes of transport on an average weekday – around 3.8 trips per person.

Private motor vehicles remain the dominant mode of transport in NSW, accounting for 69% of all trips by Sydney residents and over 80% of trips by Hunter and Illawarra residents.

Public transport patronage has increased from about 526 million trips in 2010–11 to over 727 million trips in 2016–17. Household travel survey results for Sydney residents also show that public transport trips for an average weekday have increased about 21% between 2007–08 and 2016–17. Public transport represents about 12% of weekday trips.

In 2015–16 transport was responsible for 20.8% of greenhouse gas emissions in NSW, an increase of 12% since 2005. Petrol and diesel-fuelled vehicles are the main sources of oxides of nitrogen (NOx) emissions in Sydney.

Other potential environmental impacts include noise pollution and fragmentation of ecosystems.

A range of transport infrastructure and service initiatives being delivered under *Future Transport 2056* aims to encourage travel by public and active transport (such as walking and cycling), rather than by private car, which will help reduce traffic congestion and greenhouse gas emissions.

Air quality and emissions are being addressed through new vehicle standards and vapour recovery programs.

Related topics: Climate Change | Energy Consumption | Greenhouse Gas Emissions | Population

NSW indicators

Indicator and status		Environmental trend	Information reliability
Vehicle kilometres travelled (total)	POOR	Stable	✓✓✓
Vehicle kilometres travelled (per person)	MODERATE	Stable	✓✓✓
Public transport use overall trips	GOOD	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use the report.

Context

Transport plays a key role in allowing people and goods to get from one place to another. However, vehicles, roads, freight and infrastructure can have environmental impacts. These include:

- reliance on non-renewable resources for fuel
- greenhouse gas emissions
- noise and air pollution
- land clearing and habitat loss due to construction of roads and infrastructure.

Reducing congestion and improving access between homes, work and service centres are important challenges for all metropolitan and regional centres. These challenges are especially impacted by making public transport and active transport more attractive options.

Generally, private modes of transport such as cars have greater impacts on the environment than public transport such as trains, buses, ferries and light rail. This is because they are less efficient at moving large numbers of people and predominantly rely on polluting energy sources. Improving and delivering better public transport will lead to increased use and lower environmental impacts. Use of private vehicles tends to increase with expansion in road infrastructure.

Freight transport by rail has a lower environmental impact than moving freight by road because it is more efficient at moving larger volumes of goods, but goods lines can have noise impacts. Noise can be reduced by improvements to the condition of rolling stock and the track.

Status and Trends

Distance travelled by motor vehicles in NSW

While the total distance travelled by motor vehicles in NSW increased by 12.6% from 62,732 million kilometres a year in 2007 to 70,696 million in 2016, the average distance travelled per vehicle per year decreased by 7.6% from 14,400 kilometres in 2007 to 13,300 kilometres in 2016 (ABS 2008, ABS 2017).

Personal travel

In-depth personal transport data is collected for the Sydney Region (as defined by the ABS Greater Capital City Statistical Area (GCCSA)), and for the Hunter and Illawarra regions, through the annual Household Travel Survey. The Survey is the most comprehensive source of personal travel data in these regions. The Survey's statistics inform long-term planning to reduce impacts on the environment, improve amenity and meet the State's transport needs. The most recent information is presented here.

Overall, the data indicates that demand for transport has increased over the past decade due to population growth. Use of public transport has increased in Sydney but remains a small proportion of transport use. Public transport as a proportion of all modes has continued to be consistent over the past decade. Private motor vehicles continue to dominate personal transport, but in Sydney vehicle kilometres travelled per person has declined.

Total trips

Between 2007–08 and 2016–17 on an average weekday, the number of trips in Sydney, Hunter and Illawarra regions by all modes of transport increased by 9%, from just over 20 million to around 22 million trips. This is lower than the rate of population growth over the same period (15%).

Sydney

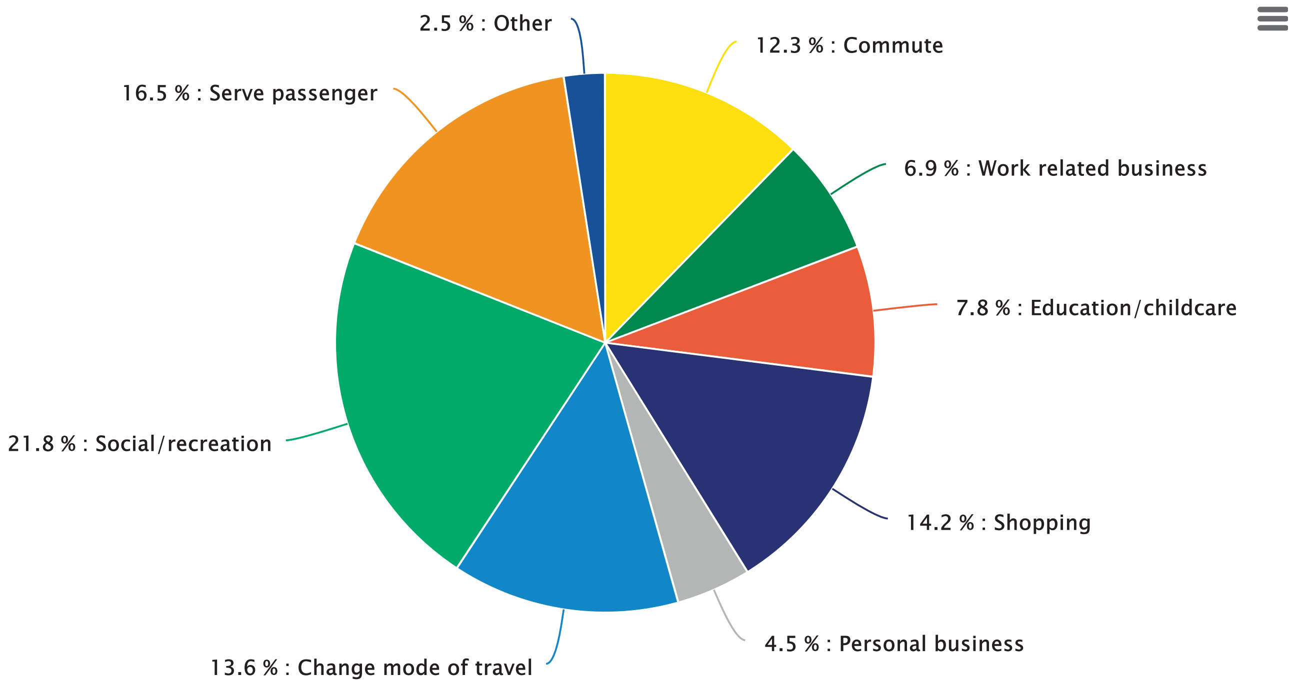
In 2016–17 on an average weekday, Sydney residents took approximately 18.7 million trips by all modes of transport. This is an increase of 10% over 2007–08 figures. Total vehicle kilometres travelled (VKT) has also increased in the Sydney Region by approximately 10% from 2007–08 to 2016–17.

Other trends in trip numbers by all modes in Sydney since 2007–08 (TfNSW 2018):

- the number of daily trips per person fell by 4.8% from 4.03 to 3.84
- average weekday trip distance rose 2% from 7.76km to 7.88km
- the number of personal business trips decreased by 24%
- work-related business trips decreased by 5%
- commuter trips increased by 15%
- shopping trips grew by 11%.

More detail about the purpose of these trips is shown in **Figure 4.1**

Figure 4.1: The proportion of travel for various purposes in 2016-17 (Sydney)



Notes:
'Change mode of travel' refers to travel to reach another mode of travel, for example walking to a bus stop or driving to park on a side street before walking to a station. The next stage of travel is categorised by another relevant purpose such as 'commute'.

Source:
TfNSW 2018

Hunter and the Illawarra

Trends for the Hunter region between 2007–08 and 2016–17 include:

- remained stable at approximately 2 million trips on an average weekday
- trips per person fell by 15% from 3.9 to 3.3
- work-related business trips decreased by 38%
- population rose by 18%.

Trends for the Illawarra region during this period include:

- 1.66 million trips on an average weekday, up 6% from 1.57 million
- trips per person fell by 5% from 3.9 to 3.7
- shopping trips increased by 17%
- personal business trips decreased by 7%
- population rose by 10%.

The impact of technology on travel patterns

The decline of per person trips coincides with the rise in smart phone and information technologies. Social changes associated with these technologies, such as online shopping and working from home may be a factor in the reduction of work-related and personal business trips, but do not account for the increase in shopping trips.

The most recent data available (ABS 2018), shows that across Australia in 2016–17:

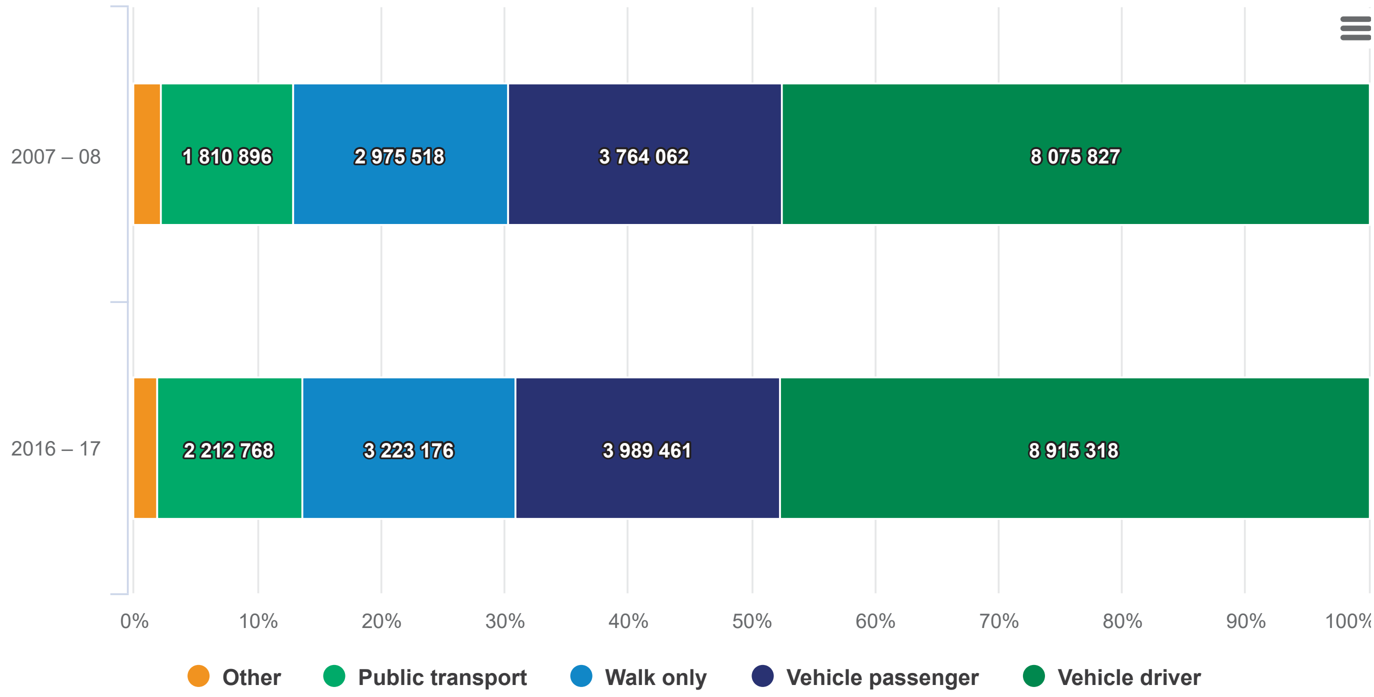
- 7% of internet users in NSW engaged in online shopping
- 46% of employed persons used the internet at home for work-related purposes.

The provision of online information on public transport services is assisting journey planning and decision making by travellers. This includes websites, contact centres, apps, social media and date feeds to third party providers. In 2016–17, 90 million trip plans were provided to public transport users through such channels (TfNSW 2017a).

Modes of transport

While public transport has numerous social, economic and environmental benefits, the Household Travel Survey indicates that private vehicles such as cars and motorbikes are the dominant mode of transport for residents in the surveyed areas (**Figures 4.2, 4.4** and **4.5**). The proportion of trips by different modes of transport has changed minimally over the past 10 years.

Figure 4.2: Proportion of trips by mode for Sydney Residents in 2016–17 compared to 2007–08



Notes:
* 'Vehicle' includes cars, motorbikes and scooters for trips by drivers and passengers
** Public Transport includes bus, train, ferry and light rail
*** 'Other' includes, bicycles, taxis, aircraft and wheelchairs

Source:
TfNSW 2018

Sydney

In 2016–17 on an average weekday in Sydney (TfNSW 2018):

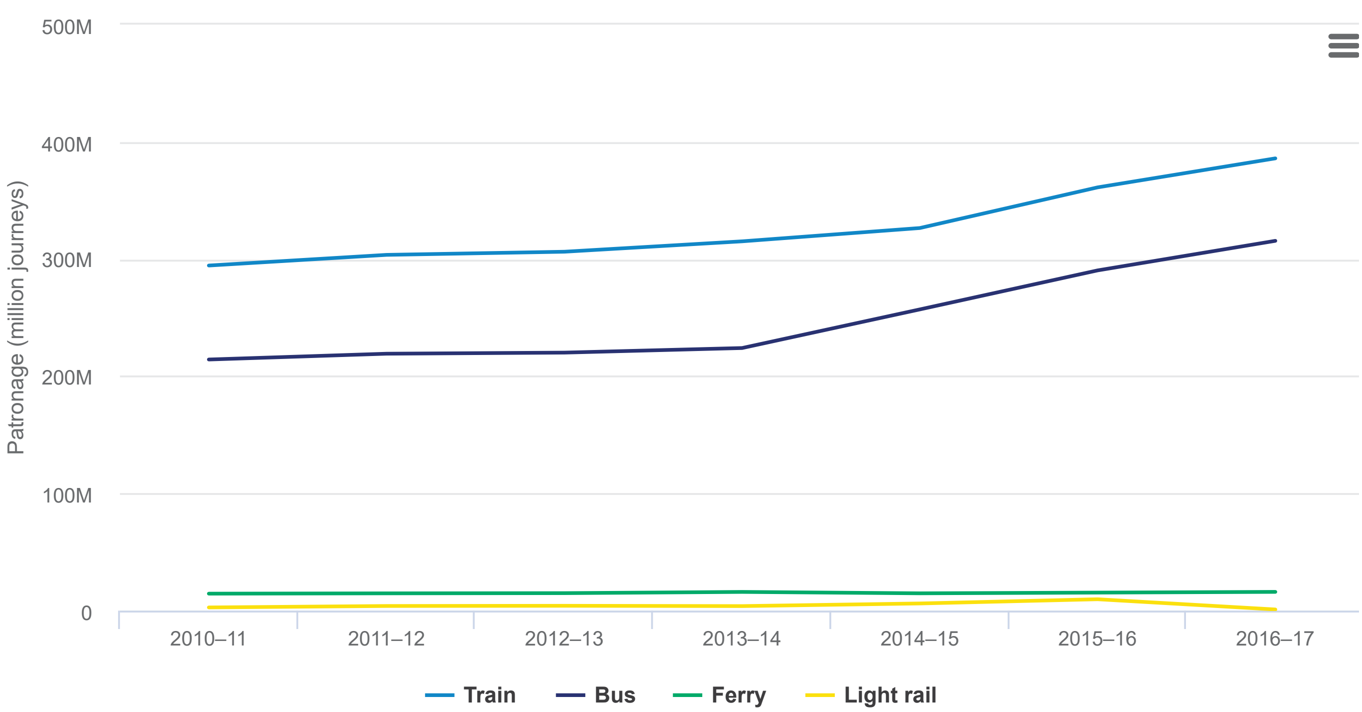
- 69% of trips were by private vehicles
- 6% were by bus
- 6% were by train
- less than 1% were by ferries and light rail
- less than 2% were by other (mainly taxis and bicycles)
- 17% were by walking.

While the proportion of trips for each mode of transport has remained constant, total trips over the 10-year period show:

- a 25% increase in train trips
- a 19% increase in bus trips
- a 10% increase in trips by private vehicles.

Trips by private vehicles are increasing at a faster rate than reported in the 2015 State of the Environment Report (5%).

Figure 4.3: Public transport patronage by mode including ticketed and unticketed journeys over the Opal public transport network, by financial year from 2010–11 to 2016–17. More than 727 million journeys were made over the year 2016–17.



Notes:
Official estimates for journeys includes Magnetic Stripe Ticketing (pre-Opal), Opal and tickets sold on board vehicles, along with estimates to account for unticketed travel.
Opal was progressively rolled out across the transport network from December 2012, starting with ferries. Trains followed from June 2013, buses from September 2013 and light rail from December 2014. From August 2016 Opal was the only form of ticketed travel.
Historical patronage data contains changes to the methodology of calculating trips resulting in figures that may not be directly comparable across years.
Historical patronage covers the Opal public transport network and may not be directly comparable to the results from the Household Travel Survey.

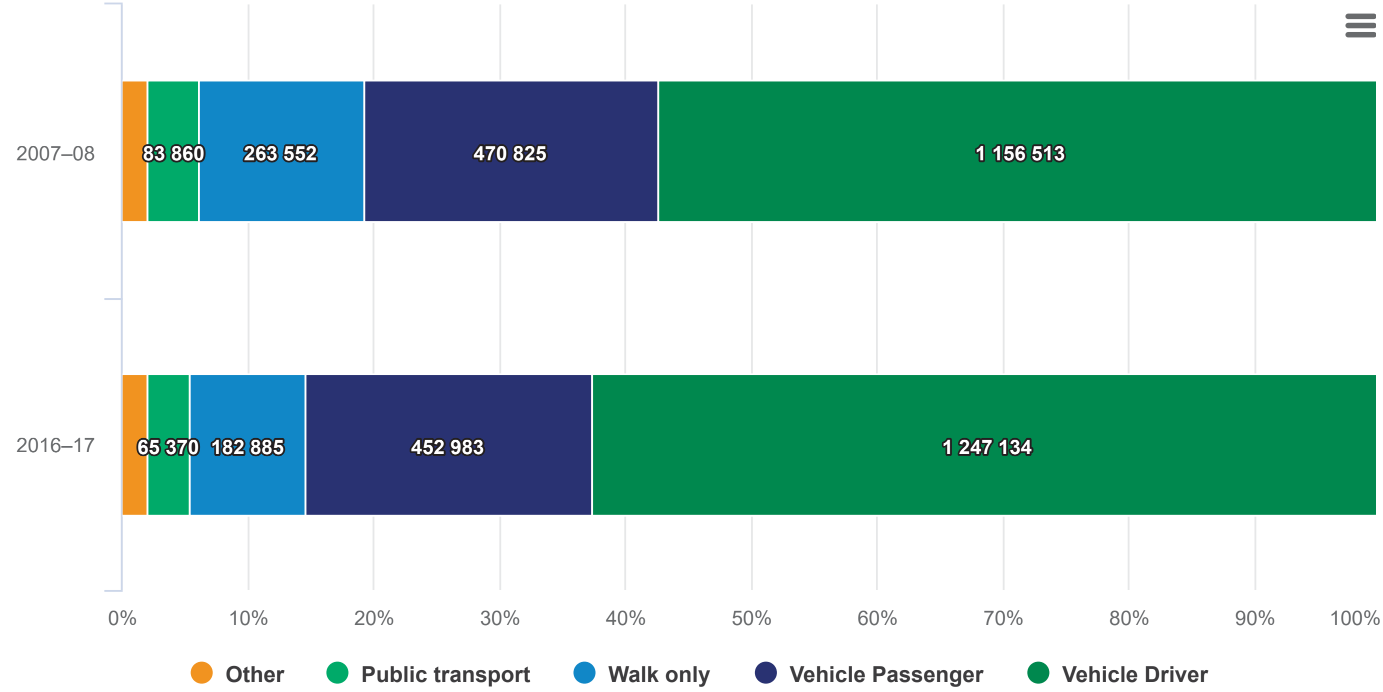
Source:
TfNSW historical annual patronage reporting across all modes from 2010–2011 to present

Hunter and Illawarra

In both regions, the Household Travel Survey shows that over 80% of trips were by private vehicle and less than 5% of trips were by public transport (**Figures 4.4** and **4.5**). Walking was a more common mode of travel than public transport in both regions.

Over the past decade, the number of trips on an average weekday by private vehicles has increased, while walking and bus trips have reduced. Although train trips reduced in the Hunter, there was an increase in train trips in the Illawarra.

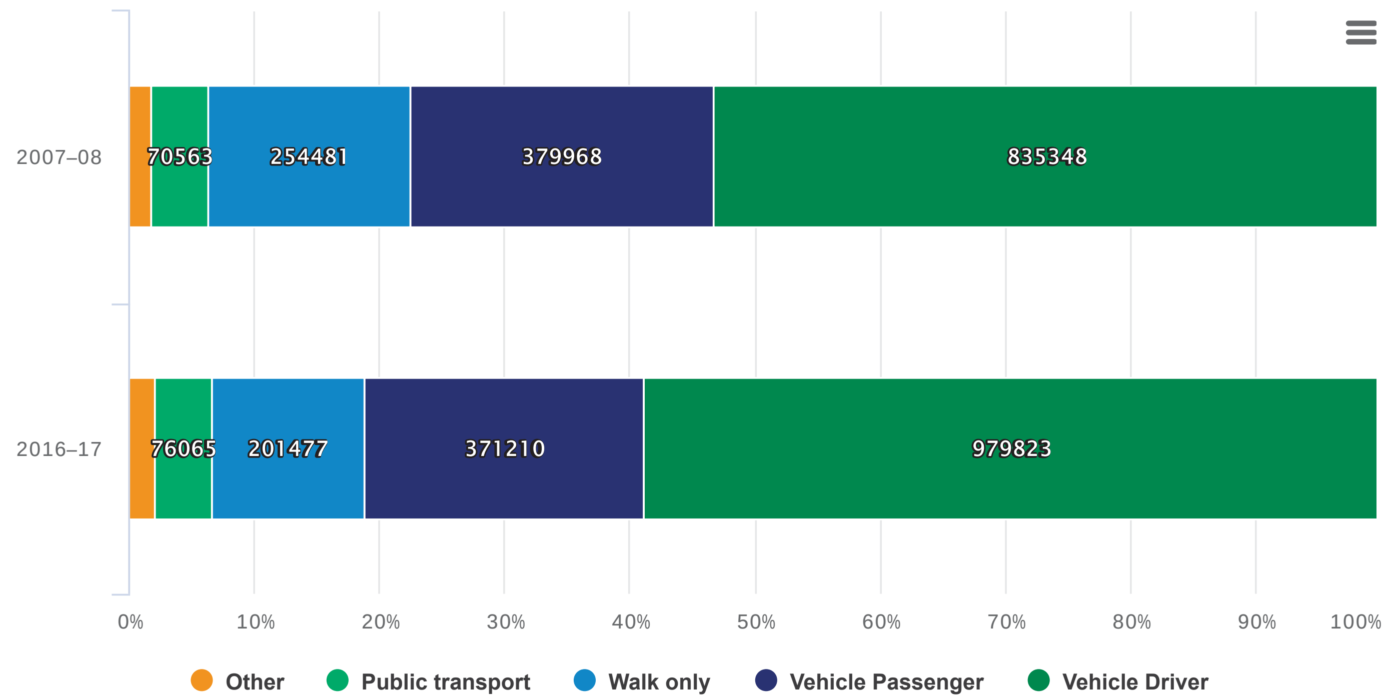
Figure 4.4: Proportion of trips by mode for Hunter residents in 2016–17 compared to 2007–08



Notes:
* 'Vehicle' includes cars, motorbikes and scooters for trips by drivers and passengers
** Public Transport includes, bus, train, ferry and light rail
*** 'Other' includes, bicycles, taxis, aircraft and wheelchairs

Source:
TfNSW 2018

Figure 4.5: Proportion of trips by mode for Illawarra residents in 2016–17 compared to 2007–08



Notes:
* 'Vehicle' includes cars, motorbikes and scooters for trips by drivers and passengers
** Public Transport includes, bus, train, ferry and light rail
*** 'Other' includes, bicycles, taxis, aircraft and wheelchairs

Source:
TfNSW 2018

Walking and cycling

Between 2007–08 and 2016–17 across all Household Travel Survey regions, walking as a proportion of weekday trips was static or declined.

In Sydney, walking as a proportion of all trips has remained the same, at 17%. While the number of trips by walking rose by 8% over the past decade, this increase is much slower than population growth (15%). In other regions, the number of trips by walking declined by 21% in the Illawarra and by 31% in the Hunter. There has been a 10% increase in resident population in the Illawarra and an 18% increase in the Hunter.

Less than 2% of trips in Sydney are by 'other' forms of transport, which includes bicycles and taxis. Local detail on bicycle use from bicycle counters on specific infrastructure is collected by NSW Roads and Maritime Services (RMS) and the City of Sydney.

Motor vehicle ownership

Vehicle ownership and decisions regarding use of vehicles are influenced by a variety of factors including reason for journey, income, fuel prices and environmental consciousness. If there are no convenient alternative transport options available, owning and using a private vehicle is viewed by many people as a necessity, not a choice.

There are several sources of data for vehicle ownership (ABS 2017, RMS 2018a, RMS 2018b). While this data varies, overall it shows an increase in passenger vehicle ownership, which is comparable to population growth.

Between 2012 and 2017 the Australian Bureau of Statistics Motor Vehicle Census data (ABS 2017) recorded a 13% increase in vehicle registrations in NSW. During this period, there was an 11% increase in passenger vehicle registrations and a 26% increase in motorbike registrations.

RMS vehicle registrations reflect a similar trend over a longer period, with a 29% increase in registrations for all types of vehicle between 2007–08 and 2016–17 (RMS 2018b). This is higher than the increase in gross state product (27%) and the rate of population growth (15%).

RMS data shows that registrations for passenger vehicles and people movers rose 2% and 5% respectively during this period, and registrations for off-road vehicles rose by 110% (this would include vehicles used for commercial purposes as well as those for private use). Off-road vehicles have higher rates of fuel consumption than cars, which would contribute to increasing greenhouse gas emissions. As of 30 June 2017, 31% of off-road vehicles were powered by diesel engines (RMS 2018a), which have been subject to progressive tightening of emissions standards (see the Air Quality topic). During the same period, there was a 44% increase in motorcycle registrations and a 53% increase in scooters.

Between 2007–08 and 2016–17 the Household Travel Survey indicates that across the Sydney region, vehicle ownership rose by 17%. This is a self-reported rate of ownership for private vehicles and does not distinguish between types of vehicle. The number of vehicles per household remained stable at 1.8. Over this period, average weekday trip distance by vehicle drivers reduced from 10km to 9km.

Household Travel Survey data for the Hunter and Illawarra regions shows a slightly higher number of vehicles per household (1.97 and 1.98 respectively) and slightly lower rates of increase in vehicle ownership than Sydney (14% and 10% respectively). Over this period, average weekday trip distance by vehicle drivers remained constant in both these regions (at 11km in the Hunter and 12km in the Illawarra).

Freight

Road is the main mode of transport for most commodities except for coal, which is usually transported by rail. Impacts of this can include increased congestion on roads, noise and emissions.

In 2016, the volume of freight moved on the NSW transport network was estimated at approximately 482 million tonnes, up from 409 million tonnes in 2011 (NSW Government 2013; TfNSW 2018c).

Between 2016 and 2036, freight volume is expected to increase by 48% in the Greater Sydney Area and 12% in regional NSW (NSW Government 2018). Population growth in greater Sydney will generate increased movements of construction materials, consumer commodities and waste.

Pressures

Population

The NSW population is expected to grow to 9.9 million people by 2036. Continued growth brings:

- an increase in passenger demand for public transport
- an increase in the number of private vehicles
- more traffic on the roads and increasing congestion
- more goods moving around the State.

The consequences of these changes, if not well managed, include:

- more noise and air pollution
- increased production of greenhouse gases
- increased pressure on non-renewable resources due to the demand for fossil fuel
- runoff from roads, which affects water quality.

Construction of new roads may induce increased road traffic through the promise of shorter travel times, and road tunnels may increase the intensity of air pollutants in localised areas. Construction of roads and transport infrastructure can also contribute to the fragmentation of ecosystems, with adverse effects on wildlife and vegetation. Road kills in newly developed areas on the urban fringe can have a particularly heavy toll on wildlife.

Air pollution

In NSW the transport sector is the fastest growing producer of greenhouse gas emissions. In 2016 the sector accounted for 20.8% of emissions, having grown steadily since 2005, an increase of 12% (Commonwealth of Australia 2018). The sector is the second largest greenhouse gas producer in the state, behind electricity generation (see the Greenhouse Gas Emissions topic). In the Greater Sydney Region, transport emissions continue to be the main source of oxides of nitrogen (NOx) and volatile organic carbon entering the atmosphere (see the Air Quality topic).

Price signals

How often and when cars are used as an alternative to public transport can be affected by various signals, including:

- road toll pricing

- fluctuations in the price of fuel
- public transport costs and ticketing integration.

Responses

Legislation and policies

Legislation

The *Transport Administration Act 1988*, includes an objective to promote the delivery of services in an environmentally sustainable manner.

The Act also requires public transport agencies to comply with the principles of ecologically sustainable development as defined in section 6 (2) of the *Protection of the Environment Administration Act 1991*.

Strategies

The NSW Government's priorities for transport, infrastructure investment and land use planning are set out in several linked strategies and plans:

- Future Transport Strategy 2056 and two supporting infrastructure and services plans for Regional NSW and Greater Sydney
- NSW State Infrastructure Strategy 2018–2030
- NSW Freight and Ports Plan 2018–2023.

The following tools have also been developed to include environmental sustainability in the planning, design, construction, operation and maintenance of transport projects:

- *NSW Sustainable Design Guidelines (v.4)* for Transport for NSW staff, contractors and industry partners
- *Integrating Green Infrastructure Guideline*
- Carbon estimate and reporting tool
- Climate risk assessment guide.

These tools are available from the Transport for NSW website.

The environmental impacts of transport will be lessened by reducing the distance people need to travel to workplaces and essential facilities. The *Future Transport 2056 Greater Sydney Services and Infrastructure Plan* sets out a vision for achieving this by shifting from one central business district to a metropolis of three cities: the Eastern Harbour City, the Central River City and the Western Parkland City. In the future, people will be able to travel to one of these cities or to their nearest strategic centre within 30 minutes from where they live to more conveniently access the jobs and services they need. Future Transport's environmental sustainability outcomes include (TfNSW 2018a):

- increasing the use of public transport
- reducing the use of single occupant vehicles
- encouraging uptake of electric, hybrid and more fuel-efficient vehicles
- encouraging active transport

- improving the resilience of the network in a changing climate.

The NSW Government has released the Freight and Ports Plan 2018–2023, which offers opportunities for reducing environmental impacts. This is through measures such as:

- working with industry to reduce noise from locomotives
- continuing treatment of affected houses under the Freight Noise Attenuation Program
- supporting the use of electric vehicles
- investigating options to improve accountability for environmental performance in the rail freight industry
- advocating for stronger national vehicle emissions standards
- encouraging the use of safer, cleaner and more productive vehicles.

Initiatives aimed at improving the efficiency of the freight network, such as the adoption of new technologies, will also have positive environmental impacts. In addition, the Plan also includes important initiatives to improve the capacity of the rail network for freight trains and increase the use of rail for transporting freight to and from Port Botany.

Other NSW government strategies that encourage the use of active transport include:

- Sydney's Cycling Future
- Sydney City Centre Access Strategy
- Cycling Safety Action Plan
- Road Safety Plan 2021.

Programs

Public transport

People are more likely to use public transport if services are frequent, reliable, there is good connectivity between different modes, and travel time is competitive with private vehicles.

A range of initiatives are in progress to meet projected demand and encourage people to use public transport.

The More Trains, More Services program will transform the rail network, creating high capacity, turn up and go services. Key elements are:

- upgrading rail infrastructure to simplify the network and improve its resilience
- deploying digital train control technology for greater capacity and reliability
- using City Circle capacity when freed up by the Sydney Metro City and Southwest (see below) to provide more services on other lines.

In 2017, a new timetable boosted capacity on the rail, bus and ferry public transport networks and encouraged increased use across the Sydney network. The new timetable delivers:

- 1,500 extra weekly train services, including 750 on the weekend
- almost 7,000 new weekly bus services
- Over 140 new weekly ferry services.

The Barangaroo Ferry Wharf, which was completed in 2017, increases Sydney's ferry capacity and services thousands of people travelling to the Barangaroo district, with commuters connected to the CBD via Wynyard Walk.

Sydney Metro is a new stand-alone railway for Sydney, opening in the second quarter of 2019. Services start in the city's north west, extend under Sydney Harbour, through new underground city stations and beyond to the south west. In 2024, Sydney will have 31 metro railway stations and a 66km stand-alone metro railway system. There will be capacity for a metro train every two minutes in each direction under the Sydney CBD. New metro rail will also link the Sydney CBD to Parramatta and Westmead. The railway servicing the new Western Sydney Airport will be also developed and delivered by Sydney Metro.

Newcastle Light Rail when complete in 2019 will provide a high capacity, frequent service through the city centre. Comprising six stops, it is designed to activate and rejuvenate the civic and shopping centre of Newcastle as part of an overall revitalisation program.

CBD and South East Light Rail, which is scheduled for completion in 2020, will connect Circular Quay along George Street to Central Station, the Moore Park sporting and entertainment precinct, Randwick Racecourse, the University of NSW and Prince of Wales Hospital at Randwick. Stops along the 12-kilometre route are designed to create easy interchange points with other transport modes. The light rail will significantly increase public transport capacity, carrying around 450 passengers – up to nine standard buses. An underground substation at High Cross Park in Randwick, uses geothermal cooling to decrease operational energy use.

Parramatta Light Rail will connect Westmead to Carlingford via Parramatta CBD and Camellia and is expected to open in 2023. In October 2017, the NSW Government announced the preferred route for Stage 2, which will connect the Parramatta CBD to Ermington, Melrose Park, Wentworth Point and Sydney Olympic Park along a nine-kilometre route.

B-Line Program includes bus priority measures and covers 10 bus stops and six new commuter car parks between Mona Vale and the Sydney CBD.

The Fleet Delivery Program includes:

- six new Inner Harbour ferries in 2017
- 24 eight-carriage suburban trains for Sydney in 2018–19
- the new Intercity Fleet, which will replace trains from Sydney to the Central Coast, the Blue Mountains and the South Coast from late 2019
- the Regional Rail Replacement project, which will replace the entire NSW regional train fleet with new trains in the 2020s.

Making journey planning easier

Public transport use is encouraged with apps that provide real time information about timetables and service disruptions. This in turn reduces the wait for services, advises on the fastest route and shows door-to-door options.

Opal is a reusable pre-pay card that can be used on trains, buses, ferries and light rail. It makes it easier for passengers to change mode of transport, streamlines ticket purchasing and reduces queues at stations. Opal cards have also reduced paper ticket waste.

Walking and cycling

The NSW Government's Future Transport 2056 describes walking and cycling as the most convenient option for short trips around local areas. It emphasises that the 30-minute city will encourage people to walk or cycle, catch public transport or access centres directly by active transport. These initiatives will help improve air quality and maximise the capacity of the existing road network.

Examples of active transport projects include:

- Wynyard Walk, which opened in 2016, provides a fully accessible pedestrian link between Wynyard Station and the CBD western corridor and Barangaroo
- Central Walk, a new underground concourse at Central Station, will improve connections between trains, buses, light rail and the new Sydney Metro
- The GreenWay Active Travel project when completed in 2021, will link the Cooks River cycling and walking track with Iron Cove while enhancing remnant native vegetation
- The Nepean River Bridge, which was completed in late 2018, provides a safe crossing for pedestrians and cyclists across the Nepean River and improves connections to existing and future shared paths, including the Great River Walk
- The proposed Sydney Harbour Bridge northern cycle ramp and southern cycleway, which would provide step-free access at the northern end of the existing Sydney Harbour Bridge cycleway.

In June 2016, the Government announced the NSW Cycling Infrastructure Fund; an $80 million cycling infrastructure package. Funded projects will help build new routes to connect growing communities, provide better access to new walking and cycling paths and help link people to transport hubs, schools, shops and strategic centres.

Delivering the Sydney Green Grid is an objective in the Greater Sydney Region Plan: A Metropolis of Three Cities and in coming decades will increase green space across the Sydney region. It will encourage active transport with cycling and walking paths to provide alternative means of access to suburban centres and open space such as parks and ovals.

The annual Walking and Cycling Program aims to make walking and cycling more convenient, safer and enjoyable for short trips. Funded initiatives aim to:

- reduce congestion
- free up capacity on the public transport system
- encourage walking and cycling as the mode of choice
- create places that successfully meet their intended purpose.

The Program's projects will prioritise delivery of the Future Transport 2056 Strategy and the Greater Sydney and Regional Services and Infrastructure Plans.

Fuel and vehicle emissions

Key initiatives to reduce emissions include vapour recovery technology at service stations, limiting petrol volatility in summer, promoting improved national vehicle emission and fuel standards and implementation of the released Diesel and Marine Emissions Management Strategy (EPA 2015). See also the responses in the Air Quality topic.

Roads

Strategies for reducing the impacts of roads and related infrastructure during construction, operation and maintenance include (RMS 2016):

- minimising the use of non-renewable resources
- recycling construction materials which diverts waste from landfill
- protecting biodiversity through Environmental Impact Assessments; implementing features such as suspended wildlife bridges and tunnels (Dexter et al. 2016; RMS 2015); and changing proposed routes
- reducing energy use and greenhouse gas emissions through LED traffic lights and GreenPower.

The Smart Motorways program uses technology to reduce congestion, which helps improve air quality. Features include traffic monitoring tools for improved network operation and ramp meters to keep traffic moving smoothly and improve travel times. The M4 Motorway (Lapstone to Mays Hill) will be the first full smart motorway, with completion expected in 2020. Some individual elements of the technology are already in place on Sydney roads including the M1, M2, M5 and M7 motorways.

New roads

Urban road projects can help relieve congestion, reduce noise and improve air quality by diverting traffic away from local roads. Improved travel times can also reduce emissions, provided increased usage doesn't cancel out these gains.

New roads currently under construction in Sydney are:

- **Westconnex**, which will be complete in 2023, will link western and south-western Sydney with the city and airport and enable new public transport options on the key corridors of Parramatta Road and Victoria Road.
- **Northconnex**, a nine-kilometre tunnel motorway which will link the M1 Pacific Highway at Wahroonga to the Hills Motorway at West Pennant Hills. When complete in 2020, Northconnex will take around 5,000 trucks off Pennant Hills Road every day.

Managing freight-related noise

The Strategic Noise Action Plan manages the impact of freight-related noise. Measures to reduce noise at the source include:

- working with operators on the standards for, and maintenance of, rolling stock
- the freight wagon steering standard, introduced in January 2018, which will contribute to a significant reduction in wheel squeal.

The Plan also addresses the use of planning controls and building regulations to minimise development in new locations acutely affected by rail noise.

The Freight Noise Attenuation Program reduces freight noise in affected homes along NSW Government managed rail corridors between Nowra and Newcastle, and west to Lithgow. Noise treatment includes upgraded windows, solid external doors and enhanced ventilation. The program, which began in 2016, aims to treat 200 homes per year over a 10-year period. Over 525 have already been treated.

Ports

From January 2019, NSW Ports is introducing levy discounts at Port Botany and Port Kembla that provide an incentive for vessels to reduce their emissions beyond standards set by the International Maritime Organisation (IMO) (NSW Ports 2018). This is consistent with IMO targets for 70% CO_2 reduction by 2050 (Ray 2018).

Future opportunities

Integrated and coordinated strategic approaches to planning will manage the impacts of population growth in NSW. Planning of new residential areas will take into account the ease and viability of public transport to key services and strategic centres in the Greater Sydney Region.

As committed in NSW's *Future Transport 2056*, Transport for NSW is leading development of a whole-of-government Electric and Hybrid Vehicle Plan. The plan outlines NSW Government actions to facilitate the take up of low emission, fuel efficient vehicles and maximise their benefits for passenger and freight mobility, productivity, the environment and liveable communities.

The Plan is being developed with input from 11 government agencies and co-design workshops with over 20 industry bodies. This approach is building effective partnerships to develop clear policy directions and actions that can be implemented in partnership with industry, to prepare for and maximise the benefits that the transition to Electric Vehicles (EVs) can bring to NSW.

Improved access to transport data will allow for better planning of services and more targeted provision of new infrastructure. The availability of anonymous Opal travel data provides new opportunities for research and system planning. Data being collected on cycleway use also warrants further analysis.

Technological changes supporting ride-sharing and delivery vehicles for online purchases may also affect road usage patterns. Data on these trip reasons is now being collected through the Household Travel Survey.

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Waste and Recycling

Growing community awareness on waste issues has increased demand for, and supply of, effective waste reduction, re-use and recycling programs.

Summary

Per person waste generation

6%

reduction since 2012–13, to 2.37 tonnes per year

Read more

Total waste generation

4%

reduction from its 2010–11 peak, down to 16.5 million tonnes

Read more

Litter volume down by

37%

against the 2013–14 benchmark

Read more

Recycling

63%

of waste is diverted for recycling (2014–15 data)

Read more

In 2014–15, total waste generated in NSW continued to fall since it peaked in 2010–11 at over 17 million tonnes. Between 2013–14 and 2017–18, the volume of litter in NSW decreased by 37% and new interim data reported in December 2018 indicates a decrease of 48%.

In 2014–15 (the latest available data) the proportion of waste diverted for recycling was 63%, compared to 62.5% reported in 2012–13.

The NSW Government's $802 million *Waste Less, Recycle More* initiative provides funding to improve business recycling, manage problem wastes, construct new waste infrastructure and develop programs to tackle illegal dumping and litter.

The NSW EPA's *Don't be a Tosser!* anti-litter campaign has helped change attitudes to litter and litterers, and rubbish in NSW is reducing. The NSW Premier has set a target of reducing the volume of litter by 40% by 2020.

The *Return and Earn* container deposit scheme for drink containers began on 1 December 2017 and is significantly reducing drink container rubbish, which makes up nearly half of NSW's litter. In the first 12 months of the scheme more than 1 billion containers had been returned to return points. An additional 710 million drink containers were collected in kerbside recycling (yellow-lid bins) between December 2017 and September 2018. Eligible drink container litter volume was down 44 per cent.

Future releases of data on recycling performance and waste generation in NSW are expected to be enhanced by improved methods of collection and analysis.

Related topics: Population | Economic activity and the environment

NSW Indicators

Indicator and status		Environmental trend	Information reliability
Total waste generation	MODERATE	Getting better	✓✓
Per person waste generation	MODERATE	Getting better	✓✓
Total and per person solid waste disposal	GOOD	Getting better	✓✓
Total and per person solid waste recycled	GOOD	Stable	✓✓✓
Litter items per 1000 m^2	GOOD	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Government education initiatives and frequent media coverage have contributed to the wider community becoming more knowledgeable about how waste is managed, and more interested in recycling and re-using waste. Issues of particular interest include reducing single use plastics, excessive packaging, e-waste and food waste (IPSOS 2016).

Public recognition of the impacts that waste and littering can have on the community, the environment and the economy has increased.

- Poorly run waste management facilities can cause dust, offensive odours and noise.

- Littering and illegal dumping can reduce the amenity of public spaces, harm plants and animals, and be expensive for councils, state government and private land holders to clean up.
- Poor waste disposal, especially of hazardous wastes, can result in harmful chemicals leaching into soil, groundwater and surface water, becoming a risk to human health and the environment.
- Poor waste management practices can result in the loss of valuable resources from the productive economy.

Growing community awareness around these issues has increased demand for, and supply of, effective waste reduction, re-use and recycling programs.

Status and Trends

Waste Levy Areas

Changes to waste regulation in 2014 influenced the way waste data was collected and reported. Waste data is now reported against the following areas:

- Metropolitan Levy Area (MLA) – the MLA is an amalgamation of the former Sydney Metropolitan Area and Extended Regulated Area and comprises Sydney, the Lower Hunter, Central Coast and Illawarra regions
- Regional Levy Area (RLA) – the RLA includes councils from the Upper Hunter region to the Queensland border, the Blue Mountains and Wollondilly
- Non-levied Area (NLA) – the NLA includes all NSW councils not in the MLA or RLA.

The data described in this report is for the latest period available at time of publication.

The EPA has developed a new and more rigorous method of measuring recycling performance and waste generation that will establish best practice benchmarks and more accurate data on NSW's waste management performance. The EPA will publish the new data when it becomes available.

Overall waste trends

In 2014–15, total waste generated continued to fall since its peak in 2010–11 at over 17 million tonnes. Total waste generation per person per year decreased from 2,341 kilograms to 2,203 kilograms between 2012–13 and 2014–15 (**Figure 7.1**).

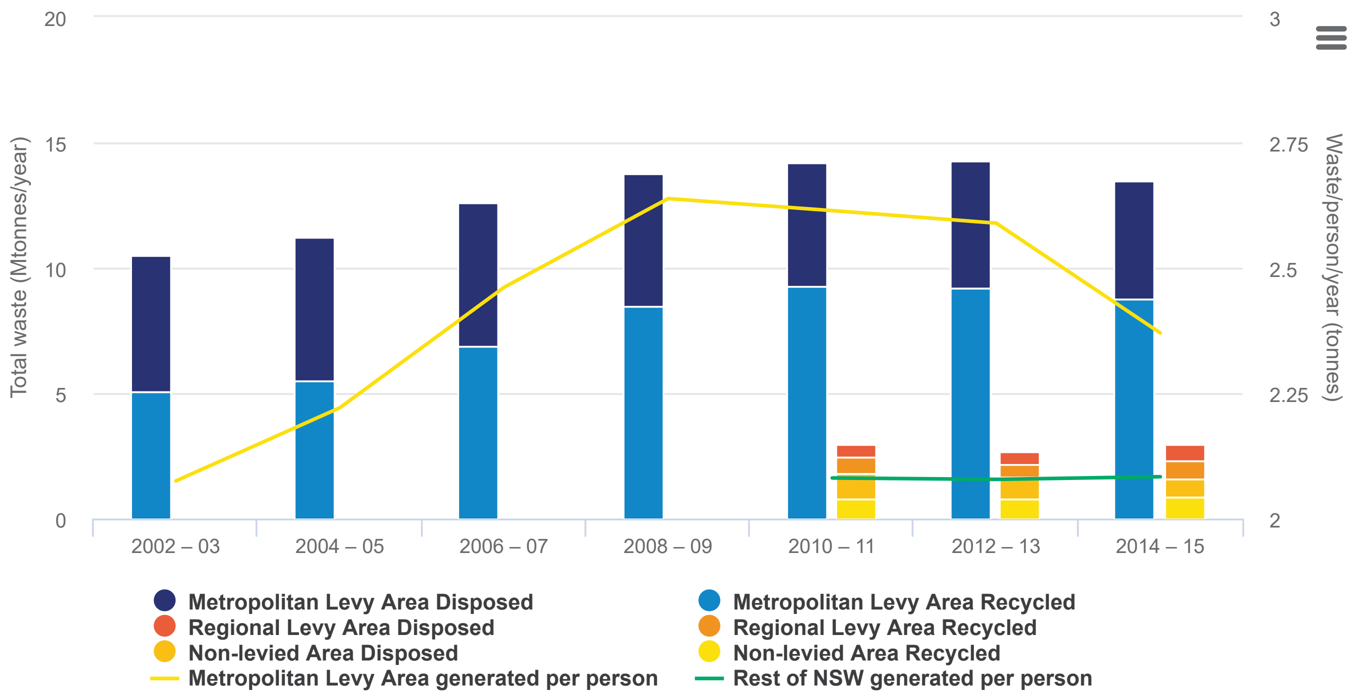
In 2014–15, total waste disposal in NSW also continued to fall since it peaked in 2006–07 at 7.4 million tonnes. Of the 6.2 million tonnes disposed of in 2014–15:

- 77% was generated in the Metropolitan Levy Area
- 11% was generated in the Regional Levy Area
- 12% was generated in the Non-Levied Area.

In 2014–15, the overall recycling rate (total waste recycled divided by total waste generated) was 63%, which was a slight improvement from the 2012–13 reporting period.

Between 2012–13 and 2014–15, the number of councils that provided a kerbside dry recycling collection service for their residents remained stationary at 86%. The number of councils that provided a kerbside collection service for garden waste or for food and garden waste increased from 47% in 2012–13 to 55% in 2014–15.

Figure 7.1: Per person waste recycled, disposed and generated



Source:
NSW Waste Avoidance and Resource Recovery Strategy Progress Report 2014–15 (EPA 2017d)

Recycling

The NSW Government collects data and implements programs for three waste streams:

- municipal solid waste (MSW) – waste generated by households and local government operations; it predominantly consists of paper, plastics, glass, and food and garden waste
- commercial and industrial (C&I) waste – waste generated by businesses, industries and institutions; it contains a great deal of metals, plastics, paper/cardboard and wood
- construction and demolition (C&D) waste – waste generated by construction and demolition activities, which consists of wood, bricks, concrete and soil.

The NSW Waste Avoidance and Resource Recovery Strategy 2014–2021 contains targets to increase recycling rates by 2021 to:

- 70% for Municipal Solid waste
- 70% for Commercial & Industrial waste
- 80% for Construction & Development waste.

Progress towards the targets is shown in **Table 7.1** below.

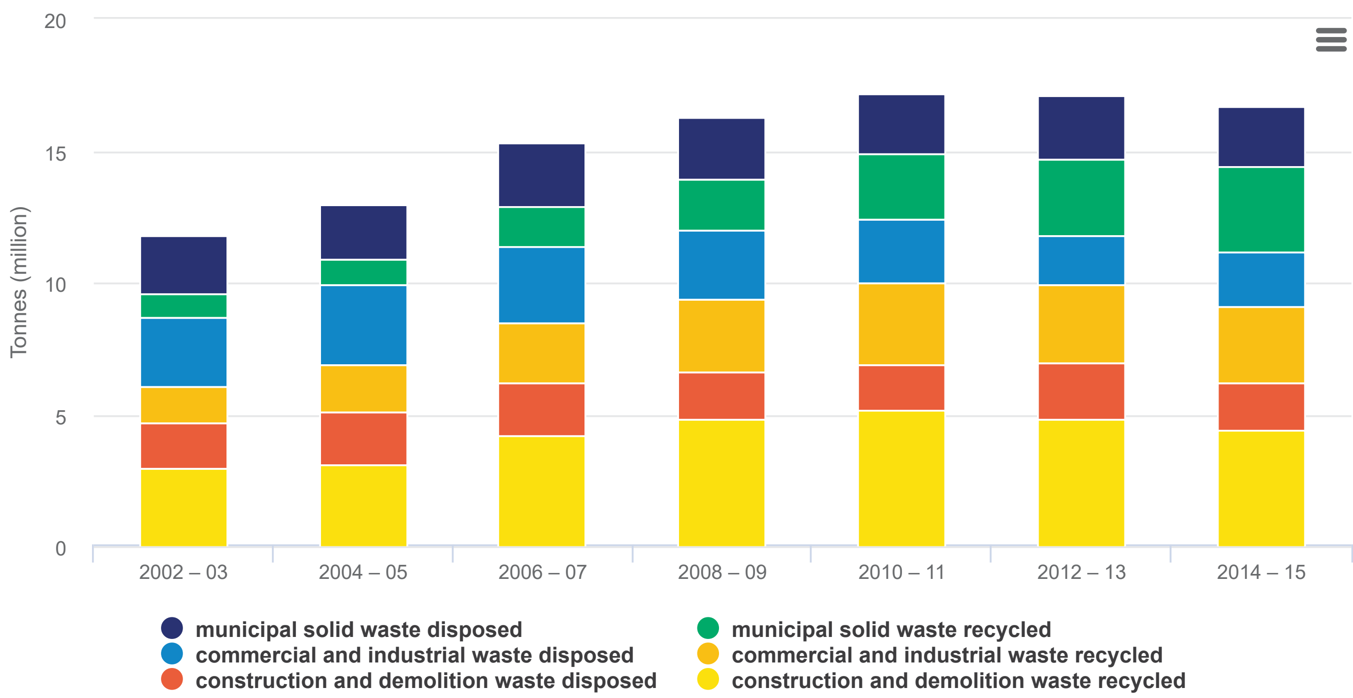
Table 7.1: Progress towards the NSW recycling targets, by waste stream

Waste stream	2002–03	2004–05	2006–07	2008–09	2010–11	2012–13	2014-15	NSW 2021 recycling target
MSW	31%	33%	38%	44%	52%	55%	58%	70%

C&I	34%	38%	44 %	52%	57%	60%	58%	70%
C&D	64%	62%	67%	73%	75%	69%	71%	80%
Total	45%	46%	52%	59%	63%	62%	63%	N/A

Source:
NSW Waste Avoidance and Resource Recovery Strategy Progress Report 2014–15 (EPA 2017d)

Figure 7.2: Waste disposed and recycled by waste stream for NSW, 2002–03 to 2014–15



Source:
NSW Waste Avoidance and Resource Recovery Strategy Progress Report 2014–15 (EPA 2017d)

Quality of waste data

Waste disposal data provided in this report was based on mandatory monthly and annual reports by all landfill operators in NSW in accordance with the Protection of the Environment Operations Regulation 2014. Resource recovery figures were provided from data supplied by local government and voluntary reprocessors.

Following the implementation of mandatory reporting for most NSW resource recovery facilities in 2015, improved resource recovery data will be provided in future SoE reports.

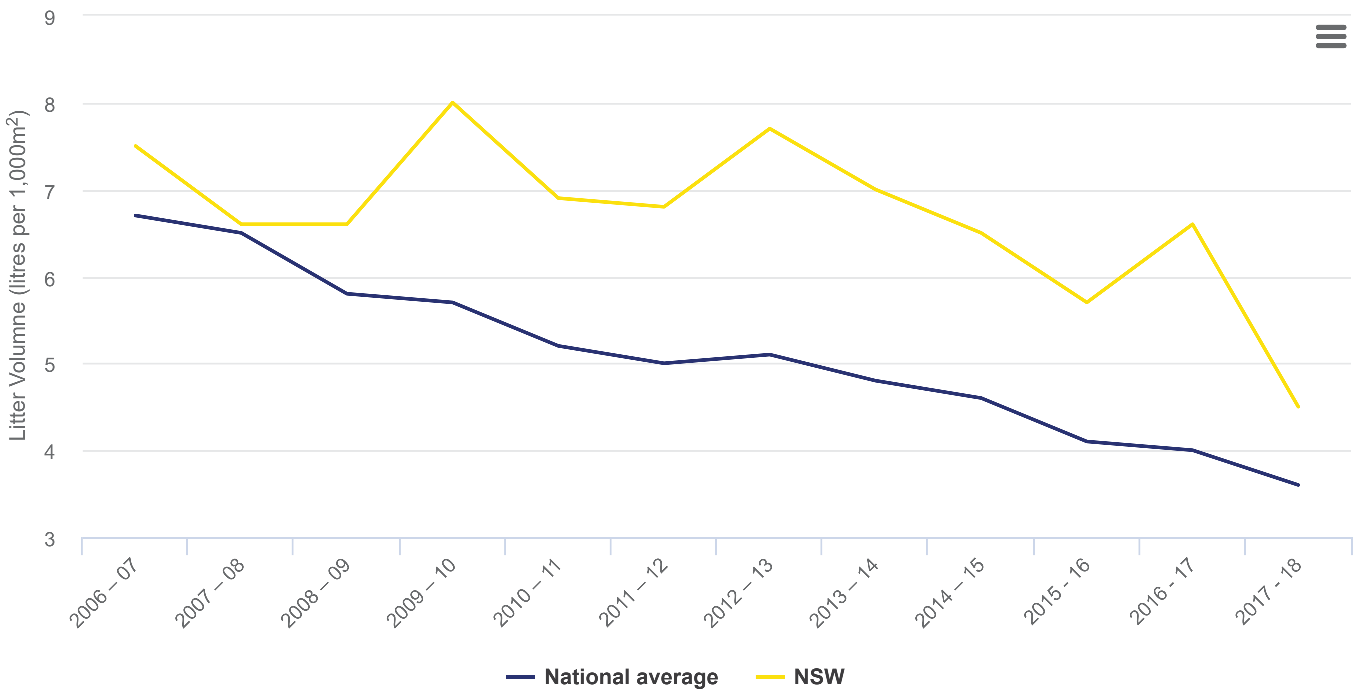
Litter trends

In September 2015, the then NSW Premier made it a Premier's Priority to achieve a 40% reduction in the volume of litter by 2020, with a baseline year of 2013–14. This supersedes the litter reduction target in the Waste Avoidance and Resource Recovery Strategy 2014–2021 (EPA 2014).

Between 2013–14 and 2017–18, the volume of litter in NSW decreased by 37%, almost reaching the Premier's litter target two years in advance. However, interim data reported in December 2018 showed a decrease of 48% since 2013.

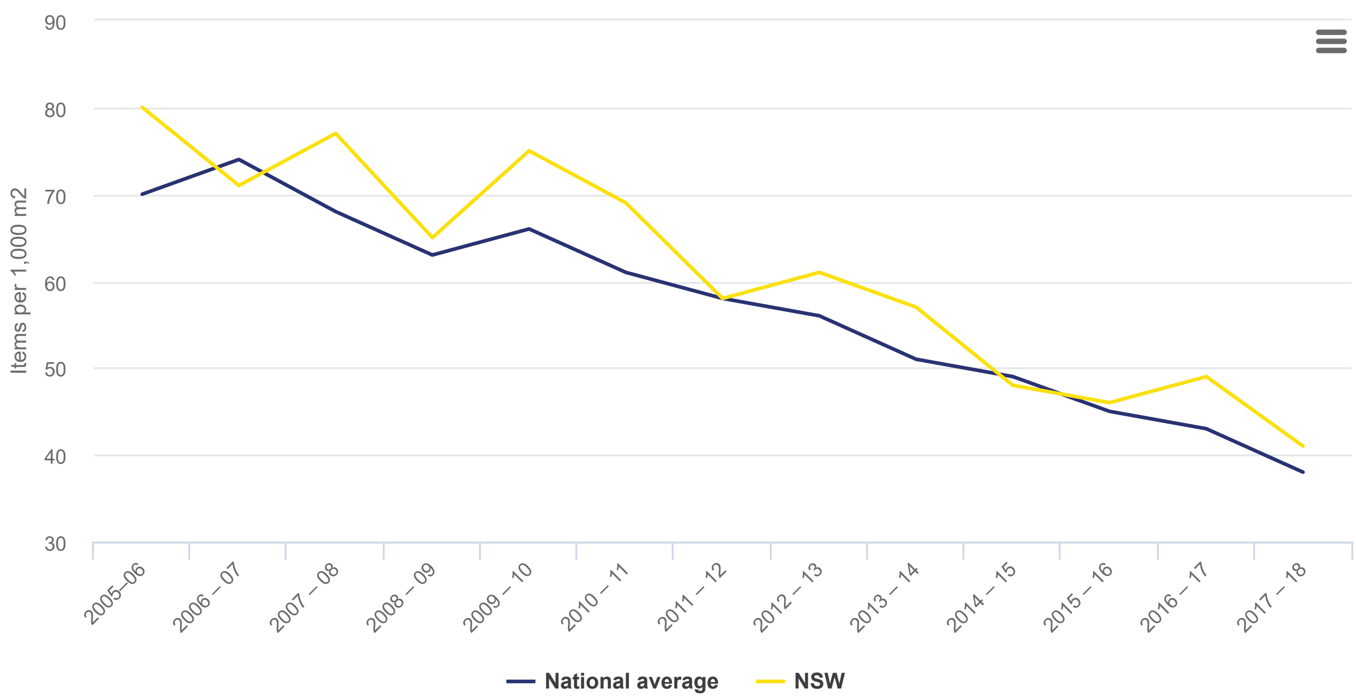
Between 2013–14 and 2017–18, the number of littered items decreased by 27%.

Figure 7.3a: NSW versus national average for litter volume 2016–2009 to 2017–18 (excluding illegal dumping)



Source:
EPA data 2018

Figure 7.3b: NSW versus national averages for litter items 2005–06 to 2017–18



Source:
Keep Australia Beautiful National Litter Index data for NSW provided to EPA 2018.

The NSW container deposit scheme, *Return and Earn*, was introduced on 1 December 2017. the scheme provides a 10-cent refund for eligible drink containers, which made up 45% of the total volume of litter generated in NSW and 9% of all littered items in 2017–18 (see **Figure 7.4a**). However, results from 2016–17 and 2017–18 showed the volume of litter from eligible containers decreased by 30% since the introduction of *Return and Earn* and the number of littered drink containers decreased by 24%.

Interim data reported in December 2018 showed a further decrease in eligible drink container litter volume: down 44% since the introduction of the scheme. By December 2018, more than half the drink containers in the marketplace (54%) were being recovered, compared with the 32 per cent collected in yellow bins before the scheme commenced.

Litter counts are conducted across Australia in November and May each year, using the National Litter Index.

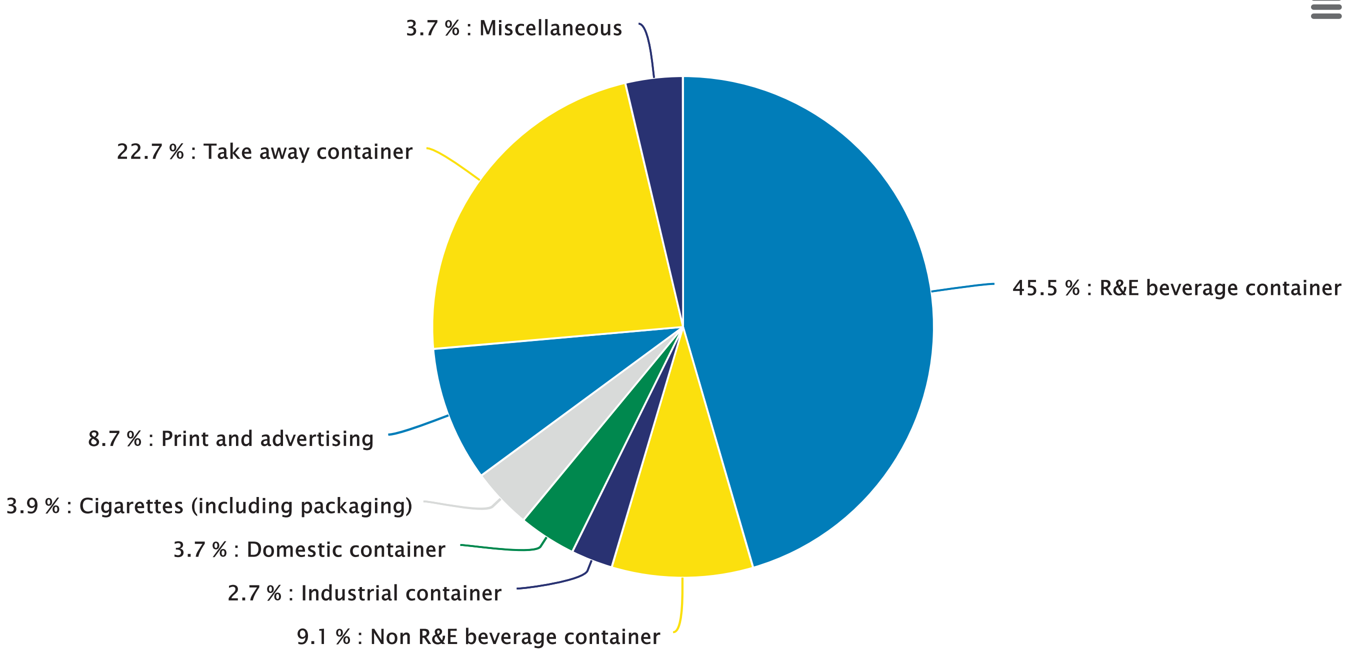
Litter composition in NSW

Regarding volume of litter, drink containers eligible for the *Return and Earn* scheme were the largest category littered (45%) in 2017–18. By December 2018 interim reports showed that eligible drink containers represented an all-time low of 37% of the NSW litter volume stream.

The next largest category in 2017–18 was takeaway food containers (23%), including hamburger wrappers, hot chip packets, plastic food containers, pizza boxes, coffee cups and milkshake containers.

Regarding the number of littered items, cigarette litter made up 41% of all litter in NSW (**Figure 7.4b**). It was closely followed by miscellaneous items (35%) including clothing, pieces of rubber, ice cream sticks and unidentified litter.

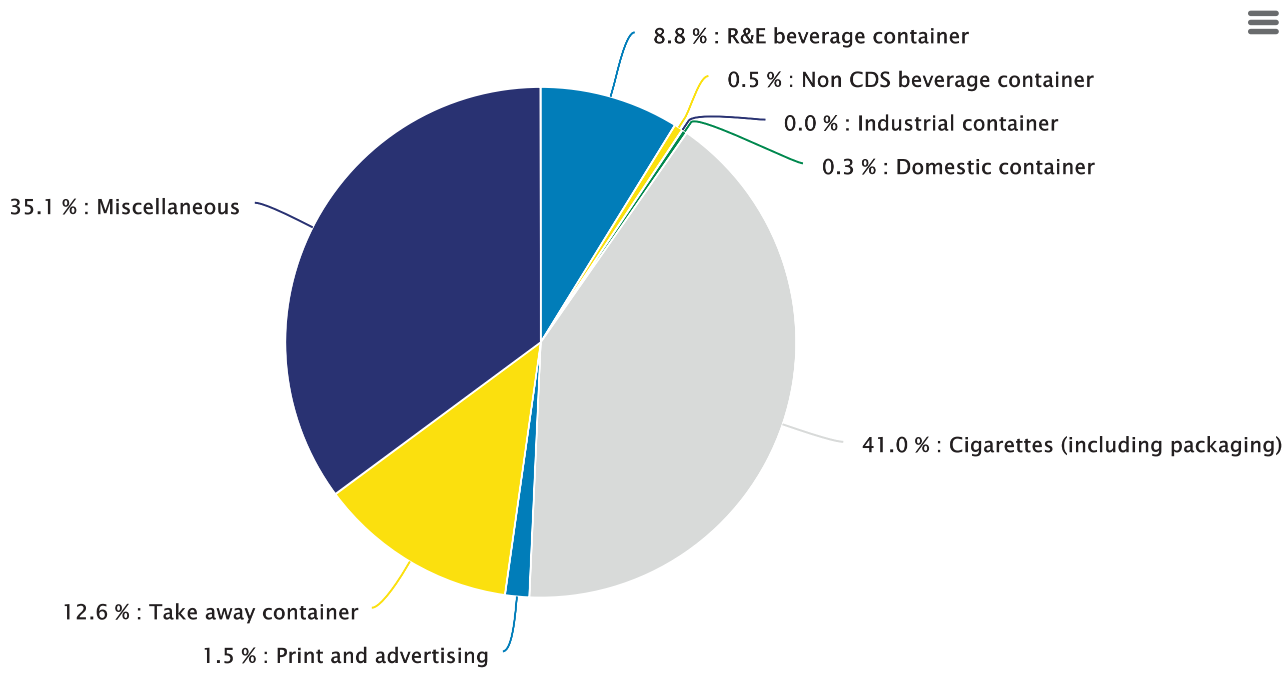
Figure 7.4a: Composition of the NSW litter stream by volume



Notes:
R&E: Return and Earn

Source:
Keep Australia Beautiful National Litter Index data for NSW provided to EPA 2018

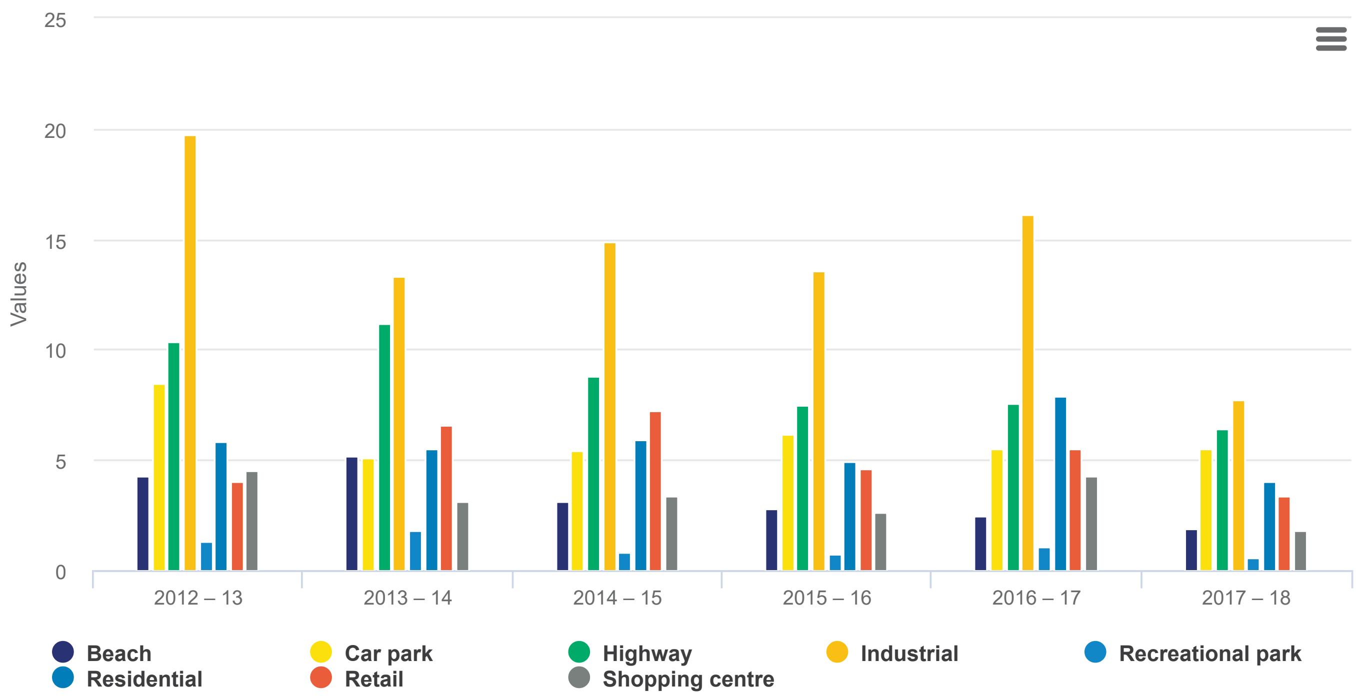
Figure 7.4b: Composition of the NSW litter stream by numbers



Source:
Keep Australia Beautiful National Litter Index data for NSW provided to EPA 2018.

- Industrial sites continue to be the most littered type of site in NSW, in terms of volume and amount (**Figure 7.5**).
- Highways and car parks are the next most littered areas.
- Residential and retail sites have moderate amounts of litter.
- Beaches, recreational parks and shopping centres are the state's least littered site types in terms of volume and amount, possibly due to these places being regularly cleaned more than any difference in littering behaviour.

Figure 7.5: NSW litter volume by site type 2012–2018



Source:
EPA data 2018

Pressures

Population growth and increasing economic activity

Waste generation is affected by both population growth and economic activity. An increase in population tends to result in more municipal waste, while an increase in economic activity tends to result in more waste from construction and demolition, commerce and industry. The population of NSW is expected to grow to around 8.3 million by 2021 (DPE 2018), and at the same time the economy of NSW is projected to grow by between 2–3% each year (NSW Treasury 2017).

These factors will increase the amount of waste that the NSW Government will need to manage. By 2021, it is expected nearly 20 million tonnes of waste will need to be processed a year (EPA 2017c).

Problem wastes

Problem wastes can be hazardous to human health or the environment, so cannot be safely or efficiently managed through the waste management system. They include unwanted paints, chemicals, treated timber, gas bottles, batteries, tyres, e-waste and plastic films.

The effective management of problem wastes requires enough suitable infrastructure to collect and treat them and community awareness of this infrastructure, which in turn needs to be easily accessible by the public.

This infrastructure can be provided by local or state government, or through product stewardship schemes which involve producers of problem wastes being more responsible for managing the environmental impact of their products throughout their life cycle.

Some problem wastes cannot be collected or treated once they have been generated, such as microbeads. These are tiny, often microscopic, pieces of plastic that are added to a range of products including rinse-off cosmetics, and personal care and cleaning products. Once in the water, microbeads can harm the environment and human health due to their composition, ability to attract toxins and transfer up the food chain and harm aquatic animals and fish. Microbeads persist in the environment as they do not readily biodegrade and are almost impossible to remove due to their miniscule size. The best way to reduce their impact is to prevent them from entering the environment (see the Responses section below).

Unnecessary long-distance transport of waste

Since the 2012 repeal of the waste levy in Queensland, an increasing volume of waste has been transported out of NSW for disposal. This waste is primarily construction and demolition waste that contains many reusable and recyclable materials. The unnecessary long-distance transport of waste for disposal can generate adverse health and environmental impacts and is inconsistent with best practice management which prioritises re-use and recycling over disposal.

The proximity principle offence can reduce these impacts but is difficult to enforce. The EPA continues to use and consider other tools to minimise the environmental, human health and resource recovery impacts of the long-distance transport of waste for disposal.

The reintroduction of the waste levy in Queensland in 2019 may reduce the long-distance transport of waste for disposal and its associated impacts. However, given the cross-jurisdictional nature of this issue, a coordinated national regulatory response is the most effective long-term solution. The NSW Government is currently advocating for a coordinated approach in the appropriate forums.

Human behaviour

Consumer behaviour strongly influences the success of waste avoidance and recovery. For example:

- if people place recyclables in the wrong bin, they can be disposed of to landfill rather than being recycled
- householders putting plastic bags and other non-recyclable items in the recycling bin can interfere with recycling equipment and contaminate outputs
- consumers' preferences or prejudices about recycled products can influence their market demand and value, which can affect the commercial viability of recycling facilities.

Research has shown that the amount of food waste is increased by:

- a lack of meal planning
- a tendency to over-cater
- incorrect food storage (EPA 2016b).

Research has also found that people are more likely to litter in places where others have already littered or where they think they will not be caught (EPA 2017b).

Behaviours such as littering and illegal dumping result in recyclable materials being unnecessarily lost from the economy, and cause pollution in public places that is expensive to clean up. A 2016 survey of NSW local councils, public and private land managers and community groups found that more than $180 million was spent each year on managing and cleaning up litter (EPA 2016a).

China's National Sword Policy

Until recently, China was the largest importer of recyclable material in the world, accepting and processing significant quantities of recyclable material from NSW and other parts of Australia and the world. China is now stringently enforcing its 'National Sword' policy, which forbids the importation of 24 types of waste and introduces strict contamination limits for other forms of waste. The NSW recycling industry cannot currently meet these stringent requirements and needs additional processing or alternative markets for recyclables such as paper, cardboard, plastics and metal.

Responses

Legislation and policy

Updates to NSW Waste Regulatory Framework

Over the past three years, updates to the waste regulatory framework have continued to drive further resource recovery, improve waste management practices and protect human health and the environment. Some of these updates build on the 2014 reforms to the Protection of the Environment Operations (Waste) Regulation. Updates that commenced in October 2015 included:

- implementing the Waste Locate system for tracking the transport of used tyres and asbestos waste

- implementing the Waste and Resource Reporting Portal, which is an online tool that allows waste facilities to fulfil their reporting duties under the Protection of the Environment Operations Act.

More recent reforms that came into effect in late-2018 included:

- draft minimum standards for managing construction waste at construction and demolition waste facilities, including mandatory minimum inspection, sorting and storage requirements
- improving landfill and asbestos handling practices, prohibiting the exhumation of waste from landfills, and increasing waste monitoring at licensed facilities
- increased on the spot penalties of up to $7,500 for individuals and $15,000 for corporations.

These reforms help to ensure waste is appropriately managed so the community's risk of exposure to contaminated material (including asbestos contaminated waste) is reduced.

Return and Earn – container deposit scheme

Implementing a container deposit scheme was identified as a future opportunity in SoE 2015 (EPA 2015). The NSW Government introduced *Return and Earn* on 1 December 2017 to reduce drink container litter. *Return and Earn* is the largest litter reduction initiative introduced in NSW and is helping to meet the NSW Premier's Priority goal of reducing the volume of litter in the state by 40% by 2020.

The scheme provides an incentive to consumers to:

- hold on to their empty container after finishing their drink and return it for a 10 cent refund
- pick up littered containers and obtain the refund for their efforts.

When fully rolled out, the scheme will provide at least:

- 270 sites across the Greater Sydney Region
- one collection point for each remote town with more than 500 people
- one collection point for each regional town with more than 1,000 people
- an additional collection point for every additional 20,000 people in larger regional towns.

In the first week of December 2018, the one year anniversary of Return and Earn, around **680 collection points** had been established and more than **one billion** containers had been collected, reducing the number of containers discarded in streets or thrown into waterways.

Collection points have been established at various convenient locations such as:

- supermarket car parks, shops and train stations in the form of automated reverse vending machines
- over-the-counter collection points, for example, in shops
- automated depots where customers take their used containers in bulk and receive a refund.

Over the next 20 years, *Return and Earn* is expected to result in:

- 6 billion fewer beverage containers littered in NSW
- almost 11 billion fewer beverage containers ending up in landfill
- 6 billion more beverage containers being recycled.

NSW Waste Avoidance and Resource Recovery Strategy 2014–21

Waste management in NSW continues to be guided by the Waste Avoidance and Resource Recovery (WARR) Strategy 2014-21 (EPA 2014).

The strategy sets ambitious targets to:

- reduce the rate of waste generation per person
- increase recycling rates for all recyclable materials
- increase the amount of waste diverted from landfill
- establish drop-off facilities to manage problem household wastes
- reduce the number of litter items to ensure NSW has the lowest litter count in Australia
- reduce illegal dumping across the state.

Draft NSW Waste and Resource Recovery Infrastructure Strategy 2017–21

The adoption of an infrastructure strategy was identified as a future opportunity in the SoE 2015 Report. Since then, the NSW Government has developed the draft NSW Waste and Resource Recovery Infrastructure Plan 2017–2021 to help the waste industry to understand the expected increase in waste, and plan enough infrastructure to process this increased volume.

Consultation on the draft plan closed in November 2017. The EPA is using the draft strategy and consultation submissions to inform the development of a broader long-term waste strategy to plan beyond 2021.

Waste Less, Recycle More Education Strategy 2016–21

In partnership with local government, industry, government agencies, community organisations and members of the public, the NSW Government has developed an education strategy called *Changing Behaviour Together: NSW Waste Less, Recycle More Education Strategy 2016–21* (EPA 2017a). The strategy aims to increase knowledge and skills, promote positive behaviour change and improve environment and community wellbeing, focusing on six objectives:

- develop and use consistent messaging
- integrate education methods
- build capacity to promote change
- promote excellence
- provide resources and tools
- work with and support stakeholders.

Programs

Waste Less, Recycle More

Waste Less, Recycle More is a nine-year funding package that invests $802.5 million in achieving the strategy's targets.

As at June 2018, *Waste Less, Recycle More* had:

- diverted an extra 2.39 million tonnes of waste from landfill each year by investing $407 million in increasing recycling and preventing littering and illegal dumping
- stimulated an additional $345 million in public and private sector investment in waste and recycling in NSW
- supported new kerbside collections for food and garden waste in 42 council areas
- supported 106 new community recycling services for problem wastes
- funded free Bin Trim waste assessments and support for over 22,000 small to medium businesses
- established five illegal dumping squads and enhanced the illegal dumping program by providing $10.4 million
- supported 200 litter prevention projects through $8.3 million in funding

- awarded \$53.5 million to constructing 17 new major resource recovery facilities
- awarded \$16 million to expanding and enhancing 34 resource recovery facilities
- awarded \$1.6 million to 54 food waste projects through the *Love Food, Hate Waste* program
- awarded \$4.5 million to 33 food donation projects to keep more than 7,400 tonnes of good food out of landfill and provide an additional 280,000 meals each week to people in need
- awarded \$4.8 million to 32 projects to improve the demand for compost in new and innovative markets
- provided \$78.55 million to local councils to develop their waste and recycling initiatives
- commenced implementation of the Aboriginal Communities Waste Management program and provided initial funding to 14 Aboriginal communities for development of waste management plans
- provided over \$20 million to regional waste groups to develop and implement 14 regional waste strategies, and waste and resource recovery projects.

Illegal Dumping Strategy 2017–21

In February 2018, the updated NSW Illegal Dumping Strategy 2017–21 (EPA 2018a) was released.

It focuses on all forms of illegal dumping and all offenders, but particularly targets problem wastes including asbestos waste, construction and demolition waste, household waste, used tyres and green waste.

The NSW Government has committed \$123 million over nine years until 2021 to combat and prevent illegal dumping. This is by bringing public land managers, local government, charities and community groups together to achieve a 30% reduction in illegal dumping by 2020.

Some key achievements of the strategy as at June 2018 were:

- establishing five Regional Illegal Dumping (RID) squads and programs covering 33 council areas
- funding local councils and public land managers to raise awareness of illegal dumping through media campaigns and educational material, including 133 projects to clean up and prevent dumping in local hotspots, in some cases eliminating the problem entirely
- cleaning up over 4,640 tonnes of illegally dumped waste and funding the installation of 554 signs, 217 surveillance cameras, 317 gates and over 4.1km of fencing
- launching the RIDonline reporting portal and database which allows the public to report dumping anywhere in NSW at any time
- the EPA running strategic campaigns to detect illegal dumping through aerial surveillance, focusing on priority issues such as repeat offenders, asbestos waste from demolition sites and illegal landfilling on private lands
- the EPA installing GPS tracking devices on vehicles transporting waste.

Litter prevention programs

Several programs are under way to deliver the Premier's Priority to reduce litter by 40% by 2020:

- a Consultation Draft NSW Litter Prevention Strategy (EPA 2017b) was released for public feedback in 2017
- the *Hey Tosser!* anti-littering campaign was revitalised to ensure it continued to help transform community attitudes to littering. It was taken up by many business and government partners including at fast-food restaurants, on public transport, on main roads signage, at government service sites and on social media sites
- Litter Prevention Grants targeted local litter hotspots though better infrastructure such as more bins, community engagement and enforcement, achieving an average reduction in litter of 60%
- hundreds of Local Litter Checks using a new diagnostic tool have helped councils and community groups to understand their litter problems, design solutions and measure results
- in 2017, a new Cigarette Butt Litter Check and a Roadside Litter Check targeted specific litter problems

- since February 2015, community members have reported littering from vehicles to the EPA, resulting in 43,246 incidents being reported as at June 2018 and 29,635 fines being issued based on those reports, a significant increase from previous enforcement activity.

Response to China's National Sword Policy

To ensure the sustainability of the recycling industry, the NSW Government has established an inter-governmental taskforce to find a long-term response to China's policy in partnership with industry and councils. The NSW Government released for public consultation a draft Circular Economy Policy in October 2018 which outlines the principles and ideas that can help to shape our approach to resource use and waste management in NSW.

As the taskforce is focused on long-term actions, one key response is to develop a circular economy policy for NSW and support the development of national circular economy principles. A circular economy values resources by keeping products and materials in use for as long as possible.

The taskforce is also working with the Commonwealth Government and other states and territories to find national solutions to strengthen local recycling industries and develop local markets.

On 20 March 2018 the NSW Minister for the Environment announced a one-off package of up to $47 million to support local government and industry to ensure kerbside recycling continues and to promote industry innovation.

Changes in the recycling market present an opportunity to strengthen local markets for recycled materials, create local employment and improve the way the NSW community manages waste.

Phase out of microbeads

Addressing emerging issues such as marine microplastics was identified as a future opportunity in the SoE 2015 (EPA 2015). Since then, the EPA and Commonwealth Government have been working with the industry association, Accord, to coordinate a voluntary phase out of microbeads in cosmetic and personal hygiene products.

An independent assessment of the sale of products containing microbeads from supermarkets and pharmacies undertaken at the end of 2017 demonstrated that 94% of cosmetic and personal care products did not contain microbeads. At the Meeting of Environment Ministers in April 2017, Ministers stated their commitment to eliminating the final 6% and to examining options to broaden the phase out to other products. NSW, Victoria and the Commonwealth will report back to Environment Ministers in 2019 with a proposal outlining options to achieve these outcomes.

Waste Crime Task Force

In recognition of criminal waste activities becoming more organised and sophisticated, in October 2017 the EPA established a Waste Crime Taskforce of dedicated investigators, operations officers, and legal and intelligence staff to deal with organised criminal behaviour in the waste industry. The Taskforce aims to prevent waste crime through:

- intelligence-led investigation of high-profile, serious or complex waste matters with a view to prosecution
- disrupting illegal activities and business models through instituting civil proceedings, administrative action and legislative reform; and collaborating with other government agencies
- working closely with the NSW Police Force and other law enforcement activities.

Future opportunities

Long-term waste strategy

The NSW Government acknowledges the importance of developing a long-term waste and resource recovery strategy and the EPA has started work to plan a 20 year waste strategy beyond the current timeframe of the *Waste Less, Recycle More* initiative which runs until 2021.

National level

NSW is seeking to build consensus with other states and the Commonwealth Government, including through the National Waste Policy, to develop a robust and coordinated regulatory response to the long-distance transport of waste for disposal, and promote consistent waste management standards across Australia that minimise the risk of harm to human health and the environment.

A cross-jurisdictional working group has been established to update the National Waste Policy, and NSW is actively working with the other states and territories to achieve this goal. As part of public consultation during 2018, the NSW Government lodged a submission on the updated Policy. NSW is committed to working with the Commonwealth Government and other stakeholders to complete this work.

Asbestos

Within NSW, the Draft Asbestos Waste Strategy 2018-22 was released for consultation in October 2018 putting forward six enhanced approaches for reducing unlawful and unsafe disposal of asbestos waste. These encompass increasing the convenience of disposing of bonded asbestos, improving asbestos regulations, reducing the costs of disposing of bonded asbestos, increasing awareness around asbestos handling and disposal, improving the upfront controls on asbestos and increasing the chance of getting caught if asbestos is disposed illegally.

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Contaminated sites

Contaminated land is where a substance occurs at a concentration above the normal level. Exposure to some substances may affect the health of people, animals or plants and make land unsuitable for use.

Summary

Significantly contaminated sites

346

sites regulated by the EPA between 1997 and 2017

Read more

Remediated sites

158

of EPA-regulated significantly contaminated sites have been remediated

Read more

Notified contaminated sites

111

contaminated sites were notified to the EPA between 2015 and 2017

Read more

Petroleum or service station sites

63%

of sites newly regulated between 2015 and 2017 are petroleum industry or service station sites

Read more

Contaminated sites continue to be notified at a steady rate, but the total number of sites being regulated has decreased slightly.

As of December 2017, a total of 1,666 contaminated sites had been notified to the EPA, of which 346 required regulation. Out of these 346 sites, 158 have been remediated. Between January 2015 and December 2017, 895 sites were assessed by the EPA and there were approximately 100 sites classified as under assessment as of December 2017.

Between January 2015 and December 2017, 111 new sites were notified to the EPA. Sixteen were regulated under the *Contaminated Land Management Act 1997* (CLM Act) and regulation was ended at 28 sites. Service stations and other petroleum industries accounted for 63% of the newly regulated sites.

Sites in the major coastal cities, particularly Sydney, are readily remediated as there is high demand for land for residential and commercial development, while there is less demand for these types of development in rural areas.

The NSW Government investigation program for emerging contaminant PFAS (per- and poly-fluoroalkyl substances) began in February 2016. PFAS have been used in fire retardants such as foam used to put out fires, many common household products and some industrial processes.

The investigation program focuses on sites where there has been historical use of products which contain PFAS and where people's contact with these chemicals may increase.

NSW indicators

Indicator and status		Environmental trend	Information reliability
Number of regulated contaminated sites	MODERATE	Stable	✓✓✓
Number of regulated contaminated sites remediated	MODERATE	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Contaminated land is land where a substance (or substances) occurs at a concentration above the normal level. Exposure to some substances may affect the health of people, animals or plants, and make land unsuitable for its current or intended use.

In some cases, substances left in soils from the past continue to be toxic, persistent, bioaccumulative or present in large quantities or in combination. There is a risk that substances may move from the source of the contamination through pathways such as groundwater, resulting in increased exposure to people and the environment.

Historic land use is the main source of land contamination, for example, land used for gas works, aluminium smelters, dry cleaners or service stations.

Dealing with contaminated land is important to:

- protect human health and the environment
- enhance local amenity, for example ensuring suitable land can be used for recreation purposes such as parks and tennis courts
- make sure land is available for development.

There are more than 30,000 contaminated sites in NSW, often as the result of poor industrial chemical storage, handling and disposal practices. Many are large, complex sites that were previously used for:

- heavy industry such as gasworks or smelters
- agriculture such as dip sites, where persistent chemicals were used to treat livestock
- commercial purposes such as storage areas for chemicals used in service stations or dry cleaners.

Many former industrial areas have been, or are being, remediated and redeveloped for high-density residential and commercial uses near infrastructure, transport and jobs, such as the Green Square–Waterloo corridor in Sydney, and the Barangaroo site in Sydney.

Status and Trends

Notification of contaminated land

Landowners or land holders must notify the EPA of land that is potentially significantly contaminated. To determine whether to declare land is 'significantly contaminated' and therefore subject to EPA regulation, the EPA assesses:

- whether the substances have already caused harm or are toxic, persistent or bioaccumulative
- whether the substances can be transferred to human beings or features of the environment, for example, through contaminated groundwater or soils
- the current or future uses of the land and the adjoining land
- whether the substances are likely to migrate from the land (or already have migrated) (*Contaminated Land Management Act 1997*, section 12).

Between 1997 and 2017, approximately 1,666 sites were notified to the EPA. Of these, 111 sites were notified between January 2015 and December 2017. During the same period 895 sites were subject to assessment.

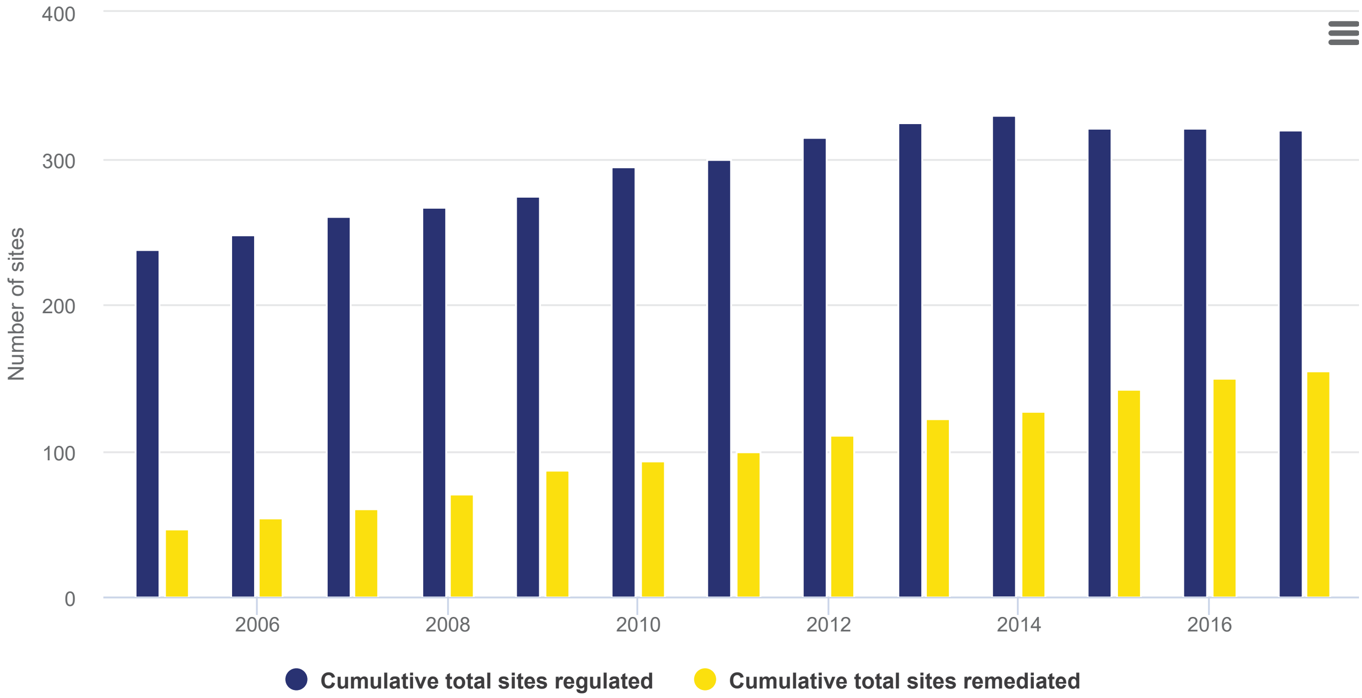
Regulation and remediation of sites

The EPA may regulate sites that are declared 'significantly contaminated' and require the person responsible for the contamination to remediate the land so contaminating substances do not further harm the environment or human health.

Between 1997 and December 2017, the EPA regulated 346 significantly contaminated sites under the *Contaminated Land Management Act 1997* and 158 sites were remediated.

Figure 9.1 shows that the total number of remediated and regulated sites rose steadily between 2005 and 2017. Between 2015 and 2017, there were 16 newly regulated sites under the *Contaminated Land Management Act 1997* and an additional 28 sites remediated.

Figure 9.1: Cumulative total of sites regulated under the Contaminated Land Management Act and remediated, 2005-17



Source:
EPA data 2018

Regulated sites by contamination type

Figure 9.2 shows fluctuations in the number of new sites regulated every year between 2005 and 2017.

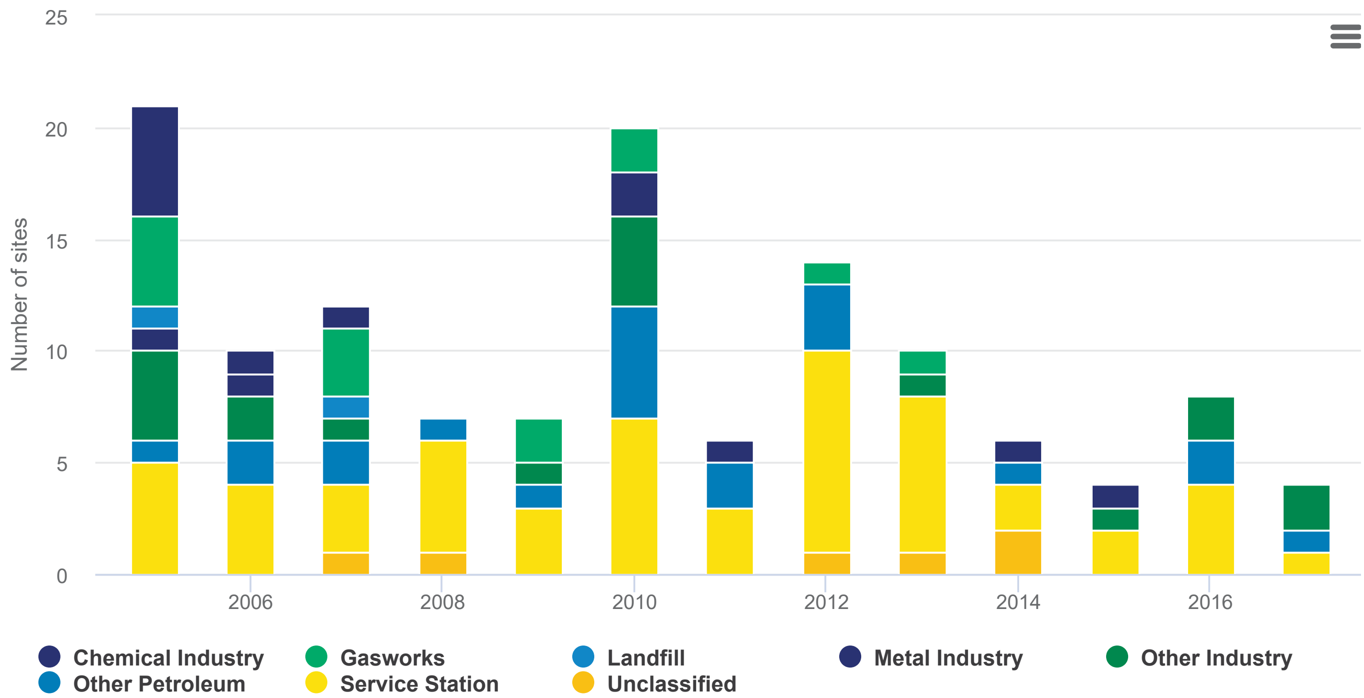
Land declared to be significantly contaminated between 2015 and 2017 were associated with:

- service stations (44%)
- other petroleum industries (19%)
- the chemical industry (6%)
- other industry (31%).

Since 2015, service stations and other petroleum industries have accounted for 63% of newly regulated sites.

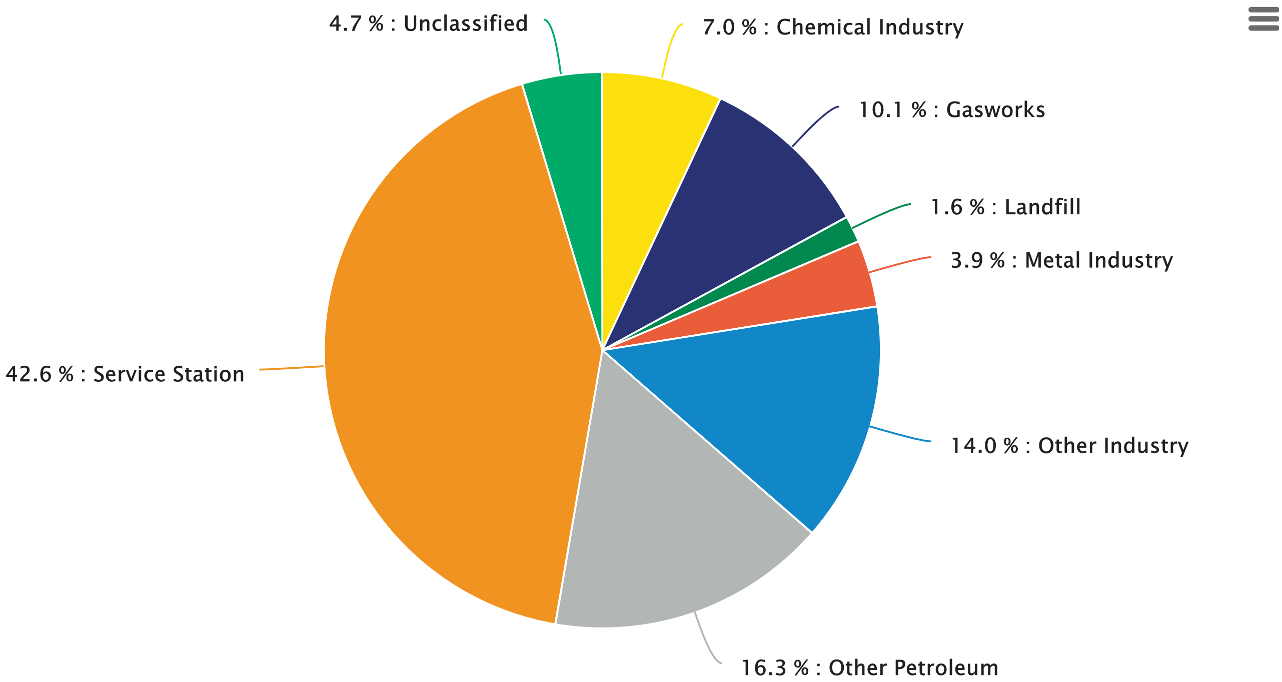
The *Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2014* (UPSS Regulation) addresses the historical practices that have resulted in service stations being the largest single source of contaminated land in NSW (**Figure 9.2**).

Figure 9.2: CLM Act newly regulated sites by contamination type, 2005-17



Source:
EPA data 2018

Figure 9.3: Proportion of newly regulated sites by contaminated type 2005-17



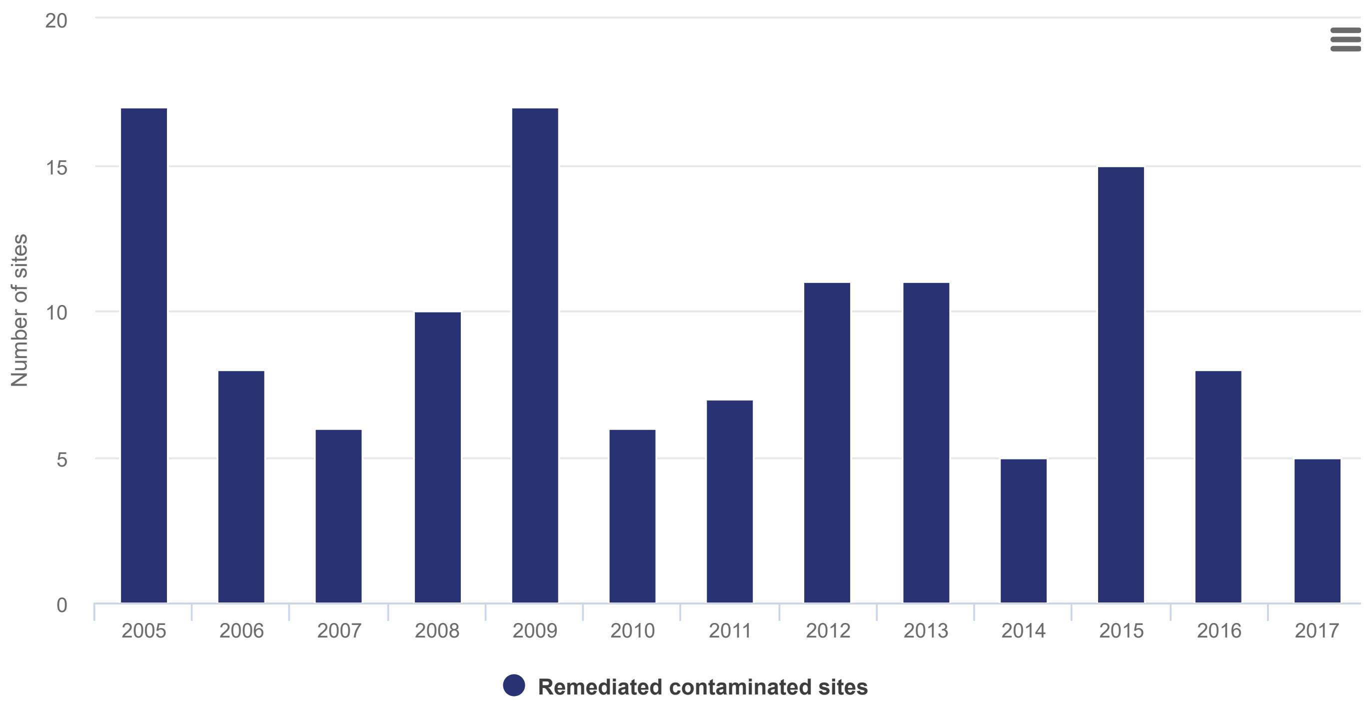
Notes:
Based on cumulative total 2005-2017

Source:
EPA data 2018

Remediation of contaminated sites

Figure 9.4 shows that 28 sites were remediated between 2015 and 2017. The regulation of large complex sites is expensive, for example, the remediation of Barangaroo in Sydney cost approximately $100 million over seven years.

Figure 9.4: Remediation of contaminated sites, 2005-17



Source:
EPA data 2018

PFAS

PFAS (per- and poly-fluoroalkyl substances) are an emerging contaminant, and research is still being undertaken to understand their long-term effects. PFAS have been used as fire retardants in fire fighting foams as well as many common household products and some industrial processes.

In 2015, the Commonwealth Department of Defence confirmed that PFAS contamination had spread from RAAF Base Williamtown. In response, the NSW Government convened the Williamtown Expert Panel, led by NSW Chief Scientist and Engineer Professor Mary O'Kane, and two working groups, to provide additional expertise and advice on health and water impacts and to propose solutions to prevent harm to the environment and human health.

Pressures

Land redevelopment

The main drivers for the remediation of contaminated land in NSW are development pressure and real estate values. Sites in the major coastal cities, particularly Sydney, are readily remediated as there is high demand for land for residential and commercial development, while in rural areas there is a lower demand for these types of development.

Information needs

Assessing the risk from substances contaminating land relies on information being available about specific substances and ways in which they could negatively affect human health and the environment, for example, through groundwater contamination. The extent of contamination beneath the surface is often difficult to identify and manage, so characterising the risks and costs can be challenging.

Sustainable remediation

Large land remediation projects can use significant amounts of electricity and emit large quantities of greenhouse gases. Since the late 2000s, there has been a global push to embrace sustainable approaches to remediation that provide a net benefit to the environment. Consideration of the principles of ecologically sustainable development is an object of the *NSW Contaminated Land Management Act 1997*.

Responses

Legislation and policy

Contaminated land management framework

The NSW contaminated land management framework establishes a system that integrates environmental and planning processes and comprises two tiers:

- the regulation of significantly contaminated land under the *Contaminated Land Management Act 1997*
- the regulation of other contaminated sites that do not pose an unacceptable risk for the current or approved use, under the *Environmental Planning and Assessment Act 1979* and *State Environmental Planning Policy No 55 – Remediation of Land* (DUAP, 1998).

NSW operates on the polluter pays principle, where clean-up and remediation costs must be borne by the polluter where they can be identified, or by the landowner if not.

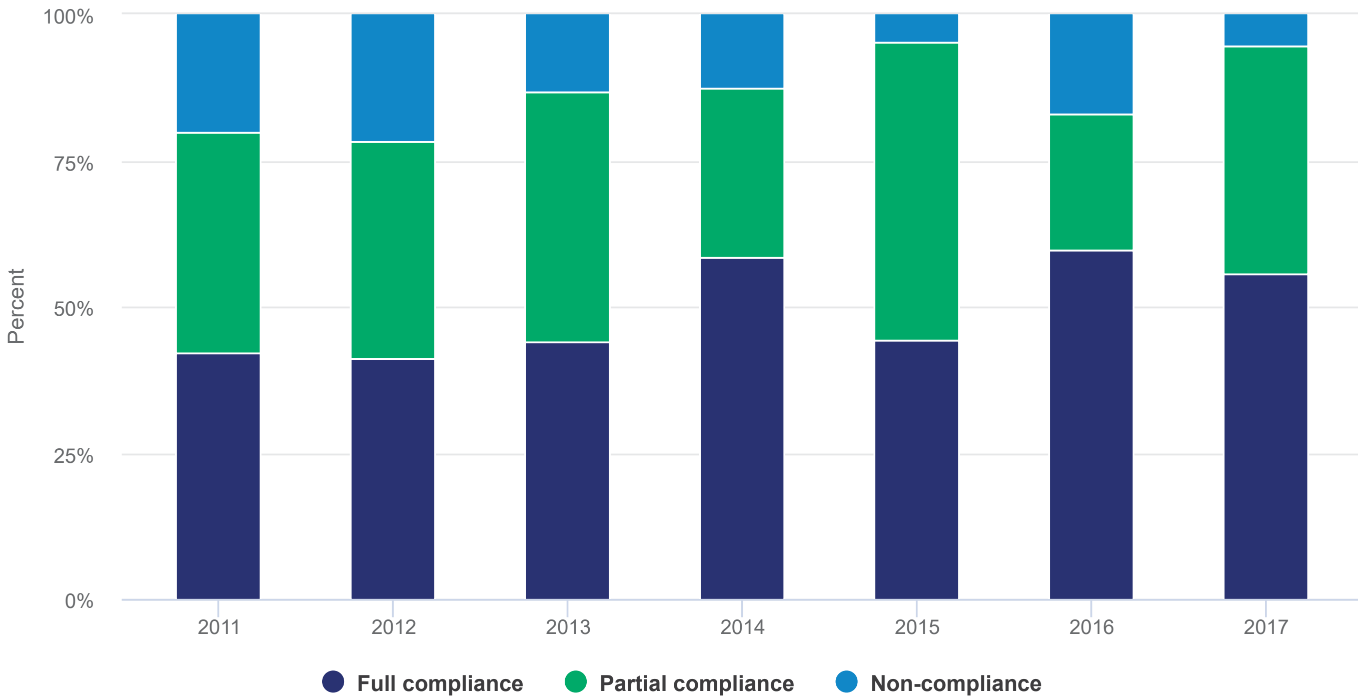
Underground Petroleum Storage Systems regulation

The NSW Government is continuing to implement the *Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2014* (UPSS Regulation), a key element of the EPA's strategy to prevent contamination.

Since the introduction of the UPSS Regulation in 2009, the EPA has undertaken over 150 site inspections in response to incidents, leak notifications and general enquiries. This work has involved close consultation and joint inspections with industry stakeholders and local councils.

Figure 9.5 shows that under the UPSS compliance program, the EPA has inspected 566 sites between January 2011 and December 2017. Since the beginning of this program, stakeholders' full compliance with the UPSS Regulation has increased, while non-compliance has decreased following initial inspections by the EPA.

Figure 9.5: UPSS Regulation compliance rates for premises the EPA has inspected between 2011 and 2017



Source:
EPA data 2018

There were significant differences in the level of compliance across the petroleum industry:

- Major fuel chains showed reasonably high levels of compliance.
- Independent and locally owned or locally operated retailers demonstrated a lower level of compliance when the EPA first inspected them. The EPA and councils are working with these retailers to help them become compliant.
- The nature of non-compliances with the UPSS Regulation shifted over time. Initially, there were deficits in infrastructure such as loss monitoring systems or leak detection systems and deficiencies in systems and procedures such as site plans and management procedures. Once the EPA detected these, service stations focused resources and time on installing leak detection and monitoring equipment and the level of compliance in these areas improved significantly.

The focus now is on ensuring systems and procedures are put in place to manage contamination risks at these sites.

The implementation of the UPSS Regulation helped:

- educate and train councils on the requirements of the Regulation
- owners and operators of UPSS throughout NSW to improve compliance with the legislation and better manage contamination risks
- assess service stations' degree of compliance through a structured inspection program.

Programs

Reviews of contaminated land management

Between 2015 and 2017, reviews of ways in which the EPA managed contamination were held, and included an assessment of the:

- management of lead contamination due to former smelting activities in north Lake Macquarie in December 2016 (Lead Expert Working Group 2016)

- EPA's management of contaminated sites and contamination from firefighting foams in December 2016 (Taylor and Cosenza 2016)
- EPA's Contaminated Land Management Act 1997 Procedural Guide for EPA Officers in June 2017 (Fell and Leeder 2017).

These reviews recommended ways in which the EPA could improve its management of contaminated sites. The Government supported implementation of 76 of the 80 recommendations, which are being progressively implemented and should be completed by December 2019.

For example, the Taylor review recommended that NSW EPA should be provided with the resources needed for in-house legal counsel to support operational staff, and to establish a specialist team to undertake sampling and assessment of emerging contaminants. In November 2017 the NSW Government announced that it would be dedicating an extra $23.5 million over four years to better deal with contaminated land and implement the review recommendations.

Preventative programs

The EPA aims to reduce the number of contaminated sites by providing information about best environmental management practices to prevent contamination. High-risk industries targeted under this program include galvanisers and UPSS sites. The EPA has worked cooperatively with stakeholders such as industry representative bodies and local councils, to ensure guidelines are comprehensive, clear and accurate. Measures implemented as part of the program include:

- site audits
- identification and sharing of best practice measures
- development and dissemination of educational materials
- liaison with industry associations.

The EPA is also undertaking a lead safety and awareness campaign targeting people such as home renovators who are at risk of being exposed to lead contamination.

Backlog program

An amendment to the *Contaminated Land Management Act 1997* in late 2008, which strengthened the duty to report contamination, resulted in the number of sites being notified to the EPA increasing significantly. The Backlog Program was established as a two-and-a-half-year project (July 2015–December 2017) to assess the backlog of 834 notified sites. The program involved allocating additional staff to obtain information relating to the sites and to assess this information to determine whether the EPA should regulate these sites under the Act. The Backlog Program was completed on 31 December 2017. Of the sites assessed, 19 required EPA regulatory action. The majority of those notified were or had been service stations.

Capacity building

The NSW Government has implemented programs to address the risks to human health and the environment from contaminated land.

Between July 2014 and June 2017, the EPA gained $6 million from the Environmental Trust to fund and administer the Contaminated Land Management Program (CLM Program):

- 63 sites of the 110 originally identified for the CLM Program were assessed

- 57 were assessed as not requiring further assessment
- four were assessed as requiring regulation
- the remainder were handed to the Backlog Program to assess.

The CLM program:

- funded and implemented the Council Gasworks Program, including the further investigation of the former Bowral Gasworks and the investigation of the Parkes and Waratah gasworks
- funded the investigation of 20 UPSS sites across nine local government areas with 17 sites being remediated, including 46 derelict tanks being removed or successfully managed
- placed specialist officers across four regions of NSW to support more than 50 local government areas, resulting in the improvement of up-to-date and regionally consistent policies and procedures on contaminated land management
- developed and published the Underground Petroleum Storage Systems Best Practice Guide for Environmental Incident Prevention and Management (EPA 2016) which is a guidance flipchart for operators of smaller service stations and other UPSS sites
- supported and funded the Broken Hill Environmental Lead Program, which responded to rising lead blood levels in children in the Broken Hill area by remediating playgrounds and educating parents on safe use of these areas
- funded the ongoing monitoring and rehabilitation of a site at Coramba in northern NSW, where petroleum from a leaking underground storage tank had been seeping into a backwater near the Orara River.

PFAS

The NSW Government PFAS Investigation Program began in February 2016. It focuses on sites where there has been a historical use of firefighting foams and where there are exposure pathways that may increase people's contact with PFAS chemicals such as through bore water, surface water or groundwater. These sites include:

- airports
- firefighting training facilities
- industrial sites.

The EPA is taking a precautionary approach to managing the legacy of PFAS use across NSW, focusing its investigation on sites where usage of PFAS-containing products is the greatest. The NSW Government is working with all relevant government agencies through the NSW PFAS Taskforce to monitor the progress of investigations and to keep local communities informed.

At the national level, in November 2016, environment ministers agreed that all jurisdictions have a critical role to play in developing nationally consistent standards for PFAS. This process has been coordinated by the Environment Protection Authority Victoria. The PFAS National Environmental Management Plan (NEMP) provides a nationally consistent approach to the environmental regulation of PFAS in Australia. Along with Victoria and the Commonwealth, the NSW Government is actively involved in the approach to PFAS and continues to raise this issue in Heads of Government meetings.

Future opportunities

Regional capacity building

Obstacles to managing contaminated land in regional and rural areas have included:

- the lack of specialist technical skills

- misconceptions of regulatory liability
- a lack of financial and human resources to manage or apply appropriate planning considerations to contaminated lands.

A Council Regional Capacity Building Program is being implemented by the EPA to increase the capacity of regional councils to manage contaminated land and enable them to employ specialist technical staff to provide assistance and capacity building in contaminated land management.

References

References for Contaminated sites

Department of Urban Affairs and Planning (DUAP) & EPA 1998, *Managing Contaminated Land: Planning Guidelines – SEPP 55–Remediation of Land*, Department of Urban Affairs and Planning and Environment Protection Authority, Sydney [www.epa.nsw.gov.au/clm/planning.htm]

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Urban Water Supply

High quality and secure water supply is essential for economic growth and community health.

Summary

Water use per person per day	Drinking water quality
306 litres	**100%**
Stable overall since 2009	compliance with guidelines for the last three years
Read more	Read more

Per person water demand has been stable in Greater Sydney and declining elsewhere. There has been 100% compliance with drinking water guidelines.

Overall demand for water decreased substantially during the Millennium Drought but since then, in Greater Sydney, demand has slowly increased in line with the city's population growth. Overall demand stayed relatively constant in the Lower Hunter and regional centres due to decreased consumption per person.

Longstanding measures to reduce water consumption prior to 2011, particularly during the Millennium Drought, helped moderate urban water use. For the last three years of available data, both Sydney Water and Hunter Water maintained per person water use below target levels. For regional water utilities, average water consumption per property supplied was relatively stable over the last three years, maintaining the trend of the past decade. However, compared to 1991–92, these regional local water utilities (LWUs) reduced average annual residential water use by 48% (as of 2015–16).

In densely populated areas, water extraction for urban supply has ongoing impacts on river flows, putting the health of some river systems under pressure.

For major water utilities, the use of recycled water remained steady in recent years, but has increased in areas serviced by local water utilities. Nineteen private schemes now recycle water in NSW; in the year to June 2017 they supplied 2,377 megalitres (ML) of recycled water. In some areas, changing market conditions may affect future demand for recycled water.

Water utilities for NSW metropolitan areas, regional cities and major towns all manage water supplies to ensure they comply with Australian Drinking Water Guidelines. In 2016–17, Sydney Water, Hunter Water and the large regional water utilities continued a multi-year trend of achieving 100% overall compliance with the guidelines' microbiological, chemical and physical criteria.

Related topics: Population | Water Resources

NSW Indicators

Indicator and status		Environmental trend	Information reliability
Proportion of the metropolitan and regional water supply meeting national guidelines	GOOD	Getting better	✓✓✓
Total and per person water consumption for metropolitan and regional centres	MODERATE	Stable	✓✓✓
Water recycling - major utilities	MODERATE	Stable	✓✓✓
Water recycling - local water utilities	MODERATE	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use the report.

Context

To provide a sustainable supply of water to urban areas, water managers must ensure water resources:

- are secured for human use
- support economic growth
- maintain healthy aquatic systems.

Water managers must also plan for key challenges, including population growth and future climate change.

Agriculture uses more than 60% of all water consumed in NSW, depending on climate conditions, while urban areas across NSW generally use 18% or less of all water consumed (ABS 2017). Water supply to urban areas is split among the following uses:

- residential
- commercial
- industrial
- irrigation (amenity, horticulture and agricultural).

Structures to store and regulate water flow are built to provide greater security of urban water supply. Yet these structures also moderate the natural variability of stream flows. By changing flow volumes and timing, extraction of water to supply high-density urban areas can have enduring effects on river health. When river health is affected this can, in turn, affect water quality in waterways. Compounding these challenges, urban stormwater discharges can also impact these waterways.

See the Water Resources and River Health topics for more details.

Status and Trends

Urban drinking water quality

Urban drinking water quality

Sydney Water and Hunter Water are NSW's two major urban water supply utilities. Water NSW manages bulk water supply and the drinking water catchments supplying Greater Sydney. Elsewhere in NSW, including the Central Coast, 95 local water utilities supply drinking water. Most of these are operated by local government councils or county councils.

Monitoring against national guidelines

The NSW Government endorses the Australian Drinking Water Guidelines (NHMRC & NRMMC 2011) as the water quality benchmark for providing water to the State's population. These guidelines include the Framework for Management of Drinking Water Quality. This framework sets out a preventative risk management approach for drinking water quality that encompasses the whole supply system, from catchment to household.

Over the last three years, drinking water monitoring in NSW's metropolitan areas, and its regional cities and towns, showed 100% compliance with these guidelines. However, the guidelines allow a small proportion of samples to not meet specified criteria. Monitoring results reported for all the State's LWUs (NOW 2015, Appendix D1; DPI Water 2016; DPI Water 2017a; BOM 2017) showed that of all samples tested:

- 99.8 to 99.9% complied with guideline criteria for *Escherichia coli (E. Coli)*
- 99.4 to 99.9% complied with guideline criteria for chemicals
- 98.3 to 99% of complied with guideline physical criteria.

Extensive sampling is one way utilities comply with the risk management framework. However, this monitoring by itself does not protect against contamination. From time to time, incidents and alerts do occur. These events highlight the need for a preventive approach, achieved by implementing a risk-based drinking water management system.

Sources and volumes of water drawn

Figure 6.1 tracks the volumes of water taken from different sources since 2011–12, including:

- supply reservoirs
- in-stream sources
- groundwater aquifers
- recycled water schemes.

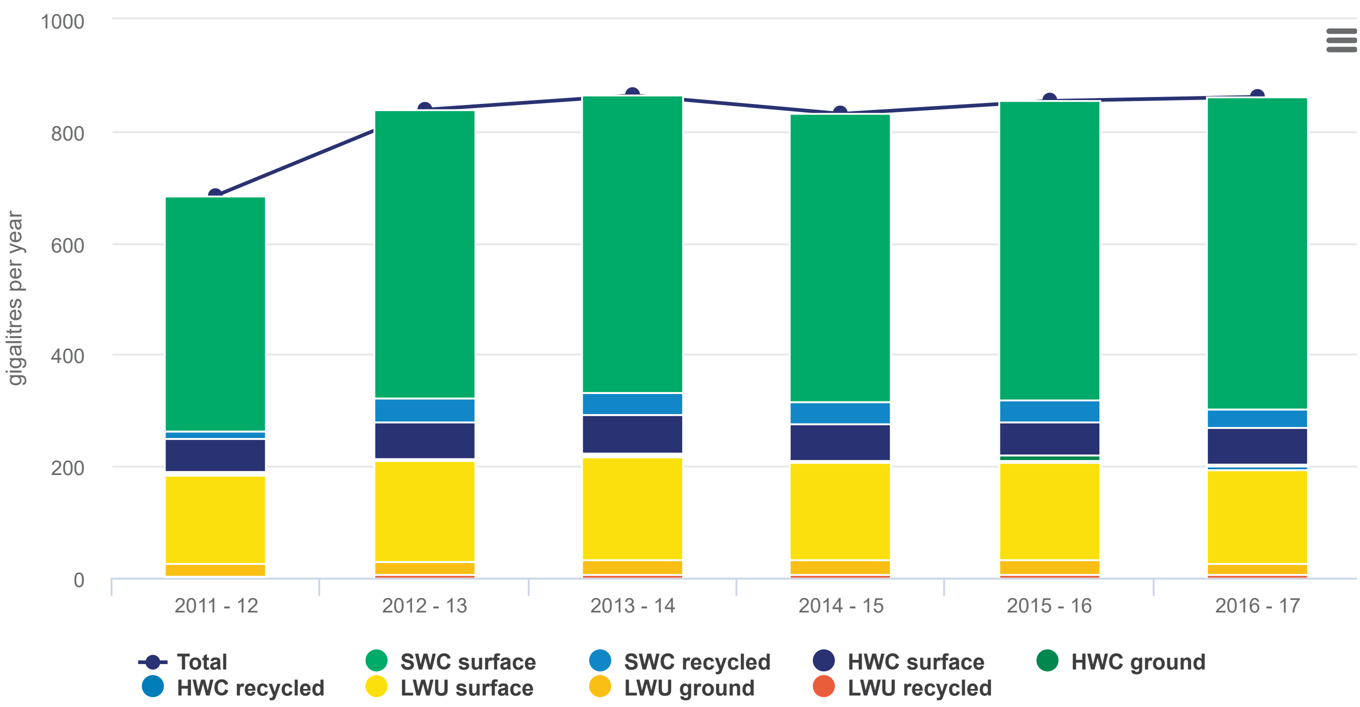
In NSW cities and large towns, surface water is the main water supply source. Across NSW's western slopes and plains, and in larger coastal catchments, groundwater is also important for water supply.

Each year, utilities vary the proportion of water they draw from each water source. This is because different conditions – mainly weather conditions – affect how much surface water is available and held in reservoirs. Sydney Water, using bulk water supplied by Water NSW, is the largest supply utility by water volume and dominates these trends, both in terms of total demand growth and total water recycling volume in NSW.

Over the three years to 2017, available data show that total statewide annual water use for urban supply varied from 936 to 974 gigalitres (GL) (BOM 2017). The 2016–17 value is an 8.8% increase in urban water use compared to the 10 years to 2006–07 (895GL; SoE 2009). This increase generally tracks population growth.

See the Population topic for more details about population growth.

Figure 6.1: Urban water supplied, by source



Notes:
Includes all local water utilities (LWUs) serving 10,000 or more properties. Data for smaller LWUs is available in the tables of the source publications.

Source:
NOW 2012, 2013, 2014, 2015; DPI-Water 2016; DPI-Water 2017a; BOM 2017

Figure 6.1 shows the proportion of water supplied by source since 2011–12. The total and LWU series do not include data for LWUs serving less than 10,000 properties due to changed reporting thresholds – during 2011–2016 the total of these small LWUs amounted to a further 105.5 to 112.6 GL per year.

Recycled water represents a small but growing portion of total water supplied by local utilities. In 2015–16, for example, effluent was recycled by 39 non-metropolitan local water utilities including Central Coast Council (DPI-Water 2017a, Table 8).

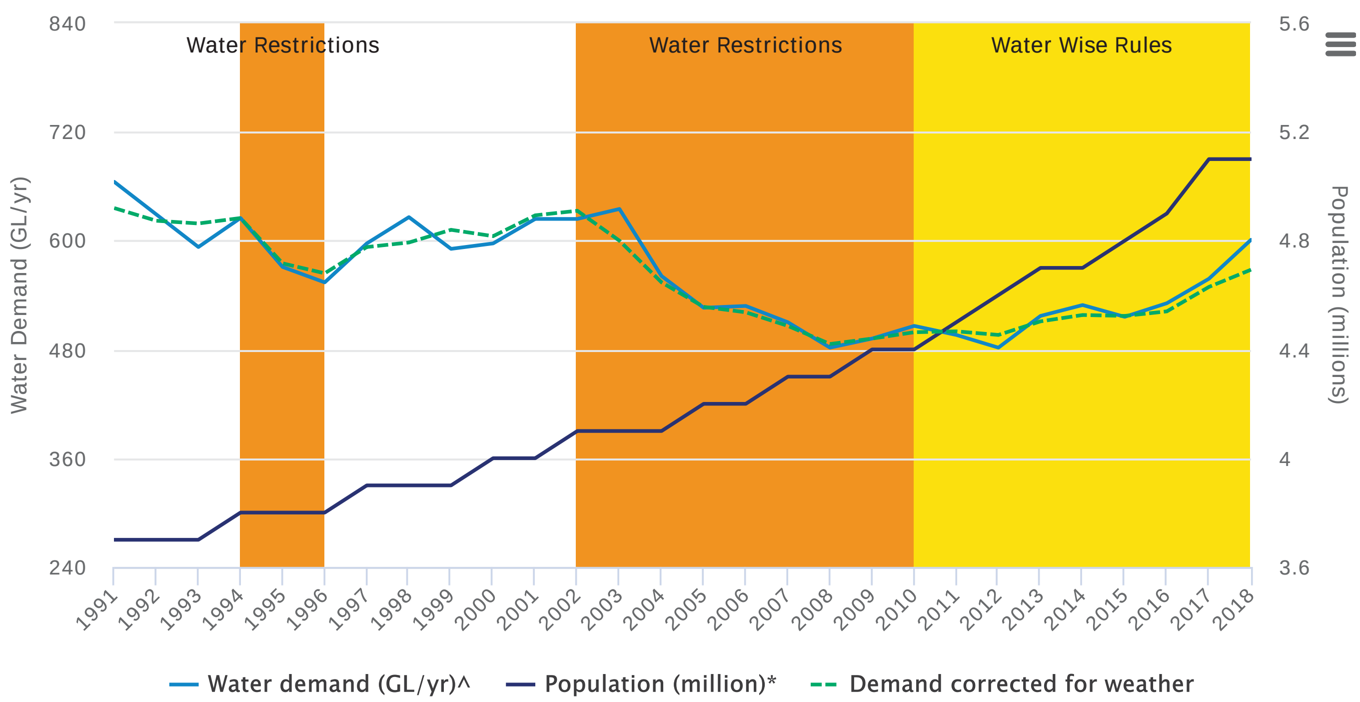
NSW now also has 19 private recycled water schemes licensed under the *Water Industry Competition Act 2006*. These schemes service 4,096 water customers and 4,185 sewerage customers. In the year to June 2017, they supplied 2,377ML of recycled water (IPART 2017).

Demand for water

Sydney

In 2017–18 Sydney's total water use (excluding recycled water use) was about 600GL (including use in the Illawarra and Blue Mountains). This amount includes residential, businesses, industry and irrigation, as well as leaks from the water supply network. Although total use increased in recent years, the 2017–18 volume remains lower than before late 2003, when mandatory restrictions were introduced, despite a 25% increase in population during the intervening period (**Figure 6.2a**). It is estimated that the hotter, drier weather in 2017–18 resulted in a 33GL increase in demand compared to what would be expected in a year with average weather conditions (Sydney Water 2018).

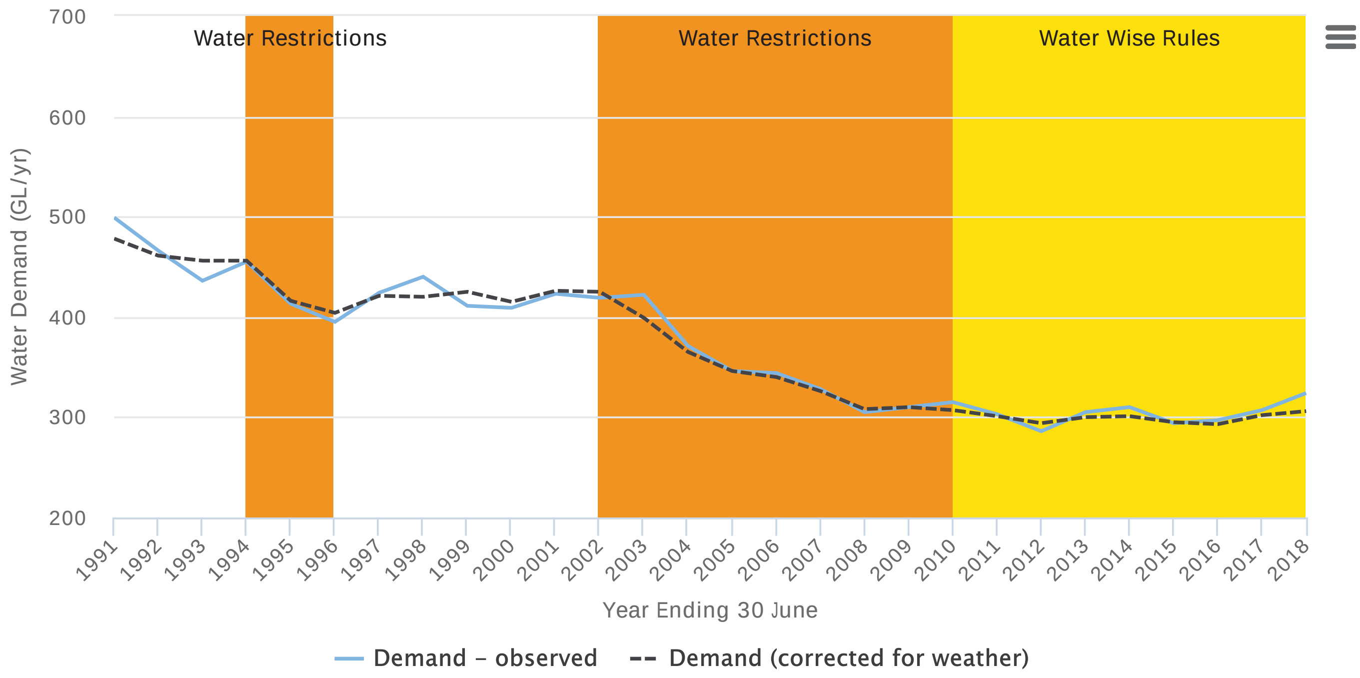
Figure 6.2a: Demand for potable water, Sydney Water 1991–2018



Notes:
*estimated
^not corrected for weather
This figure shows total residential and non-residential consumption relative to total population across Sydney Water's operational area.

Source:
Sydney Water data 2018

Figure 6.2b: Water demand per person, Sydney Water, in relation to water restrictions (1991–2018)



Source:
Sydney Water data 2018

Figure 6.2b shows that in recent years, the amount of potable water the average person consumes each day remained fairly stable when corrected for weather. In 2017–18 the absolute daily volume consumed per person was 324 litres (L); but correcting for climate influences, this equates to 306L per person per day (Sydney Water 2018).

Residential demand accounts for almost 75% of potable water use in Sydney. The balance, about 25%, is consumed for non-residential uses on industrial, commercial and Government properties.

Lower Hunter

Over the 12 years to 2016–17, Hunter Water supplied 63.2 to 77.7GL of potable water per year across its area of operations, comprising local government areas of:

- Newcastle
- Lake Macquarie
- Maitland
- Cessnock
- Port Stephens
- Dungog (since 2008).

Historical water consumption per person and per property varies each year due to weather. In 2011–12, for example, wet conditions and a mild summer saw residential water use (both per person and per property) drop to a 10-year low in the Lower Hunter.

In 2016–17 and 2017–18, total rainfall was lower than the year before, and periods of below average rainfall persisted over long timeframes, including from July 2016. As a result, 2016–17 and 2017–18 water consumption increased over 2015–16 levels (Hunter Water 2018).

Total daily potable water consumption in the Lower Hunter remained relatively constant for the 12 years to 2016–17, despite population growth of about 14%. In fact, on a per person basis, annual potable water consumption actually declined 12% over this period. This decrease occurred because household water efficiency has increased, and because large industrial users have reduced their consumption (**Figure 6.3**).

Figure 6.3: Demand for potable water, Hunter Water (2002–03 to 2016–17)

Notes:
This figure shows total residential and non-residential consumption across Hunter Water's operational area.

Source:
Hunter Water data 2018

Statewide including regional NSW, Sydney, the Blue Mountains, the Illawarra and the Lower Hunter, residential use consumes the largest share of potable water, at 65–75% of the total used.

In regional NSW, residential use accounts for two-thirds of total urban water consumed (DPI Water 2017, Table 8). In 2016–17, the average annual volume LWUs supplied per-property was 48% less than in 1991–92 (162 versus 330 kilolitres [kL] per connected property; DPI Water 2017b, Chart 3). In absolute terms, total annual urban water demand has remained fairly constant in regional NSW for most of the past 10 years, but consumption per property has been generally declining (**Figure 6.4**).

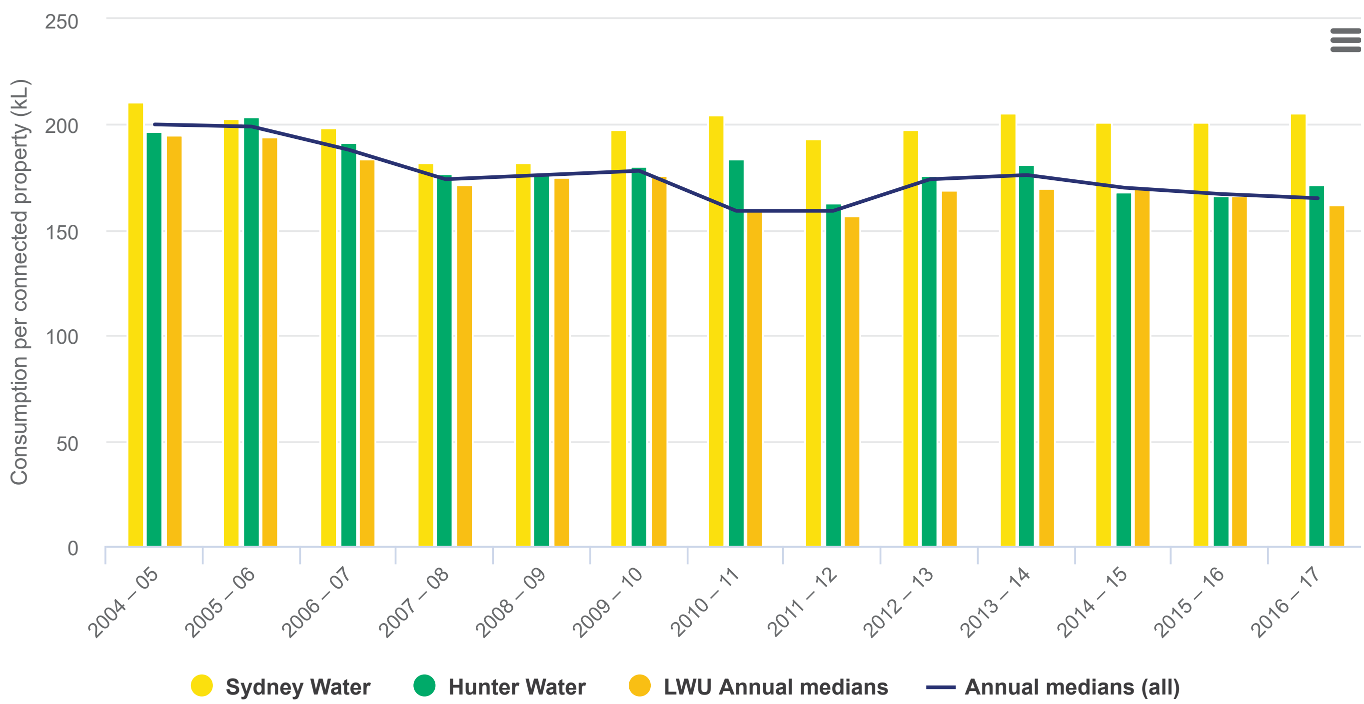
Figure 6.5 compares per-property residential consumption for Sydney Water, Hunter Water and the LWU median, alongside the combined median for all these utilities.

Figure 6.4: Median of average annual per-property residential water consumption, local water utilities 2004–05 to 2016–17

Notes:
This figure shows the median of annual average water consumed per residential connection for NSW local water utilities (LWUs) with more than 10,000 connected properties. For data on individual LWUs and those with less than 10,000 connections, see the tables in the source publications.

Source:
DWE 2009a, Table 10; DWE 2009b, Table 10; NOW 2010, Table 10; NOW 2011, Table 10; NOW 2012, Table 10; NOW 2013, Table 10; NOW 2014, Table 10; NOW 2015a, Table 10; NSW DPI-Water 2016, Table 10; NSW DPI-Water 2017, Table 10; BOM 2017

Figure 6.5: Annual per-property residential water consumption for LWUs, Sydney Water and Hunter Water, 2004–05 to 2016–17



Notes:
This figure shows annual consumption per residential connection for each of the various utility operational areas, as well as the median value of annual average residential consumption for all utilities.
For local water utilities (LWUs), the figure is based on the median value of annual average residential consumption for those utilities with more than 10,000 connected properties. Data on the smaller LWUs is available in the tables in the source publications.
Because the Hunter Water supply network interconnects with adjacent LWUs, it can supply and receive bulk treated water from Central Coast Council and MidCoast Water.

Source:

DWE 2009a, Table 10; DWE 2009b, Table 10; NOW 2010, Table 10; NOW 2011, Table 10; NOW 2012, Table 10; NOW 2013, Table 10; NOW 2014, Table 10; NOW 2015a, Table 10; NSW DPI-Water 2016, Table 10; NSW DPI-Water 2017; BOM 2017

Pressures

Water pollution

Poor water quality affects its suitability for human use, increases the cost of treatment for supply and may affect the health of aquatic ecosystems. The following have important effects on water quality:

- vegetation cover
- land management practices in river catchments
- land overlying aquifer recharge zones
- stormwater runoff (in urban areas)
- wastewater discharge (in urban areas).

See the River Health and the Coastal, Estuarine and Marine Ecosystems topics for more details.

Water demand

For the last nine years of available data, water consumption per person remained relatively constant in NSW. Nevertheless, water supplies have come under constant upward pressure from:

- hotter and drier than average weather conditions
- a growing population (see the Population topic)
- increases in non-residential water use over the last three years.

Key drivers of water demand are the economy, environment and demographics. In turn, these high-level drivers affect other factors that influence demand, such as:

- people's attitude to water (for example, water use behaviour, appliance choices and rainwater use)
- the price of water
- development and adoption of new technology or practices (for example, water-efficient appliances, water source substitution)
- investment in water efficiency programs
- housing density, household size, and extent of outdoor water use
- change in non-residential water use:
  - changes in industry type
  - efficiencies
  - use of alternative water sources.

Weather also has a major effect on water demand. Deviation from average weather conditions can increase or decrease annual water consumption by 2–6% (Sydney Water 2017 & 2018). Prolonged extreme weather events such as heatwaves can cause more variation, particularly in the short-term. Climate strongly influences customers' water use levels, mainly by affecting residential outdoor and cooling tower use.

Residential customers' water use follows seasonal patterns: higher use over summer and lower use in cooler months. However, the disparity in summer and winter water use levels has diminished because people have maintained behaviours established during drought restrictions and because housing density has increased.

Day-to-day and week-to-week weather changes can also cause short-term fluctuations in water use significantly above or below seasonal trends.

Climate variability and climate change

Droughts are a natural feature of Australia's climate. Planning and response for wide-ranging, enduring droughts constitute a major urban water security challenge.

Climate change necessitates new, adaptive ways to plan for urban water security. Under climate change, projected long-term changes in rainfall are expected to create risks for water availability (Vaze & Teng 2011). In addition, the way climate change affects heavy, flood-causing rainfall events (both their frequency and intensity) is likely to differ from its effects on seasonal or average rainfalls (DECCW 2010).

The volume of water held in storages will vary with climatic conditions due to:

- changes to rainfall
- changes to evapo-transpiration and runoff
- increased watering of lands
- people's use of evaporative coolers in response to hotter, drier conditions.

The 2017 Metropolitan Water Plan includes a drought response strategy. This strategy aims to ensure greater Sydney can withstand a drought more extreme than any experienced over the past century.

See the 2017 Metropolitan Water Plan section in this topic and the Climate Change topic for more information.

Responses

Legislation and policy

Metropolitan water management plans

Water use planning must balance both socioeconomic demands and environmental needs. It must also account for long-term changes in water availability due to climate extremes (such as droughts and floods).

2017 Metropolitan Water Plan

The 2017 Metropolitan Water Plan sets out how the NSW Government will provide a secure and sustainable water supply to meet the needs of Sydney, the Blue Mountains and the Illawarra. Following an extensive review, the former (2010) plan was updated with the latest data, research findings and technological advances.

Developed through a collaborative approach, the plan is structured around four broad outcomes and 11 major strategies. It is underpinned by an adaptive planning response.

The plan's key aspects include:

- optimising water supply system management by changing the mix of water supply and demand measures (such as dams, desalination or water restrictions) to provide water security at the lowest cost
- a water conservation approach that applies economic criteria to ensure investment is optimised
- a drought response strategy that is flexible and designed to withstand a drought more extreme than any experienced over the past century
- a new WaterSmart Cities Program for a more integrated approach to providing water, wastewater and stormwater services to new urban release areas, and to significant new developments in existing areas
- improving river health by releasing variable environmental flows from Warragamba Dam to bolster the health of the Hawkesbury-Nepean River.

The plan also includes a drought response strategy with a broad suite of supply and demand management measures to deploy as dam storage levels fall. Measures include:

- a drought supply options study
- implementing water restrictions
- building new water supplies
- contingency plans for response to an extreme drought.

Lower Hunter region

The Lower Hunter Water Plan (DFS 2014), released in April 2014, is a package of water supply and demand measures. These measures aim to ensure reliable water supply over the long term and set out actions to respond to severe droughts. As a key recommendation, the plan's Water Wise Rules were implemented on 1 July 2014.

Drinking water quality management

The *Public Health Act 2010* and *Public Health Regulation 2012* require all water suppliers to establish and adhere to the NSW Guidelines for Drinking Water Management Systems.

NSW Health records water quality monitoring compliance data, which is incorporated into the NSW performance monitoring and benchmarking system.

Improved pricing of water

Strong water pricing signals can reduce customers' water consumption and more accurately reflect the value of water resources and true costs of water supply. Important water pricing reform since the mid-1990s has seen tariffs shift away from fixed annual charges and toward pay-for-use pricing (DPI Water 2017b).

All NSW water utilities now have domestic water metering. As of 2007, all free water allowances for potable water supply ceased. Up to 2011–12, a gradual increase in the median residential water usage charge for local water utility customers was reflected in ongoing reductions in average demand per connected property. This demand reduction fostered relatively stable costs for the typical residential water supply bill (Consumer Price Index adjusted) since that time.

At current levels of demand per connected property, the average water supply bill for the typical NSW residence was $625 in 2015–16 (Jan 2017 dollars, NSW DPI-Water 2017b). This represents only a 22% increase over 21 years (DPI Water 2017b).

Mandatory plans

Under the *Water Management Act 2000*, statutory water sharing plans were developed to help secure long-term potable water supplies for regional towns and cities. These water sharing plans provide better security of entitlement for all water users, as well as for environmental flows. In NSW, most regional water use is now covered by a water sharing plan.

See the Water Resources topic for more details.

Programs

Consumers' average water consumption is likely to decrease due to:

- the long-term shift towards higher-density living
- greater use of water-efficient appliances through the Water Efficiency Labelling and Standards (WELS) scheme.
- the implementation of Water Wise Rules
- the NSW Building Sustainability Index (BASIX) requirements.

In addition to national and state-wide initiatives, there are three distinct components to water management in NSW:

- metropolitan water use (Sydney, the Illawarra, the Blue Mountains and adjacent areas; and the Lower Hunter)
- urban water use in regional areas (the Upper Hunter, Central Coast and country towns)
- rural water use (see the Water Resources topic).

National programs

National Water Initiative (NWI)

The National Water Initiative (NWI) is a shared commitment by governments across Australia to increase water use efficiency. NSW's implementation plan for the NWI lays out specific actions for the initiative's eight key elements (NSW Government 2006). All 32 eligible NSW urban water utilities have met the national auditing requirements of the initiative. Information is published annually by the federal government through National performance reports. The Productivity Commission reports good progress by states and territories on NWI implementation. However it recommends addressing the re-emergence of out-dated public policy and the challenges associated with climate change and population growth, particularly for the urban water sector. (Productivity Commission 2017).

National Australian Built Environment Rating System (NABERS)

Initially a NSW program, the National Australian Built Environment Rating System (NABERS) became a national program to rate buildings for their measured environmental impacts, including water consumption.

Commercial office buildings, hotels, shopping centres and homes were the first spaces to be eligible for NABERS water ratings. In 2016–17 the scheme was extended to public hospitals, and the following year (2017–18) NABERS jointly certified 274 hospitals. Also during 2017–18, NABERS began ratings for apartment buildings. A NABERS internal benchmarking tool for schools, which includes water ratings, has been developed in partnership with the NSW Department of Education.

NABERS has driven substantial water efficiency gains for offices, hotels and shopping centres (NABERS 2018). From 2010–18, for example, cumulative water savings for rated NSW office buildings totalled 279,431kL.

Labelling standards

The national Water Efficiency Labelling and Standards scheme (WELS) mandates registration and water efficiency labelling for washing machines, water-using dryers, dishwashers, toilets, urinals, taps and showers. The NSW Government has further made WELS compliance mandatory for plumbing fixtures in rental properties and for water-using appliances in residential complexes. The state government has incorporated WELS into the BASIX scheme in NSW.

State-wide programs

Water Wise Rules

Water conservation measures adopted during droughts over the last decade have been replaced by simpler, common-sense Water Wise Rules for Sydney, the Blue Mountains and the Illawarra (see **Figure 6.1**). These permanent rules aim to save water by embedding good practice among all water users. Present water consumption remains well below levels seen prior to the previous drought. However, obtaining the level of water use reduction achieved during times of water restrictions, and maintaining them, is yet to be accomplished.

Building Sustainability Index (BASIX)

NSW's Building Sustainability Index for new homes was introduced in 2004 to ensure homes are designed to use up to 40% less urban water compared to pre-BASIX levels. Commitments made on BASIX certificates indicate that, in the average BASIX-compliant home, a person consumes about 135 litres of water each day. Savings provided by BASIX reduce state-wide demand by 13GL a year and by the end of 2013–14, cumulative water savings in NSW exceeded 134GL of potable water (DPE 2015).

Rainwater tanks

People across NSW are using more rainwater tanks to complement their piped water supply. For example, 26 local water utilities saw 42,600 residential rainwater tanks (typically 4–5kL) installed in areas they service (DPI Water 2017a, Appendix J).

Efficiency and recycling initiatives

Water recycling schemes reduce the need to discharge wastewater and can also improve nutrient levels that affect the health of streams and rivers. By making water use more efficient, these schemes free up water supply, which dams can instead release for environmental flows, improving downstream river health. In 2015–16, a total of 28.2GL of water was reported as being recovered from urban water recycling schemes. The schemes were operated by Sydney Water, Hunter Water, local councils and private schemes (DPI Water 2017a, Table 8).

In 2016–17, Sydney Water and Hunter Water estimated daily water leakage at 83L and 96L per connected property, respectively (BOM 2017).

Sydney Water and Hunter Water actively look for and repair leaks. Under its Water Conservation Plan Sydney Water expects leak detection and other programs to achieve water savings of 17.9GL over five years (Sydney Water 2018). Hunter Water expects to save 215ML annually with targeted infrastructure improvements, such as relining the Black Hill Reservoir (Hunter Water 2017).

Although the Regional NSW Water Loss Management Program was completed in 2011, most local water utilities continue to build on the program with further water loss management activities. Prior to the program, state-wide average real water loss was 154L daily per connected property; it is now down to 70L daily per connected property for participating local water utilities (DPI Water 2017b).

Urban water management in regional centres

In NSW, more than 1.9 million people in over 500 country towns receive support from programs to maintain and augment water supply systems. These programs aim to protect public health and water security and deliver better environmental and social outcomes.

Safe and Secure Water Program: This program provides $1 billion to co-fund eligible water and sewerage projects. These include projects for catchment, town and local-scale water security, town water quality, public health, and risk remediation works on some dams. This new program has already allocated funding to the Broken Hill water supply pipeline.

Country Towns Water Supply and Sewerage Program: Concluded in 2017, this was a key program to assist regional local water utilities provide urban water supply and sewerage services. Along with the NSW Best-Practice Management of Water Supply and Sewerage Framework (NOW 2015b), the program mandated:

- strategic business planning
- sound pricing to achieve full cost recovery and encourage efficient use of services
- use of the NSW performance monitoring and benchmarking system (operated by DOI Water)
- integrated water cycle management planning to help local water utilities achieve sustainable, affordable and cost-effective water supply, sewerage and stormwater services.

Infrastructure improvements funded under the program were required to deliver improved public health and environmental outcomes, and security of water supply. Running for more than two decades (1994–95 to 2016–17) the program invested over $1.27 billion for more than 500 projects (DPI Water 2017b).

Future opportunities

Water-sensitive urban design aims to integrate the water cycle and the built environment. This planning approach for cities, towns, suburbs and even high-rise buildings is already a longstanding requirement for new developments in many local government areas.

With its strategy A Metropolis of Three Cities, the Greater Sydney Commission explicitly aims to capture and re-use energy and water flows (Greater Sydney Commission 2018; Objective 34). This objective complements commitments under the 2017 Metropolitan Water Plan. As Sydney grows, opportunities to apply water-sensitive urban design will expand, producing exemplars of best practice that can then be applied elsewhere in NSW.

In August 2018, the NSW Government approved a new policy and planning framework to manage Greater Sydney's urban water. This new framework will be implemented between 2018 and 2020 and reviewed in 2022. Key initiatives include:

- Sydney Water and WaterNSW will jointly develop an integrated, 20-year capital and operational plan to identify capital investment required to meet Sydney's future water needs.
- A stand-alone emergency drought response plan will identify measures to take during drought; the plan will be reviewed every five years.
- A Greater Sydney Water Strategy will replace the 2017 Metropolitan Water Plan. The strategy will provide a comprehensive approach to Sydney's water management.
- Obligations under the framework will be embedded into Sydney Water's and WaterNSW's operating licences.
- A new performance monitoring framework will be introduced to ensure utilities are held accountable for delivering their responsibilities under these plans.

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Climate and Air

The State of the Environment Report – 2018

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Climate Change

The effects of climate change on the people and the environment of NSW are expected to become more pronounced and increase in severity as warming continues over the next century.

Summary

Increase in temperature

1.0°C

increase in average temperature
from 1960–90 to the present time

Read more

Sea level rise

3.2mm

rise in sea level per year
for the NSW coast since 1993

Read more

The climate of New South Wales is changing due to global warming. The effects of climate change on the people and the environment of NSW are expected to become more pronounced and increase in severity as warming continues over the next century.

Emissions of CO_2 and other greenhouse gases from human activity (including power generation, industry, transport and agriculture) are leading to a build-up of these gases in the atmosphere, trapping heat and leading to global warming.

Average temperatures for the most recent decade (2008 to 2017) are 0.99°C higher than early in the last century (1910 to 1939), with 2014 and 2017 reaching up to 1.5°C higher. Other observed changes include increased variability in rainfall and temperature and some increase in the incidence of extreme weather events.

Since the late 20th Century, sea surface temperatures have warmed by 0.5–0.8°C. The rate of sea level rise has almost doubled, increasing from an average of 1.7mm per year for the past century to approximately 3.2mm per year since 1993.

The changes to climate are expected to become more severe over time. Best estimates suggest that by 2070 temperature will have risen by a further 2.1°C with much larger increases in extreme temperatures. Sea levels are expected to rise by a half to one metre by the end of the 21st Century.

The future effects of climate change will be extensive, including more extreme weather events, increasing coastal erosion and inundation and impacts on infrastructure, human health and wellbeing. The survival of many species and ecosystems, water availability and the productivity of some agricultural systems will be affected.

Effective action to counteract the effects of climate change will depend on concerted action globally. The extent of the impacts from this threat will be determined by the actions and the time taken to reduce greenhouse gas emissions.

The NSW Climate Change Policy Framework released in 2016 sets targets for NSW to achieve net zero emissions by 2050 and to become more resilient to a changing climate and sets out directions for adaptation to climate change.

The NARCliM climate modelling project provides projections of likely changes in climate at regional levels of NSW. Integrated Regional Vulnerability Assessments have been completed across NSW to identify specific regional vulnerabilities. The AdaptNSW website provides guidance on implementing adaptive responses.

NSW indicators

Indicator and status		Environmental trend	Information reliability
Annual mean temperature (present)	MODERATE	Getting worse	✓✓✓
Sea level rise (present)	MODERATE	Getting worse	✓✓✓
Rate of temperature warming	POOR	Stable	✓✓✓
Annual mean temperature (2070): projected outcomes	POOR	Getting worse	✓✓
Sea level rise (2070): projected outcomes	POOR	Getting worse	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

A natural greenhouse effect has been warming the Earth for some 4 billion years, keeping it habitable for life. Energy radiated by the Sun passes through the atmosphere and reaches the Earth's surface relatively unimpeded. Some is absorbed by oceans, soils and vegetation. The rest is either reflected or re-radiated as infrared radiation (heat). This radiation is less able to pass through the atmosphere and is partly trapped by naturally occurring greenhouse gases in the atmosphere, including carbon dioxide, methane, water vapour, nitrous oxide and ozone.

The temperature of the Earth has not been constant over time. Global temperatures and atmospheric greenhouse gas concentrations have fluctuated naturally over the millennia. Climate change is therefore not a new phenomenon. The difference between a planetary ice age and a warm interglacial period is a variation in global average temperature of 6–7°C. Temperature changes of this scale can lead to substantial disturbance of the world's climate and ecosystems and have triggered mass extinctions in the past. (IPCC 2007b).

However, these natural cycles of change have taken place gradually over millennial timeframes. Since the start of the industrial age in about 1750 the burning of fossil fuels (coal, oil and gas) together with land-use changes, agriculture and other human activities, have resulted in growing emissions of greenhouse gases. This is leading to an accumulation of these gases in the atmosphere. From the middle of the 20th Century these emissions have escalated markedly. The rates of increase now being observed in the atmospheric concentrations of greenhouse gases and consequentially in temperature are unprecedented in the past 800,000 years (Lüthi et al. 2008).

The Intergovernmental Panel on Climate Change (IPCC) is a United Nations body that assesses the latest scientific research on climate change and its effects from around the world. The IPCC has published five comprehensive assessment reports to date, the most current being the Fifth Assessment Report in 2014 (IPCC 2014).

Key findings include the following:

- warming of the climate is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia
- human influence is clear and is the dominant cause of global warming since 1950.

Without substantial action, climate change poses a major threat to humanity and most living systems on Earth. While impacts are being observed now, they will become more pronounced over time. Some extreme climate events are projected to increase in duration, magnitude and frequency in the future with impacts on human communities and infrastructure.

Sea level rise is expected to lead to increased erosion of coastlines and more frequent and extensive coastal flooding. In the longer term, permanent inundation of low-lying coastal areas is likely. Ocean warming and acidification due to increased levels of carbon dioxide dissolved in seawater will lead to changes in the composition of marine ecosystems.

Climate conditions are likely to become less favourable for many species and ecosystems, which will be forced to migrate or adapt physiologically to survive. Changes in climate will also lead to reduced productivity in some existing agricultural systems, requiring a transition to alternative crops or shifting the location of some industries. Detrimental effects are also expected on human health and wellbeing.

In 2016, a total of 194, or 98% of nations, signed the Paris Climate Agreement, which has a focus on limiting global warming to well below 2°C and aims to limit it to 1.5°C. Each country has pledged to make national contributions to reducing greenhouse gas emissions. But presently, concentrations are continuing to rise at rates that will see temperatures increase above the Paris Agreement targets. Cuts in emissions well beyond those already pledged under the agreement will be necessary to meet the target. The extent of the impacts of climate change will ultimately be determined by the actions taken by nations globally to reduce greenhouse gas emissions.

Status and Trends

Changes in climate

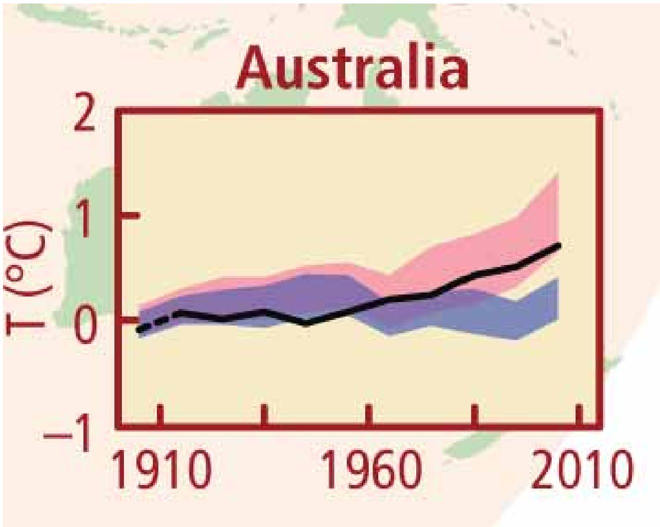
Temperature

Temperatures are rising across the planet due to global warming, caused by the build-up of greenhouse gases in the atmosphere. The global average temperature in 2017 was the second highest on record since pre-industrial times (before 1850). The same year was Australia's third hottest on record, and the hottest for NSW (BoM 2017).

In Australia and NSW, average temperatures over the past decade show a rise faster than the global average of 0.82°C, with temperatures now 0.95°C for Australia and 0.99°C for NSW, above their early 20th Century averages (BoM 2017).

Figure 21.1 shows model simulations of temperature for Australia using solely natural atmospheric drivers (e.g. solar and volcanic) in blue shading and those including all atmospheric drivers (e.g. natural drivers, greenhouse gases and ozone) in pink shading and compares these to observed temperature trends (black curve).

Figure 21.1: Climate model mean projections for temperature averaged over Australia

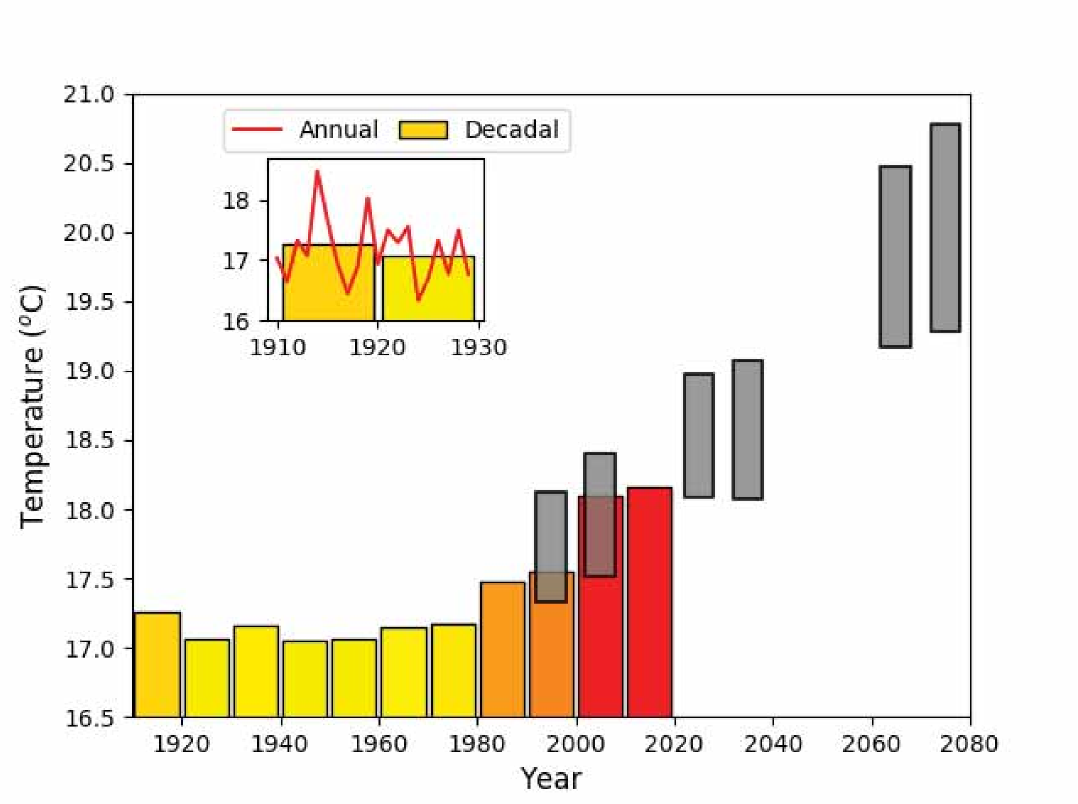


Source:
IPCC 2014 AR5 WG1 Figure SPM.6

Natural forcing alone does not account for the observed temperature trends. The observed build-up in greenhouse gases is needed to explain the observed increases in Australian temperatures.

Temperatures in NSW vary from year to year, but since the 1960s there has been a warming trend in NSW, with the average temperature of every decade being warmer than the previous decade (see **Figure 21.2**).

Figure 21.2: Measured and projected average temperatures for NSW/ACT for selected decades in the 20th and 21st centuries



Notes:
Grey bars represent the range of temperatures projected by regional climate models adjusted to the observed 1990–2009 BoM data).
The final BoM decadal average presented is only for the period 2011–2017.
Inset: The temperature varies from year to year within each decade. The first two decades of the BoM data, shown as decadal averages (yellow columns) and annual averages (red lines), illustrate year-to-year temperature variability.

Source:
BoM & OEH data 2018: NSW and ACT Regional Climate modelling (NARCliM) project

This warming will continue in the future, withe the amount dependent on how much reduction has occurred in global emissions. By 2030, average NSW/ACT temperatures are projected to rise by 0.7°C above the 1990–2009 period, with a 2.1°C increase expected by 2070 (OEH 2014) (**Figure 21.2**). This is the mean increase projected across regional climate models for a high-emissions scenario that assumes the Paris Agreement will fail to achieve its target. These changes may be mitigated if significant action is taken to reduce greenhouse gas emissions by the second half of the 21st Century.

By 2070, the temperature increase over the early 20th Century average will be 2.6 °C.

The nation is also experiencing new record high temperatures on a regular basis. In early April 2018, NSW and other states experienced record high temperatures for April, with inland NSW temperatures unusually exceeding 30°C (BoM data 2018).

Inland NSW currently experiences around 80 hot days (temperatures reaching over 35°C) annually, with coastal NSW experiencing fewer than 10. The number of hot days across NSW has been increasing since the mid-20th Century, with a decrease in the number of cold nights (temperatures dropping to less than 2°C overnight).

By 2030, the number of hot days for inland NSW is projected to increase by 10–20 days annually, with an increase of over 40 days annually by 2070. Meanwhile, by 2030, cold nights in the Snowy Alpine regions will decrease by 5–10% and by 2070, by almost 20%.

Significant temperature changes have been observed along the NSW coastal and marine waters. Since 1950, average sea surface temperatures in NSW coastal waters have increased by 0.13°C each decade (CSIRO & BoM 2016).

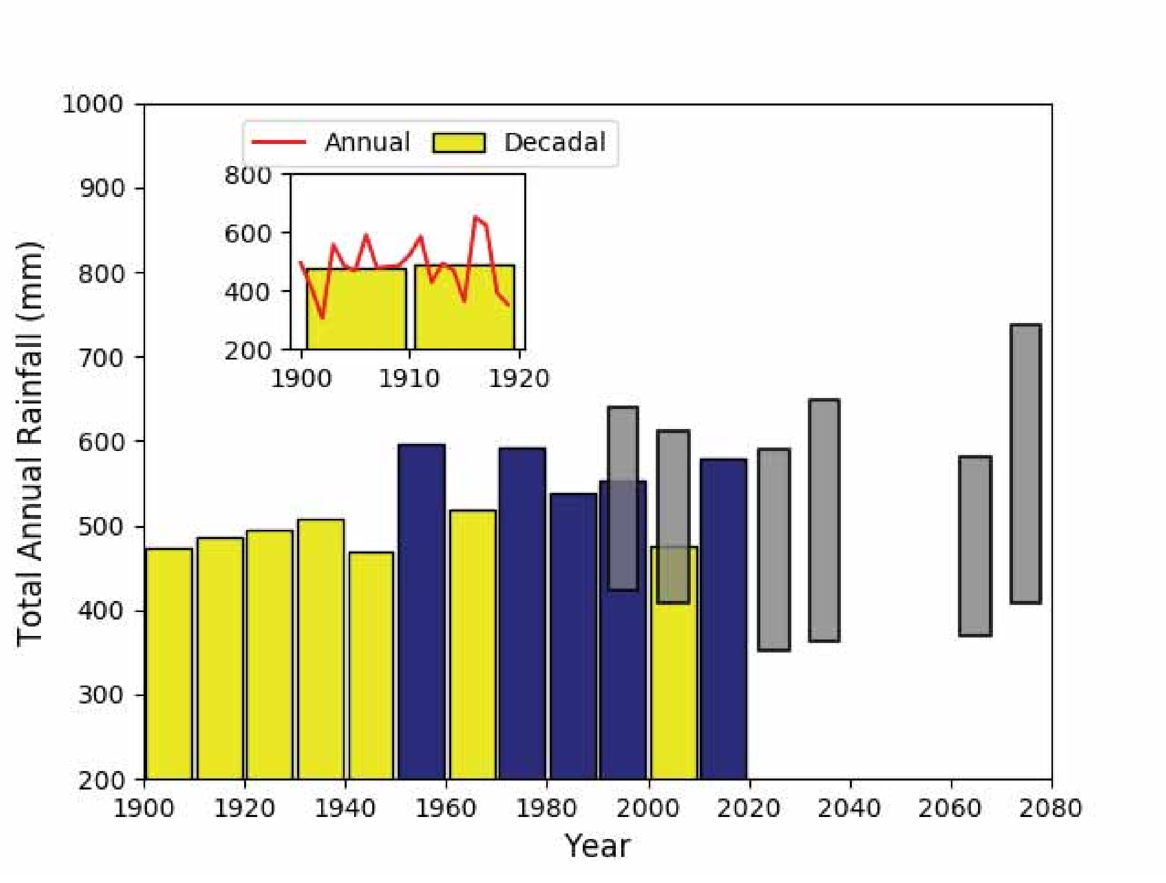
Climate change predictions for NSW include higher sea surface temperatures (potentially by up to 4°C by 2070), more frequent and powerful storms and stronger currents that affect nutrient distribution and impact ecosystems (Hobday et al. 2006; Hobday & Lough 2011, Wernberg et al. 2011).

Sustained ocean surface warming over periods of months to years of 2 to 4°C above average (termed 'marine heatwaves') has been observed in south-east Australian coastal waters and other coastal regions globally (Oliver et al. 2017, Oliver et al. 2018). This has major impacts on marine ecosystems (Wernberg et al. 2016).

Rainfall

Unlike temperature, which shows a clear increase over the past 50 years, no clear pattern of change is evident for rainfall across the state. This is due to the large variability in natural rainfall patterns in NSW. As shown in **Figure 21.3**, the main feature of NSW rainfall since the beginning of the 20th Century is large annual and decadal variations between wet and dry periods.

Figure 21.3: Measured and projected average annual rainfall values for NSW/ACT for selected decades in the 20th and 21st centuries

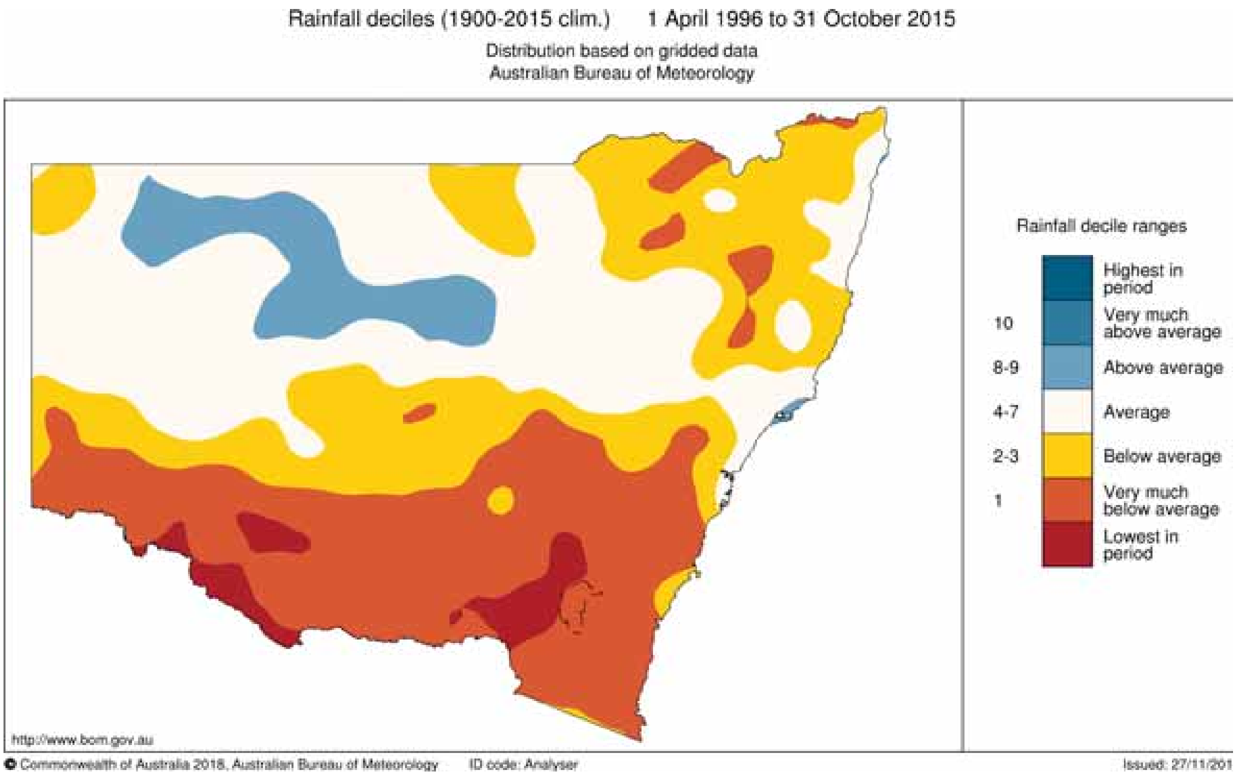


Notes:
Periods drier than the 1900–2010 average are represented by yellow bars, with wetter periods shown in blue. The grey bars represent the range of rainfall values projected by regional climate models. The final BoM decadal average is only for 2011–2017.
Inset: Rainfall varies from year to year within each decade. The first two decades of the BoM data are shown as decadal averages (yellow bars) and the annual averages (red line), illustrating large year-to-year rainfall variability.

Source:
BoM & OEH data 2018: NSW and ACT Regional Climate Modelling (NARCliM) project

Despite this large natural variability, underlying longer-term trends are becoming evident in the warm season (October to April) and cool season (April to October) since the mid-1990s (BoM & CSIRO 2016). The cool season has seen the largest change with rainfall very much below average over the past 20 years in southern NSW as shown in **Map 21.1.**

Map 21.1: Southern growing season (April–October) rainfall deciles for the last 20 years (1996–2015)



Source:
BoM 2016

NSW will continue to experience considerable rainfall variability from year to year (grey bars in **Figure 21.3**), making longer-term changes difficult to discern as they take effect. However, over the next 20 years, some areas of the state may start to experience significant changes in rainfall in some seasons as part of underlying longer-term trends. These trends will be different for each region and season of the year.

The latest regional climate projections suggest:

- a decline in both summer and winter rainfall is likely in the north-east of NSW
- some parts of the south-east may experience drier springs but wetter summers
- summer and autumn may become wetter in some parts of the west (OEH 2014).

The combined effect of increasing temperatures and declining rainfall across most of NSW during the winter and spring period mean that the time spent in drought will likely increase over the course of the century (OEH 2014; CSIRO & BoM 2015).

Changes in the behaviour of heavy rainfall events are not the same as changes in seasonal average rainfall. Since 1911, the amount of heavy rainfall on the wettest day of the year has increased significantly across most of NSW (Evans et al. 2014b).

Climate change is expected to bring further increases in the intensity of heavy rainfall, even where average rainfall is expected to decrease. However, it may be difficult to discern long-term changes against significant year-to-year variability. The smaller scale weather systems responsible for many rainfall extremes are especially difficult to represent in computer models, which means there is uncertainty in exactly how the behaviour of heavy rainfall may change in the future.

Recent research shows that most modelling studies may have underestimated future changes in heavy rainfall, especially for the most intense rainfall events (Bao et al. 2017). Ongoing developments in computer modelling may lead to more precise information becoming available (Kendon et al. 2017).

Ocean temperatures

Climate change has increased ocean temperatures, with periodic variations sometimes referred to as 'marine heat waves'. These will have extreme consequences for the survival of marine and estuarine species and lead to changes in the distribution of many others. South-east Australia is a global hotspot for ocean warming, occurring at around four times the global average, due to the increased strength and southward penetration of the East Australian current (Hobday et al. 2006; Ridgway 2007; Poloczanska et al. 2012).

However, predictive studies show that changes in the movement of water masses, rather than temperature, will have the greatest potential impact on future distributions of species in NSW waters (Cetina-Heredia et al. 2015); though this is an area that needs further research.

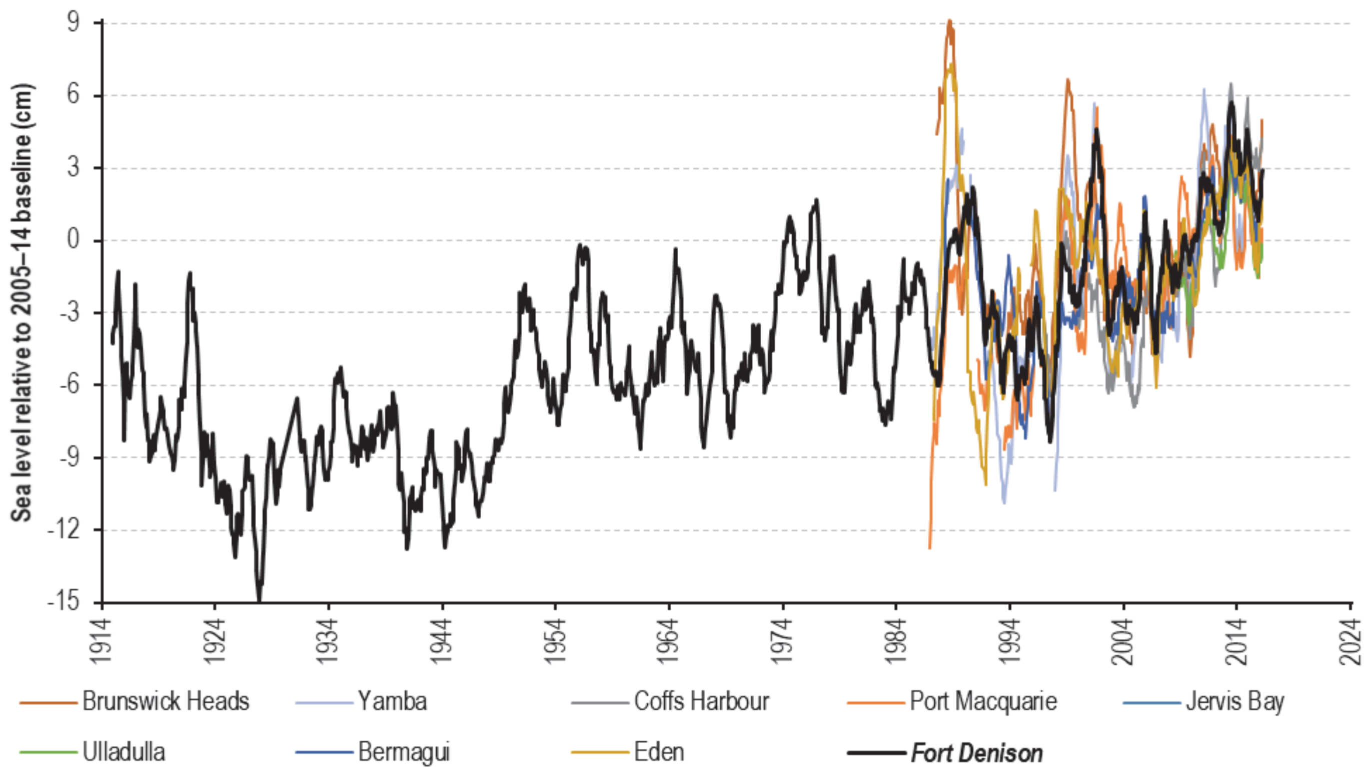
Sea level rise

Over the 20th Century, globally averaged sea levels rose at a rate of approximately 1.7mm per year. More recently this has increased to around 3.2mm per year (Rhein et al. 2013). Rates of sea level rise in south-east Australia are generally consistent with the global average (White et al. 2014).

The magnitude of future sea level rise will largely be dependent on the extent of ocean warming and the loss of land-based ice from Greenland and Antarctica. Due to the long response times of the ocean, sea levels will rise for centuries, even if greenhouse gas emissions are curbed and their atmospheric concentrations stabilised.

For NSW, model predictions suggest sea level rise of up to 10% above the global average by the end of the 21st Century (0.54 to 1.06m for the business-as-usual, high emissions future climate pathway; Church et al. 2016). However, much higher sea level rise is possible. A recent review by the US National Oceanic and Atmospheric Administration (NOAA) indicates a physically plausible global mean sea level rise in the range of 2.0 to 2.7m by 2100 (Sweet et al. 2017).

Figure 21.4: Sea level (cm) for Fort Denison (black) and other NSW stations (see legend), relative to the 2005–2014 average



Source:
Manly Hydraulics data 2017

Environmental impacts of climate change

The observed changes to climate and the projected future changes that are described above are already having widespread impacts on the NSW community and the urban and natural environments of NSW. In many areas the environmental effects of climate change are already apparent, and impacts will become more extensive and pronounced over time.

Extreme weather and climate events

Heatwaves

Heatwaves are a significant hazard for the people and environment of NSW. The risk of premature death has been shown to escalate quickly as temperatures increase (Gasparrini et al. 2015).

Over the period 1911–2013, heatwaves in parts of NSW have become longer, hotter and more frequent. Since the late 1950s, these changes have accelerated in most regions (OEH 2015).

Climate change is expected to increase the frequency and duration of heatwaves in the future with the extent of these changes varying by location. Projections indicate that by 2030 there could be an additional heatwave per year on average and an additional three or four heatwaves per year on average by 2070, across most of NSW (Argueso et al. 2015). By 2030, the length of the longest heatwave in a year is projected to be two or three days longer, on average, and by 2070, three to nine days longer.

Cities create their own microclimates by influencing the surrounding atmosphere and interacting with climate processes. The most striking characteristic of an urban microclimate is the urban heat island effect. As a result, air temperatures in Sydney are expected to increase due to climate change and increasing urbanisation. By 2030, climate change is projected to increase maximum temperatures in Sydney by 0.7°C, while a change in land-use from grasslands to medium-density housing will contribute a further increase of between 0.5°C–0.9°C (NSW Government 2015).

Storms

Climate change is expected to affect the behaviour of storms and associated phenomena (e.g. high winds, hail and lightning) in NSW. Some research indicates that in some parts of eastern Australia climate change may be associated with future increases in the frequency of thunderstorms (Allen & Karoly 2014). The storms that have the greatest impact on NSW are East Coast Lows, which are low-pressure systems that develop off the east coast of Australia. Current climate modelling for NSW suggests a decrease in the number of small East Coast Lows during winter, but an increase in the frequency of extreme East Coast Lows during summer. Further research is needed to refine projections of changes in thunderstorms and East Coast Lows and their impacts.

Floods

Floods and extreme storms damage property and infrastructure and affect the health and wellbeing of NSW communities. Flooding in urban and rural NSW costs the economy an average of about $250 million each year and causes loss of life and emotional distress. It is likely that the frequency and intensity of floods and storms will be affected by climate change. Modelling projections, combined with our understanding of the physical processes involved, indicate that an increase in the intensity of extreme rainfall events and associated flooding is likely in the future, although the magnitude of the increases cannot be confidently projected.

Sea level influences flooding in the lower parts of coastal waterways. Any increase in sea level would alter the frequency and severity of flooding in coastal waterways caused by storm events of a given frequency.

Bushfires

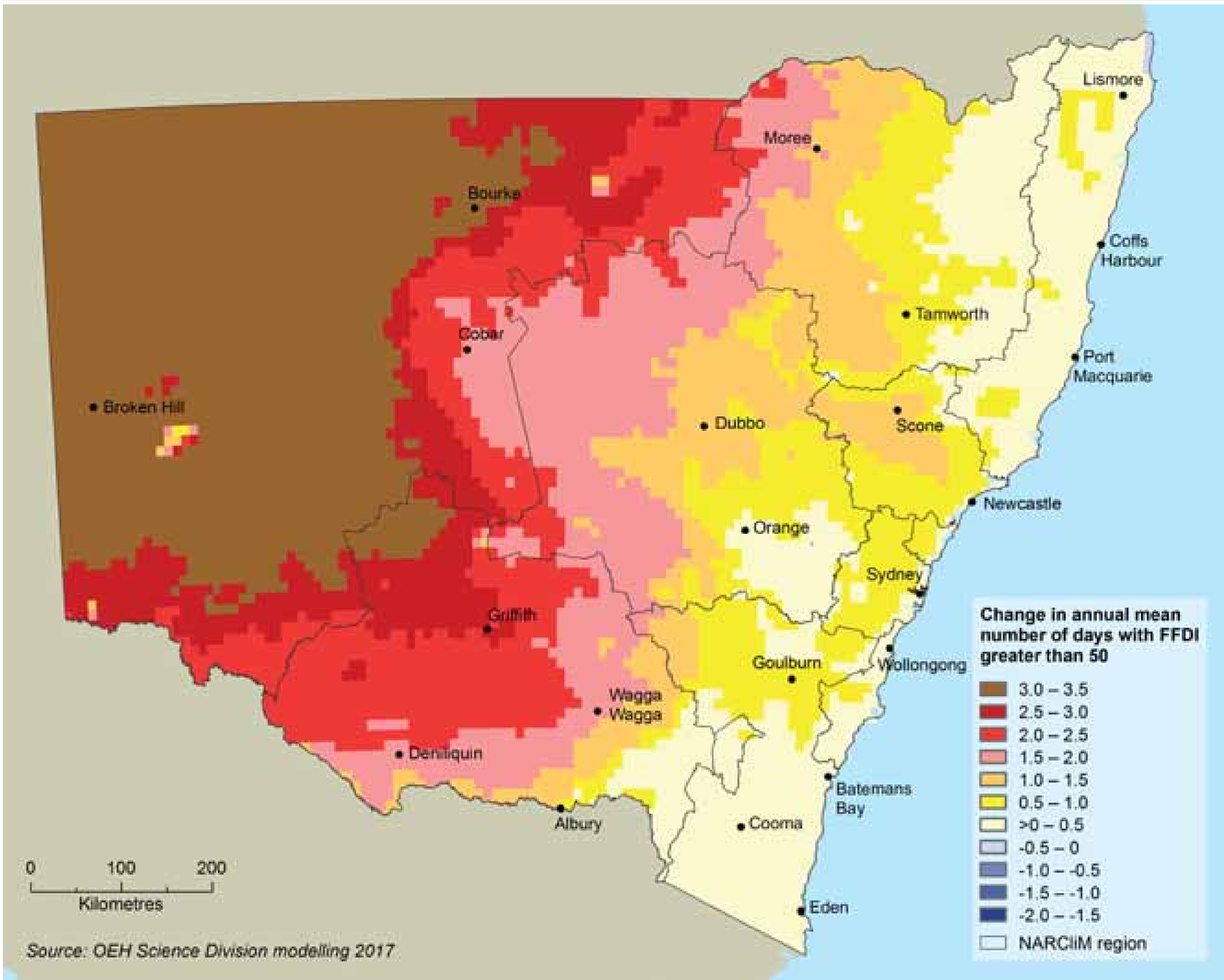
Bushfires can cause loss of life and large economic costs. The risk of bushfire depends on several factors (Bradstock 2010):

- an ignition source
- enough sufficiently dry vegetation to burn (fuel)
- favourable weather conditions for fire to spread.

Most studies of the impact of climate change on bushfire risk focus on weather conditions conducive to fire. Weather can influence the intensity and frequency of fire and the risk it poses to life and property (Blanchi et al. 2010, 2014). Over recent decades, fire weather conditions have become more severe and the fire season has lengthened in some parts of NSW. This is at least partly due to a warmer climate and large-scale drying (Clarke et al. 2013; Dowdy 2017). However, the effect that warming has had on fire activity itself is uncertain as it is difficult to isolate from the influence of other factors, such as changes in ignition sources, vegetation management and prescribed burning.

The Rural Fire Service issues fire weather warnings when the Forest Fire Danger Index (FFDI) is forecast to be over 50, indicating severe fire weather. Climate projections for NSW suggest future increases in the frequency of severe fire weather, especially in the state's west (OEH 2014). **Map 21.2** shows the projected change in the average number of severe fire weather days per year between 1990–2009 and 2060–2079. More recent research suggests that fuel loads available to bushfires will also increase in the future (Clarke et al. 2016). The bushfire season will extend earlier into spring but severe fire weather in autumn is projected to decrease in eastern NSW due to a projected increase in rainfall.

Map 21.2: Projected change in average annual number of severe fire days between 1990–2009 and 2060–2079



Notes:
The projection is based on regional climate model estimates (also used in **Figure 21.2** and **Figure 21.3**)

Source:
AdaptNSW NSW Climate Change Downloads website

Some of the most intense and damaging bushfires in Australia (e.g. the 2003 Canberra fires and the 2009 Black Saturday fires) have involved an atmospheric phenomenon called pyroconvection. This occurs when a fire releases heat and moisture into the lower atmosphere, causing conditions similar to those that drive thunderstorms. This can contribute to the spread and unpredictability of fires.

The effect of climate change on the incidence of pyroconvection is uncertain. Some recent research has suggested that the risk of pyroconvection in NSW has been increasing in spring and summer (Dowdy & Pepler 2018) and that the climate could become more conducive to intense bushfires in the future (Sharples et al. 2016).

Land and marine ecosystems and processes

Soil health

Soils support the growth of most plant life and are a crucial element of all terrestrial ecosystems. By 2070, substantial changes are predicted to the condition and make-up of soils, due to the impacts of changes in climate. These will need to be considered in the future management of soils and associated agriculture and native ecosystems across NSW.

Soil erosion has impacts on soil condition, agricultural productivity and water quality. Over the next 20–50 years the erosion rate of soil is predicted to be 7–19% higher due to the effects of climate change. The areas most affected will be mountainous regions of the Great Dividing Range especially along the Central Coast, North Coast and Hunter Valley (Yang et al. 2016).

Soil organic carbon is a widely used indicator of soil health. This is expected to decline throughout the state due to climate change, resulting in losses up to 10t/ha. In the southern alpine region, losses greater than 20 t/ha are likely.

The pH of a soil represents its degree of acidity or alkalinity. Higher pH or more alkaline soils are projected over most the state due to climate change, generally increasing from east to west. The largest increases of up to 0.5 pH units are expected in the southern alpine areas.

Terrestrial species and ecosystems

As many Australian species are adapted to highly variable climates, they are likely to have some capacity to cope with changes in climate. However, the resilience of many species may have been eroded by existing pressures on biodiversity which have resulted in documented declines (see the Native Fauna and Threatened Species topics).

Climate change is expected to exacerbate the effects of existing threats and introduce additional pressures (Steffen et al. 2009; Hughes 2011). Scientific studies suggest that over the next few decades climate change could surpass habitat destruction as the greatest threat to biodiversity (Leadley et al. 2010). This impact could be comparable to the historical losses of biodiversity that have occurred in NSW, and Australia.

As the climate changes, the capacity of landscapes to support ecosystems in their current state will decline. Many of the most vulnerable ecosystems in Australia are found in NSW and are sensitive to changes in climate. These include:

- ecosystems that only exist at certain elevations, such as alpine systems
- coastal floodplains and wetlands
- the wetlands and floodplains of the Murray–Darling Basin
- temperate eucalypt forests
- saltmarshes and mangroves.

The main threats to these ecosystems are extreme weather events and changes to fire regimes or water balance and hydrology (Laurence et al. 2011).

By 2070, many areas of NSW are projected to become 30–60% less suitable for their present ecosystems, requiring species to either migrate or adapt to survive. Some of the greatest changes are expected to occur across the highly modified landscapes of the wheat/sheep belt, where the capacity to support change has been diminished.

Many plant and animal species are sensitive to changes in climatic variables, such as temperature, rainfall and humidity. Species identified as the most at risk from climate change include those with:

- a narrow range of physiological tolerances
- low genetic variability and long generation times
- specialised requirements for other species or narrow geographic ranges
- limited capacity to disperse or move to new habitats (Steffen et al. 2009).

There is evidence that recent climatic and atmospheric changes are already having wide-ranging effects on some species (OEH 2011). Observations of range shifts for species and changes in the timing of life cycles, are among the best-documented impacts that have been linked to changes in climate (Bellard et al. 2012; Hughes 2000; Hughes 2003a; Hughes 2003b; Parmesan 2006; Parmesan & Yohe 2003; Walther et al. 2002).

Some examples of observed changes in species in Australia consistent with the effects of climate change include:

- Native and feral animals from lower elevations are colonising alpine ecosystems (Green 2003; Pickering et al. 2004).
- Snow gums (Eucalyptus pauciflora) are encroaching into subalpine grasslands at higher elevations (Wearne & Morgan 2001).
- Sleepy lizards (Tiliqua rugosa) are changing their mating behaviour, with warmer and drier winters leading to earlier mating and longer pairings (Bull & Burzacott 2002).
- Long-term studies of 24 bird species migrating to south-east Australia each year indicate that 12 species are arriving 3.5 days earlier each decade, and leaving 5.1 days earlier (Beaumont et al. 2006).
- Birds of the same species tend to have smaller body sizes in warmer parts of their range and for eight NSW species, smaller individuals are now being found further south, consistent with the effects of a warming climate (Gardner et al. 2009).
- Bold-striped cool skinks in south-east Australia are changing the depth of their nests and the time at which they lay their eggs, and more females are now being born, as nest temperature affects the sex of offspring (Telemeco et al. 2009).

A recent study also found that the main factor affecting the distribution of the platypus had switched from the availability of aquatic habitat to heat tolerance (estimated by annual maximum temperature). This switch is directly attributable to temperature changes in south-east Australia and raises concerns for the future of the species (Klamt et al. 2011).

Species and ecosystems may adapt to the effects of climatic change through a range of strategies, such as:

- evolving or changing their behaviour in their current location
- taking refuge in local areas that are buffered from the changes
- migrating or dispersing to areas where the climate is more suitable.

However, these natural adaptive responses of native species and ecosystems may be constrained by both the increasing speed of the changes in climate and pre-existing threats to biodiversity.

Ocean acidification

The rise in atmospheric carbon dioxide concentrations is increasing ocean acidity. Elevated carbon dioxide may affect marine organisms through changes to their metabolic physiology and the calcification rates of hard structures (e.g. shells and external skeletons). Acidification will cause losses to species diversity and abundance, with shifts to unusual communities of non-calcifying organisms.

Evidence for the impacts of acidification comes mostly from experimental work on calcifying, stationary animals, which are most vulnerable to ocean acidification (Parker et al. 2013, Ross et al. 2011). A particularly vulnerable group is marine molluscs (e.g. oysters, abalone and whelks), especially in their juvenile reproductive stages (Parker et al. 2010, Scanes et al. 2014). Acidification acts in concert with temperature to reduce fertilisation in Sydney rock oysters, resulting in smaller size, longer development times and increased abnormality of larval stages (Parker et al. 2010), and with other stressors to limit their survival (Scanes et al. 2017).

Coastal erosion and inundation

Of all the impacts from climate change, sea level rise is likely to be among the most difficult to handle. Over time, the rate of sea level rise is expected to increase (e.g. see **Figure 21.4** above), resulting in greater exposure of coastal lakes and estuaries to inundation and erosion. The potential implications include:

- higher and more frequent inundation by tides and storm surge events, eventually leading to permanent inundation of low-lying areas
- the landward recession of sandy shorelines
- salt water intrusion into groundwater aquifers
- the landward advance of tidal limits within estuaries
- changes to the frequency of entrance opening and flooding behaviour of intermittently closed and open lakes and lagoons
- the failure of stormwater infrastructure and sewerage systems.

Image 21.1: Inundation from high tides, Woy Woy, January 2018

Source:
Photo: Dave Hanslow

Considerable development along the NSW coast is currently exposed to inundation and erosion hazards and this is expected to grow significantly with climate change. A recent erosion assessment for NSW found approximately 250 property lots where more than half the allotment is currently exposed to coastal erosion. The number of property lots affected by coastal erosion is expected to increase to around 1,860 by 2050, and to around 3,300 by 2100 (Kinsela et al. 2017).

Exposure to tidal inundation during king tides currently affects around 600 properties located near estauries in NSW. This increases to 4,300 with 0.5m of sea level rise to 22,100 for 1m of sea level rise, and to 43,300 with 1.5m of sea level rise
(Hanslow et al. 2018).

Marine species and ecosystems

The long-term impacts of climate change are expected to have significant effects on marine species and ecosystems across south-east Australia (Hobday et al. 2006; Wernberg et al. 2011; Verges et al. 2014). This includes changes to:

- the distribution and abundance of marine species
- the timing of life cycle events
- the physiology, morphology and behaviour of individual species (e.g. rates of metabolism, reproduction or development)
- the composition of biological communities
- connectivity among populations, species and habitats (Coleman et al. 2013; Coleman et al. 2017).

Specific studies have identified that increases in temperature are likely to result in:

- the establishment, spread and virulence of pathogens and exotic species (Wernberg et al. 2011, Campbell et al. 2011; Harvell et al. 2002)
- changes in the range and distribution of harvested species (Pecl et al. 2011; Cetina Heredia et al. 2015)
- changes in the composition, structure and dynamics of communities (Verges et al. 2014; Provost et al. 2017)
- induced disease in seaweeds (Campbell et al. 2011; Qui et al. in review)
- the poleward contraction of kelp and other macroalgal habitats (Smale & Wernberg 2013)
- a reduction in kelp habitat and associated changes in community composition and ecosystem function, particularly in northern NSW (Verges et al. 2016).

Socio-economic effects

Agriculture, fisheries and forestry

The $15.4 billion (2016–17) NSW primary industries sector operates in one of the most variable climates in the world. Primary industries are already experiencing the effects of climate change. The impact is mainly due to rising temperatures, but also some change to rainfall patterns, resulting in lower than average winter and spring rainfall in some areas (see Part 1. Changes in climate).

Despite operating in an environment of substantial climate variability the agricultural sector has maintained relatively high rates of productivity. There is still considerable uncertainty about future regional rainfall patterns and the impacts of increasing carbon dioxide concentrations on plant growth, so climate change will provide both challenges and opportunities for existing and emerging industries. Climate impacts on agricultural industries are complex and reflect the specific sensitivities of each production system to climate at key times of the year.

The trend towards lower winter and spring rainfall will generally place downward pressure on dryland broadacre crop yields. However, higher carbon dioxide concentrations under climate change may be beneficial to crop growth and could offset some level of rainfall decline. The interaction between higher carbon dioxide and lower rainfall levels and increased evapotranspiration needs to be better understood. Due to lower rainfall and inflows into major storages irrigated crops are likely to face reduced water supplies. However, a reduction in the number of cooler days under climate change may benefit major irrigated crops (such as rice and cotton), which are sensitive to low temperatures at key times in their production cycle.

Rising temperatures are likely to pose challenges for the horticulture and viticulture sectors. Higher minimum temperatures, for example, are likely to reduce essential winter chill and reduce yields for some fruit and nut crops, such as cherries. Some wineries are reporting that harvesting is now occurring several weeks earlier than past records and that the climate is becoming too warm to produce good quality crops of some premium grape varieties.

Climate change is likely to have mixed effects on the livestock sector. While higher carbon dioxide levels may promote pasture growth, higher temperatures and less rainfall at key times could negatively affect production. Higher minimum temperatures in winter may reduce stock losses from cold snaps. Conversely, increases in maximum temperatures will increase heat stress and result in reductions in animal productivity.

In the forestry sector, higher concentrations of carbon dioxide are likely to result in increased woody growth rates, but these effects may be counteracted by reduced soil nutrient and moisture levels. The forestry sector also faces a higher risk of bushfires and increased damage from pests. Climate change may result in the development of new bioclimatic niches for weeds, pests and diseases, which may lead to increased biosecurity issues for some regions or primary industry sectors.

Increasing temperatures and changes in rainfall patterns will also affect the migration and breeding patterns of freshwater fish, as well as altering their habitat and food sources (DPI 2018).

Human health

Climate change is expected to have detrimental impacts on the health and wellbeing of the people of NSW. The intensity and frequency of extreme climatic events, particularly heatwaves, is anticipated to increase over coming decades. Periods of successive extreme heat and cold have been shown to have major effects on human health and increase rates of health service utilisation (Jegasothy et al. 2017).

Pressures

The NSW State of the Environment (SoE) framework, is based on the Pressure-State-Response model of reporting. Within this report, the issues of economic activity (the economy) and population growth are treated as drivers of environmental change. Unlike pressures, which have a direct impact on environmental outcomes, the effects of growth in population and the economy are more diffuse and are mediated through a complex network of pathways for resource use and consumption, the production of goods and services, and the generation of waste.

More specific issues, such as energy use and transport, are described as pressures. These account for the bulk of greenhouse gas emissions in NSW and Australia. The build-up of greenhouse gases in the atmosphere is the main cause of human-induced climate change. The changes that are happening to the Earth's climate are leading to a range of disturbances to physical and biological systems and processes, human society and infrastructure, reported as outcomes to environmental resources and assets.

Economic activity

It is generally accepted that a level of growth in the economy is desirable to improve living standards, but economic growth does not necessarily need to be achieved at a significant cost to the environment. The decoupling of economic growth (gross state product or GSP) from carbon emissions in the NSW economy over the past 30 years is demonstrated in the topic *Economic activity and the environment*. Since 1990 there has been a 60% reduction in carbon emissions per dollar of GSP in the NSW economy. The decoupling is clearer for carbon emissions than for most other benchmarks of environmental performance.

A report for the Australian Business Roundtable for Disaster Relief and Safer Communities (Deloitte Access Economics 2017) estimates the total economic cost of natural disasters in Australia. For NSW this figure is $3.6 billion per year, on average, at the current time. By 2050, this is estimated to rise to $10.6 billion. However, this estimate is conservative and explicitly excludes climate change from the analysis, so these costs are likely to be substantially higher. The costing of climate change impacts and responses is discussed further in the topic *Economic activity and the environment.*

Population

Over the past five years the NSW population has grown at a rate of 1.5% annually. Higher population leads to an increased demand for food, resources, energy and transport, all of which have associated greenhouse gas emissions. Over the past 10 years, total energy consumption has remained stable, but there has been an overall decline in the per capita consumption of electricity in NSW.

Energy use and transport

The production and use of energy from non-renewable sources is the main cause of greenhouse gas emissions in NSW. Total energy use has fallen slightly over the past 10 years. Fossil fuels currently account for about 93.5% of the final energy use.

Transport is the largest (and fastest growing) sector for total energy use, at 45%. Electricity use has fallen slightly and accounts for around one-fifth of total energy use. For more information see the topics Energy Consumption and Greenhouse Gas Emissions.

Greenhouse gas emissions

The main cause of global warming and climate change is the build-up in the atmosphere of greenhouse gas emissions from human activities, including power generation and use, transport, industry and agriculture.

In NSW, greenhouse gas emissions peaked in 2007 and are now about 22% lower than their 1990 levels. Stationary energy from electricity generation is the most carbon intensive form of energy use and is responsible for the largest proportion of emissions in NSW (51%), while the transport sector accounts for about 21%.

NSW (and Australia's) contribution to total global greenhouse gas emissions is small, but on a per capita basis it is relatively high. In isolation, efforts to reduce emissions will have little impact, so global cooperation is needed to achieve effective reduction and change.

Climate tipping points

The more greenhouse gas build-up in the atmosphere, the greater the risk that a climate tipping point will be triggered (Drijfhout et al. 2015). Climate tipping points can occur when gradual changes to the climate system produce feedbacks, which can result in abrupt climate shifts.

Our ability to predict when and at what temperature these climate tipping points will be reached is currently limited. Three climate tipping points associated with greenhouse gases are (OECD report 2017, Box 2.1):

- the release of organic carbon (methane) from melted permafrost in the Arctic region, which would drastically increase atmospheric greenhouse gas concentrations and sea levels (Saunois et al. 2016)
- a collapse of the Atlantic meridional overturning ocean circulation, which influences the global distribution of heat, nutrients and gases, associated with increased freshwater and warming near the ocean surface (Boulton et al. 2014)
- deforestation that would permanently damage the rainfall cycle and reduce the ability of forests to absorb greenhouse gases and to sustain local ecosystems (Galford et al. 2010; Lovejoy and Nobre 2018).

Responses

There are two main strategies available to address the effects of climate change – mitigation and adaptation.

Mitigation of climate change describes the actions taken to limit or reduce the extent of global warming by reducing the levels of greenhouse gas emissions produced by human activity, and the actions taken to remove emissions from the atmosphere or from sources of emissions. Adaptation describes the actions taken to reduce, moderate or adjust to the expected or actual effects of climate change, or to take advantage of new opportunities.

This section outlines the key adaptation responses to the impacts of climate change that global efforts to reduce greenhouse gas emissions (mitigation) are unable to avoid. Responses to mitigate emissions are described in the Responses section of the Greenhouse Gas Emissions and Energy Consumption topics.

Because global action is needed for mitigation of climate change to be effective, a pragmatic response to climate change, with a balance between mitigation and adaptation strategies, is appropriate.

Legislation and policies

NSW Climate Change Policy Framework

In November 2016, the government released its NSW Climate Change Policy with the aspirational objectives to achieve net zero emissions by 2050 and make NSW more resilient to a changing climate. The framework articulates the state's endorsement of the Paris Agreement, and sets key policy directions for mitigation and adaptation. For adaptation these include:

- taking advantage of opportunities to grow new industries in NSW
- reducing risks and damage to public and private assets in NSW arising from climate change
- reducing climate change impacts on health and wellbeing
- managing impacts on natural resources, ecosystems and communities.

In line with the objectives of the policy framework, several long-term planning strategies set goals for the government to build the state's resilience to climate impacts and to prepare for changes in the climate.

State Infrastructure Strategy

The State Infrastructure Strategy prioritises making the state's $300 billion asset base resilient to shocks and stresses such as floods, bushfires and storms. This includes:

- improving the collection and sharing of data on natural hazards
- undertaking regular assessments of the vulnerability of assets
- consideration of natural hazards in land-use planning
- undertaking investment assessments for new and upgraded infrastructure.

Future Transport Strategy

The Future Transport Strategy commits to making the transport network more resilient to greater extremes of weather and more frequent extreme weather events.

Greater Sydney Region Plan and Regional Plans

The Greater Sydney Region Plan and Regional Plans for 10 state planning regions across NSW include strategies for minimising the impacts of climate change on local communities. The Greater Sydney Region Plan proposes to strengthen Sydney's resilience to climate change by increasing the urban tree canopy to reduce the impact of extreme heat and to use energy and water resources more efficiently.

Coastal Management Framework

The NSW Government's new Coastal Management Framework, which started in 2018, establishes a new strategic land-use planning framework for coastal management. This requires local councils to prepare management programs that consider the effects of climate change on coastal processes. It also includes a Coastal Management State Environmental Planning Policy and local planning direction, which requires councils and other planning authorities to consider current and future hazards in strategic planning when assessing coastal development proposals.

State Level Emergency Risk Assessment

The government's 2017 State Level Emergency Risk Assessment made recommendations to integrate climate change impacts and adaptation mechanisms into emergency management arrangements.

Critical Infrastructure Resilience Strategy

The NSW Critical Infrastructure Resilience Strategy, released in 2018, highlights the benefits of improved adaptation of critical infrastructure to address long-term stresses, such as climate change. The strategy notes the responsibility of the state government to integrate climate change adaptation into government assets and services.

Programs

There are three integrated work areas within the NSW Climate Change Adaptation program:

- Climate Change Information and Knowledge Delivery – programs and products that provide NSW communities with access to locally specific climate change data, tools and resources to help them make informed and effective decisions
- Cultural and Ecosystem-based Adaptation – programs to minimise the impact of climate change on urban and natural environments by protecting and enhancing ecosystem services and cultural values, including through the NSW National Parks Adaptation Strategy
- Regional Preparedness – programs to help regional decision makers to address local climate change vulnerabilities, safeguard government assets and services by tracking their exposure to climate risks, provide training to build skills, and direct technical and financial support to implement adaptation projects and build the capacity for effective response.

NSW and ACT Regional Climate Model

The NSW and ACT Regional Climate Modelling (NARCliM) project is a world-leading climate modelling system developed in partnership with the ACT Government and the Climate Change Research Centre at the University of NSW. It provides detailed regional projections for use by decision makers across NSW. NARCliM provides short-term (2020–39) and long-term (2060–79) projections of likely changes in climate, including:

- temperature and rainfall
- fire weather
- hot days (maximums >35ºC)
- cold nights (minimums <2ºC).

These projections are assisting in planning and adapting to likely changes in future climate.

AdaptNSW website

The AdaptNSW website provides comprehensive climate change information, analysis and data to support action to address climate change risks and capture opportunities. It includes information on the causes of climate change and likely impacts on biodiversity, bushfires, east coast lows, heat, human health, sea level and coasts, soil and water resources. The website also identifies regional climate change vulnerabilities and provides guidance on implementing adaptive responses to climate change.

Integrated Regional Vulnerability Assessments

Integrated Regional Vulnerability Assessments have been completed for 11 regions across NSW, involving over 1,500 state and local government representatives. These assessments identify how climate change can create vulnerabilities in key regional systems through socio-economic and demographic change, and opportunities to respond through the planning and delivery of government services.

Building Resilience to Climate Change

The NSW Government is helping local councils and communities adapt to climate change by investing in programs that help reduce exposure to natural hazards and other climate risks. The Building Resilience to Climate Change grants program has provided nearly $1.3 million dollars for 62 councils to implement 21 climate change adaptation projects across the state.

NSW Climate Change Adaptation Research Hub

The government established the NSW Climate Change Adaptation Research Hub in 2012, as a collaboration between leading NSW universities and the Office of Environment and Heritage. It has delivered over 70 research projects on action for climate change adaptation across four priority areas:

- biodiversity
- adaptive communities
- coastal processes and responses
- human health and social impacts.

Five Million Trees Initiative

The government is promoting the use of urban green cover to alleviate urban heat, including the Five Million Trees Initiative to increase the urban canopy in Sydney from 16% to 40% by 2030. This will provide more shade, cooler suburbs and increased comfort for communities to adapt to increasing temperatures and more frequent heatwaves.

Other programs

Many other natural resource management programs incorporate a consideration of climate change and the development of resilience in their objectives and delivery. These include:

- The **Enhanced Bushfire Management Program**, which is designed to improve hazard reduction and bushfire response capabilities to protect against increasing fire risks due to the impacts of climate change.
- **Private land conservation:** the NSW Government has provided $240 million in funding through the Biodiversity Conservation Trust to support willing landholders to manage their land for conservation and increase the resilience of the land sector.
- **Protected Area Management**, which supports the delivery of on-park infrastructure and works to build resilience to climate change and other pressures and to increase awareness of the importance of adaptation
- The **Hawkesbury-Nepean Flood Risk Management Strategy:** the Hawkesbury-Nepean Valley has a high risk of flooding and climate change may increase the risk so the NSW Government has committed $58 million for Phase One of the Flood Strategy, including funding to support planning and a final assessment of the upgrade to the Warragamba Dam.

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Greenhouse Gas Emissions

Energy produced from non-renewable sources is leading to a build up of greenhouse gas emissions which are the primary cause of climate change. Emissions peaked in 2007 and are now 18.7% lower than 2005 levels.

Summary

Greenhouse gas emissions in NSW

131.6 Mt

of CO_2-e in 2016, representing 25.1% of Australia's total emissions

Read more

Greenhouse gas emissions peaked in 2007 and are now

18.7% lower

than in 2005

Read more

In 2016, greenhouse gas emissions for NSW were 131.6 million tonnes CO_2-e. Emissions peaked in 2007 and are now 18.7% lower than 2005 levels. Emissions have declined across most economic sectors, with the exception of transport, which has undergone almost uninterrupted growth in emissions.

In 2016, NSW emissions were about 17 tonnes CO_2-e per capita. This is below the national average of 21.8 tonnes per capita. Both are much higher than the global average of 6.6 tonnes per capita recorded last in 2014.

Stationary energy (primarily from electricity generation) is the largest source of emissions (51%) and these follow the overall pattern. Together, the stationary energy and transport sectors represent 72% of total NSW emissions, and forecasts indicate the emissions from both will grow in the future.

The NSW Government has an aspirational objective of achieving net-zero emissions by 2050. This was established as a long-term objective in 2016 within the Climate Change Policy Framework for NSW.

Related topics: Energy Consumption | Climate Change

NSW indicators

Indicator and status		Environmental trend	Information reliability
Atmospheric concentrations of greenhouse gases	POOR	Getting worse	✓✓✓
Annual NSW greenhouse gas emissions	POOR	Getting better	✓✓✓
Annual NSW per capita greenhouse gas emissions	POOR	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Greenhouse gases occurring naturally in the atmosphere, along with physical processes (such as solar heat absorption by land, vegetation, oceans and atmospheric dust), act to maintain an average global surface temperature of about 14°C, which would otherwise be about –20°C (IPCC 2007, p.946). However, the dominant cause of recent global warming has been human-induced greenhouse gas emissions and not natural climate variability (BOM & CSIRO 2016).

The impacts of increased greenhouse gas concentrations and Climate Change is more fully explored in the Climate Change topic.

Since the beginning of the industrial era (about the mid-18th century), the increased use of fossil fuels, along with agricultural and land-use changes, have led to a build-up of greenhouse gases in the atmosphere. These gases include carbon dioxide (CO_2), methane and nitrous oxide (IPCC 2014). This build-up is causing extra heat to be trapped by the atmosphere, resulting in an increase in global surface temperatures (IPCC 2007, p.4).

Concentrations of the major greenhouse gases now substantially exceed the highest concentrations of the past 800,000 years, as recorded in ice cores. The mean rates of increase in atmospheric concentrations over the past century are unprecedented in the last 22,000 years (IPCC 2013).

In terms of both volume and effect, CO_2 is the largest single contributor to human-induced emissions, being responsible for approximately 76% of the change in the climate observed since pre-industrial times (IPCC 2017). The last time CO_2 concentrations were comparable to these modern levels was 10 to 15 million years ago, when the world climate was, on average, 3 to 6°C warmer than at present and sea levels were much higher (Tripati et al. 2009; Allison et al. 2011).

Since the start of the industrial period, the global mean temperature has risen by 1.1°C. The warmest 10 years on record have occurred since 1998. Each year since 1985 the global mean temperature has been higher than the 1961–90 average (BOM & CSIRO 2016).

Temperatures in the Australasian region have risen to their highest levels in more than a thousand years (**Figure 5.1**). Since 1910, Australia's climate has warmed by 1°C, heat events and extreme fire weather have increased, and rainfall patterns have changed (BOM & CSIRO 2016).

Status and Trends

Global greenhouse gas emissions

In 2016, annual global human-induced greenhouse gas emissions reached 49.3 ± 0.5 Gt CO_2-e (gigatonnes of CO_2 equivalent) excluding emissions from Land Use, Land Use Change and Forestry (Oliver et al. 2017). About 73% of global emissions in 2016 arose from fossil fuel (i.e. coal, oil and gas) combustion and industrial processes (EDGAR Emissions Database for Global Atmospheric Research; Oliver et al. 2017).

Global emissions (excluding Land Use, Land Use Change and Forestry) have slowed in growth over the 2013 to 2016 period with calculated increases of 1.0%, 0.2% and 0.5% from the combustion of fossil fuels and industrial processes (Oliver et al. 2017). These rates are lower than the long-term average of 1.6% over the period 1990–2016. However, emissions are projected to increase by 2% in 2017 (Le Quéré et al. 2018). Economic and population growth are key drivers of global CO_2 emissions, but in recent years their effects are being moderated by a decoupling of the global economy from energy consumption (Oliver et al. 2017, p.14).

Australian greenhouse gas emissions

Using the estimation and reporting rules of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), 525 Mt CO_2-e of greenhouse gases were emitted in Australia during 2016 (Commonwealth of Australia 2018 volume 1, p.xi). While its contribution to global emissions is small, Australia is one of the highest per capita emitters of greenhouse gases in the world (IEA 2017, p.130). Australia's per capita emissions from fuel combustion (15.83 tonnes CO_2-e per person in 2015) were significantly higher than the Organisation for Economic Cooperation and Development (OECD) average of 9.18 tonnes CO_2-e per person (IEA 2017, p.130).

Australia has committed to the Paris Climate Agreement, and has set its Intended Nationally Determined Contributions (INDC) target to reduce emissions by 26–28 per cent below 2005 levels by 2030. More detail on the Paris Agreement and its aims is provided in the context section of the Climate Change topic.

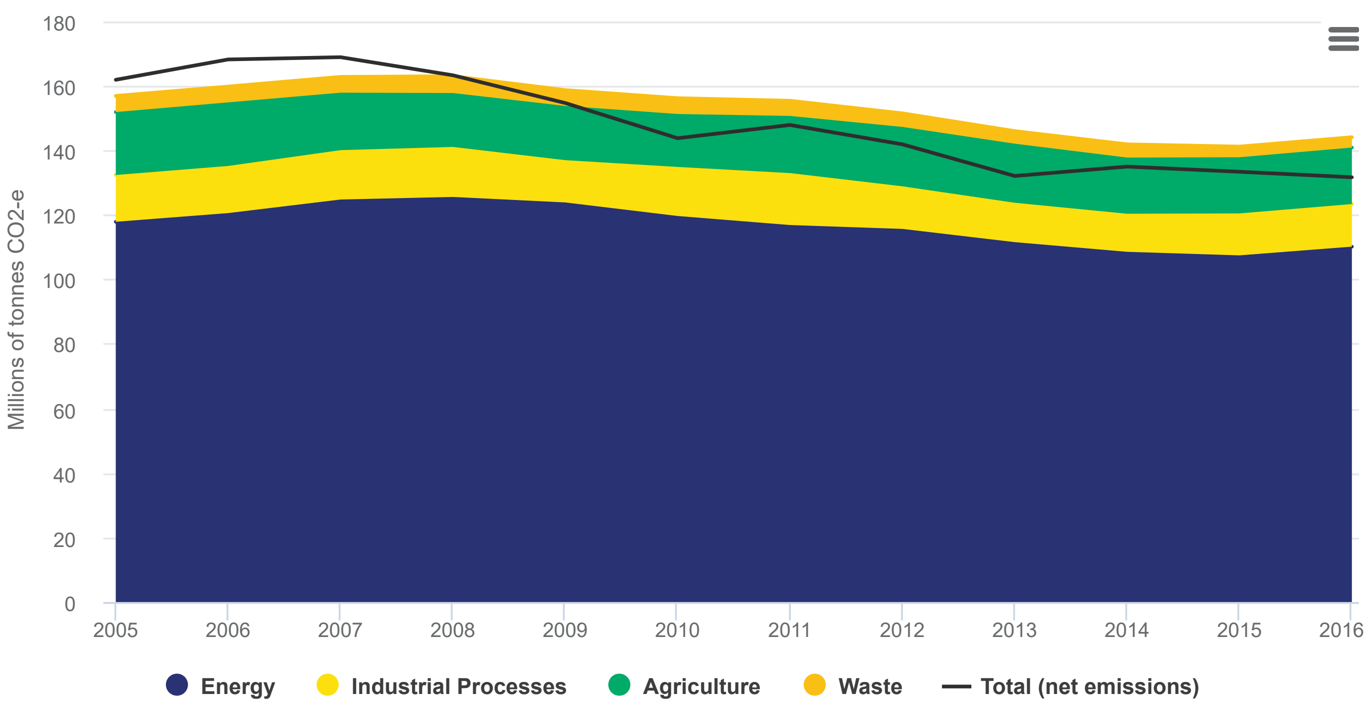
NSW greenhouse gas emissions

In 2016, NSW's greenhouse gas emissions were 131.6 Mt CO_2-e, which was 18.7% lower than in 2005. Using the estimation and reporting rules of the IPPC and the UNFCCC, NSW's emissions predominantly arise from the energy sector, which incorporates stationary energy and transport emissions, followed by agriculture, industrial processes and waste. Emissions in NSW peaked in 2007 and have since fallen (**Figure 5.1**).

NSW's net emissions follow the general trend for the combined energy, agriculture and industrial processes sources. However, since 2008 they have been moderated by the effect of the Land Use, Land Use Change and Forestry category, becoming a net sink of emissions rather than a source (**Figure 5.1**).

Current and projected climate change impacts for NSW from increasing greenhouse gas emissions are described in the Climate Change topic.

Figure 5.1: Total NSW greenhouse gas emissions, 2005–16



Source:
Australian Greenhouse Information System, State Greenhouse Gas Inventory

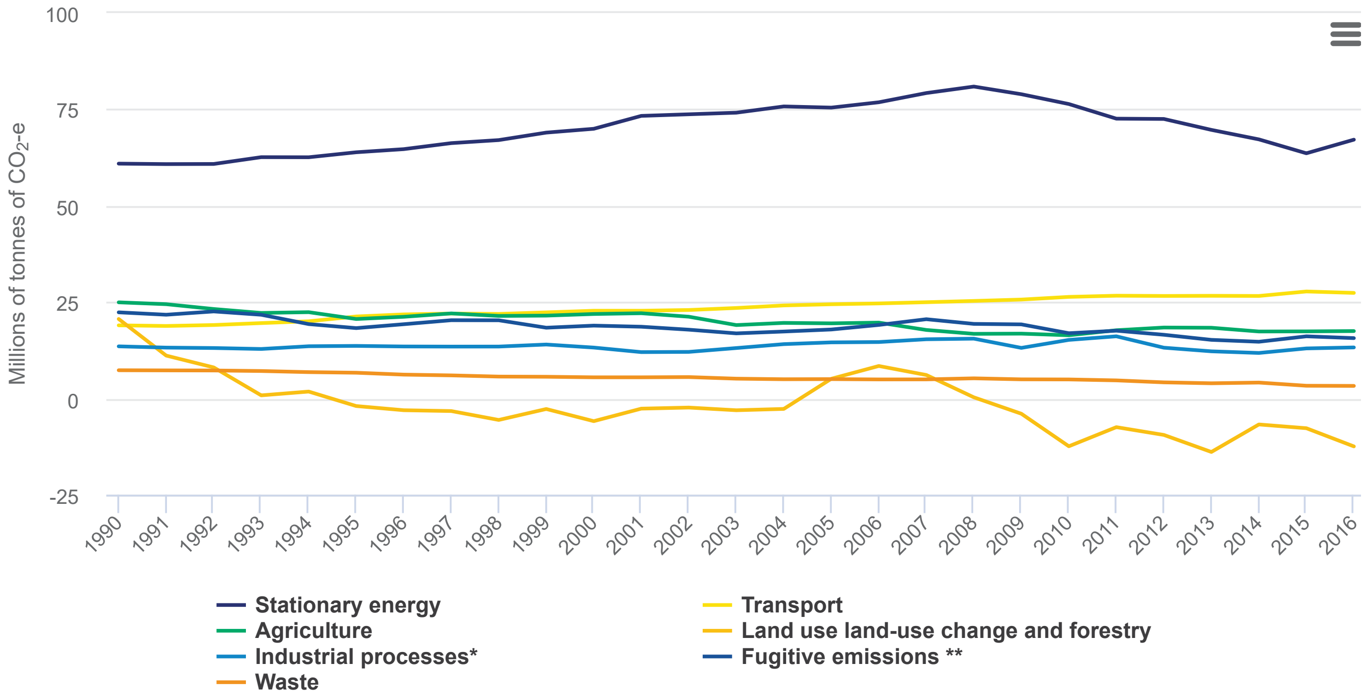
NSW emissions components

The combustion of fossil fuels account for 80% of NSW emissions, which includes fugitive emission of 11% from coal mining (**Figure 5.2**).

In NSW, stationary energy emissions (primarily fuel combustion for electricity and other gas use) increased by 4% since 1990, due to population and economic growth. This increase is tempered by:

- energy efficiency improvements
- the deployment of gas-fired power stations
- increased energy generation from renewable sources
- a shift in the structure of the NSW economy towards sectors that are less intensive for energy use and greenhouse gas emissions (see the Economic Activity and the Environment topic).

Figure 5.2: NSW greenhouse emissions components, 1990–2016



Notes:
* Includes fuel combustion for manufacturing industries and construction etc
** 94% of NSW fugitive emissions come from coal mining

Source:
Australian Greenhouse Emissions Information System

Electricity generation and use in NSW is expected to resume growing, albeit slowly (see Energy Consumption topic).

The transport sector is the fastest growing component of NSW-generated greenhouse gases. Although transport energy consumption was relatively stable from 2011 to 2016 (see Energy Consumption topic), the sector is a significant source of greenhouse gas emissions for NSW because of its growth rate and the size of its contribution to total emissions, which was 20.8% in 2016.

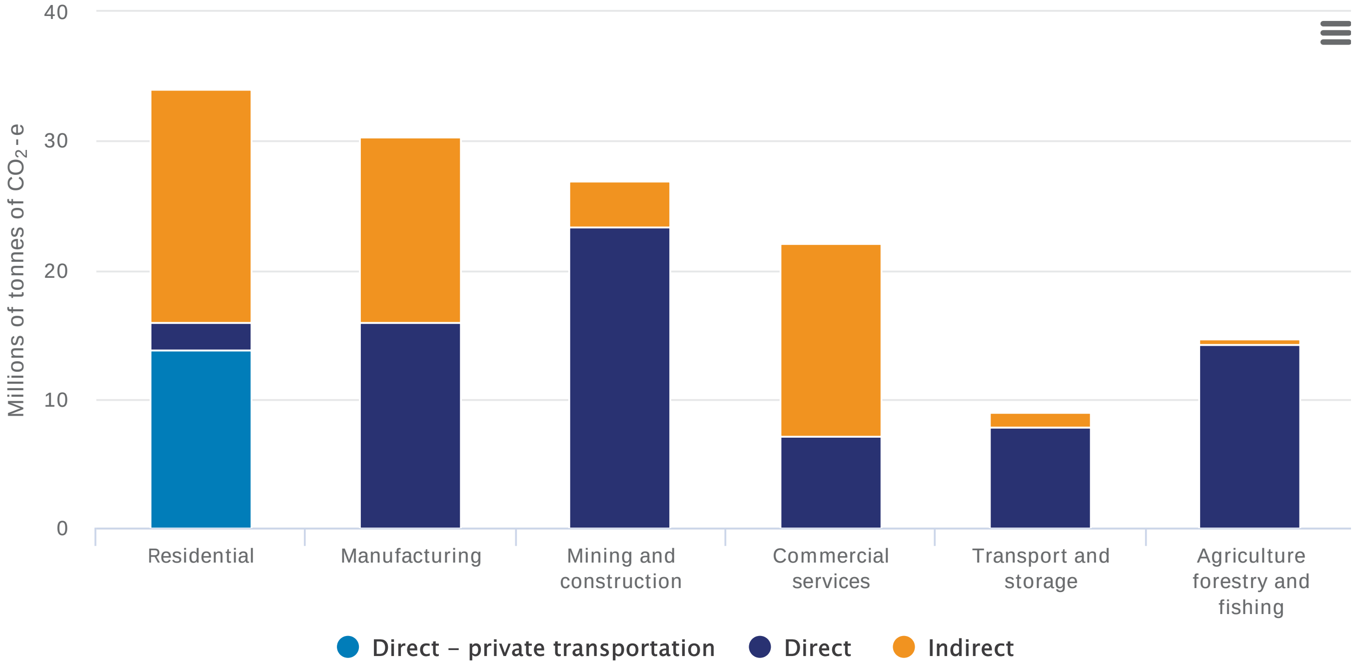
The Land Use, Land Use Change and Forestry sector has gone from being a net generator of emissions to a net sink for emissions. This principally reflects the impact of declines in emissions from land clearing and enhanced sinks from the development of new forests, the regeneration of bush and forests after clearing, and existing forest management (Commonwealth of Australia 2018b).

NSW greenhouse gas emissions by economic sector

Total greenhouse gas emissions arising from the direct consumption of energy and fuel as well as industrial processes, along with indirect sources of emissions arising from the generation of electricity, can all be attributed to their end-use sectors (**Figure 5.3**).

In 2016, the largest contributor of greenhouse gas emissions in NSW was the residential sector, which included emissions from private transportation (33.5 Mt CO2-e, about 26% of NSW's total emissions). This was followed closely by manufacturing (30.1 Mt, about 23%) and mining and construction (26.7 Mt CO2-e, about 21%).

Figure 5.3: NSW greenhouse gas emissions by end-use sector and emissions type, 2016



Notes:
Values are rounded. Totals may not match due to rounding.

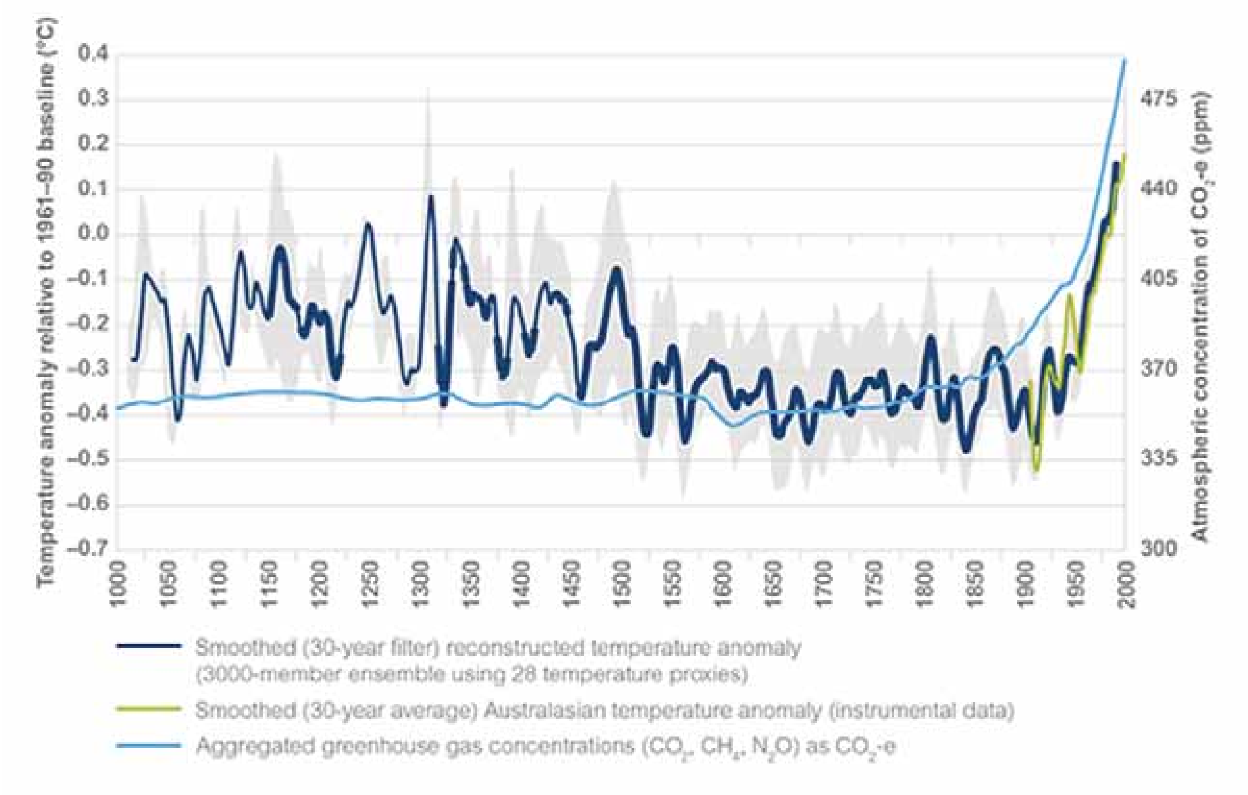
Source:
Australian Greenhouse Emissions Information System (National Inventory by Economic Sector)

Pressures

Temperature warming

Changing greenhouse gas concentrations will alter the heat balance of the atmosphere, resulting in global warming. For most of the past 2,000 years, global atmospheric concentrations of greenhouse gases have been fairly stable and only since the Industrial Revolution (c. 1750) have they increased significantly. This trend is also seen in the Australasian region (**Figure 5.4**).

Figure 5.4: Australasian summer temperature reconstruction, temperature observations and CO_2-e, since AD 1000



Notes:
This temperature reconstruction is based on 28 temperature proxies from the Australasian region and was generated using multivariate principal component regression. The most reliable periods of the reconstruction are shown by the thick sections of the dark blue line with less reliability indicated by the thin dark blue line. The light green line represents the instrumental data. Statistical error bands from the regression analysis are shown in light grey.
The light blue CO_2-e line is composed of the sum of the atmospheric concentrations of three main greenhouse gases (CO_2, CH_4 and N_2O; as measured in ice cores from Law Dome, Antarctica) multiplied by their individual radiative efficiencies relative to CO_2.

Source:
Gergis et al. 2016; CSIRO data; Hartmann et al. 2013, Table 2.1

Climate Change

The accumulation of greenhouse gas emissions in the Earth's atmosphere is the main environmental pressure leading to global warming and changes in climate. The impacts on climate that are already occurring and projections of future changes are described in the Changes in climate section of the Climate Change topic. These impacts include increasing air and ocean temperatures, greater variability and changes in the seasonality of rainfall and rising sea levels.

In turn, the induced changes in climate described in Change in climate section will act as environmental pressures that have broad impacts on a wide range of biophysical systems. These are described in the Environmental impacts of climate change section of the Climate Change topic. They include increasing extreme weather events, such as storms and floods; increased coastal erosion and inundation; less favourable climate conditions for many species, ecosystems and agricultural systems; and impacts on human health and wellbeing.

Global emissions

The extent of the impacts of climate change will ultimately be determined by the actions the world's nations take globally to reduce greenhouse gas emissions and the level at which greenhouse gases in the atmosphere can be stabilised. In 2016, a total of 196 (98%) of the world's nations signed the Paris Climate Agreement to limit global average temperature rise to well below 2°C, while aiming for a safe 1.5°C target, with each party to the agreement pledging national contributions to reducing greenhouse gas emissions (UNFCCC 2015).

In 2017, a UNFCCC analysis of 189 countries, covering 99% of the emissions of parties to the convention, found that reductions are not yet sufficient to put the world on track to limit global temperature rise to 2°C (UNFCCC 2017). In effect, worldwide emission reductions of around 5% per year would be required. This corresponds to limiting cumulative emissions, post-1750, to the equivalent of 1 trillion tonnes of carbon (Allen et al. 2009). Business-as-usual activities will see the 1 trillion tonne level exceeded in about 17 years (University of Oxford 2009).

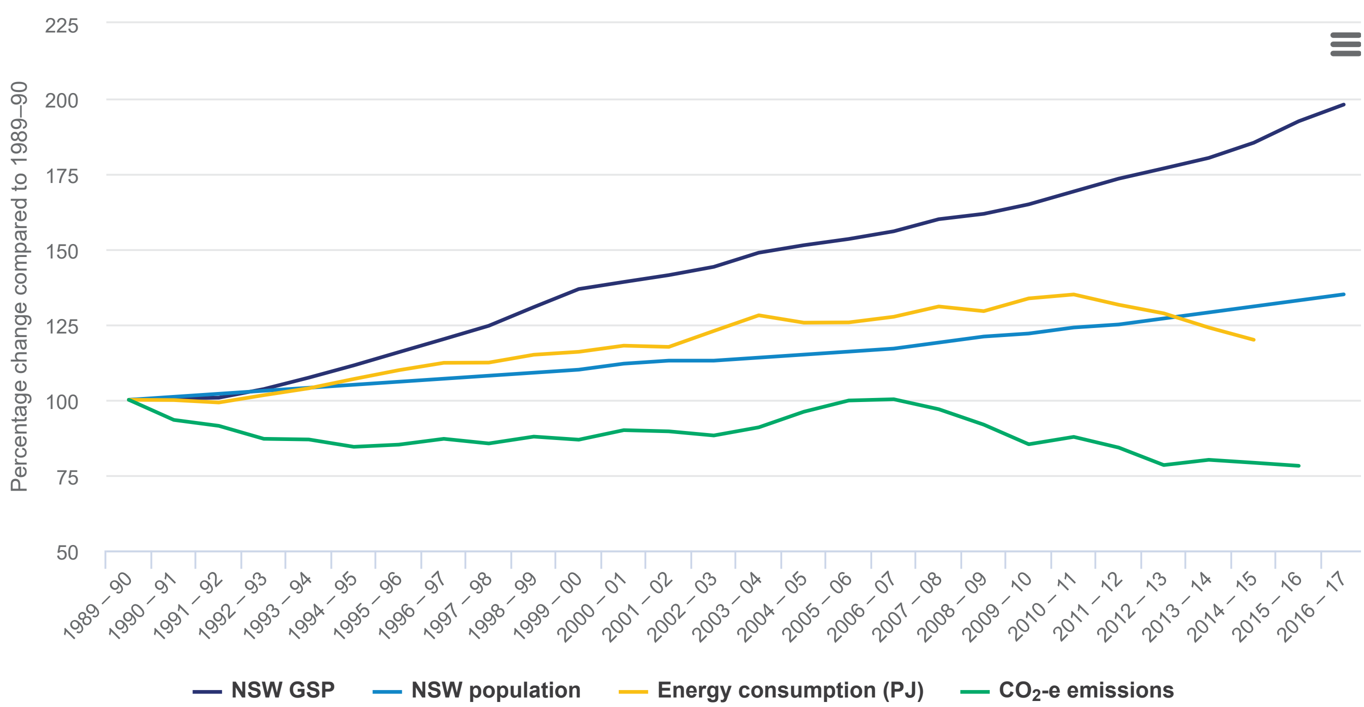
A UN Intergovernmental Panel on Climate Change (IPCC) report (IPCC 2018) found that global net human-caused emissions of carbon dioxide (CO_2) would need to fall by about 45% from 2010 levels by 2030, reaching net zero around 2050. The report highlights that a number of climate change impacts could be avoided by limiting global warming to 1.5°C compared to 2°C, or more.

Environmental drivers

In the SoE framework, the economy and population are seen as drivers of environmental change rather than direct pressures. **Figure 5.5** shows the relationship between economic growth, population, energy use and greenhouse gas emissions from 1990 until the present. The figure shows a steady decoupling of the economy from greenhouse gas emissions over this time. There is, however, a much stronger relationship between the levels of energy use and population growth over the same period.

The relationship between energy use, greenhouse gas emissions, population and the economy is more fully explored in the Economic Activity and the Environment topic. This demonstrates a 60% decoupling of greenhouse gas emissions from economic growth (gross state product, or GSP) since 1990.

Figure 5.5: Trends in NSW energy use, compared with key NSW statistics, 1990–2017



Source:
ABS cat 3101.0; Australian Demographic Statistics
ABS cat 5220.0; Australian National Accounts: State Accounts, 2017–18
Australian Energy Update 2017; Department of the Environment and Energy, 2017
State and Territory Greenhouse Gas Inventories 2016; Department of the Environment and Energy, 2018

Future energy supply and demand

In recent years, electricity consumption has declined in NSW. This is due to a variety of economic factors, such as increased local generation by residential and commercial users and improvements to energy efficiency (see the Energy Consumption topic). In addition, there has been a decline in the emissions intensity of electricity generation from the National Electricity Market (NEM) (Saddler 2018).

Nevertheless, population and economic growth from 2018–19 to 2036–37 is projected to be sufficient to increase electricity demand. However, the demand from the grid is expected to remain steady as consumers increasingly opt for more onsite power generation and storage (see the Energy Consumption topic). Emissions from the electricity generation sector in NSW are expected to decline over the coming decades with the announced closure of 4.64GW of coal-fired power stations, representing 45% of the existing fleet of coal-fired power stations. The rate of this decline will be determined by replacement technology, which in turn will be influenced by government policy, changes in technology cost and consumer demand.

Demand for gas has been stable over the past three years and is forecast to remain at its current level over the next 10 years (AEMO 2017). The Australian Energy Market Operator (AEMO) predicts a number of uncertainties could impact residential and commercial demand, including weather and population variances, responses to changing energy prices and bills, and gas to electric appliance switching.

Responses

There are two main strategies for response to climate change – mitigation and adaptation.

Mitigation of climate change describes the actions taken to limit or reduce the extent of global warming by reducing the levels of human induced greenhouse gas emissions, and the actions taken to remove greenhouse gas emissions from the atmosphere. Adaptation is the actions taken to reduce, moderate or adjust to the expected or actual negative effects of climate change, and take advantage of new opportunities.

This section outlines the key mitigation responses to greenhouse gas emissions in NSW, with some further policies and programs outlined in the Energy Consumption topic. Adaptation responses to climate change are outlined in the Responses section of the Climate Change topic.

Legislation and policy

NSW Climate Change Policy Framework

The NSW Climate Change Policy Framework (OEH 2016) includes aspirational objectives to achieve net zero emissions by 2050 and make NSW more resilient to a changing climate. The framework states the NSW Government’s endorsement of the Paris Agreement and sets out policy directions for mitigation, such as boosting energy productivity and reducing household and business energy bills.

The government’s net zero objective is supported by other policies as described below.

NSW Climate Change Fund

The NSW Climate Change Fund (CCF) was established in 2007 under Part 6A of the *Energy and Utilities Administration Act 1987* to provide funding to reduce greenhouse gas emissions and the impacts of climate change associated with water and energy activities. The CCF has typically funded programs for energy efficiency, renewable energy and climate change adaptation.

Using energy more efficiently

The NSW Energy Efficiency Action Plan (EEAP) (OEH 2013) ran over a four-year period to July 2017 and implemented measures that reduced the cost of consumers' energy bills and improved economic performance. The EEAP contained 30 actions to grow the market for energy saving products and services and demonstrated NSW's leadership in energy efficiency.

The Energy Affordability Package and Energy Efficiency Package supports low-income households in social and private housing to save energy. This support package includes:

- An appliance replacement offer which provides eligible households with the opportunity to replace their existing inefficient fridge or television with a new efficient appliance at a discounted cost
- Upgrading more than 20,000 rental homes to enable low-income renters to benefit from energy efficient lighting, heating, and hot water systems
- Partnering with social housing providers to install energy efficiency measures at social housing properties.

Government Resource Efficiency Policy

The NSW Government is leading by example through the Government Resource Efficiency Policy (GREP) (OEH 2014). This policy responds to rising resource costs and economic, environmental and community impacts by setting measures, targets and minimum standards that will drive resource efficiency in the areas of energy, water, waste and clean air for Government. This is through energy efficiency projects, encouraging renewable energy development (e.g. mid-scale solar development) and reducing waste generation.

The NSW Government also supports various state and national standards that are coordinated through the Council of Australian Governments (COAG), such as:

- Greenhouse and Energy Minimum Standards (GEMS), which regulates energy efficiency and standards for appliances and other products (see Energy Consumption topic)
- National Australian Built Environment Rating System (NABERS), which rates buildings using measured environmental impacts
- the National Construction Code, which sets out minimum standards for energy efficiency in building design and construction.

These standards are complemented by NSW's Building Sustainability Index (BASIX), a compulsory ratings system for new residential buildings and renovations. BASIX aims to improve water with compulsory targets for energy efficiency and improving waste management and indoor air quality. The NSW Government estimated that in 2015, BASIX homes had reduced emissions of greenhouse gases by over 4 million tonnes (DPE 2015).

Lower emissions energy

NSW supports the Australian Government's 2014 Renewable Energy Target (RET) of 33,000GWh of renewable generation by 2020. The NSW Renewable Energy Action Plan (REAP) (NSW Government 2013) positions NSW to offer increased renewable energy at the lowest cost to customers. The REAP contains 24 actions to attract renewable energy investment, build community support and grow renewable energy expertise.

Under the RET and the Renewable Energy Action Plan, the use of renewable energy sources for electricity has more than doubled in proportion between 2008 and 2017 from 6.1% to 15.8% (11,469GWh) of total energy consumption in NSW (see Energy Consumption topic).

In June 2018, more than 420,000 households and small businesses across NSW had solar photovoltaic (PV) systems, representing an installed capacity of 1.6GW (Clean Energy Regulator data).

The NSW Government also has policies beyond these plans that help reduce greenhouse gas emissions from energy. These include mandating biofuel supply in NSW to help support the development of a market for cleaner and alternative fuels. Biofuels, such as ethanol and modified vegetable oil (biodiesel), can reduce greenhouse gas emissions, create jobs in regional NSW, help farmers and reduce reliance on foreign fuel imports.

In addition, government actions to support public transport use can help reduce energy use and greenhouse gas emissions from the transport sector (see Transport topic).

Programs

Carbon sequestration

Careful land management can avoid greenhouse gas emissions by sequestering (storing) carbon in the plants and soil. It can also protect biodiversity and maintain landscape values.

As public lands in NSW (around half the state) store about 1.5 billion tonnes of carbon, the NSW Government is working to improve the management of carbon across all public lands (e.g. see NSW Legislative Council 2013) and in land covered by agreements for private land conservation.

The Australian Government's Emissions Reduction Fund provides incentives for storing carbon in the agriculture and forestry sectors as well as for emissions avoidance across the economy. This program now integrates the former Carbon Farming Initiative that ran between September 2011 and December 2014. There are over 200 ERF projects in NSW, many of which sequester carbon in trees and vegetation.

Helping households be more energy efficient

The following programs support households to reduce greenhouse gas emissions by becoming more energy efficient and saving money on their energy bills.

Home Energy Action

Expanded in September 2017, the $50 million Home Energy Action (HEA) Program works in partnership with community housing providers, the community services sector and industry to deliver energy efficiency improvements to households experiencing energy stress and to improve household comfort, health and wellbeing.

The program operates three streams:

- Social Housing Upgrades – a co-investment model with social housing providers across the state to install energy efficient retrofit measures on public, community and Aboriginal housing. Retrofit measures include solar panels, ceiling insulation, draught proofing, LED lighting, heat pump hot water systems, split system air-conditioning and energy performance upgrades for new build projects. These upgrades reduce energy bills and increase comfort for tenants.
- Appliance Replacement Offer – replaces old fridges and televisions with new energy efficient models at discounted prices, to eligible households directly or through community service organisation partners.
- Energy Hardship Assist – a co-investment model to deliver subsidised solar panels, in partnership with energy retailers, to customers in social housing.

More efficient homes for low-income tenants

Announced in August 2018, this new program provides $24.5 million in discounts for upgrades to more than 20,000 homes rented by low-income tenants, so they can benefit from energy efficient lighting, heating and hot water systems. The program will also provide guidance to help landlords choose appropriate energy saving technologies for the type of house and climate zone.

Helping communities be more energy efficient

The following programs support businesses and households to reduce greenhouse gas emissions by becoming more energy efficient.

Household and small business upgrade program

This five-year program was launched in April 2018 to help households and small businesses save energy and money. It will provide up to $44m in incentives to help them upgrade to energy efficient equipment, such as lighting and air-conditioning.

Energy Savings Scheme

The Energy Savings Scheme (ESS), established in 2009, is the longest running energy efficiency certificate trading scheme in Australia. The scheme creates incentives for households and businesses to invest in energy efficient products and services by reducing the upfront cost of upgrades. The ESS helps to build a sustainable energy efficiency market by encouraging the private sector to develop products and services that are scalable and sustainable, helping households and businesses to reduce their energy use.

Helping businesses be more energy efficient

The following programs support businesses to reduce greenhouse gas emissions by becoming more energy efficient.

Energy savings for energy intensive manufacturers

On 20 August 2018, the NSW Government announced a new program to help businesses stay competitive by reducing their energy costs. The program will provide assistance for approximately 250 manufacturing businesses to install energy efficient equipment, such as upgraded boilers, refrigeration, and metering technology to help track their energy use.

Energy Management Services

The Energy Management Services Program provides blended learning (including online modules, webinars, tools and guidance), training, coaching and technical support that help businesses and business service providers to adopt proven energy management practices that reduce energy use and associated emissions. The program participates in industry engagement, partnership development and dissemination of information to showcase best practice in energy management.

Sustainability Advantage

The Sustainability Advantage Program works with organisations to solve complex sustainability challenges. The program collaborates with businesses on innovative projects and shows how they can be leaders in their communities. Members of the program achieve savings of more than $100 million every year, directly supporting the Government's target of achieving net zero emissions by 2050.

NABERS

NABERS (the National Australian Built Environment Rating System) is a rating system that measures the energy, water and waste impact of buildings in Australia using a star scale. NABERS can be used to rate a variety of buildings, including office buildings, office tenancies, apartment buildings, shopping centres, hotels and data centres.

The highly regarded program has assessed 81% of office space in Australia with improvements of 8.5% in energy efficiency, 383,000 tonne reductions in annual greenhouse gas emissions, 11% in water efficiency and 1.6 billion litres of water saved.

Helping government agencies and local councils be more energy efficient

The following programs support government agencies and local councils to reduce greenhouse gas emissions by becoming more energy efficient.

More efficient street lighting

On 20 August 2018 the government announced $12.5 million of funding to help local councils upgrade 60,000 energy inefficient street lights to LEDs. This will lead to around $22 million in energy bill savings by 2035, which will enable councils to free up funding for local services and infrastructure.

Sustainable Government

The Sustainable Government Program works closely with NSW Government agencies to help them lead the way on sustainability action and reduce the impact of government activities. The program provides tailored services and support to help agencies develop sustainability plans and embed sustainability leadership. To date, the program has delivered 71 sustainability projects across 144 sites resulting in $70 million in savings to government.

Future opportunities

Energy generation is becoming less carbon intensive and this trend is expected to continue. Combined with energy efficiency measures, emissions from electricity generation should decrease in coming decades. Complementary research and development into cost-effective technologies to reduce generation emissions will continue. For example:

- carbon mineralisation – the Coal Innovation NSW Fund is partnering with the Australian Government and Orica in Mineral Carbonation International, a project trialling a new technology that permanently and safely stores CO_2 by transforming captured emissions into forms of carbonate rock for potential use as new green building materials in the construction industry
- improving combustion efficiency, such as by chemical looping air separation technologies to produce oxygen for use in oxy-fuel combustion power stations; and the direct carbon fuel cell (both are being funded by the Coal Innovation NSW Fund)
- enabling systems and technologies for very high penetration renewable energy generation.

Reduction of emissions from power generation will bring a greater focus on reducing emissions from industrial processes and transport. Additional opportunities include capturing fugitive emissions, such as methane from landfill waste decomposition; and waste heat from industrial processes.

The NSW Government has recently set a high-level direction for addressing transport-related emissions with the Future Transport 2056 Strategy. The strategy includes commitments towards reducing energy intensity of NSW passenger transport and support for zero emissions vehicles (TfNSW 2018). Further gains can also be expected by continuing to improve light and heavy vehicle efficiency.

There are opportunities within the agriculture and forestry sectors to mitigate greenhouse gas emissions through practice changes that are both profitable and sustainable.

Key opportunities being investigated by NSW Department of Primary Industries (DPI) in conjunction with the Commonwealth Government include:

- increased soil organic carbon
- increased perennial vegetation in agriculture
- reduced methane emissions from livestock
- reduced emissions from nitrogenous fertilisers
- utilisation of agricultural and forestry residues for bioenergy and biochar.

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Air quality

Ensuring that air quality remains at a high level is essential for providing a clean living environment and maintaining the health of the NSW population.

Summary

Rural Air Quality Monitoring Network

35 sites

monitor particles in NSW

Read more

Petrol vapour capture during vehicle refuelling

92%

compliance by service stations

Read more

Particle concentrations exceeded national standards up to

16 days a year

between 2015 and 2017 in rural areas

Read more

Ground level ozone exceeded national standards up to

9 days a year

between 2015 and 2017 in Sydney

Read more

NSW air quality is generally good or very good and consistently complies with national air quality standards for carbon monoxide, nitrogen dioxide, lead and sulfur dioxide. Levels of fine particle pollution and ozone continue to be of concern.

Fine particles are invisible to the naked eye and can be inhaled into the lungs. PM_{10} is particulate matter 10 micrometers or less in diameter and includes $PM_{2.5}$. $PM_{2.5}$ is particulate matter 2.5 micrometers or less in diameter. Particle pollution generally meets national air quality standards in Sydney, except when natural events such as bushfires or dust storms occur, or hazard reduction burning is conducted. Between 2015 and 2017, particle concentrations exceeded the national air quality standards on up to 20 days a year in Sydney, and up to 16 days a year in regional areas of NSW monitored under the Rural Air Quality Monitoring Network (Albury, Bathurst, Tamworth and Wagga Wagga North).

There is growing evidence about the adverse health impacts of airborne particles so in 2016 national air quality standards were strengthened to address this issue. Australia now has the most stringent $PM_{2.5}$ standards, offering the best health protection in the world.

Between 2015 and 2017, concentrations of ground-level ozone, a key component of photochemical smog, exceeded national air quality standards in Sydney on up to nine days a year. Emissions of nitrogen oxides and volatile organic compounds are the main precursors of ozone and include emissions from industrial facilities, power stations and motor vehicle exhaust. To help reduce these emissions, the NSW Government has introduced strategies such as the Vapour Recovery Program to reduce petrol emissions from service stations.

Nitrogen dioxide and sulfur dioxide levels are usually 25–75% lower (better) than the national air quality standards.

The NSW Government has delivered a range of programs to further improve air quality in NSW, including the Dust Stop program, which reduces dust from coal mines, and the Wood Smoke Reduction Program, which helps to reduce smoke from domestic wood heaters.

Related topics: Climate Change | Energy Consumption | Greenhouse Gas Emissions | Transport

NSW indicators

Indicator and status		Environmental trend	Information reliability
Concentrations of ozone	MODERATE	Stable	✓✓✓
Concentrations of particles (PM_{10})	MODERATE	Stable	✓✓✓
Concentrations of particles ($PM_{2.5}$)	MODERATE	Stable	✓✓✓
Concentrations of carbon monoxide	GOOD	Stable	✓✓✓
Concentrations of nitrogen dioxide	GOOD	Stable	✓✓✓
Concentrations of sulfur dioxide	GOOD	Stable	✓✓✓

Concentrations of lead	GOOD	Stable	✓✓✓

Notes:
Terms and symbols used above are defined in About the report

Context

Since the early 1990s, research has emerged about the adverse health effects of air pollution. Short-term exposure to elevated air pollutants exacerbates respiratory and cardiovascular problems and increases the risk of acute symptoms, hospitalisation and death (NEPC 2014). Repeated long-term exposure increases the risk of chronic respiratory and cardiovascular disease and mortality, can impact on birth weight, and can permanently affect lung development in children (WHO 2013b).

The International Agency for Research on Cancer has classified diesel exhaust (WHO 2012) and outdoor air pollution (WHO 2013a) as human carcinogens.

Monitoring indicates that most common air pollutants occur in NSW in concentrations generally well below dangerous levels. The main air pollutants of concern are:

- particles ($PM_{2.5}$ and PM_{10})
- ground-level ozone (O_3)
- gases forming ozone: oxides of nitrogen (NOx) and volatile organic compounds (VOCs).

The main human sources of these pollutants are:

- industry
- motor vehicles
- domestic wood smoke
- hazard reduction burns and human-caused bushfires.

Australians spend an average of 20 hours a day indoors, largely at home (enHealth 2012). As a result, there may be greater personal exposure to indoor airborne pollutants than to air pollution outdoors. Indoor emissions can come from building fixtures, fittings and furniture, indoor activities such as heating and cooking, chemical cleaning products, tobacco smoke and outdoor air pollutants that have come inside.

Health costs of air pollution

In 2005, the annual health costs of air pollution in the Sydney Greater Metropolitan Region (GMR) were estimated to be $893 per head of population or $4.7 billion (DEC 2005), equivalent to $6.4 billion a year in 2015 terms (EPA 2016a).

The 2014 *Impact Statement to the Draft Variation to the National Environment Protection (Ambient Air Quality) Measure* (NEPC 2014) noted that the savings in associated health costs, of reducing ambient PM_{10} concentration to 10 micrograms per cubic metre (µg/m^3) and ambient $PM_{2.5}$ concentration to 5µg/m^3 in the GMR, was estimated to be $5.7 billion per annum.

In 2005, the health costs of motor vehicle pollution across Australia's capital cities were estimated to be up to $3.3 billion per year ($1.5 billion for Sydney) (BTRE 2005).

Status and Trends

National standards and goals

In 1998, to help protect the health of Australians, the National Environment Protection Council (NEPC) set national air quality standards and goals, in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM).

The AAQ NEPM sets standards for seven common air pollutants to which Australians may be exposed:

- ground-level ozone (O_3)
- particles (PM_{10} and $PM_{2.5}$)
- carbon monoxide (CO)
- nitrogen dioxide (NO_2)
- sulfur dioxide (SO_2)
- lead.

In 2016, governments amended the AAQ NEPM, after wide consultation, in response to increasing awareness of the risks posed by fine particles.

Table 8.1 lists the new standards and goals. The section on particles provides details of the changes to standards and goals for PM_{10} and $PM_{2.5}$.

The NEPC is currently reviewing the AAQ NEPM standards for SO_2, NO_2 and O_3.

Table 8.1: National Environment Protection (Ambient Air Quality) Measure standards and goals (updated 2016)

Pollutant	Averaging period	Standard (maximum concentration)	Goal (maximum number of allowable exceedances)
Carbon monoxide	8-hour rolling average	9.0 ppm	1 day a year
Nitrogen dioxide	1-hour average	0.120 ppm	1 day a year
	1-year average	0.030 ppm	None
Photochemical oxidants – as ozone	1-hour average	0.100 ppm	1 day a year
	4-hour rolling average	0.080 ppm	1 day a year
Sulfur dioxide	1-hour average	0.200 ppm	1 day a year
	1-day average	0.080 ppm	1 day a year
	1-year average	0.020 ppm	None
Particles as PM_{10}	1-day average	50.0 µg/m^3	None
	1-year average	25.0 µg/m^3	None
Particles as $PM_{2.5}$	1-day average	25.0 µg/m^3	None
	1-year average	8.0 µg/m^3	None

Pollutant	Averaging period	Standard (maximum concentration)	Goal (maximum number of allowable exceedances)
Lead	1-year average	0.50 $\mu g/m^3$	None

Notes:
In 2016, the goal for PM_{10} was revised from allowing five exceedance days per year of the 24-hour standard of 50$\mu g/m^3$, to no exceedances, unless determined as an exceptional event.
Information about averaging periods is available on the OEH website.

Monitoring air pollutants

To measure compliance with national standards and goals, the NSW Government operates an extensive air quality monitoring network across the state.

The Office of Environment and Heritage (OEH) monitors air quality in NSW. The NSW air quality monitoring network, which is accredited by the National Association of Testing Authorities (NATA), monitors air quality in the Sydney Greater Metropolitan Region (GMR) and regional population centres, and compares air quality in these regions with national air quality standards. OEH operates over 80 ambient air quality monitoring stations across NSW. All data is reported on the OEH air quality website in near-real time.

Air quality monitoring regions include:

- rural areas monitored by the Rural Air Quality Monitoring Network
- regional centres
- Sydney GMR (Sydney, Illawarra, Central Coast, Lower Hunter and the Upper Hunter).

The OEH Rural Air Quality Monitoring Network was established in December 2017, and consists of 35 community monitoring sites measuring particles across rural NSW. The network is separate from the NATA-accredited OEH monitoring network and measures particulate matter as total suspended particles, and where possible as PM_{10} and $PM_{2.5}$. This network will gradually be extended to provide information on particle pollution across all NSW.

There are 22 air quality monitoring sites that report compliance with the AAQ NEPM (see **Maps 8.1** and **8.2**). All regions except for the Upper Hunter include AAQ NEPM-designated stations.

OEH operates a number of sites that are not designated for AAQ NEPM reporting. These include:

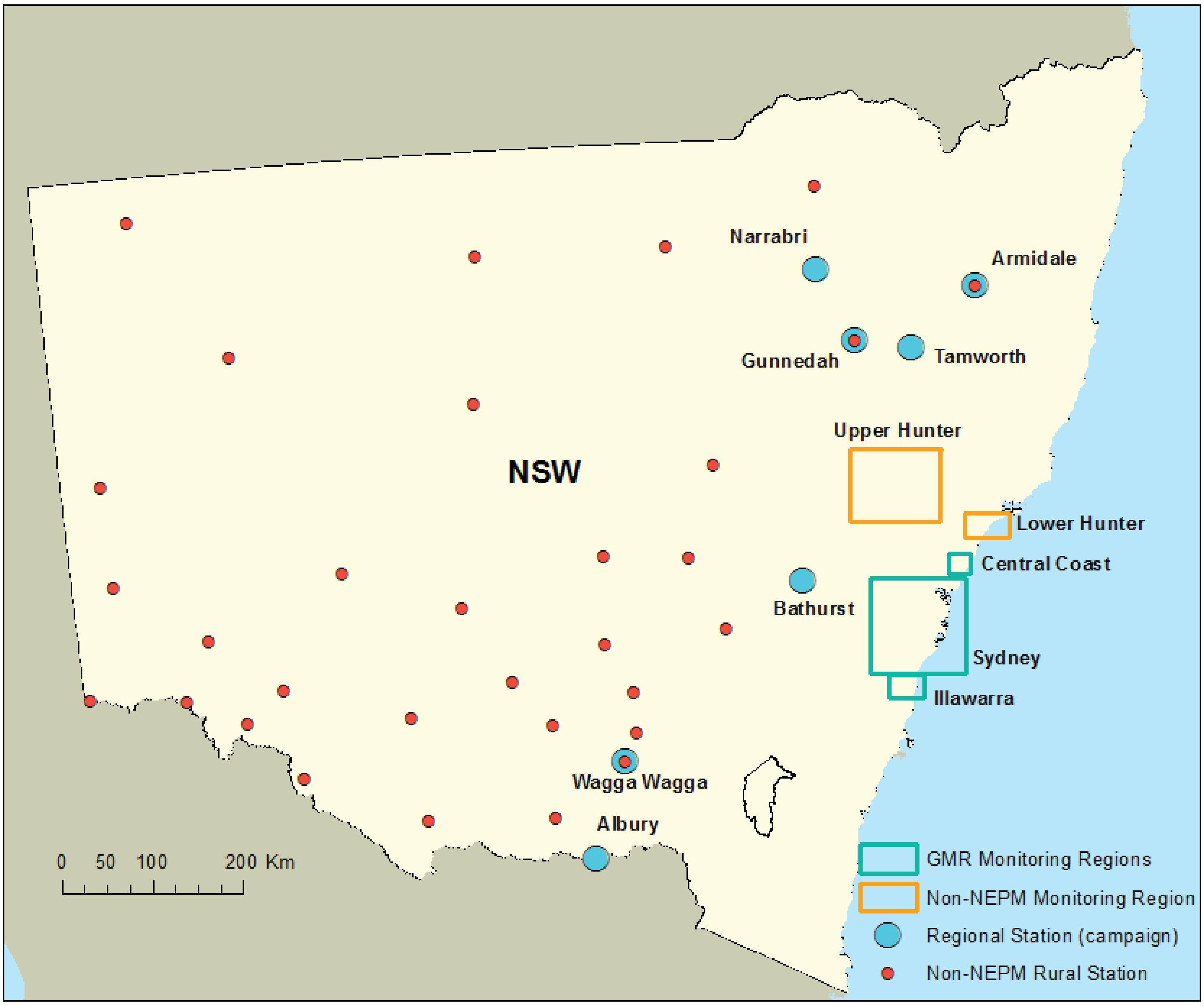
- 35 rural sites, located predominantly in western NSW (see **Map 8.1**); but also including four sites in Victoria and one in South Australia where source areas affect NSW (the interstate sites are not on the maps)
- five sites in the Sydney region
- 14 industry-funded sites in the Upper Hunter Valley
- three industry-funded sites in Newcastle.

Non-AAQ NEPM sites provide information on the impacts of local sources of airborne pollutants and assist the NSW Government to develop actions to reduce air pollution.

In December 2017, three new air quality monitoring stations were established at Parramatta North in the Sydney GMR, and at Gunnedah and Narrabri in the Namoi region. In May 2018, an additional regional air quality monitoring station was established at Armidale, bringing the total number of stations in NSW to 47 – the largest air quality monitoring network in Australia.

The Gunnedah, Narrabri and Armidale sites have not yet been classified as AAQ NEPM or non-AAQ NEPM sites.

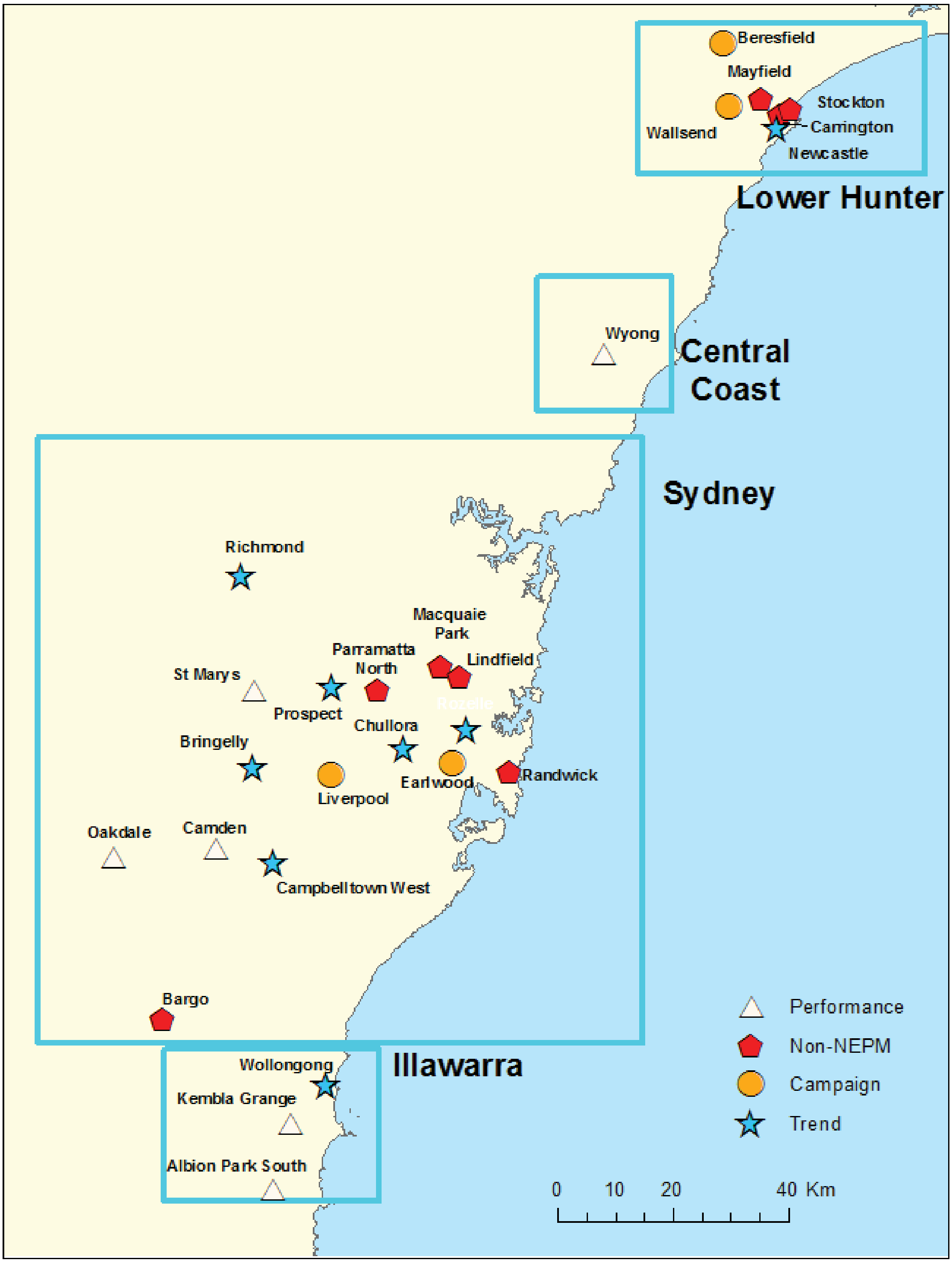
Map 8.1: The NSW air quality monitoring network



Notes:
Air quality monitoring regions (station groups), including rural monitoring network, regional centres and the Greater Metropolitan Region or GMR (Sydney, Illawarra, Central Coast, Lower Hunter and the Upper Hunter). All regions except for the Upper Hunter include NEPM-designated stations.

Source:
OEH air quality monitoring

Map 8.2: The Sydney GMR and lower Hunter air monitoring network



Notes:
Air quality monitoring stations in the NSW Greater Metropolitan Region, including designated AAQ NEPM stations. Gunnedah, Narrabri and Armidale sites were established from December 2017 and are yet to be classified.

Source:
OEH air quality monitoring

NSW consistently complies with national standards and goals for:

- CO
- NO_2
- SO_2 (except for one exceedance of the hourly average standard at a station in the Upper Hunter region in December 2016).

As motor vehicles, fuels and industries have improved:

- CO levels are now generally only high when traffic is congested and there is little or no wind
- NO_2 and SO_2 levels are usually 25–75% lower than the standards.

Ambient lead monitoring was discontinued from January 2005, following a decrease in lead levels to well within the national standard, largely due to the introduction of unleaded petrol.

Particles and ozone levels continue to be of concern (see relevant sections below).

Particles

Airborne particles (particularly PM_{10} and $PM_{2.5}$) are invisible to the naked eye, with $PM_{2.5}$ pollution known as 'fine particle pollution'. PM_{10} is particles that are 10 micrometres or less in diameter and includes $PM_{2.5}$, which is 2.5 micrometres or less in diameter.

Visible dust deposited on household surfaces creates nuisance problems, although it is not considered a health hazard.

Ongoing research shows that the smaller the particles, the greater their potential health hazard (WHO 2013b). Smaller particles ($PM_{2.5}$) can be inhaled more deeply into the lungs. As well as causing respiratory irritation, some are small enough to pass into the bloodstream where, even at relatively low levels, they can trigger heart attacks in people with health conditions and severely affect children and the elderly (WHO 2013a).

Emissions that can form particle pollution include:

- SO_2
- NOx
- VOCs
- ammonia (NH_3).

These emissions are caused by a combination of natural and human sources.

Human sources include:

- industrial and commercial activities
- road and non-road diesel vehicles (non-road diesel vehicles include bulldozers and trains)
- household activities
- hazard reduction burns.

Natural causes include:

- bushfires
- windborne dust
- sea salt spray
- emission of VOCs from vegetation
- pollen and spores from grasses, plants and trees.

Fine particles can be transported by wind and other air movement between regions.

Particle concentrations are monitored across the GMR, covering about 75% of the NSW population, and some regional centres, to measure compliance with national standards. Levels recorded in regional centres generally represent the air quality in surrounding regions. Concentrations can vary, depending on sources, regions and seasons.

Between 2015 and 2017, particle concentrations exceeded the national air quality standards on up to 20 days a year in Sydney, and up to 16 days a year in parts of regional NSW. Where an exceedance occurred on the same day in a region for both PM_{10} and $PM_{2.5}$ that day was only counted once.

For consistency in presenting trends in this report, **Figures 8.1**, **8.2**, **8.4** and **8.6** include all exceedances, including those due to exceptional events.

Changes to standards and goals

In 2016, NEPC amended the AAQ NEPM to introduce more protective standards and goals for fine particles. These were:

- adding an annual average PM_{10} standard of 25 µg/m^3
- adopting formal $PM2_{2.5}$ standards:
  - a 24-hour average standard of 25 µg/m^3
  - an annual average standard of 8 µg/m^3
- adding a goal to reduce $PM_{2.5}$standards to 20 µg/m^3 for the 24-hour average and 7 µg/m^3 for the annual average by 2025
- reporting annually from June 2018 on population exposure to $PM_{2.5}$ particles.

Before 2016, there was an allowance of five days a year when fine particles could exceed these standards. The 2016 amendment removed this allowance, but allows instead for ‘exceptional events’, such as a fire or dust storm that:

- adversely affects air quality at a specific location
- causes an exceedance that is higher than normal historical fluctuations and background levels
- is directly related to bushfires, authorised hazard reduction burning or continental-scale windblown dust.

PM_{10}

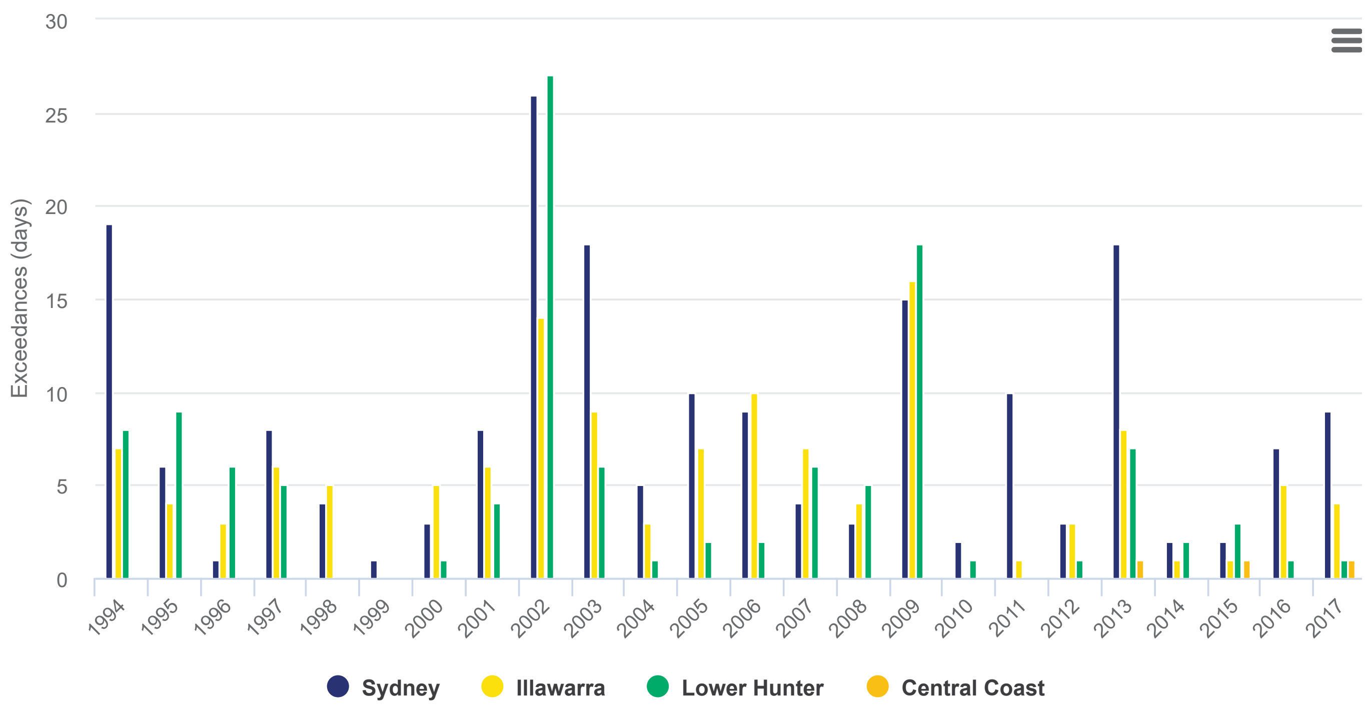
Elevated PM_{10} concentrations occur in both metropolitan and regional areas (**Figures 8.1** and **8.2**) and vary from year to year.

The greatest number of days with PM_{10} levels above the 24-hour standard occurred between 2002 and 2009 when NSW experienced prolonged dry conditions during the Millennium Drought. The drought ended with the arrival of wet La Niña conditions in 2010 and 2011.

Bushfires, hazard reduction burns and dust storms have also contributed to variations in PM_{10}. **Figures 8.1** and **8.2** show the impacts of:

- bushfires in 1994 and 2001–2003 in Sydney and the Hunter region respectively
- bushfires in 2006–2007 across western NSW
- major statewide dust storms in September 2009
- hazard reduction burns in 2011 in Sydney
- a NSW bushfire emergency in late 2013
- bushfires in November 2016
- hazard reduction burns in Sydney in May 2016 and August 2017.

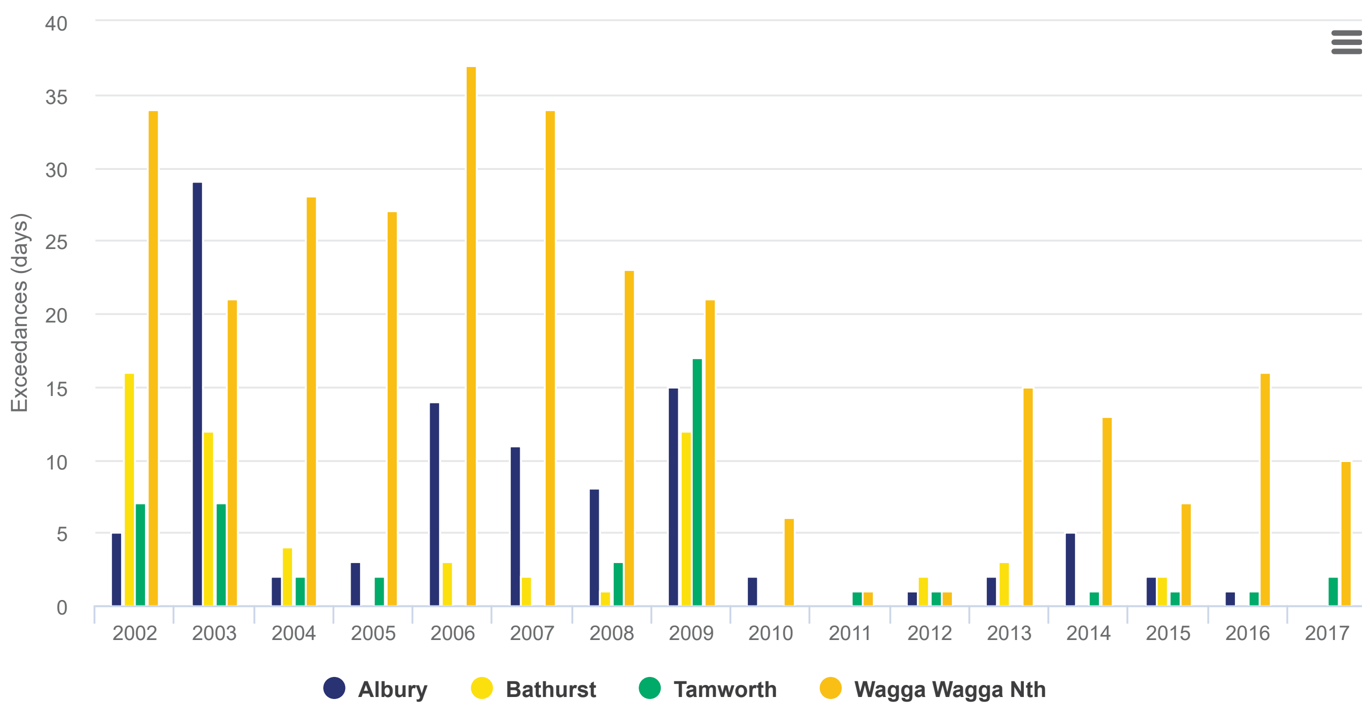
Figure 8.1: Number of days the AAQ NEPM 24 hour standard for particles (PM_{10}) was exceeded in the Sydney GMR



Notes:
To ensure consistency in presenting trends, this chart includes all exceedances, including those due to exceptional events.
PM_{10} monitoring commenced at the Central Coast in 2012.

Source:
OEH air quality monitoring data

Figure 8.2: Number of days the AAQ NEPM 24 hour standard for particles (PM_{10}) was exceeded in NSW rural centres



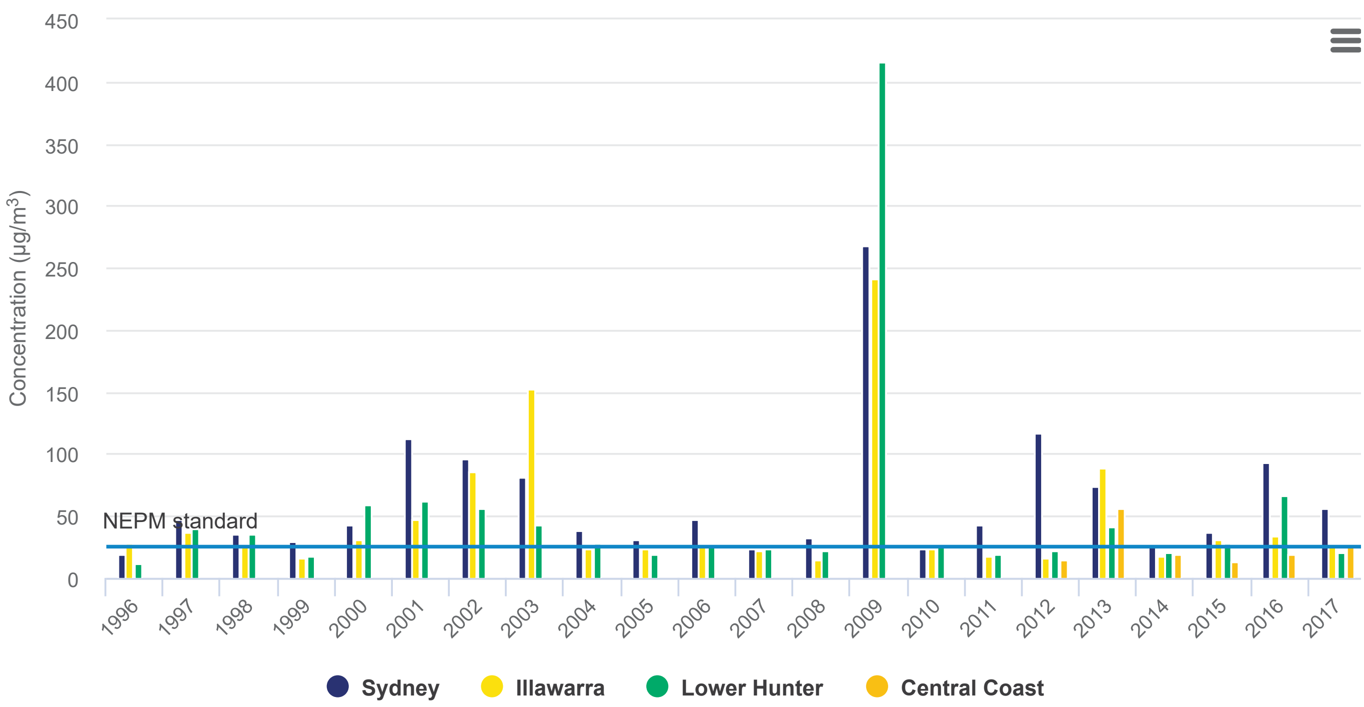
Notes:
To ensure consistency in presenting trends, this chart includes all exceedances, including those due to exceptional events. PM_{10} monitoring in rural centres was limited before 2002.

Source:
OEH air quality monitoring data

$PM_{2.5}$ (fine particles)

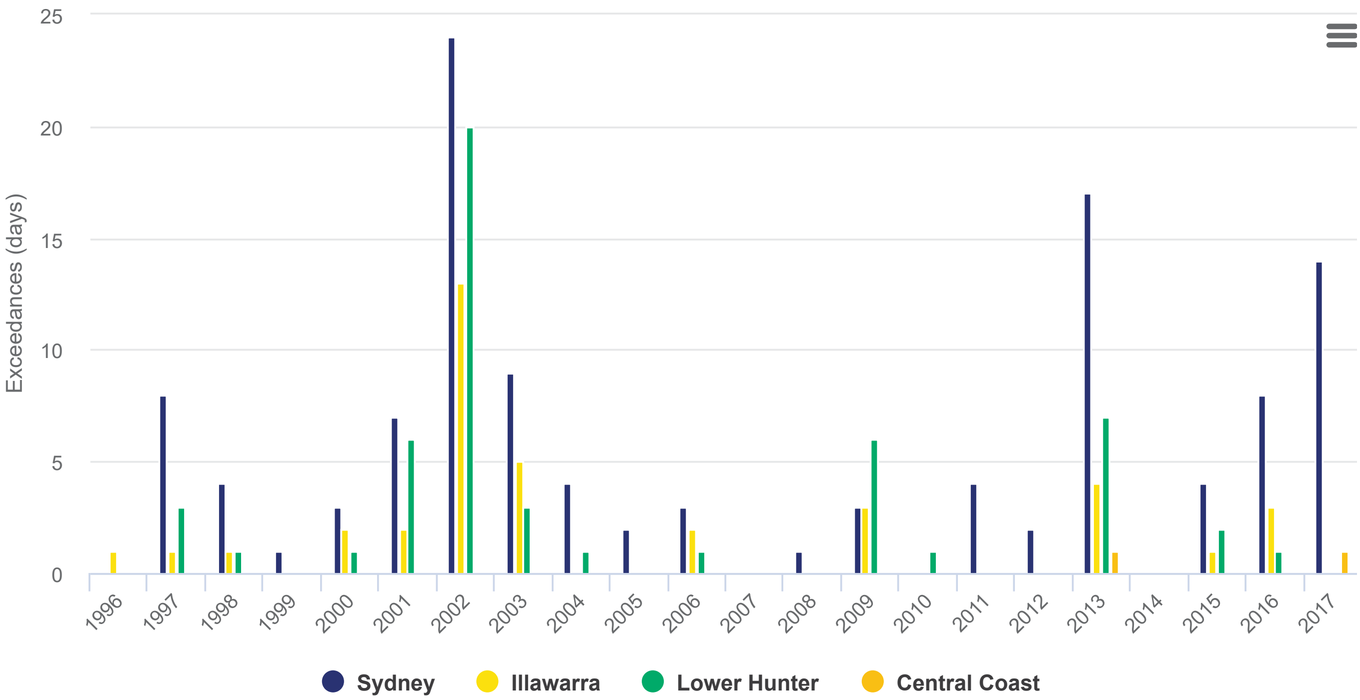
Monitoring results for $PM_{2.5}$ include fine particle pollution caused by dust storms, bushfires and hazard reduction burns. **Figure 8.3** shows spikes related to large-scale, drought-related dust storms in 2003 and 2009. The spikes in 2013 and 2016 were related to bushfires and hazard reduction burns.

Figure 8.3: Annual maximum 24 hour average concentrations for particles ($PM_{2.5}$) in the Sydney GMR



Source:
OEH air quality monitoring data

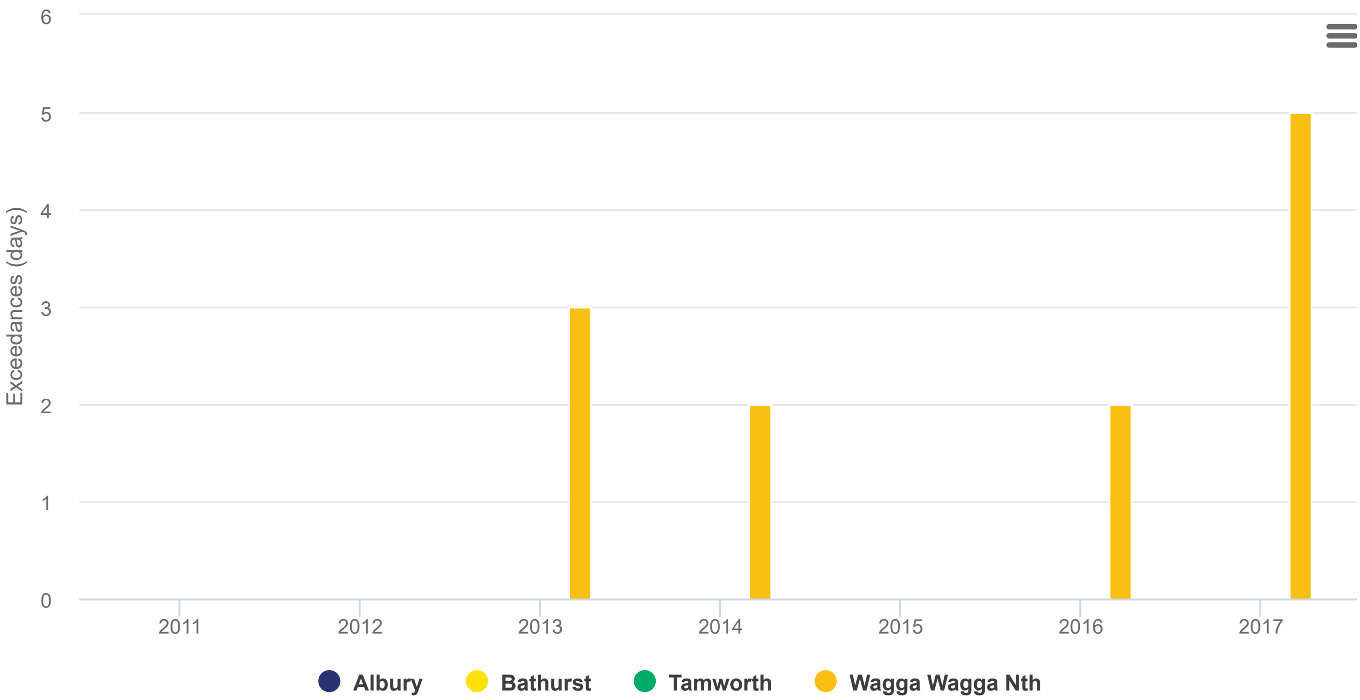
Figure 8.4: Number of days the AAQ NEPM 24-hour standard for particles ($PM_{2.5}$) was exceeded in the Sydney GMR



Notes:
To ensure consistency in presenting trends, this chart includes all exceedances, including those due to exceptional events.

Source:
OEH air quality monitoring data

Figure 8.5: Number of days the AAQ NEPM 24-hour standard for particles ($PM_{2.5}$) was exceeded in NSW regional centres



Notes:
$PM_{2.5}$ monitoring commenced in 2011 at Wagga Wagga North, in 2016 at Bathurst and Tamworth, and in 2017 at Albury. Agricultural stubble burning in the Wagga Wagga region contributed to particle exceedance days.
There were no exceedance days recorded in 2011, 2012 or 2015.
To ensure consistency in presenting trends, this chart includes all exceedances, including those due to exceptional events.

Source:
OEH air quality monitoring data

Ozone

Ozone ($O_{3)}$ is present in both the upper atmosphere (stratosphere) and the lower atmosphere (troposphere). The 'ozone layer' in the stratosphere protects all life forms by reducing the intensity of the sun's damaging ultraviolet radiation.

Stratospheric ozone is not a pollutant. In contrast, tropospheric ('ground-level') O_3 is an air pollutant that is harmful to human health and the environment (WHO 1998).

O_3 is formed when the precursors NOx and VOCs react to produce smog during warm, sunny weather when wind speeds are low. Bushfires can contribute significantly to high O_3 concentrations.

Ozone precursors can be emitted from human activities or natural sources such as vegetation. Human sources include:

- motor vehicle exhaust and evaporative emissions,
- household and commercial solvent emissions
- industrial emissions.

O_3 is only measured at sites in Sydney, the Lower Hunter region, the Illawarra region, and on the Central Coast, as high ozone concentrations are not likely to be experienced at other centres due to fewer traffic, commercial and industrial emissions of NOx and VOCs.

Elevated ozone concentrations tend to occur during warmer months, so are likely to be exacerbated by future climate change (DECCW 2010).

While all parts of Sydney can experience O_3 concentrations above the AAQ NEPM standards, the west and south-west are more exposed to high levels (DECCW 2010), due to summertime patterns of atmospheric circulation in the Sydney Basin, when sea breezes carry O_3 and its sources NOx and VOCs to this area (Jiang et al. 2016, 2017).

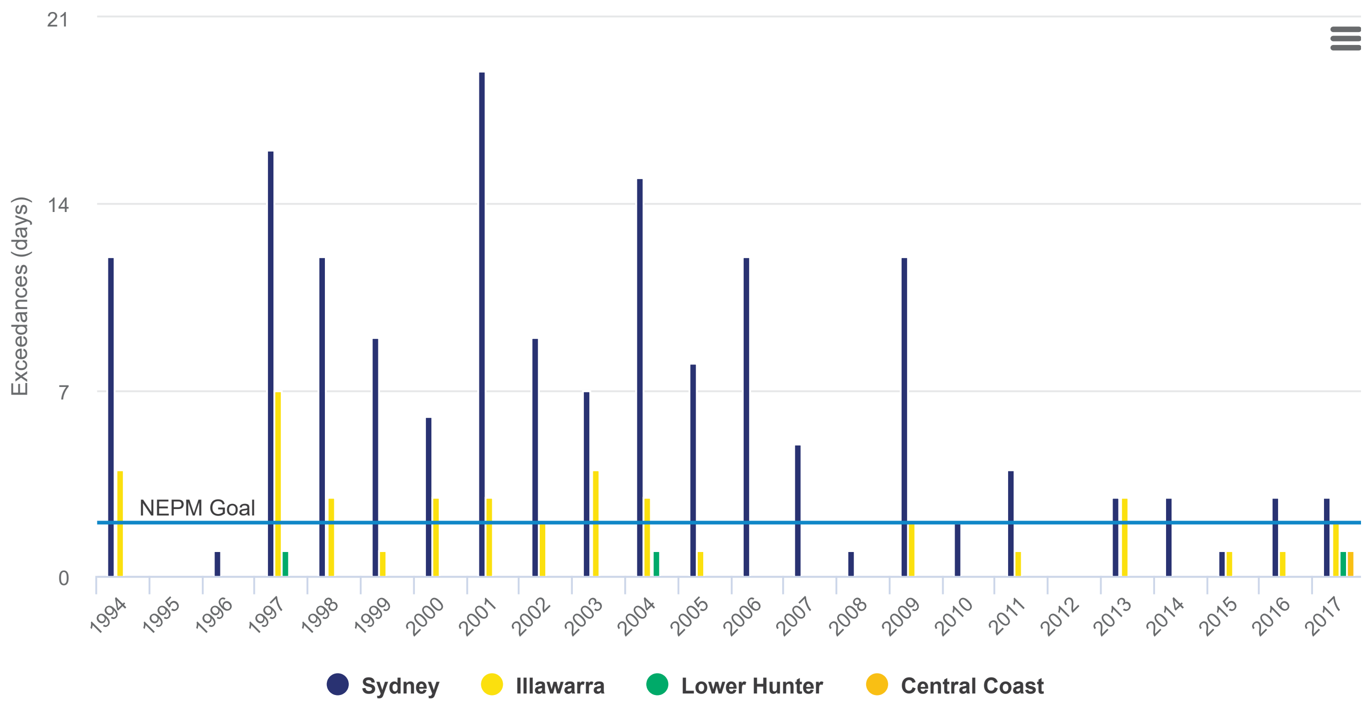
The AAQ NEPM sets two standards for ozone:

- a one-hour standard of 0.10 parts per million (ppm)
- a rolling four-hour standard of 0.08 ppm.

The AAQ NEPM goal for ozone stipulates a maximum allowable exceedance of one day per year for each standard (see **Table 8.1**).

Sydney has exceeded one or both ozone standards on at least one day every year since 1994 (see **Figures 8.7** and **8.8**).

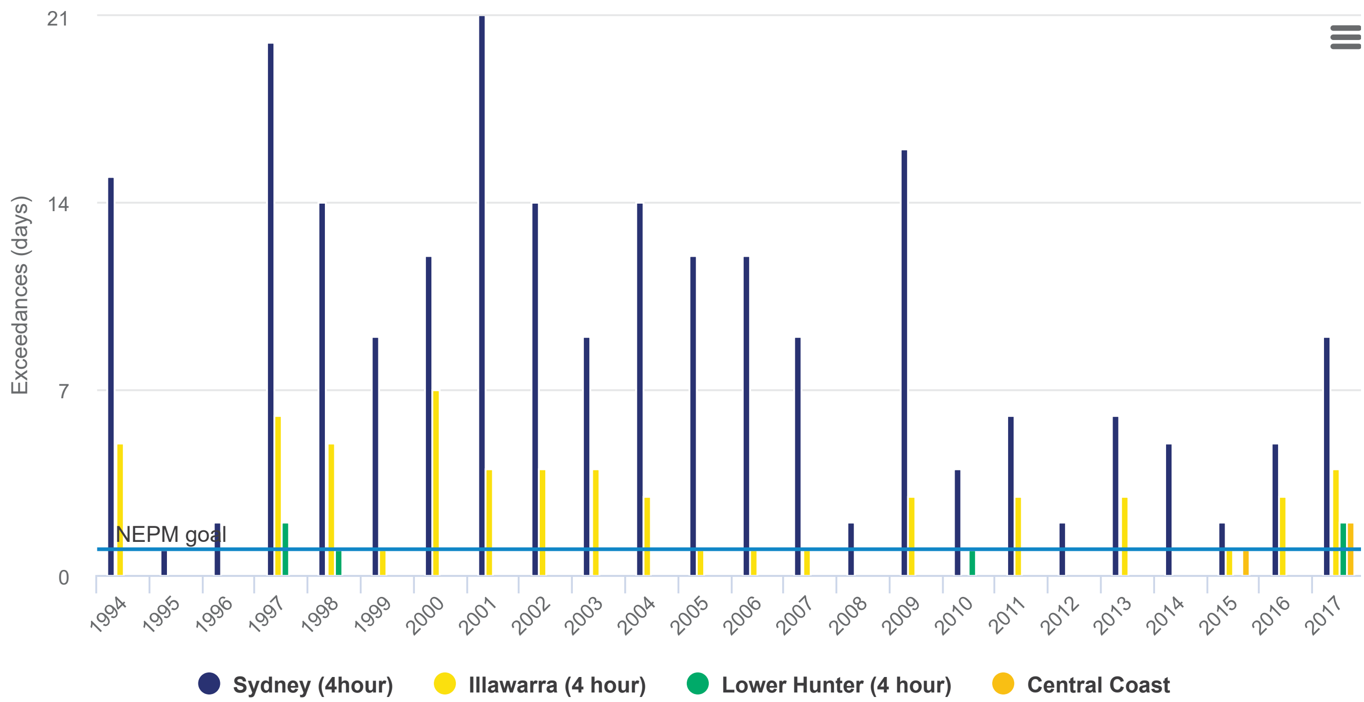
Figure 8.6: number of days the one-hour AAQ NEPM standard for ozone was exceeded in the Sydney GMR



Notes:
A day is counted only once per region, even if exceedances occur at multiple monitoring sites on that particular day.

Source:
OEH air quality monitoring data

Figure 8.7: number of days the four-hour AAQ NEPM standard for ozone was exceeded in the Sydney GMR



Notes:
A day is counted only once per region, even if exceedances occur at multiple monitoring sites on that particular day.

Source:
OEH air quality monitoring data

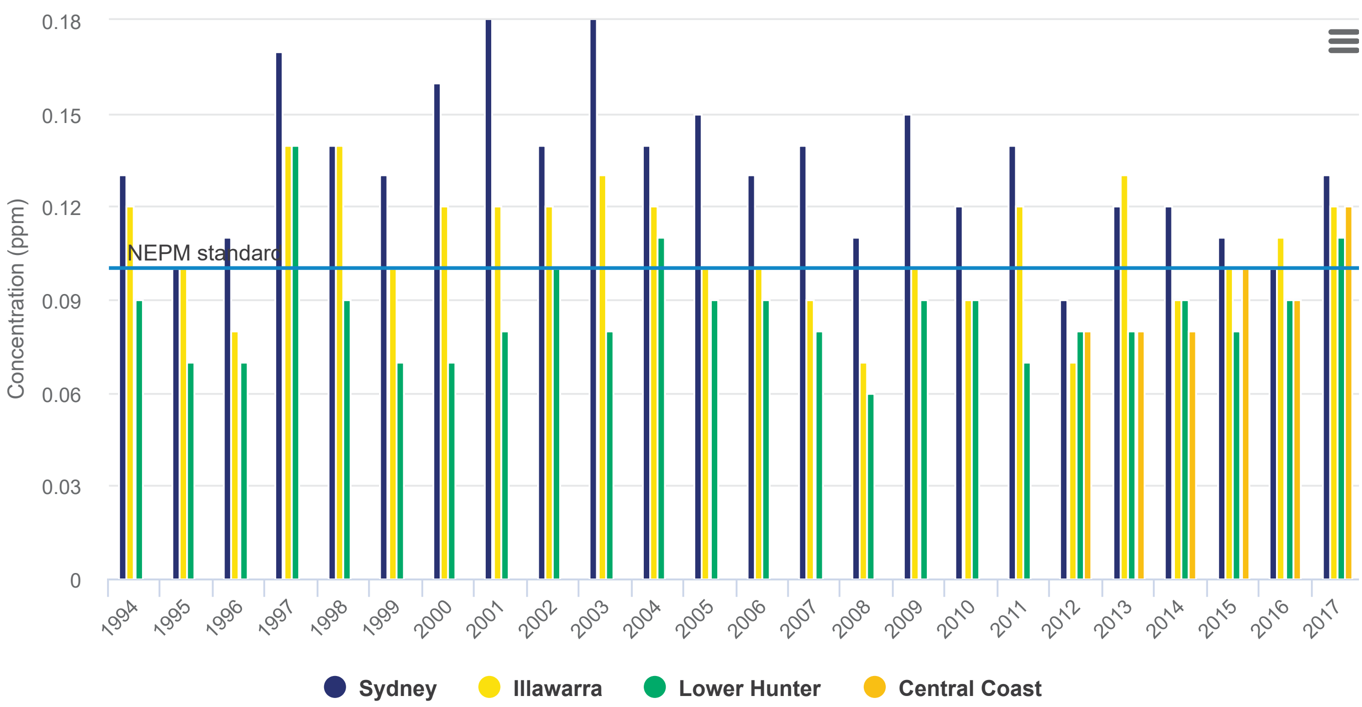
Since 1994, ozone concentrations in Sydney have exceeded the one-hour standard on up to 19 days per year and exceeded the rolling four-hour standard on up to 21 days per year.

- In Sydney, between 2015 and 2017, ozone concentrations exceeded the standards on up to nine days a year.

- In the Illawarra region, ozone concentrations exceeded both standards on up to seven days per year, in 60% of the years recorded.
- In the Lower Hunter region, neither standard has been exceeded on more than two days a year since 1994.

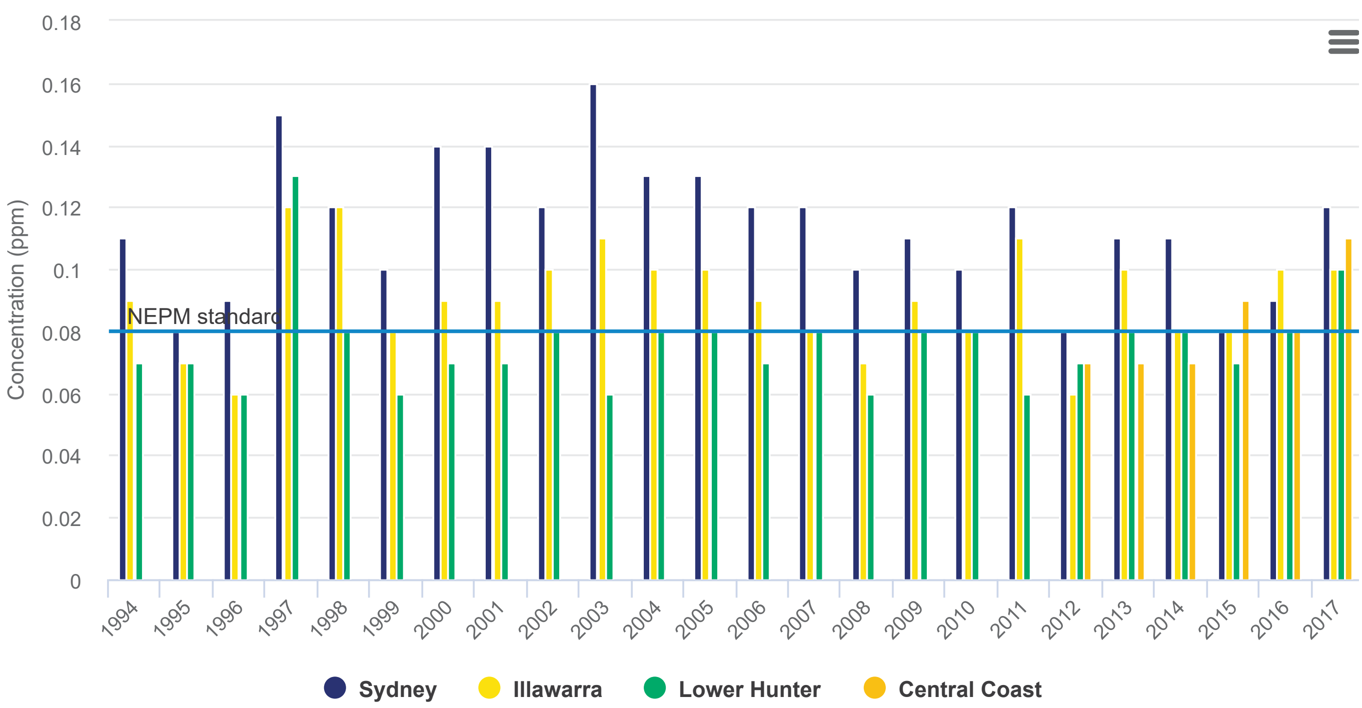
Figures 8.8 and **8.9** show the maximum recorded concentrations of ozone for each region from 1994 to 2017. These have been highest in Sydney and lowest in the Lower Hunter region.

Figure 8.8: Annual maximum one-hour-average concentrations for ozone in the Sydney GMR



Source:
OEH air quality monitoring data

Figure 8.9: Annual maximum four-hour-average concentrations for ozone in the Sydney GMR



Source:
OEH air quality monitoring data

Reasons for the standard being exceeded

The number of days when ozone standards are exceeded in a year depends on meteorological conditions and the presence of precursor emissions (NOx and VOCs). For example, high temperatures and intense sunlight can cause chemical reactions between NOx and VOCs, forming ozone from motor vehicle, household, commercial and industrial emissions. Bushfires and hazard reduction burns also contribute to ozone exceedances, with high concentrations of NOx and VOCs occurring in smoke plumes. (DECCW 2010, Jiang et al. 2017).

Air Toxics NEPM pollutants

In 2004 NEPC established the National Environment Protection (Air Toxics) Measure (Air Toxics NEPM) to help manage toxic air pollutants, namely:

- benzene
- toluene
- xylenes
- formaldehyde
- benzo(α)pyrene (BaP).

NSW previously achieved the NEPM requirement to estimate human exposure to the five NEPM air toxics using a consistent national framework. The most recent ambient air toxics monitoring (NEPC 2010, Tables 1–5) shows that concentrations of all these pollutants were well below investigation levels that would trigger the NEPM requirement for ongoing monitoring.

Indoor air quality

Significant indoor air pollutants include:

- emissions from building furniture and fittings and chemical cleaning products
- biological contaminants such as pet hair, skin and saliva, dust mites and mould spores
- dust and lead particles disturbed by renovations (in older buildings)
- ambient air pollution, particularly fine particles and gases, infiltrating from outdoors (Sheppeard et al 2006).

Poor indoor air quality in NSW homes is also caused by:

- secondary tobacco smoke and emissions from wood heaters
- emissions from gas stoves and unflued gas heaters.

The most recent data shows a decline in:

- the use of solid fuelwood heaters as the main source of heat in NSW homes from 13.7% in 2008 to 10.2% in 2014 (ABS 2014)
- secondary tobacco smoke as a contributor to poor indoor air quality in NSW – in 2016, 94.3% of NSW households were smoke-free, compared to 79.4% in 2002 (Centre for Epidemiology and Evidence 2018).

NSW Health's Indoor Air Pollution web page provides additional information (NSW Ministry of Health 2015).

Pressures

Pollutants

Pollution sources

The air pollutants of ongoing concern for NSW air quality are ozone and particles, especially fine particles ($PM_{2.5}$), due to their more significant impacts on human health. Occasionally, national air quality standards continue to be exceeded for ozone and particle pollution, and health effects are known to occur even at concentrations that are within national standards.

Sources of primary particles which are released directly into the air, and sources of precursor pollutants for secondary particles (formed in the air) and ozone, are therefore a focus in NSW.

For information on ozone, and its main precursors oxides of nitrogen (NOx) and volatile organic compounds (VOCs), see the Ozone section in 'Status and trends'.

For information on particle and fine particle pollution, see the Particles section in 'Status and trends'.

Recent research findings

Airborne particles in Sydney

Studies into the sources of airborne particles conducted in Sydney have found (Cope et al.2014; Cohen et al. 2016):

- wood smoke, mainly from residential wood heating, contributes significantly to fine particle pollution in autumn and winter, particularly in western Sydney
- the contribution of motor vehicle emissions to $PM_{2.5}$ concentrations reduced between 2000 and 2014, but remains a significant source of fine particles
- secondary sulfate particles from SO_2 emissions from sources such as power generation, industry and motor vehicles contribute significantly to fine particle pollution, especially in summer
- organic matter in summer and autumn, and sea salt in summer, are large sources of $PM_{2.5}$
- major sources of secondary organic particles in the air include VOCs from vegetation in summer and wood heaters in autumn and winter.

Airborne particles in the Hunter region

Studies of sources of airborne particles in the Lower and Upper Hunter regions have found:

- dominant sources of $PM_{2.5}$ in Muswellbrook and Singleton included wood smoke, vehicle emissions and industrial emissions from power stations – fine particle pollution was higher in winter, due to wood fires used for residential heating (Hibberd et al. 2013)
- main sources of $PM_{2.5}$air pollution in the Lower Hunter region included motor vehicle emissions; wood smoke; industrial and shipping emissions; soil and sea salt
- sources of precursor pollutants contributing to fine particle pollution included SO_2 from fossil fuel burning, ammonia from industry, vehicles and agriculture, and NOx from vehicles, industry and off-road equipment (Hibberd et al. 2016)

- the larger particles of visible black dust found on inner city surfaces were made up of soil particles (approximately 69%), coal dust (around 10%), rubber particles (4%) and soot (3%), with the remaining 14% from other sources (AECOM 2016).

As well as being the largest source of particles in the Sydney region and contributing significantly to particle pollution in the Hunter, wood smoke contains other air pollutants such as carbon monoxide, oxides of nitrogen, and a range of organic compounds, some of which are toxic or carcinogenic (e.g. benzo(α)pyrene and benzene).

The NSW GMR Air Emissions Inventory for 2008 (EPA 2012a), found that emissions of key air pollutants were decreasing in Sydney despite increases in population and other drivers. However, emissions of NOx and PM_{10} were increasing – see State of the Environment 2012 (EPA 2012b).

Climate change

Temperatures in NSW are approximately one degree Celsius above pre-industrial times and are projected to further rise over the 21st century (BoM 2018). Future trends in rainfall are not known, given uncertainties in the modelling of clouds and convection.

The relationship between climate change and air quality is complex. While there may be decreases in some types of emissions, such as wood smoke, and NOx from vehicles, due to higher than average temperatures, chemical and temperature changes in the atmosphere may lead to increases in key air pollutants. This will influence the formation of ozone and secondary particles ($PM_{2.5}$).

Events such as droughts and bushfires, which may become more frequent with climate change, may also increase air pollution (OEH undated, OEH 2014a). For example, the frequency and severity of dust storms increases with the frequency of droughts (Speer 2013).

Warmer temperatures and increased carbon dioxide levels are associated with higher pollen production and mould growth, leading to higher levels of airborne allergens (Katelaris and Beggs, 2018). Changing weather patterns may also result in an increase in unusual storms that trigger asthma in some people (ASCIA 2016, Asthma Australia).

Research into the interactions between climate change and air quality is ongoing. Sources include Adapt NSW, Cope et al 2008, DECCW 2010, Jacob & Winner 2008, Lacressonnière et al 2014, Pfister et al 2014, Walsh 2008.

See also the Climate Change and Greenhouse Gas Emissions topics

Population

The NSW population is projected to grow to 9.9 million people by 2036 (NSW Department of Planning and Environment, 2018). Increased residential and commercial development and higher population density in cities mean that more people will be exposed to air pollution, due to:

- expanded transport infrastructure and increased development along transport corridors
- increased economic activity from industries such as mining, shipping and freight
- increased household emissions, for example, from wood heaters and household chemical products
- new developments exposed to smoke from hazard reduction burns and bushfires
- higher population densities leading to increased air pollution from traffic and increased emissions from households.

Older people are particularly vulnerable to the health impacts of air pollution. This is of concern given the increasing proportion of people over the age of 65 in NSW.

See also the Population topic

Transport

In the Sydney region, motor vehicles are a significant source of ozone precursor emissions (NOx and VOCs), and particle pollution. In 2016–17, Sydney residents made 18.6 million trips each weekday, 69% of which were by car (TfNSW 2018).

The 2008 NSW GMR Air Emissions Inventory showed that in the Sydney region, motor vehicles accounted for:

- 62% of anthropogenic NOx emissions
- 24% of VOCs
- 14% of as $PM_{2.5}$ fine particle pollution.

In 2015–16, transport was responsible for an estimated 20.8% of greenhouse gas emissions in NSW (Commonwealth of Australia 2018).

Ships and diesel locomotives are other sources of particles and NOx that contribute to air pollution affecting some NSW regions and communities.

See also the Transport topic

Responses

Legislation and policy

The *Protection of the Environment Operations Act 1997* (POEO Act), the POEO (Clean Air) Regulation 2010 and POEO (General) Regulation 2009 set the framework for managing air pollution from major industry in NSW. These controls also help reduce localised emissions of air toxics and include provisions for managing emissions from commercial and domestic sources, such as wood smoke and open burning.

The National Clean Air Agreement enables governments to reduce air pollution and improve air quality through cooperative action with industry at national, state and local levels. Completed actions include implementation of:

- strengthened air quality reporting standards for particles
- new emission standards for non-road petrol engines
- tighter wood heater emissions and efficiency standards.

Legislative changes

Wood smoke: The EPA administers wood smoke regulations in NSW and works with industry, other Australian jurisdictions and the Commonwealth Government to improve standards for heating appliances. In 2016, the NSW Government adopted a regulatory amendment requiring all new wood heaters sold in NSW to comply with updated national emission and efficiency standards. EPA audit programs help ensure wood heaters offered for sale meet these standards.

Tobacco smoke: The Smoke-free Environment Regulation 2016 strengthens the Smoke-free Environment Act 2000, while the NSW Tobacco Strategy 2012–2017 (NSW Ministry of Health 2012) provides an overarching framework for reducing smoking and tobacco-related harm in NSW.

Smoking is now banned in all enclosed public places and commercial outdoor dining areas, as well as in motor vehicles when children under 16 are present.

In NSW, 9 out of 10 adults now live in a smoke-free home.

Product emissions: The Commonwealth Product Emissions Standards Act 2017 sets national maximum emission limits for specified new products sold in Australia. Emissions-controlled products covered by the Act include new outdoor power equipment such as gardening equipment and outboard motors.

Standards

Fine particles: In February 2016 a variation to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) commenced which:

- formally adopts fine particle ($PM_{2.5}$) standards, and
- adds an annual average PM_{10} standard of 25 µg/m^3.

The revised national standards for $PM_{2.5}$ are more health protective than World Health Organization guidelines and are the most health protective $PM_{2.5}$ standards in the world. The national review was led by the NSW Government.

For more information on the variation to the particles standards see Changes to standards and goals in the Particles section.

Managing Particles and Improving Air Quality in NSW (EPA 2013) explains the management of particle pollution in NSW and provides a set of principles and actions to reduce particle emissions.

National review of vehicle and fuel emissions: The Commonwealth Government manages fuel quality and vehicle emission standards for new road vehicles. These standards are being reviewed. The NSW Government's 2017 submissions to the Australian review supported the early introduction of stricter national standards that would:

- meet international best practice (Euro 6/VI) emission standards for light and heavy-duty vehicles
- introduce low sulfur (10ppm) petrol to maximise environmental and human health benefits.

Cruise ships: The Commonwealth Government regulates fuel used for all ships, including cruise ships, in Sydney Harbour and regional NSW ports. In December 2016, following NSW Government and community representations, the Australian Government introduced requirements for cruise ships to use low sulfur fuel (0.1% or less) while at berth in Sydney Harbour.

From January 2020, the International Maritime Organization will reduce the global sulfur cap from 3.5% to 0.5% for fuel and this will be the minimum requirement for all shipping.

Policy

The NSW Government Resource Efficiency Policy (GREP) (OEH 2014b) sets minimum emissions standards for mobile non-road diesel plant and equipment, such as construction equipment, purchased by NSW Government agencies. Minimum standards applied from January 2015 and were tightened in January 2018. The GREP requires agencies to:

- collect information from construction project contractors on their equipment

- include a weighting for lower-emission machines in their tender processes
- use low volatility paints and surface coatings that comply with the Australian Paint Approval Scheme, where fit for purpose.

OEH is currently conducting a review of the GREP to:

- analyse whole-of-government progress in implementing the GREP
- identify challenges agencies faced in adopting the GREP
- determine if reforms are required.

Diesel emissions: The Diesel and Marine Emissions Management Strategy (EPA 2015) aims to improve air quality and public health in NSW by reducing harmful emissions from non-road diesel and marine sources, such as shipping, equipment used in coal mines, locomotives, and industry activities licensed by the EPA.

Climate change: Policies to reduce greenhouse gas emissions in sectors such as transport and energy can also reduce air pollution. For example, NOx is both a greenhouse gas and a contributor to photochemical smog, so strategies to reduce NOx pollution will both improve air quality and reduce greenhouse gas emissions.

See responses section in Energy Consumption, Climate Change, Greenhouse Gas Emissions and Transport topics.

Programs

Monitoring NSW air quality

Monitoring air quality, conducting research, and regional airshed modelling provide a sound evidence base for developing and implementing air quality policies and programs. OEH monitors air quality in NSW and data is publicly reported. Full details are available on the OEH website. See also 'Status and trends'.

Informing the public: OEH provides up-to-date air quality information, forecasts and alerts online, via SMS and email. This information allows communities to know about local air quality, engage in informed discussions on air quality issues, and manage their exposure when pollutant levels are high.

The EPA's Air Emissions in my Community web tool, released in 2013 and upgraded in 2018, provides community access to information on air pollution sources in local areas within the GMR. The tool presents aggregated data and charts for different geographic areas including by local government area and by postcode.

Controlling transport emissions

Key initiatives to reduce emissions and improve health and liveability include requiring vapour recovery technology to capture VOC emissions from service stations across the Sydney, Wollongong, Central Coast and Newcastle metropolitan areas. Data from 2016–17 showed that:

- 92% of service stations required to install vapour recovery technology at the bowser for refuelling vehicles had done so
- 98% of service stations required to install technology to recover vapours when refilling underground storage tanks were compliant.

It is estimated that vapour recovery controls will eliminate more than 5,000 tonnes of VOC emissions per year when fully implemented.

Another key achievement has been limiting the volatility of petrol supplied in Sydney from 15 November to 15 March each year to 62 kilopascals, with petrol importers and blenders required to test batch volatility and report to the EPA.

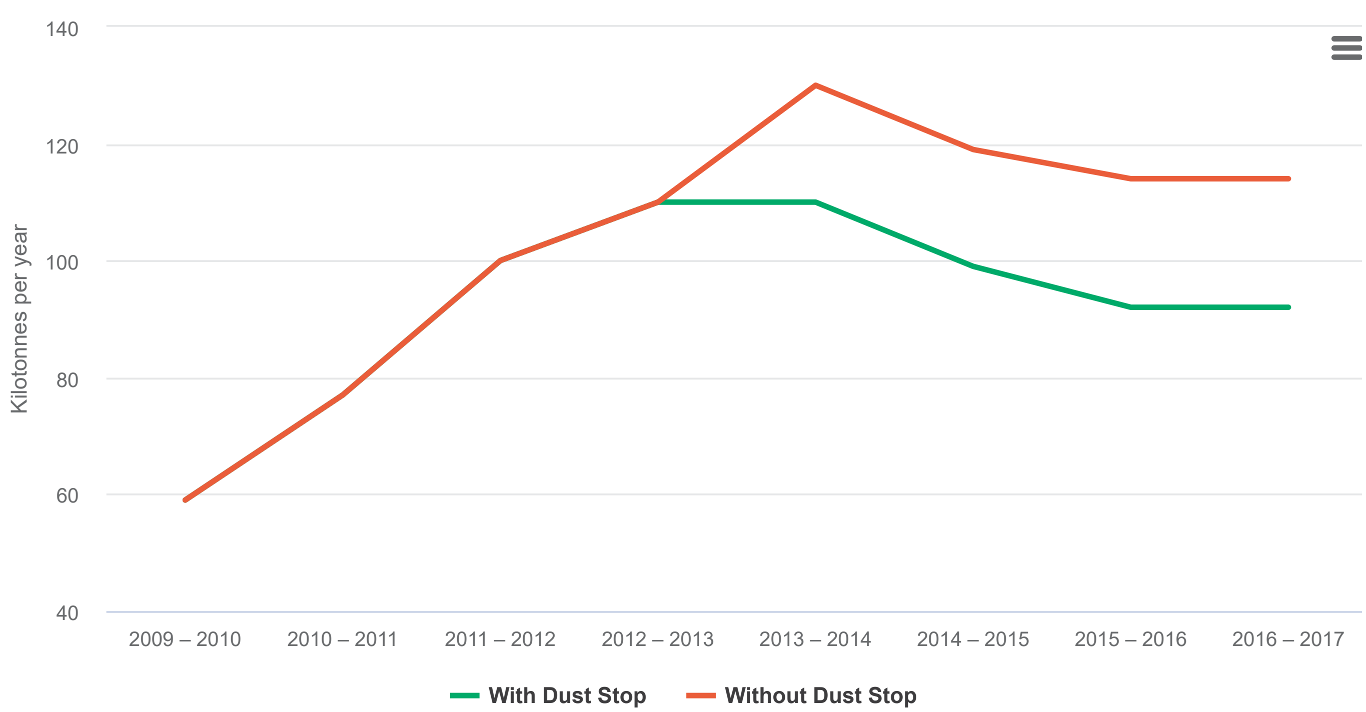
Controlling industrial emissions

The EPA reduces industrial emissions through licensing, regulation and working in partnership with industry stakeholders on strategies to improve air quality.

Air quality impact assessment: in 2017, the EPA updated the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA 2016b) to include particle assessment criteria consistent with the 2016 revisions to the AAQ NEPM standards.

Mining and transport of coal: between 2012 and 2017, coal mine particulate emissions were reduced by about 22,000 tonnes per year. In 2016, the EPA's Dust Stop program required key coal mines to stabilise excessive areas of land exposed to wind erosion, reducing annual particulate emissions by a further 2,000 tonnes. The practices implemented through the Dust Stop program are now part of standard mining operations throughout NSW.

Figure 8.10: Dust Stop program – Reduction in PM_{10} emissions (tonnes)



Source:
EPA Dust Stop program

The Upper Hunter Valley dust risk forecasting system: From September to November 2017, the NSW Government trialled an Upper Hunter Valley Dust Risk Forecasting System. The system predicted weather that would increase dust generation, so mines could take extra precautions at those times. During the trial, the EPA required mines to record the mass of material moved each day. The EPA and OEH are now completing analysis of the results and considering the next steps in consultation with stakeholders.

Monitoring lead levels at Broken Hill: In 2016, the NSW Government commissioned monitoring of airborne lead levels at Broken Hill as part of the Broken Hill Environmental Lead Study. The monitoring aimed to identify sources of lead pollution related to mining and smelting and determine the effectiveness of remediation works.

The study was a partnership between the NSW Government and Macquarie University to:

- monitor airborne and deposited lead
- assess current mining emissions
- assess legacy emissions, where lead has been resuspended from areas affected by past activities.

Controlling commercial and domestic emissions

Wood smoke program: The EPA supports councils across NSW in managing wood smoke through periodic Wood Smoke Reduction Programs and providing community educational materials for use by councils. Social research undertaken for the EPA (Databuild 2016) identified lack of awareness of wood smoke impacts on health as the key barrier to changing people's wood heater use.

In 2017, the EPA developed a new suite of wood smoke awareness materials, which was trialled by the Upper Hunter councils of Muswellbrook and Singleton before being rolled out to councils across NSW for the winter of 2018. The local community education campaign materials are available on the EPA website.

Managing indoor air quality

Heating in schools: NSW schools and school buildings built since 2012 are no longer fitted with unflued gas heaters. Existing unflued heaters are replaced with flued gas heaters when they reach the end of their serviceable life or a school requires a heating upgrade. Schools in colder areas are prioritised for heater replacement as it is less practical for those schools to leave windows open in winter for ventilation (NSW Department of Education 2016).

Building rating schemes: The National Australian Built Environment Rating System (NABERS) is a national rating system administered by OEH on behalf of all states, territories and the Australian Government. NABERS provides tools to rate the environmental impact of commercial building operations (office buildings, shopping centres, hotels, data centres and hospitals).

The NABERS Indoor Environment (IE) certification scheme assesses the quality of the indoor environment and includes an assessment of the building's capability to provide fresh air indoors and control the concentration of indoor pollutants, including particulate matter.

As of March 2018, 126 NSW buildings had been certified with NABERS indoor environment ratings, out of 297 buildings certified nationally.

Green Star certification, administered by the Green Building Council of Australia, also includes air quality measures for rating indoor environments. Where a building has completed a NABERS Indoor Environment rating, the rating contributes to the *Green Star – Performance* certification.

For more information about NABERS see the Energy Consumption topic.

Future opportunities

Emissions control

Current emission control measures being progressed under the National Clean Air Agreement include:

- reviewing the reporting standards for sulfur dioxide, nitrogen dioxide and ozone under the AAQ NEPM
- evaluating the potential for a national approach to manage non-road diesel engine emissions (Commonwealth and NSW governments are co-leading this project).

Cross-agency and community collaboration

In 2016 and 2017, the EPA consulted widely on air quality issues and potential new control measures, through the Clean Air for NSW Consultation Paper (EPA 2016a) and Clean Air Summit. There is ongoing engagement of stakeholders, councils and communities regionally through Community Consultative Committees, for example those in Newcastle and the Upper Hunter, as well as targeted stakeholder engagement on specific air issues and projects.

The EPA-led Interagency Taskforce on Air Quality in NSW considers whole-of-government approaches to existing and emerging air quality issues and collaborates with the EPA and OEH on air quality management and communication.

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Land

The State of the Environment Report — 2018

NSW EPA

www.soe.epa.nsw.gov.au

Soil Condition

Healthy soil resources support natural ecosystems, provide essential ecosystem services and the productivity that enables our agricultural industries to prosper.

Summary

Soil acidification

~20%

of modified agricultural land in NSW (excluding rangelands) is at high risk of acidification

Read more

Loss of soil organic carbon

12.6%

of natural carbon stocks have been lost across NSW

Read more

While most soils are in a moderate condition, some parts of the State have suffered a greater decline in condition than others and display a significant loss in their ability to deliver ecosystem services.

Much of the change in soil condition has occurred over longer timeframes, largely reflecting historical losses due to the lack of knowledge earlier about managing soils sustainably in Australian conditions.

More recently, the increasing intensity of land use, climate variability and extreme weather events are greater risk factors in maintaining soil condition.

On a statewide level, the increasing acidification of agricultural soils due to the intensification of land use continues to be the land degradation issue that contributes most to ongoing declines in soil condition and productivity across NSW.

Other factors such as decline in soil organic carbon, salinisation and loss of topsoil due to hillslope and wind erosion are still of concern, but appear to be stable or decreasing in impact.

New conservation farming practices, such as maintenance of groundcover vegetation and reduced tillage, have helped to control erosion and maintain soil condition. The extent to which these practices improve the management of organic carbon levels and prevent acidification is less clear.

Related topics: Climate Change | Native Vegetation

NSW indicators

Indicator and status		Environmental trend	Information reliability
Soil pH (acidification)	MODERATE	Getting worse	✓✓
Organic carbon	MODERATE	Stable	✓✓
Hillslope erosion	MODERATE	Getting better	✓✓
Wind erosion	MODERATE	Getting better	✓✓
Salinisation	MODERATE	Stable	✓✓

Notes:
Terms and symbols used above are defined in How to use the report.

Context

Soils make a significant contribution to the economic prosperity and ecological integrity of the NSW environment. Healthy soils deliver essential ecosystem services, including:

- nutrient transformation and cycling
- water infiltration and filtering
- climate regulation through carbon storage and cycling
- providing habitat for biota
- supporting natural ecosystems and
- enabling farming for food and resources.

Soil is essentially a non-renewable resource, as its formation is an extremely slow process that is beyond human timeframes (Bui et al. 2010; Commonwealth of Australia 2014; Stockmann et al. 2014). Therefore, to maintain productivity and ecosystem services, soils must be managed sustainably to prevent them becoming degraded.

The consequences of most types of soil degradation, such as soil loss from accelerated erosion, dryland salinity and subsoil acidity, are long-term and often irreversible, or, and costly to reverse. While some other forms of degradation, such as nutrient decline and surface soil acidification may be remediated if addressed early, restoration is often expensive (Lockwood et al. 2003). Applying best management practices can prevent or even reverse some lesser degradation processes in rural production landscapes.

Status and Trends

Introduction

This topic describes changes in soil condition that have occurred over the past 10–15 years. It refers to six characteristics of soil condition that provide a useful description of the status and trends in soil health and land management across NSW. These soil characteristics are:

- soil pH, particularly acidification, (the lower the pH of the soil, the higher its acidity)
- soil organic carbon (SOC)
- hillslope erosion
- wind erosion
- salinisation
- acid sulfate soils (ASS).

There is a close relationship between the characteristics of soil condition and the degradation processes that result in a decline in soil ecosystem services and damage to the broader environment, as described in **Table 10.1**.

Table 10.1: Characteristics of soil condition and associated processes causing land degradation

Soil characteristic	Degradation process	Characteristics of the degradation processes
Soil pH	Acidification	Soil pH is an important chemical characteristic of soil health. Most plants and crops grow best in soils that are slightly acidic to slightly alkaline. Both strongly acidic and strongly alkaline conditions affect plant growth, but acidification is the main process of soil degradation. Acidification is generally caused by intensified land management with the associated leaching of soil nutrients and the use of acidifying nitrogen-based fertilisers.
Soil organic carbon	Loss of organic carbon	The level of organic carbon is an important determinant of soil biological health, that promotes recycling of soil nutrients and improves soil structure. A decline in organic carbon in soils is generally due to vegetation clearing and changes in land management, leading to reduced replenishment of organic matter and greater losses to the atmosphere.
Hillslope erosion	Loss of topsoil	Topsoil is the soil layer that supports most plant growth as it contains most of the nutrients and organic matter. Its structure supports root development, and the uptake of nutrients and water. Removing the topsoil harms the health of vegetation and encourages erosion. Hillslope erosion, including sheet and rill erosion, is caused by rain splash and diffuse water flows during heavy rain, with soils and their nutrients flowing into waterways, where they affect water quality and aquatic ecosystems.

Soil characteristic	Degradation process	Characteristics of the degradation processes
Wind erosion	Loss of topsoil	Wind erosion is caused by strong winds in dry conditions. Many soils have eroded in the past to the extent that the loss of topsoil has substantially impacted on productivity. Some of these areas are recovering naturally, but others require active reclamation. Wind erosion is a serious threat when soils are bare, or the groundcover falls below 50%. Reduction in groundcover is caused by poor growing conditions, clearing, overgrazing, cultivation or burning.
Soil salinity	Salinisation	Soil salinity is the accumulation of salt on or near the ground surface due to rising water tables. It is caused by land use practices that alter the hydrological balance of the landscape such as vegetation clearing, poor drainage or excessive irrigation of crops or pastures, particularly with poor quality water. Soil salinity has impacts on land and surface water quality. An excessive level of salt in soil is detrimental to plant growth and ecosystem processes.
Acid sulfate soils	Acidic water contamination	Acid sulfate soils develop in aquatic and estuarine environments containing pyrites (iron sulfide). The exposure of pyrite to oxygen through activities such as drainage, excavation and dredging leads to the generation of sulfuric acid. The soils are also often highly saline. Thus, disturbance of these soils and the release of acid solutions can cause severe problems, including degradation or loss of aquatic ecosystems and adjoining vegetation, and corrosion of building foundations and underground services.

The last consistent statewide assessment of soil condition and the extent of sustainable land management was carried out in 2008–09 through the NSW Monitoring, Evaluation and Reporting Strategy program. The final results of this assessment were reported in OEH (2014) and summarised in SoE 2015 (EPA 2015).

It found that soil condition in NSW was generally moderate. However, 74% of NSW was subject to at least one issue of some concern, with different regions associated with different soil condition issues. These outcomes demonstrated the need to manage soils sustainably, with land use practices appropriate for, and adapted to, specific sites.

The approach adopted in this report builds on the broad-scale information collected in the previous assessment (OEH 2014). Additional data has been derived from ongoing assessment programs, such as Community DustWatch, as well as satellite derived groundcover mapping and updated land use data.

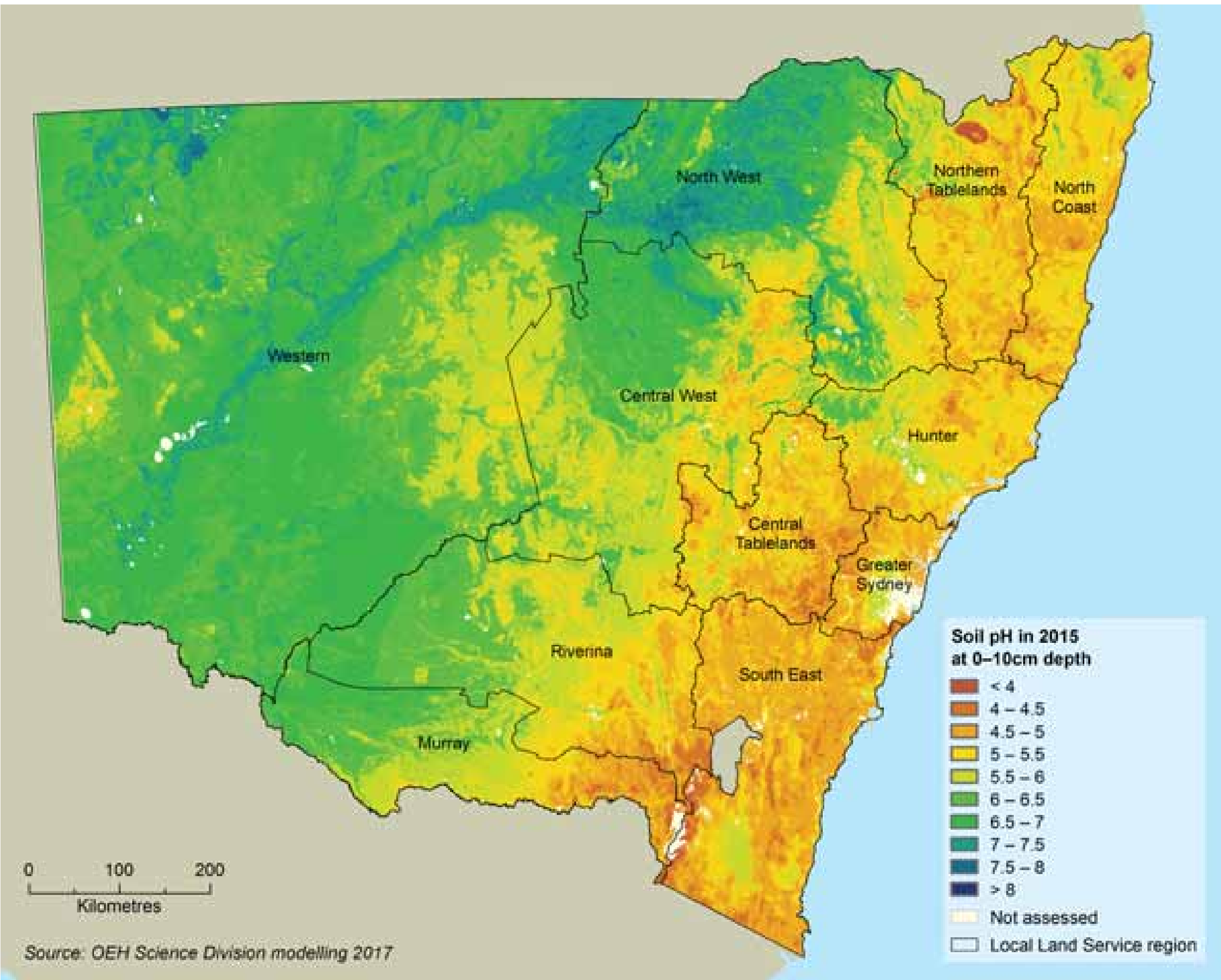
Soil pH (acidification)

Naturally occurring acidic soils are widespread over much of NSW. Acidification induced by agricultural activity exacerbates natural soil acidity and can affect the productivity of soils. The level of soil pH (acidity) is measured as the decline in pH relative to the natural pH level. This is moderate on a statewide basis, but there are significant areas where soil pH is poor. There is a statewide trend towards increasing acidification, with associated implications for agriculture.

Current pH levels in the top 10 centimetres of soil are displayed in **Map 10.1.** These were derived from modelling using a similar methodology to that described in OEH (2017).

The map displays many areas of low pH (high acidity), particularly in the eastern and central tablelands regions, tending towards more alkaline conditions in the drier western regions of the State. Acidic conditions inhibit the growth of many agricultural crops, particularly when pH falls below 4.5 (Hazelton and Murphy 2007).

Map 10.1: pH levels in the top 10 centimetres of soils in NSW, 2017

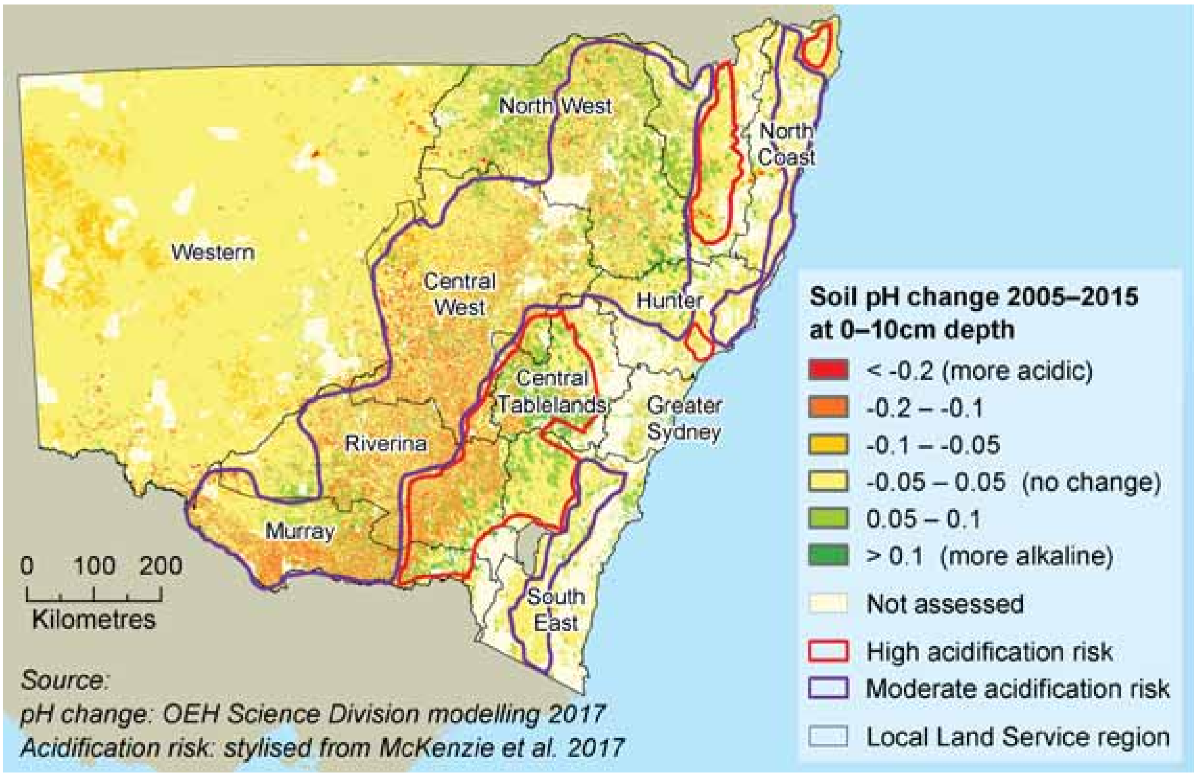


Source:
OEH Science Division modelling 2017

The change in pH levels in the top 10 centimetres of soil over the past 10 years (2005–2015) was also modelled for all agricultural areas of NSW (i.e. all land excluding nature conservation reserves and production forests). This modelling incorporated changes in land use, groundcover and 40 years of climate data, but did not consider lime application due to lack of suitable data. The results are presented in **Map 10.2.**

The map reveals a weak overall trend to more acidic soils, particularly in southern NSW.

Map 10.2: Change in pH levels for the top 10 centimetres of soil for the period 2005–15 and areas of acidification risk



Source:
pH change: OEH Science Division modelling 2017; acidification risk areas: stylised from McKenzie et al. 2017

The modelling suggests that about 11% of the State's agricultural land is becoming more acidic with declines of more than 0.05 pH units. The trend towards acidification is most evident in the Central West, Riverina and Murray Local Land Services (LLS) regions, with decreases in pH levels of as much as 0.2 pH units in many locations. Even minor declines in pH can harm crop and pasture growth, especially when pH levels are already critically low. This is particularly the case with acid sensitive crops and pastures.

Slight increases in pH levels leading to increased soil alkalinity of more than 0.05 pH units are also indicated in some central and northern regions, affecting about 6.9% of the State's agricultural land.

Mean changes in pH levels for the top 10 and top 30 centimetres of soil are presented in **Table 10.2** for all LLS regions in NSW. The highest average decline occurs in the Central West LLS region, with changes of -0.03 pH units in both soil depths.

Table 10.2: Recently modelled changes in mean pH levels, soil organic carbon and hillslope erosion by region

LLS Region	pH level (0-10 cm)	pH level (0-30 cm)	Soil organic carbon - t/ha (0-30 cm)	Hillslope erosion (% change)
Central Tablelands	0.03	0.04	-0.69	-25.04
Central West	-0.03	-0.03	0.28	5.02
Greater Sydney	0.02	0.01	0.06	-26.13
Hunter	0.01	0.00	-0.19	21.10
Murray	-0.01	0.01	-0.41	-39.54
North Coast	-0.01	-0.02	0.64	-13.25
North West	0.02	0.03	-0.61	-17.99

LLS Region	pH level (0-10 cm)	pH level (0-30 cm)	Soil organic carbon - t/ha (0-30 cm)	Hillslope erosion (% change)
Northern Tablelands	0.02	0.03	-0.39	-33.32
Riverina	-0.02	-0.01	-0.10	-38.08
South East	0.02	0.02	-0.18	-20.24
Western	-0.01	-0.02	0.60	-32.48
NSW	-0.01	-0.01	0.14	-13.51

Notes:
Changes in pH and soil organic carbon are over the period 2005–15.
Hillslope erosion percentage change is from 2015–17 relative to the average of the previous 15 years.
Negative figures for hillslope erosion describe reduced erosion levels.
The value for all NSW is not the simple average of the LLS regions, due to their differing areas.

Source:
OEH Science Division modelling 2017

The trend in pH change from 2005–2015 that is described above and shown in **Map 10.2**, should be considered in conjunction with data on current pH levels as shown in **Map 10.1**. Areas with very low pH coinciding with further declines in pH are locations of particular concern for acidification. McKenzie et al. (2017) mapped acidification risk, that is, the level of threat from further decreases in pH across Australia. Stylised areas of acidification risk in NSW as identified by McKenzie et al. 2017 are also displayed on **Map 10.2**. This analysis was based on current acidity, buffering capacity and land management pressures.

This analysis identified:

- approximately 20% of modified agricultural land (i.e. excluding rangelands) in the northern, central and southern tablelands and south-western slopes of NSW, was at high risk of serious acidification
- a further 60% of modified agricultural land was at medium risk
- seven of the 11 LLS regions had widespread acidification risk which threatens the long-term viability of agricultural businesses if left untreated.

The overlap between the areas of declining pH over the past 10 years, identified earlier, and high acidification risk, occurs over much of the Central West, Riverina and Murray LLS regions. The 2016 National SoE report (Metcalfe and Bui 2017), also reveals widespread areas across NSW with poor soil acidification, particularly in the agricultural lands of southern NSW.

Although slight when averaged across regions, the trend towards increasing acidity modelled throughout the NSW central agricultural belt over the past decade is especially a matter for management concern where those areas coincide with areas of high acidification risk.

The trend towards higher acidification associated with agriculture has been widely reported recently across NSW and Australia (Fenton and Helyar 2007; McKenzie et al. 2017).

The main reasons for increased acidification in soils used for agriculture are:

- an increase in the intensity of land use over the past 10 years, with more improved pastures and an expansion of cropping lands
- the greater removal of organic matter from the soil
- more use of nitrogenous fertilisers.

Organic carbon

The condition of soil organic carbon (SOC) content in soils across NSW is moderate, based on the extent of change in current stocks relative to natural (pre-European) stocks and the associated loss of soil quality and function. The trend for this indicator is broadly stable across NSW.

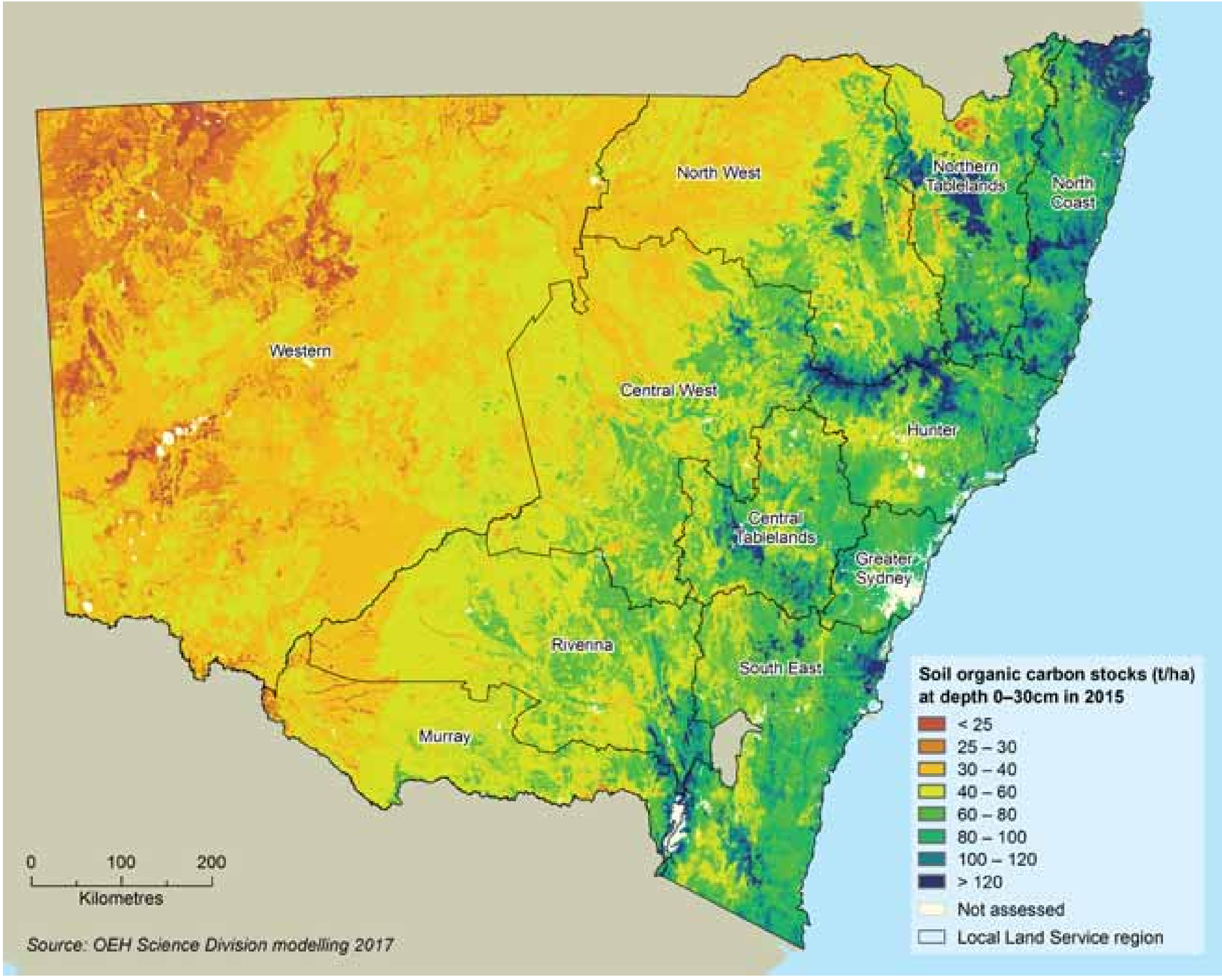
Table 10.2 displays the average levels of change in SOC by LLS region across NSW, with an overall increase of 0.14 tonnes per hectare.

Increasing SOC is associated with improved soil condition as it contributes to many desirable processes such as:

- high biological activity
- nutrient availability
- soil physical structure
- water-holding capacity and aeration (McKenzie & Dixon 2006; Baldock et al. 2012; Murphy 2015)
- offsetting atmospheric carbon levels and mitigating climate change (Wilson et al. 2011; Baldock et al. 2012).

Current SOC stocks for the top 30 centimetres of soil across NSW were derived through spatial modelling of soils using the methodology described in OEH 2017. The results are displayed in **Map 10.3**. SOC stocks vary across NSW, with generally lower levels in western regions of the State, primarily due to the drier climate (Gray et al. 2015b).

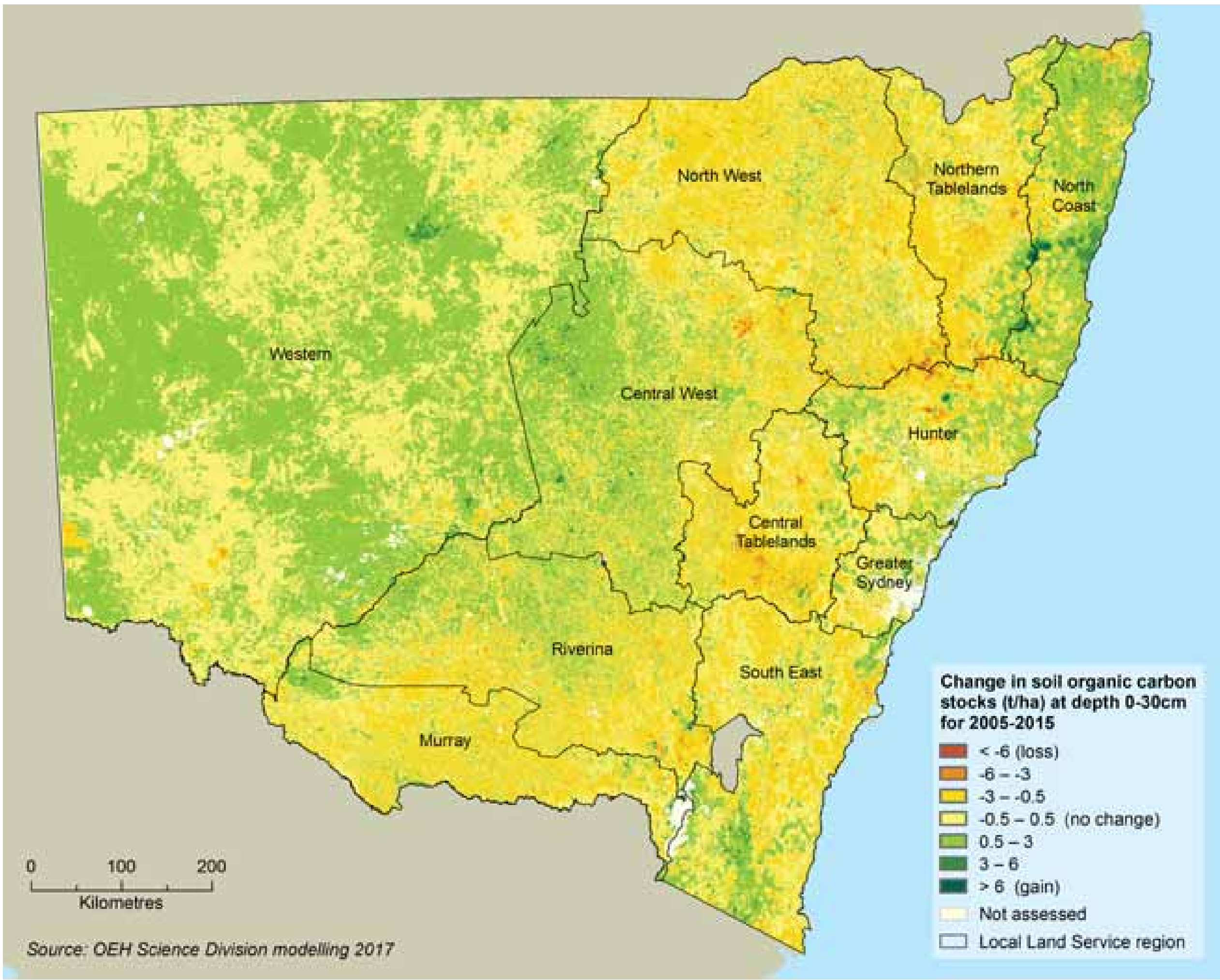
Map 10.3: Soil organic carbon stocks for the top 30 centimetres of soil across NSW in 2017



Source:
Source: OEH Science Division modelling 2017

The change in SOC levels over the 10 years 2005–15 was also derived through modelling based on data for changes in land use, groundcover and the past 40 years of climate data. The results are presented in **Map 10.4**.

Map 10.4: Change in NSW soil organic carbon stocks, 2005–15



Source:
OEH Science Division modelling 2017

In **Map 10.4** and **Table 10.2**, increases in SOC levels are shown in the Western, Central West and North Coast LLS regions, with increases of up 0.64 tonnes per hectare indicated for the North Coast region. The increase in much of the Central West and Western regions is attributed to improved land management practices, including increased levels of vegetative groundcover.

However, declines in SoC levels were identified for most other regions, with losses up to -0.7 tonnes per hectare in the Central Tablelands LLS region. At many specific locations, the gains or losses of SOC are three tonnes per hectare or more.

The modelled declines in SOC stocks over much of the State are consistent with declines since pre-European times that were recently modelled by Gray et al. (2015a). Those previous results suggest that 530 million tonnes of SOC, or 12.6% of the original stocks, have been lost from the top 30 centimetres of soils across NSW, since European settlement.

The extent of SOC decline is strongly affected by land use, with the greatest decline of 44.3 tonnes per hectare, or a 50% loss, occurring under regular cropping of high fertility clay soil in cool and moist conditions.

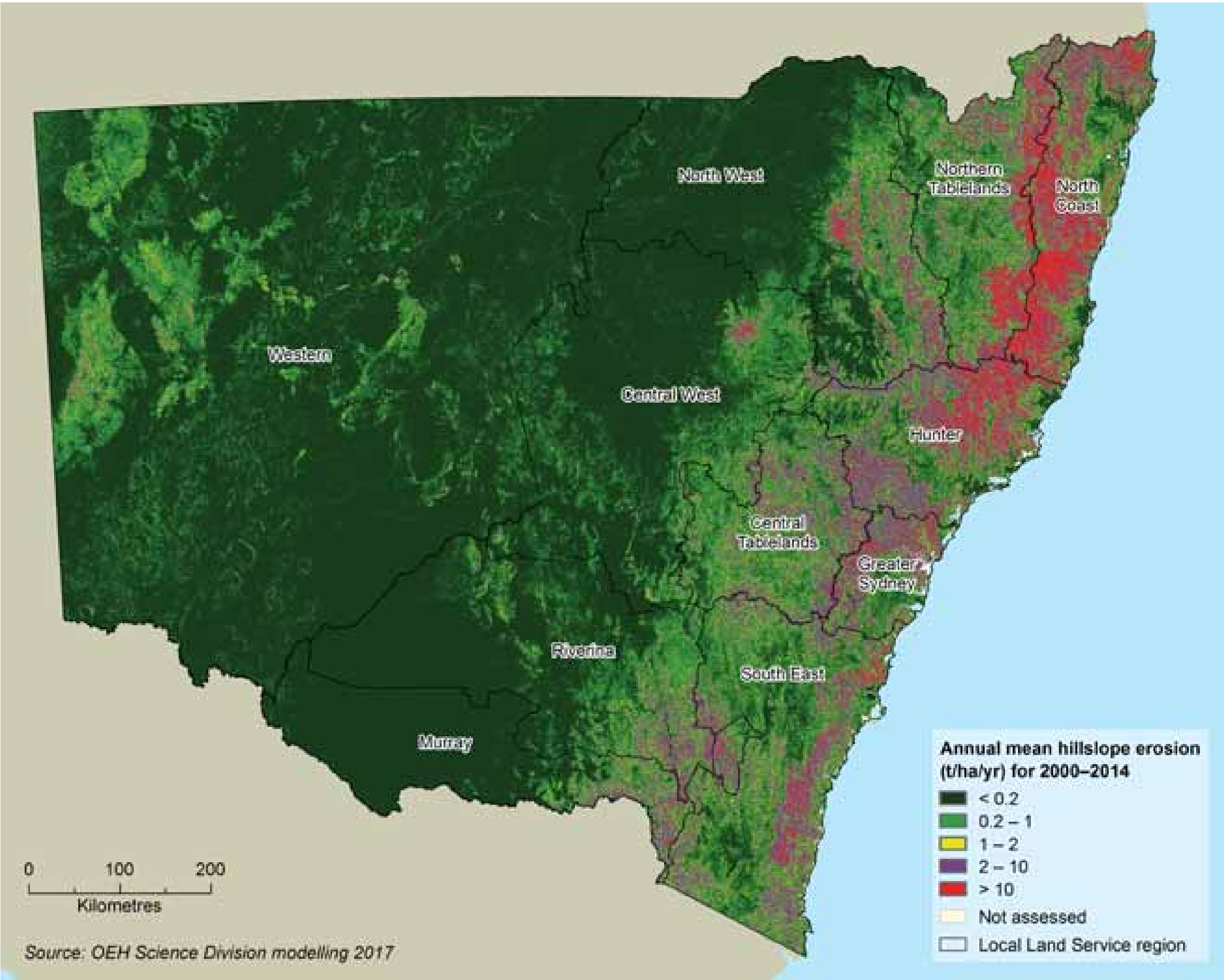
Under projected climate change scenarios, the greatest loss of SOC will also occur in cool, moist areas with native vegetation on high fertility clay soils, so these are the areas of highest potential when designing carbon sequestration programs.

Hillslope erosion

Historically, hillslope erosion has contributed to extensive soil loss and the associated decline in ecosystem function, but hillslope erosion has decreased across NSW due to improved land management. The condition of hillslope erosion is now moderate across the State, although some problem areas remain. The trend is towards further reduction of impacts on soil and land condition from hillslope erosion.

The average annual rate of hillslope erosion across NSW for the period 2000–14, was derived by modelling based on the Revised Universal Soil Loss Equation (Renard et al. 1997; Yang et al. 2017) and is shown in **Map 10.5.**

Map 10.5: Annual mean hillslope erosion 2000–14



Source:
OEH Science Division modelling 2017

The areas of highest erosion are the North Coast, Hunter and Greater Sydney LLS regions. The Western region has the lowest levels due to its flat terrain. Erosion rates range from 0.12 tonnes per hectare per year in the Western region to 5.57 tonnes per hectare per year in the North Coast region, differing by a factor of 46.

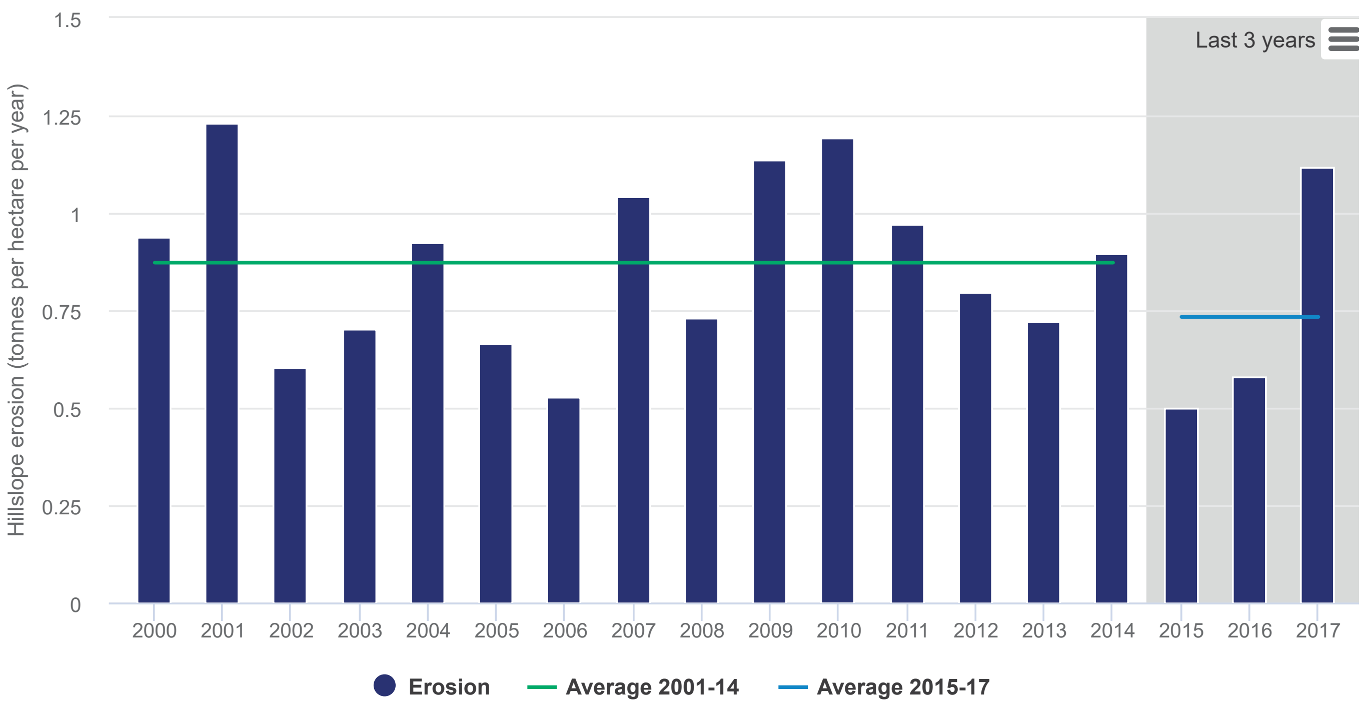
The yearly averages for rates of hillslope erosion between 2000 and 2017 across NSW are presented in **Figure 10.1**, which shows:

- the average erosion rate for the three years 2015–17 was 0.73 tonnes per hectare per year
- the average hillslope erosion rate for the previous 15 years 2000–14 was 0.87 tonnes per hectare per year
- hillslope erosion over the past three years of data decreased by 16% compared to the average for the previous 15 years.

The reduction is largely due to a slight increase in the level of groundcover of about 3% and a moderate decrease in the intensity of erosive rainfall (about 21%) over 2015–17.

The percentage change by LLS region is shown in **Table 10.2** above.

Figure 10.1: Hillslope erosion in NSW 2000–17



Source:
OEH Science Division modelling 2017

There is great variation in hillslope erosion rates between seasons, as well as years. Summer is the season with the lowest groundcover levels and highest rainfall erosivity, thus the highest hillslope erosion risk. Based on average monthly erosion rates between 2000 and 2017, the risk of hillslope erosion in February is about 10 times higher than in July. The variation in average annual hillslope erosion rates is 2.46 times.

Hillslope erosion also varies greatly according to land use. Hillslope erosion rates for different land uses in tonnes per hectare per year are:

- mining (19.29)
- horticulture (3.33)
- nature conservation (3.09)
- grazing modified pastures (0.73)
- grazing native vegetation (0.32)
- cropping (0.12)
- irrigated cropping (0.03).

Erosion rates can be explained by the associated groundcover and terrain factors. In nature conservation areas such as national parks, the relatively high rate is attributable to the steep ground parks often occupy and the impact of bushfires. The relatively low erosion rates in cropping areas are due to the flat terrain and effective erosion control through conservation farming techniques.

Wind erosion

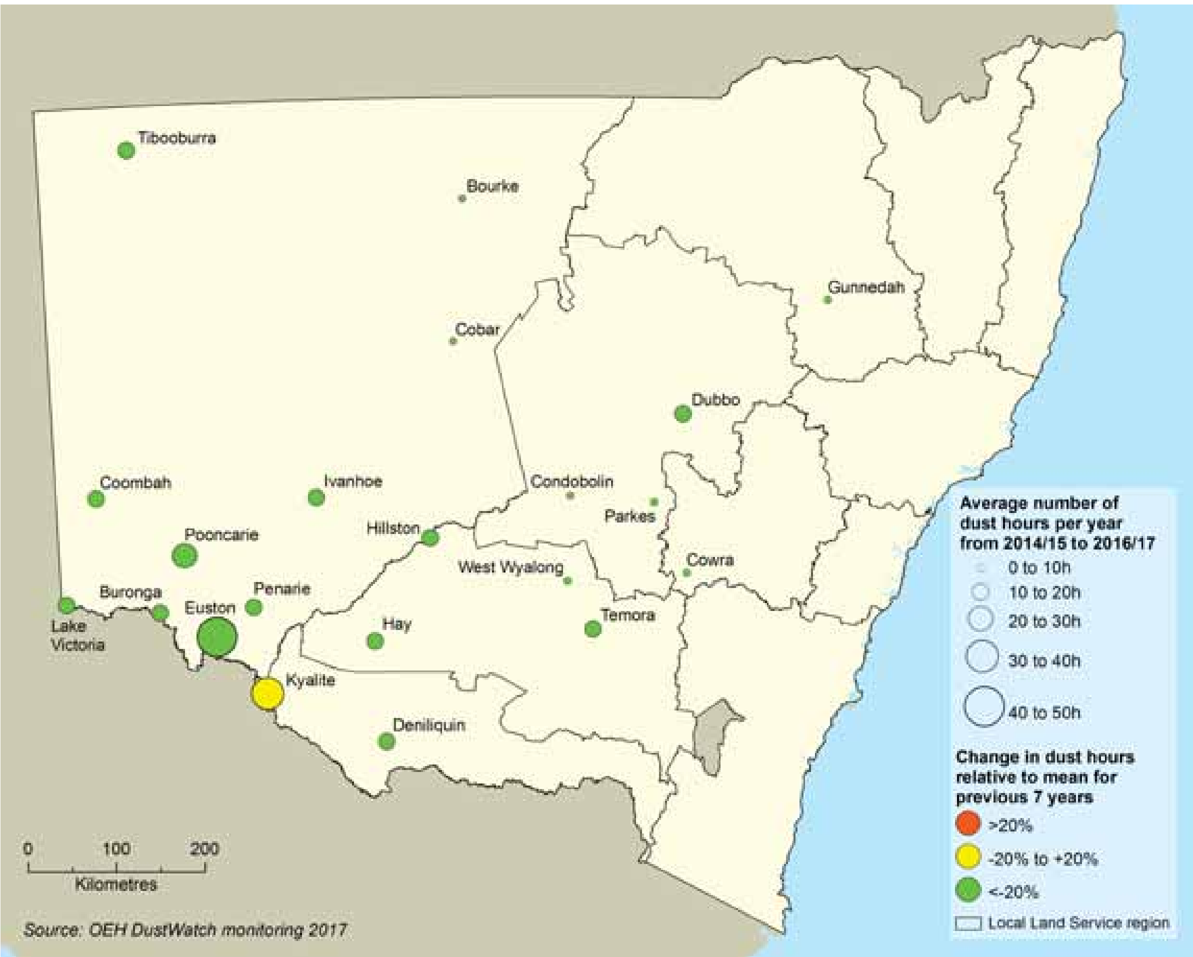
Wind erosion, like hillslope erosion, has historically contributed to extensive soil loss and the decline of soil condition throughout NSW, primarily in the drier western regions. However, in recent decades rates of wind erosion have reduced due to improved land management practices. The condition of wind erosion is currently considered to be moderate to good across NSW. The current trend is for reducing impacts on soil and land condition from wind erosion.

Dust activity is an indicator of wind erosion. If there is dust in the air, the soil is being degraded in regions further up-wind. Dust activity (measured in hours), is defined by the number of hours per year when the average dust concentration is more than 25µg/m3. Monitoring data is available from the DustWatch Program which has 20 sites west of the Great Dividing Range, with 10 years of records.

Dust activity tends to be related to season, with summer having the highest levels of dust activity. For this reason, yearly wind erosion data is presented for the 12 months July to June.

Map 10.6 displays the average number of dust hours per year (size of circle) for the three years 2014–15 to 2016–17. It also shows the change in dust hours (colour of circle) for those years, compared to the previous seven years (2007–08 to 2013–14).

Map 10.6: Status and change in the average number of dust hours for the three-year period from 2014–15 to 2016–17 compared to the 7-year mean (2007–08 to 2013–14)



Notes:
Status (size of circle) and trend (colour of circle) for change in the average number of dust hours per year between 2014–15 to 2016–17. Trends are:
red: more than 20% increase above the seven-year mean (2007–08 to 2013–14)
yellow: less than 20% change (increase or decrease) from the seven-year mean
green: more than 20% decrease below the seven-year mean.

Source:
DustWatch data 2017

Between 2014–15 and 2016–17, rainfall was approximately average. Dust activity for this period was 67% lower than the average for the previous seven years (2007–08 to 2013–14). Since this data was compiled, conditions have become drier and dust levels have increased slightly, but not to the levels of 2007–08 to 2013–14. Results across the monitoring sites reveal:

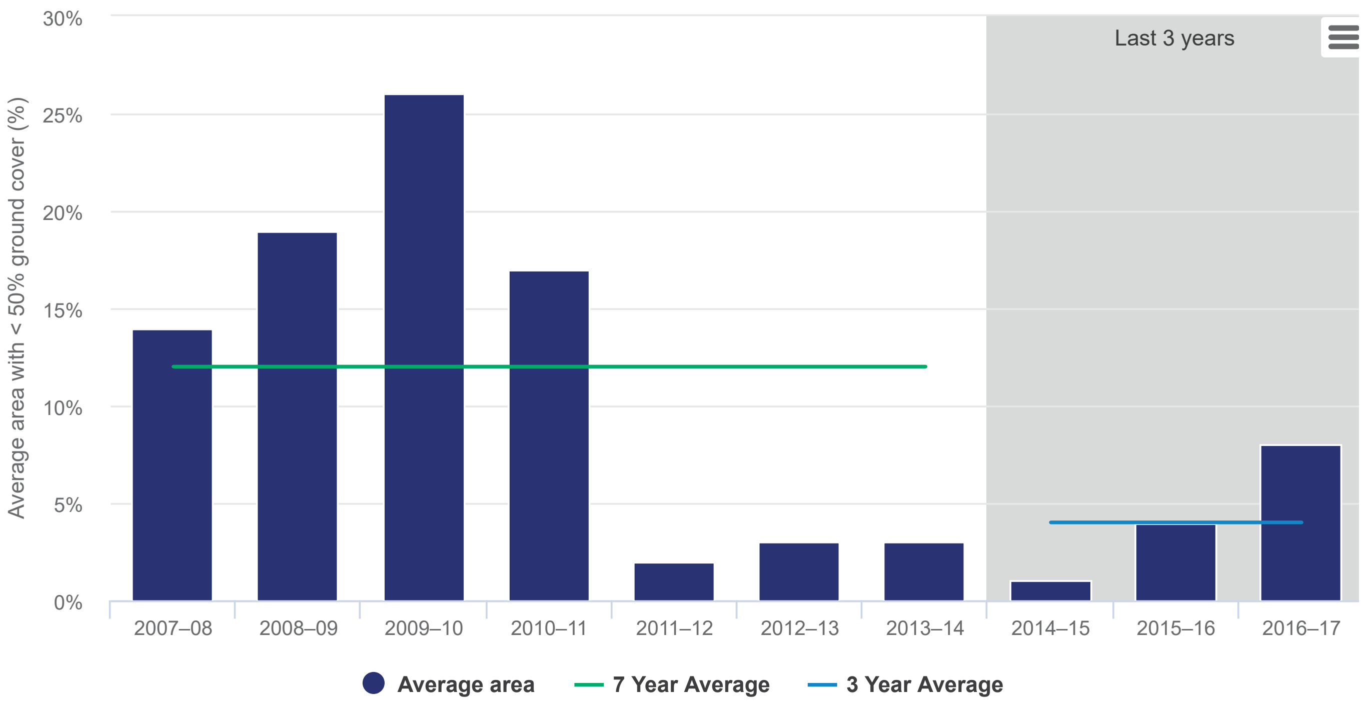
- between 2007–08 and 2013–14, Tibooburra was the driest and dustiest place in the State with 99 hours of dust
- from 2014–15 to 2016–17, the three dustiest places were Euston, Kyalite and Pooncarie, each with more than 20 hours of dust
- over the same period Tibooburra, with lower rainfall, only experienced 19 hours of dust.

This implies that land management activities, rather than climate variability, are the main factor in lower groundcover levels at the three dustiest sites, leading to wind erosion.

Dry years result in less soil moisture, making it harder for land managers to maintain groundcover above 50%, the level required for effective control of wind erosion. Land management practices like over-grazing, cultivation and the burning of crop residues reduce ground cover and increase the risk of erosion. Therefore, the level of ground cover is a good predictor of wind erosion that reflects the effects of climate and land management.

Figure 10.2 shows the average area with less than 50% groundcover within 50 kilometres of each of the 20 DustWatch sites.

Figure 10.2: Average area with less than 50% groundcover within 50 kilometres of each DustWatch site from 2007–08 to 2016–17



Notes:
Horizontal bars are averages for the seven years 2007–8 to 2013–14 and latest three-year period 2014–15 to 2016–17 respectively.

Source:
DustWatch data 2018

Figure 10.2 shows the area of less than 50% groundcover has decreased from 12% to 4% in the last three years, attributed to improved groundcover management.

Salinity

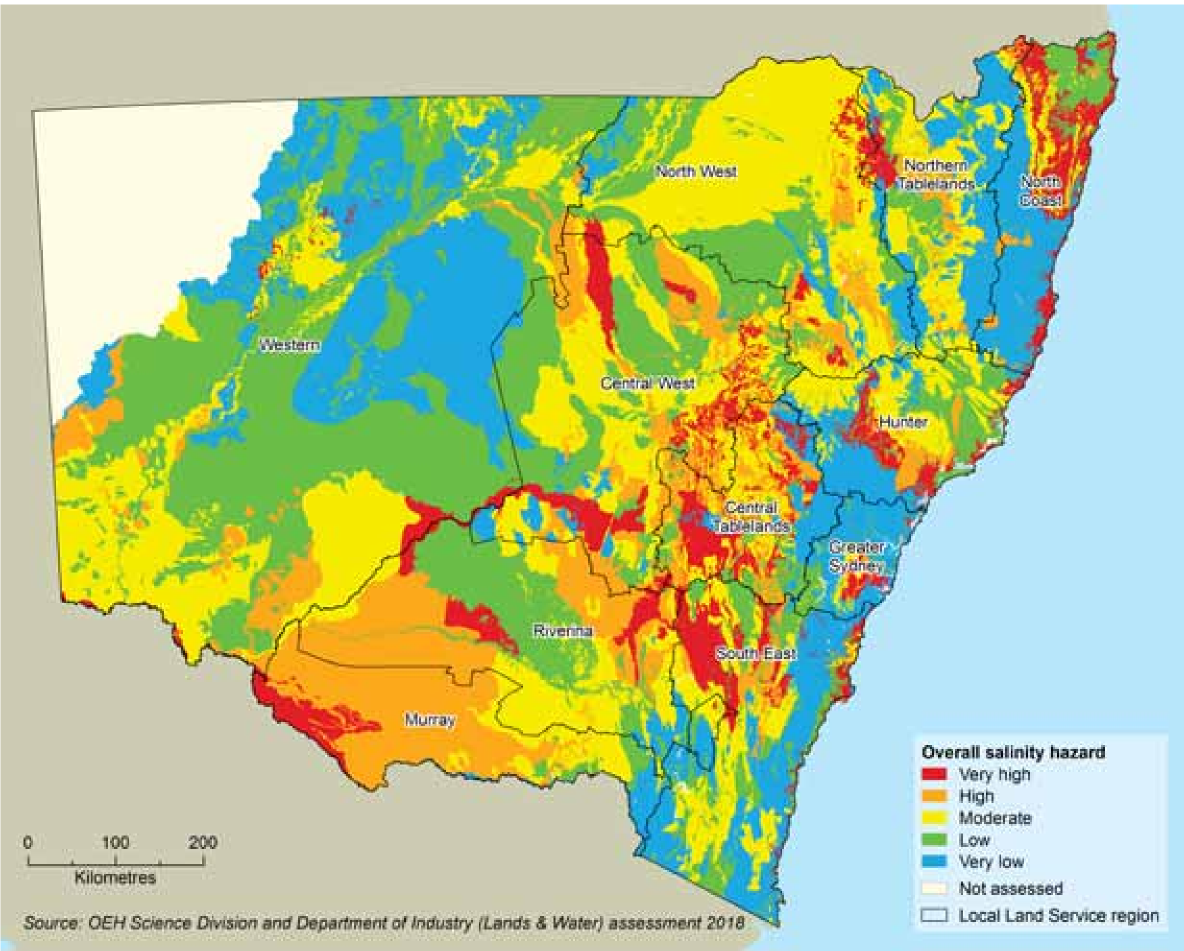
Salinity remains a land degradation issue of some concern across NSW, with detrimental impacts on agriculture and infrastructure. Soils in several regions throughout the State are subject to high salinity risk, which is influenced by prevailing climatic conditions. The condition of salinity is currently considered to be moderate, with a predominantly stable trend.

There has been no recent quantitative assessment of soil salinity in NSW. However, from salinity hazard assessments for the water quality component of NSW Water Resource Plans (2017–18), together with previous Hydrogeological Landscape (HGL) hazard assessments (2008–17) and salinity hazard assessments for catchment action plans (2012), a generalised, qualitative salinity hazard map for most of NSW can be compiled.

Overall salinity hazard ratings are based on the likelihood that salinity will occur and its potential impact. Assessments consider both the on-site impacts of salinity on the land, and the off-site impacts in streams of salt concentrations and loads. The severity of each of these will vary depending on local factors that influence how salt and water move through the landscape. The distribution of salinity hazard across NSW is shown in **Map 10.7**.

Map 10.7: Overall salinity hazard assessment for NSW, 2017

Map 10.7: Overall salinity hazard assessment for NSW, 2017



Source:
OEH Science Division and Department of Industry (Lands & Water) assessment 2018

Approximately 10% of NSW contains landscapes where areas of high or very high salinity hazard may occur. Areas of concern are:

- the North Coast, Hunter and Central West regions
- the Greater Sydney, Yass and Boorowa regions
- the lower Murray, Murrumbidgee and Murray-Darling valleys.

Significant impacts on land and local infrastructure may occur in high hazard areas, as well as streams in the catchment area.

Salinity has not been recognised as an issue by land management groups in the north-west of the State where little assessment work has been conducted. However, the area that falls within the Murray-Darling Basin (MDB) is currently being assessed for NSW Water Resource Plans. The Murray–Darling Basin Authority also maintains a register of salinity credits and debits to keep account of actions that affect salinity in the MDB.

Future changes in rainfall and evaporation in all regions (DECCW 2010; Littleboy et al. 2015) will affect the balance between runoff and overland flows, and shallow drainage and deep drainage. These changes will affect the mobilisation and concentration of salts. Impacts on soil salinity are likely to be complex and difficult to predict. Whether salinity will increase or decrease in particular areas will depend on local factors.

Acid sulfate soil

Acid sulfate soils (ASS) are soils containing pyrites (iron sulphide). The exposure of such soils to the air where previously they were covered by water, through excavation or water drainage projects, has caused serious environmental impacts throughout NSW, particularly in coastal areas. With improved understanding and land management practices, such as shallower drainage channels, the severity of this issue has decreased.

The extent of ASS over NSW coastal lands is presented in the NSW ASS Risk Maps. The most recent assessment of NSW coastal ASS, carried out in 2009 and reported in OEH (2014), found the overall condition of ASS soils was moderate. However, 23% of the sites assessed were poor or worse.

Since then, ongoing remediation of problem areas has improved the condition of these soils. Of the 28 ASS hotspots identified, remediation works have now been carried out in 21 (75%). See the 'Responses' section for more details.

It is now known that areas of high ASS soils also occur in NSW inland river valleys (MDBA 2011). For example, Tulau and Morand (2012) found 30 of the 60 sites (50%) examined along the banks of the Edward–Wakool River system were sulfidic and prone to the release of acidic solutions into the riverine environment.

Pressures

Unsustainable land management and land use

When European settlers first arrived in Australia they adopted traditional farming practices that had been developed for different soil and climate conditions in a different part of the world. Much of the soil degradation in NSW is historic in nature and had occurred before an understanding developed of how to manage soils sustainably in Australian conditions.

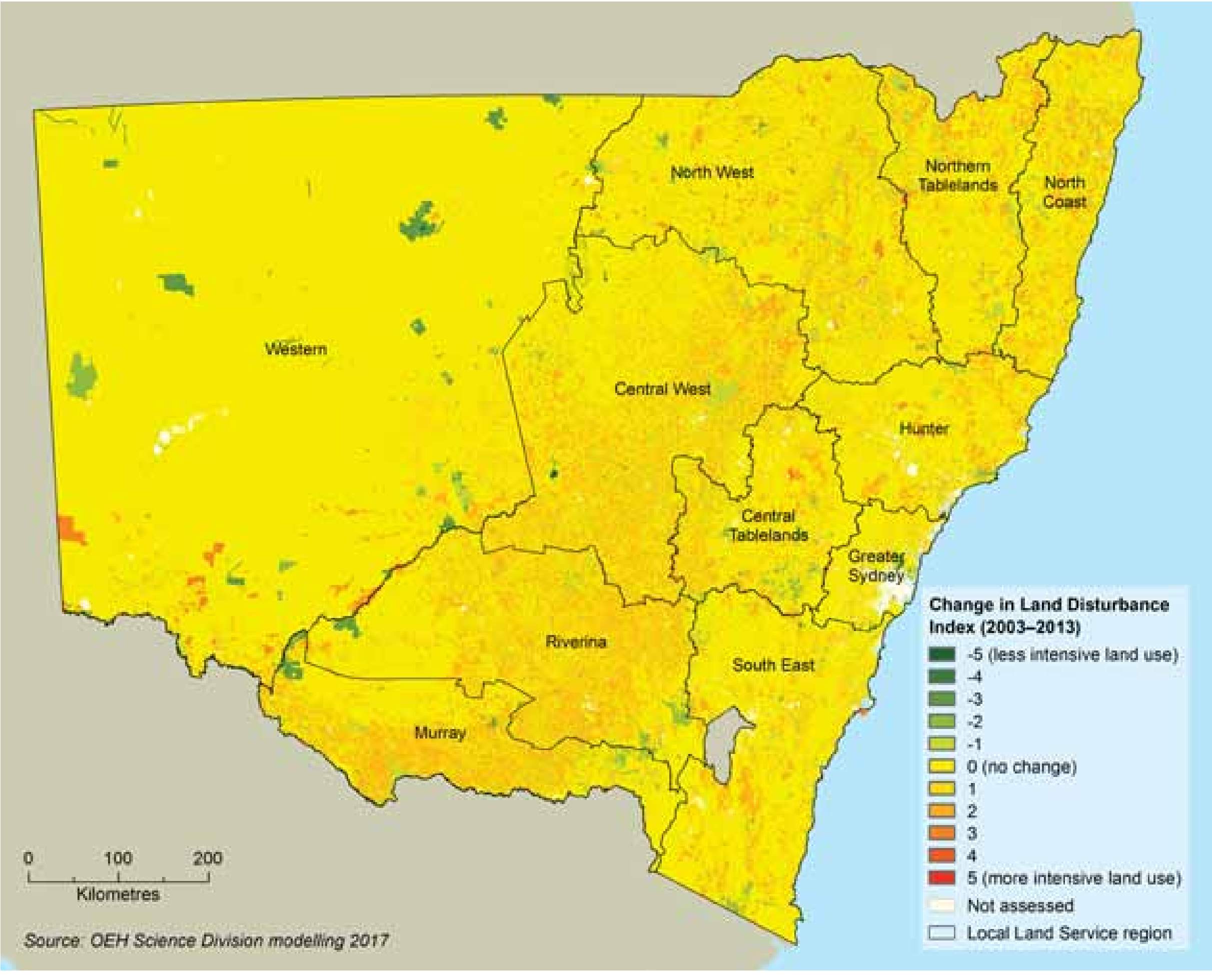
The development of modern land management systems such as conservation farming, pasture rotation and no-tillage, together with better maintenance of groundcover, have largely halted, and in some cases reversed, the decline in soil condition. However, there is still some way to go before best practice land management is being implemented consistently across the State.

While land management practices have generally improved, the pressure on soil condition continues due to the increasing intensity of land use across NSW. There is, therefore, a greater need to ensure that soils and land are managed sustainably and within their inherent physical capacity – i.e. according to their capability to handle a specific level of disturbance or use.

As part of the NSW Monitoring, Evaluation and Reporting Strategy program 2008–09, an assessment was made of the extent to which soils were being managed within their capability, described in (OEH 2014) and summarised in the 2015 SoE Report (EPA 2015).

The pressure on soil condition from different types of land uses across NSW and the levels of soil disturbance associated with them, is represented by the land disturbance index (LDI). This system assigns land use to one of six classes, from 1 for undisturbed land such as native vegetation reserves to 6 for intense cropping land (Gray et al 2015c; based on NCST 2009). **Map 10.8** presents the change in LDI from approximately 2003–13, based on land use information collected by the NSW Government.

Map 10.8: Change in land disturbance index, approximately from 2003–2013



Source:
OEH Science Division modelling 2017

An overall trend towards more intensive land use over recent years is revealed by the map, with a statewide increase in the LDI of 0.20 units (see **Table 10.3**).

Table 10.3: Change in land disturbance index (LDI) from approximately 2003-2013, by LLS region

Local Land Service region	Change in land disturbance index (units)
Central Tablelands	0.29
Central West	0.40
Greater Sydney	0.08
Hunter	0.27
Murray	0.40
North Coast	0.35
North West	0.23
Northern Tablelands	0.27
Riverina	0.45
South East	0.20
Western	0.01

Local Land Service region	Change in land disturbance index (units)
NSW	0.20

Source:
OEH Science Division modelling 2017

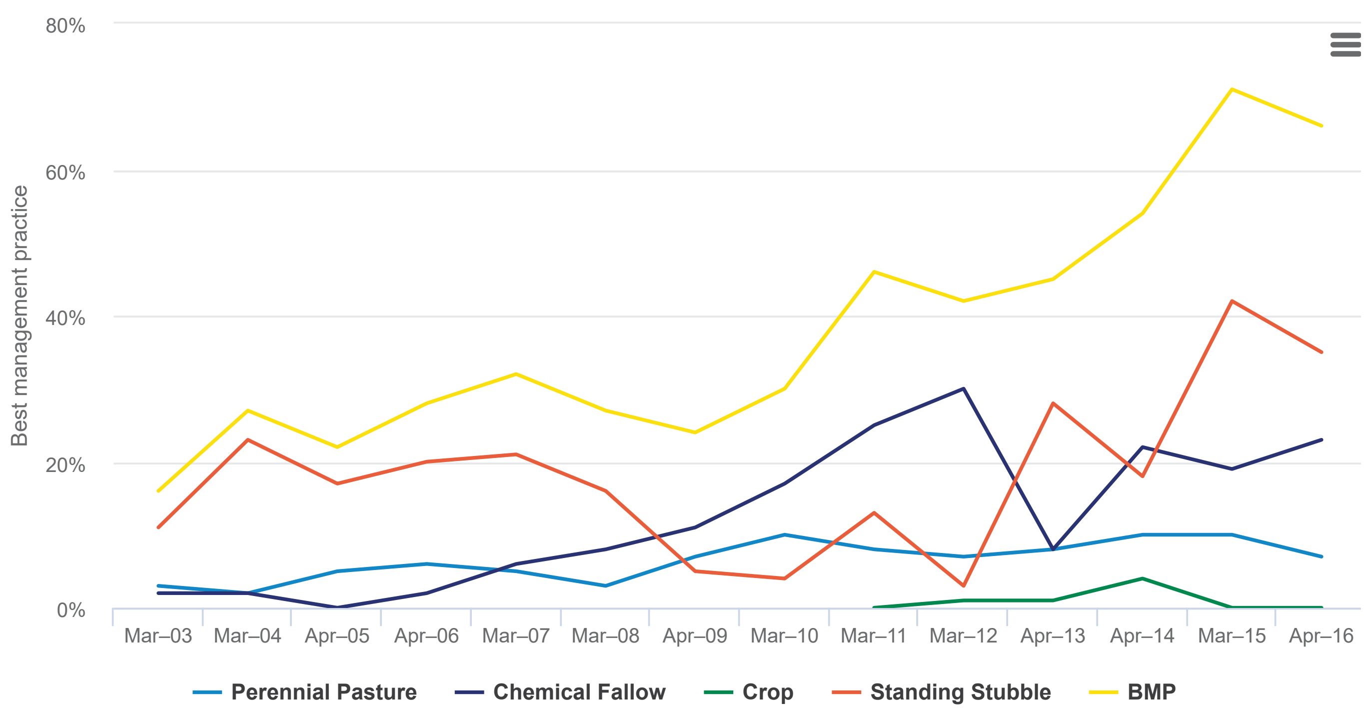
The LLS regions with the largest average increases are the Riverina, Central West and Murray (0.45, 0.40 and 0.40 units respectively). Many locations throughout the State, particularly in these three LLS regions have an increase of two LDI units, which for example, represents a change in land use from predominantly pasture to predominantly cropping.

However, some areas, particularly in the Western region, have changed to less intensive land uses, shown by the deep green in **Map 10.8**. These may, for example, reflect a change in land use from pastural lands to a protected conservation area. While a change in land management has occurred, a change in site conditions may not be evident immediately.

Although land use intensity may be increasing slightly across the State, as revealed by **Map 10.8** and **Table 10.3**, land management practices may be improving simultaneously in many regions, to compensate.

For example, the Western region has a long history of wind erosion. The National Landcare Program and Catchment Action NSW have invested in changing land management practices on farms in this region, resulting in a 50% increase of sites with best management practices, from 16% in 2003, to 66% in 2016, as shown in **Figure 10.3**.

Figure 10.3: Trend in best management practices in the south-west of the Western LLS region, 2003–2016



Source:
Leys et al. 2016

Climate change

While soil may be managed sustainably with little risk of degradation during normal weather patterns, the unpredictability and variability of severe weather events can lead to conditions where the soil's capacity to cope is suddenly exceeded, leading to loss of soil condition and degradation.

Climate change is expected to lead to more extreme weather events and generally drier conditions across much of NSW (Baldock et al. 2012; OEH 2015). This will increase the challenge in managing for weather variability and weather extremes such as high erosivity rainfall events, increased fire and drought. A changing climate will require a rethink of the way that soils and land are currently managed by geographic locations. Without adjustments, it is possible that land may be used beyond its capability.

Climate change will also increase the risk of some soil degradation hazards, particularly wind erosion and loss of soil carbon (Rengel 2011). For more information on the effects of climate change see the Climate Change topic of this report.

Changed population and settlement patterns

Rising population in urban areas and increased demand for food at various levels – local, regional, national and international, is leading to an intensification in the use of productive land and greater risk of soil degradation. At the urban fringe, highly productive land is coming under growing development pressure, while population loss from rural areas reduces the capacity to manage land effectively (see DECCW 2009).

Economic factors

Economic factors such as declining farm profitability, or poor international trading conditions, including surplus stocks of resources or high foreign exchange rates (as occurred in the recent past), may lead to the intensifying of land uses and production activities in order to maintain viability, which may not be sustainable over the longer term.

Increasing fuel prices and competition for essential resources like water and fertilisers are other significant factors that pose challenges for managing the land sustainably (Cribb 2010).

Responses

Legislation and policy

The *Soil Conservation Act 1938* provides for the conservation of soil and water resources and the mitigation of erosion. Through this Act the Soil Conservation Service was established, a NSW Government-owned soil conservation and environmental consulting business.

The *Local Land Services Act 2013* (amended in 2016) regulates the clearing of native vegetation on rural lands while the *Biodiversity Conservation Act 2016* (BC Act) promotes conservation on private land. These laws aim to achieve a balance between land use and biodiversity conservation in NSW.

Clearing of native vegetation in urban areas and land zoned for environmental protection is regulated by State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017 (the Vegetation SEPP) as well as some provisions in the BC Act that provide for the biodiversity offsets scheme. For more information see the Native Vegetation topic.

The current approach to soil management in NSW is to consider soils as part of a broader approach to natural resource management rather than as a standalone issue (Webb et al. 2015). Specific policies for sustainable soil management in NSW include:

- the State Environmental Planning Policy (Rural Lands) 2008
- the Policy for Sustainable Agriculture in NSW (NSW Agriculture 1998).

Programs

Landcare and other on-ground initiatives

Landcare is a community network that contributes to the integrated management of natural resources at the grass-roots level across NSW, including improved soil management and land remediation.

There are presently about 3,000 Landcare groups in NSW, who are working to:

- reduce soil and streambank erosion
- control weeds
- revegetate river banks, farmland and other public lands.

Landcare groups also promote the sustainable use of soils through education and community awareness programs.

The NSW Government currently funds the Landcare program, including the NSW Local Landcare Coordinator Initiative, a four-year program running through to June 2019. This initiative involves 72 local Landcare Coordinators working with 34 organisations across NSW to build the capacity of the Landcare movement to achieve its goals of:

- improving natural resources
- encouraging sustainable agriculture
- empowering the community to improve their local environment.

Local Land Services work with local communities, including Landcare groups and landholders, to develop strategies and programs to improve natural resource management and sustainable land use across NSW.

Catchment Action NSW is a NSW Government-funded program to deliver natural resource management priorities in the State, usually in conjunction with the National Landcare program. One high-level outcome is to protect or rehabilitate soils to support ecosystem services. This program is continuing in 2018–19.

Phase two of the National Landcare Program commenced in the second half of 2018.

The Emissions Reduction Fund (ERF) operates under the *Carbon Farming Initiative Amendment Act 2014*. The ERF provides funding through a reverse auction mechanism to enable land managers to be financially rewarded for sequestering carbon. The first round of auctions in early 2015 resulted in 47 million tonnes of CO_2-e abatement (28 million tonnes of CO_2-equivalent gases being contracted for sequestration and 19 million tonnes by other means).

Advisory bodies and instruments

The Natural Resources Commission provides independent advice to the NSW Government on how to most effectively manage natural resources to maintain production and conservation. It works with the State's regional communities and other stakeholders to improve or maintain the health and productivity of landscapes across NSW.

The Australian Soil Network oversees soil research and development strategies and their implementation throughout Australia. It comprises representatives from Rural Research and Development Corporations, government agencies, CSIRO, the University sector, and is currently co-chaired by the NSW Government (Department of Primary Industries).

The National Committee on Soil and Terrain coordinates and provides advice on soil and land assessment standards and policy. National protocols for monitoring soil acidification and soil carbon have been published (Grealish et al. 2011).

The National Committee for Acid Sulfate Soils (NatCASS) is assisting the Commonwealth Department of Agriculture and Water Resources to develop guidelines on acid sulfate soil management issues that are not being adequately addressed in some jurisdictions, including:

- the clean-up of groundwater in areas of acid sulfate soils
- dredging of sulfidic sediments
- managing mono-sulfidic black ooze accumulations.

NatCASS is also completing a Code of Practice for the re-use of ASS materials that are excavated and removed from development sites, and NSW is actively represented. Guidelines for the identification and management of inland ASS were developed through the National Water Quality Management Strategy (NWQMS) (Baldwin 2011)

The management of salinity throughout NSW is guided by NSW Water Resource Plans in combination with the Hydrogeological Landscape program.

Research, development and data collection

The National Soil Research, Development and Extension Strategy (Commonwealth of Australia 2014) aims to conduct research that meets the needs of farmers and primary producers and provide information promoting sustainable soil use and management.

The NSW Office of Environment and Heritage (OEH) collects data on soil and land management processes, conducts surveys and maintains NSW soil data through eSPADE.

The NSW Department of Primary Industries (DPI Agriculture) has a large research and development program that develops technologies and management systems to:

- maintain and enhance the physical, chemical and biological productivity of soils
- protect soil resources,
- build resilience and reduce environmental impacts.

It works in partnership with Local Land Services and private stakeholders to ensure research and development findings are delivered to industry.

Monitoring programs

The performance monitoring system of the Soil Health Evidence Based Assessment (SHEBA) program (formerly SoilWatch) is applied in many regions of NSW. It complements and supplements other surveillance monitoring.

The cross-agency collaborative Community DustWatch program has been monitoring the extent and magnitude of dust events across NSW for the past 10 years. NSW Government agencies also lead the national assessment of wind erosion (Leys et al. 2016) and the use of remote sensing to assess the extent of groundcover.

Under Phase 2 of the National Landcare Program, groundcover will be a key reporting indicator, with the reporting methods developed in NSW being proposed for use nationally.

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Native Vegetation

Maintaining native vegetation in good condition is critical to the survival of the species and ecosystems that depend on it.

Summary

Native vegetation in NSW

61%

of NSW still has native vegetation cover

Read more

Clearing rate of woody vegetation

14,700 ha

of woody native vegetation is cleared annually (2014–15)

Read more

Native vegetation covers 61% of NSW. At the time of publication, the latest reported statewide clearing rate of native vegetation was 14,700 ha/year (2014–2015).

Only 9% of NSW, or 15% of all native vegetation, is considered to be in close to natural condition. The condition of the remaining 52% of NSW still with native vegetation cover, is variable, but has deteriorated, largely due to the effects of different land uses and land management practices.

Land clearing is the main threat to the extent and condition of native vegetation in NSW. The latest reported clearing rate of woody native vegetation is about 14,700 hectares per year.

While some vegetation classes, particularly woodlands and grasslands, have been substantially depleted since European settlement, others remain largely intact.

The condition of native vegetation largely reflects the main use of the land and this is being addressed through better land management practices. However, pressures on condition are likely to remain for the foreseeable future, due to the long-term effects of fragmentation following clearing, coupled with increasing threats from invasive species and climate change.

Substantial programs of restoration and revegetation are occurring at local and regional levels to enhance the condition of native vegetation. The Biodiversity Offsets Scheme has been introduced to encourage landholders to protect and conserve biodiversity and vegetation habitat on private land.

Related topics: River Health | Wetlands | Coastal, Estuarine and Marine

NSW indicators

Indicator and status		Environmental trend	Information reliability
Clearing rate for woody native vegetation 2014–15	MODERATE	Stable	✓✓✓
Extent of native vegetation	MODERATE	Stable	✓✓
Levels of pressure on the condition of native vegetation	MODERATE	Stable	✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

NSW contains a great variety of native vegetation, including some outstanding areas of rainforests, eucalypt forests and woodlands, grasslands, wetlands, coastal heaths, alpine habitats and arid shrublands. Native vegetation provides essential habitat for plant and animal species, and is an integral component of healthy, functioning ecosystems.

The extent and condition of native vegetation are broad indicators of ecosystem health and diversity (Saunders et al. 1998). The description of vegetation in NSW in this topic draws on generalised mapping based on vegetation structure and growth form. This provides a useful overview for reporting on the statewide status and extent of native vegetation. More detailed vegetation mapping that is based on vegetation communities and species composition and hence more descriptive of ecosystems and habitats is not yet available on a consistent basis across the State.

This topic is only concerned with the state of land-based vegetation. Freshwater aquatic vegetation is considered in the River Health and Wetlands topics, and coastal and marine vegetation is considered in the Coastal, Estuarine and Marine Ecosystems topic.

Status and Trends

Vegetation extent

Information on the extent of native vegetation in NSW was compiled under the *NSW Natural Resources Monitoring Evaluation and Reporting Strategy 2010–2015* (DECCW 2010) by combining vegetation mapping with remote sensing analysis (Dillon et al. 2011). The extent of native vegetation was described according to four categories of vegetation extent, representing various degrees of modification of native vegetation. A summary of the outcomes of this analysis is displayed below in **Table 13.1**.

Table 13.1: Extent of native vegetation in NSW

Vegetation extent category	Description	Area (% of State)
Native – intact	Native vegetation in which the structure has not been substantially altered	61%
Native – derived	Vegetation that is predominantly native but is no longer structurally intact as it has been substantially altered and is missing important structural components or layers	8%
Native/non-native mosaic	Vegetation that cannot be classified as native or non-native using current remote sensing technologies	20%
Non-native/other	Non-native vegetation (crops, plantations, pasture) or other non-vegetative land cover	11%

Source:
EPA 2012

Extent of intact native vegetation

'Native – intact' vegetation covers 61% of NSW. This category describes vegetation communities that occur naturally and are structurally intact, so they can still be readily identified as native vegetation communities (Keith & Simpson 2006; Keith & Simpson 2008).

However, these communities are not all in good condition. About 15% of this native vegetation (or 9% of NSW) is regarded as being in a state that is close to natural, as it is managed with conservation as the primary objective. The condition of the remaining 85% of vegetation in this category (or 52% of NSW) has deteriorated due to the impacts of various land uses.

The extent to which different vegetation types (formations or classes) remain intact is due to the differing rates of clearing, largely historical, that have occurred across various parts of the State. Generally, flat productive lands have been favoured for development, with particularly high rates of clearing in native grasslands, grassy woodlands, some types of wetlands and eucalypt forests. Some other native vegetation formations, such as arid shrublands and alpine areas, occur on land that is less attractive for development, so have experienced little change in extent. The status of intact native vegetation formations in NSW is summarised in **Table 13.2** below.

Table 13.2: Extent of clearing of native vegetation formations in NSW since 1750

Vegetation formation	Status
Native grasslands	Extensively cleared or modified with only small fragments remaining outside the semi-arid zone, although some grazing lands retain important remnants
Grassy woodlands	Substantially depleted with less than 10% of some classes remaining

Vegetation formation	Status
Rainforests	Littoral rainforests and those on coastal lowlands have been substantially reduced. Other classes of rainforests occurring in more rugged terrain are less depleted, although changes in structure and species composition have occurred in areas with a history of timber harvesting
Dry sclerophyll forests	Less cleared, because of constraints imposed by terrain and less fertile soils, although levels of depletion are still substantial in some classes
Wet sclerophyll forests	Less cleared, because of constraints imposed by terrain and less fertile soils, although levels of depletion are still substantial in some classes
Semi-arid woodlands	Have undergone low to moderate levels of clearing (10–60%), although this has increased in recent decades
Arid shrublands	Still largely intact as they are generally less suitable for development
Heathlands	Still largely intact as they are generally less suitable for development
Alpine complex	Still largely intact as they are generally less suitable for development

Source:
Keith 2004

The remaining vegetation extent categories listed in **Table 13.1** (39% of NSW) describe vegetation that has been extensively modified, so that while native it no longer forms a natural community, or is non-native, or there is no vegetation cover at all.

Vegetation condition

Where native vegetation has not been cleared, its condition varies from close to natural if undisturbed, to degraded where it has been heavily disturbed. The condition of native vegetation has been modified to varying degrees by the effects of land management practices and unplanned threats such as weed invasion, drought and fire. The impacts of these threats include:

- changes to the structure, ecological function and species composition of native vegetation
- lower rates of regeneration and reduced vigour
- prevalence of parasites, pathogens and diseases
- presence of weeds and pests.

The combined effect of these impacts is diminished habitat values and impaired ecosystem processes. Declines in vegetation condition are generally less immediately visible than clearing and tend to occur over longer timeframes, making them more difficult to monitor and assess.

The condition of vegetation is often used as a broad indicator of habitat quality. However, the traditional framework for describing vegetation in terms of its extent and condition is not sufficient to provide an effective assessment of habitat quality (Tulloch et al. 2018). An alternative approach for assessing habitat quality in NSW is presently being developed.

Pressures

Pressures on vegetation extent

Land clearing

Clearing is recognised as the main threat, not only to the extent of native vegetation cover, but also, due to the ongoing effects of fragmentation, to its condition.

Native vegetation has been extensively cleared in some parts of NSW for settlement, industry and agriculture. Clearing occurs to enable changes in land use and it is generally irreversible, due to the ongoing nature of subsequent land uses. Clearing displaces many native animals and plants and has a negative impact on biodiversity. Over time, the effects of fragmentation and disturbance lead to invasion by weeds and further deterioration in the condition and habitat values of the remnant vegetation.

Clearing of native vegetation, and the destruction of habitat that is associated with it has been identified as the single greatest threat to biodiversity in NSW (Coutts-Smith & Downey 2006). Land clearing is also listed as a key threatening process under the *Biodiversity Conservation Act 2016*.

Clearing of woody vegetation

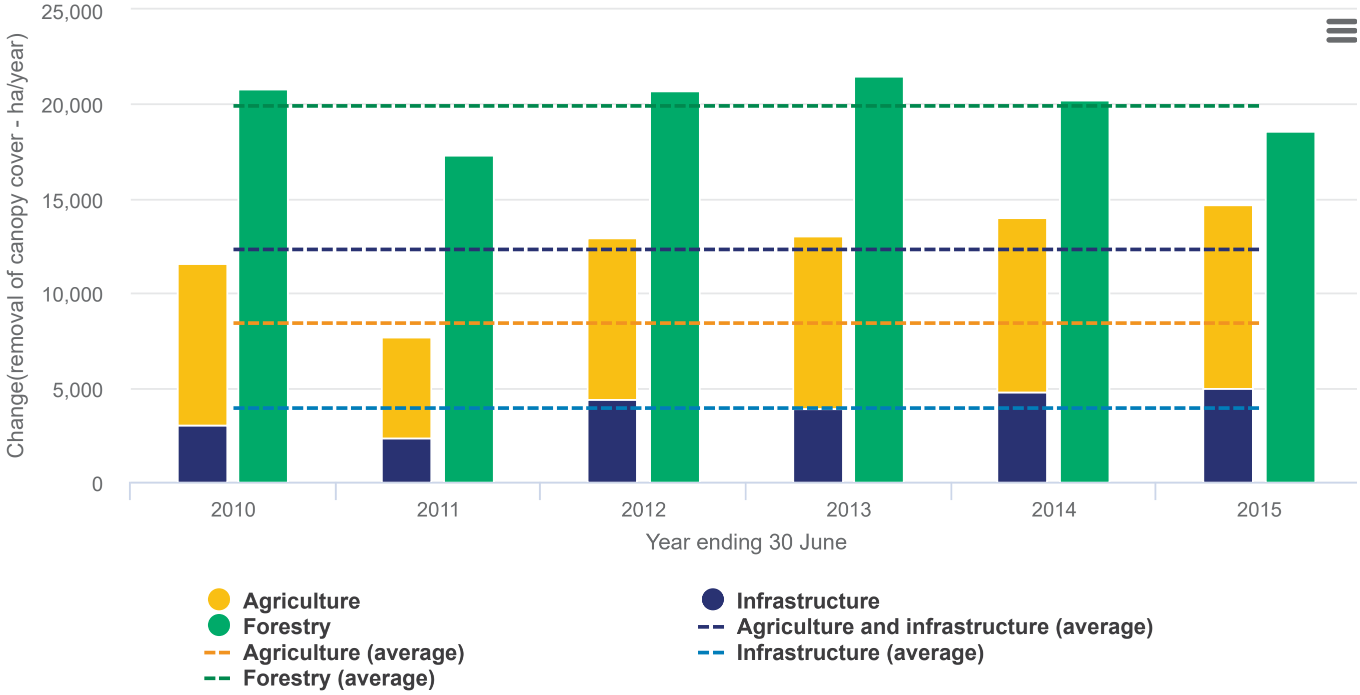
For 23 years up to 2011, the clearing of woody vegetation in NSW was monitored by analysing Landsat remote sensing data using the Statewide Landcover and Trees Study (SLATS) processing methodology (DNRW 2007). Due to the failure of the Landsat 5 satellite in November 2011 this monitoring was replaced by the analysis of SPOT 5 data from 2009–10 onwards, using the same methodology. There were two years of overlap, where data were available for comparison from both platforms.

Woody vegetation change based on Landsat imagery had a 30-metre resolution. This led to a definition of woody vegetation as being woody communities that are taller than about two metres and have 20% or more canopy cover (e.g. woodlands open forest and closed forest). SPOT 5 imagery has a finer resolution at five metres and hence provides more detailed mapping. It can monitor woody vegetation down to 5% canopy cover, enabling changes in tree cover to be detected in open woodlands, grasslands with scattered trees and highly modified areas.

Comparison of the estimates of change in woody vegetation derived from the two platforms shows that SPOT 5 imagery detects more and smaller changes than Landsat, while Landsat tends to overestimate change due to the coarser resolution. Due to this variability, clearing rates derived from the two platforms are not directly comparable.

Figure 13.1 presents SPOT 5 data on the changes in woody vegetation due to clearing for agriculture and infrastructure development and harvesting due to forestry operations over the six years of monitoring up to 2014–15.

Figure 13.1: Loss of woody vegetation in NSW, 2009–10 to 2014–15



Notes:
There is some variability in the actual length of the yearly intervals, depending on the availability of remote sensing data suitable for analysis, due to seasonal factors.

Source:
OEH 2018

The estimate of clearing provided in this report relates only to activities that lead to permanent changes in land use, that is, changes due to agriculture and infrastructure development. Forestry operations are not described as clearing because they do not lead to land use change. Most timber harvesting areas are expected to be regenerated as regrowth forest.

The six years of SPOT 5 data to 2014–15 displays a relatively stable pattern of clearing at about 12,300 hectares per year on average. The unusually low result in 2010–11 is attributed to a particularly wet year, affecting the ability to conduct broadscale clearing operations. The clearing rate for 2014–15, the final year of available data is 14,700 hectares, slightly higher than the six-year average.

The overall pattern is also consistent with the last seven of the 23 years of Landsat data available, which also displayed a relatively stable pattern from about 2004 onwards.

The monitoring of increases in woody vegetation, mainly due to revegetation, is more complex than the monitoring of clearing. A methodology is being developed to measure such change and estimates of revegetation should be available for future reporting.

Clearing of non-woody vegetation

Non-woody vegetation is vegetation that does not meet the criteria to be classified as woody vegetation, described earlier in this topic. It refers to all grasslands and large areas of open woodlands and arid shrublands characteristic of western NSW.

In 2012, the vegetation extent data described previously in **Table 13.1** were combined with the current (2011) map of woody vegetation change to determine how much woody vegetation there was in each extent category (EPA 2012). This analysis is summarised in **Table 13.3**.

Table 13.3: Extent of woody native vegetation in NSW in 2011–12

Table 13.3: Extent of woody native vegetation in NSW in 2011–12

Vegetation extent category	Area (% of State)	Proportion woody (%)*
Native – intact	61%	55%
Native – derived	8%	50%
Native/non-native mosaic	20%	15%
Non-native/other	11%	–
Total	100%	45%

Notes:
* This describes the percentage of each category that is woody and the figures do not sum to 100%. Overall, 45% of all native vegetation was categorised as woody.

Source:
EPA 2012

While 55% of intact native vegetation category is woody, only 45% of all native vegetation in NSW is woody. Clearing of woody vegetation therefore only accounts for about a half of all native vegetation.

However, not all clearing occurs by directly removing trees in areas of woody vegetation, so the clearing of non-woody vegetation is harder to monitor. Much of the native grassland in NSW has been cleared or modified by:

- the process of pasture improvement
- the application of fertilisers
- the ploughing and sowing of introduced grasses and clovers.

Some arid shrublands have, in effect, also been cleared through prolonged overgrazing, and some freshwater wetlands by drainage works.

Pressures on vegetation condition

Land use

The level of disturbance of natural systems and impact on the condition of native vegetation increases with intensifying land use. A framework for land use mapping is described in Guidelines for Land Use Mapping in Australia: Principles, procedures and definitions (ABARES 2011). These land uses have been reclassified into five pressure categories according to the intensity of the operations associated with different land uses. The extent of vegetation in the different categories is summarised in **Table 13.4**.

Table 13.4: Land-use pressure on native vegetation

Category	Description	Area (% of State)
Conservation and natural environments	Land set aside primarily for conservation, where natural ecosystems are maintained	18%
Relatively natural environments	Land used primarily for agriculture, with limited changes to native vegetation	40%
Dryland agriculture and plantations	Land used mainly for agriculture, based on dryland farming	38%
Irrigated agriculture and plantations	Land used mostly for agriculture, based on irrigated farming	2%

Intensive uses	Land subject to extensive modification, generally in association with residential settlement, or commercial or industrial uses	2%

Source:
EPA 2012

However, it should be noted that the intensity of land use can be moderated by the specific land management practices adopted in carrying out a land use.

Other pressures

Pressures other than land use also have an impact on the condition of native vegetation. These include:

- the longer-term effects of fragmentation after clearing
- invasive species (especially weeds and plant pathogens)
- altered fire regimes
- soil degradation
- overgrazing
- changes to water regimes
- the emerging effects of climate change.

Fragmentation

Habitat fragmentation caused by land clearing continues to have long-term impacts on native vegetation well after the initial clearing occurs, including:

- the dieback of vegetation and lack of regeneration
- invasion by weeds and feral animals
- loss of native species and variability.

Overgrazing

While most arid shrublands and grasslands are not subject to extensive clearing, they are affected by overgrazing. This is due to the cumulative impact of native species, farm stock and feral animals. The effects of overgrazing are often compounded by cycles of drought. Overgrazing reduces the cover of ephemeral plants, simplifies fauna habitat and promotes an overabundance of species which are less palatable to grazing animals.

Altered fire regimes

Altered fire regimes – too much or too little burning or burning at too high an intensity – affects regeneration and alters the composition of vegetation communities. Some native species require a level of fire to stimulate regeneration, but too much fire supresses this regeneration.

Climate change

Climate change is a pervasive threat that is expected to have increasing effects on all types of native vegetation in NSW. Alpine vegetation, wetlands and rainforests are likely to be especially sensitive (Laurence et al. 2011). The continuing reduction of snow cover in alpine areas (Nicholls 2009) is decreasing the area and suitability of habitat for a range of specialised alpine species (Green & Pickering 2009).

Some of the pressures on the condition of native vegetation are described in more detail in other topics of this report, including:

- changes to water regimes (see the River Health and Wetlands topics)
- soil degradation (see the Soil Condition topic)
- invasive species (see the Invasive Species topic)
- climate change (see the Climate Change topic).

Responses

Legislation and policies

Biodiversity Conservation Act

Biodiversity legislation in NSW has been consolidated under the *Biodiversity Conservation Act 2016* (BC Act), which replaces the *Threatened Species Conservation Act 1995*, *Nature Conservation Trust Act 2001* and the plant and animal provisions of the *National Parks and Wildlife Act 1974*. A new rural land management framework was also introduced with the *Local Land Services Amendment Act 2016,* which replaced the *Native Vegetation Act 2003*. The new laws commenced on 25 August 2017

Programs

Biodiversity Offsets Scheme

A new biodiversity offsets framework was introduced with the BC Act. The **Biodiversity Offsets Scheme** establishes a framework to avoid, minimise and offset the impacts on biodiversity from development or clearing. It simplifies assessment and improves biodiversity outcomes by creating consistent requirements for the assessment of biodiversity at development and offset sites.

Under the Biodiversity Offsets Scheme, offset sites must be secured using Biodiversity Stewardship Agreements, which are voluntary in-perpetuity agreements between a willing landholder and the Minister for the Environment. Stewardship agreements generate biodiversity credits, representing the gain in biodiversity achieved by protecting and managing the land.

The BC Act also establishes a scheme for the biodiversity certification of land which strengthens and improves the previous certification framework. Biodiversity certification offers planning authorities a streamlined process for assessing biodiversity in areas marked for development at the strategic planning stage. These areas can be avoided and protected while identifying areas more suitable for development. Certification offers a range of secure options for offsetting impacts on biodiversity.

Biodiversity Assessment Method

The Biodiversity Assessment Method (BAM) was established to support the Biodiversity Offsets Scheme by providing:

- a consistent method for assessing of biodiversity on a proposed development or State significant project, or clearing site
- guidance on ways in which a developer or farmer can avoid and minimise potential biodiversity impacts
- the number and class of biodiversity credits that need to be offset to achieve a standard of ‘no net loss’ of biodiversity.

The BAM assesses the biodiversity value of land and calculates likely losses resulting from the clearing of native vegetation and habitat destruction. It also calculates gains from conserving native vegetation and actively managing land for conservation as a stewardship site.

Biodiversity Values Map

The Biodiversity Values Map identifies land with high biodiversity values in NSW that could be affected by future development and helps determine whether proposed development or clearing activities require offsets.

Eleven types of land may be considered in the Biodiversity Values Map, including:

- coastal wetlands and littoral rainforest as per the *Coastal Management Act 2016*
- core koala habitat identified in a plan of management under *State Environmental Planning Policy No. 44—Koala Habitat Protection* (SEPP 44)
- Ramsar wetlands as defined by the *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth)
- land that contains threatened species or threatened ecological communities identified as species vulnerable to serious and irreversible impacts under Section 6.5 of the BC Act
- protected riparian land
- high conservation value grasslands or groundcover
- old growth forest
- rainforest
- declared areas of outstanding biodiversity value
- council nominated areas with connectivity or threatened species habitat that the Environment Minister considers will conserve biodiversity at bioregional or state scale
- any other land that is of sufficient biodiversity value to be included.

Biodiversity Conservation Trust

The NSW Biodiversity Conservation Trust (BCT) is a not-for-profit statutory body that was constituted with the commencement of the BC Act. The work of the BCT is guided by its Business Plan for 2017–18 to 2020–21, approved by the Minister for the Environment and the Biodiversity Conservation Investment Strategy 2018.

The BCT was established to support and encourage landholders to protect and conserve biodiversity on private land. The BCT is delivering $240 million over the five years to 2020–21, and $70 million per annum (escalated) thereafter, subject to reviews of its performance.

The BCT works in partnership with landholders to establish private land conservation agreements to conserve and manage high-value biodiversity on private land. Three types of voluntary private land conservation agreements are available to landholders:

- biodiversity stewardship agreements (BSAs)
- conservation agreements
- wildlife refuge agreements.

Landholders who enter voluntary agreements to conserve and manage biodiversity can access a range of funding programs, subject to eligibility criteria, that may help to diversify their income streams, with potential for long-term annual payments. Further details on the operation and uptake of private land agreements are provided in the Protected Areas and Conservation topic.

The NSW BCT plays a key role in the delivery of the Biodiversity Offsets Scheme. Proponents can choose to satisfy offset obligations in the consent conditions to their development approval by paying money into the Biodiversity Conservation Fund managed by the NSW BCT. Once a payment is made into the fund, the BCT is responsible for finding the offsets needed. This is achieved by purchasing biodiversity credits (generated under biodiversity stewardship agreements) or funding biodiversity conservation actions that benefit species impacted by the development.

The BCT assists landholders who wish to enter BSAs to generate and sell biodiversity credits and administers those agreements.

Land management

Land management reforms were introduced with the *Local Land Services Amendment Act 2016* to regulate clearing of vegetation and to protect threatened species or ecological communities.

The clearing of native vegetation for everyday land management activities such as constructing and maintaining rural infrastructure (including fence lines, dams, sheds and tracks) is permitted under the Act. However, there are requirements to minimise impacts on native vegetation and, where possible, to co-locate infrastructure. Land with threatened species or ecological communities present is more highly regulated than other land.

A new Land Management (Native Vegetation) Code has been introduced to help landholders manage their land sustainably and ensure more productive farming methods and systems while responding to environmental risks. The Code sets out clearing parameters and requirements to offset the impacts of clearing.

Native Vegetation Regulatory Map

A Native Vegetation Regulatory (NVR) Map is being developed to underpin the new land management framework. The NVR Map shows rural land where clearing of native vegetation can occur without approval and land where clearing requires approval.

Land is categorised based on the ecosystems present and their condition, as:

- unregulated (unrestricted) land that can be cleared without approval
- regulated land managed under the Land Management (Native Vegetation Code)
- vulnerable regulated land
- sensitive regulated land
- excluded land.

Landholders can request a report which explains the basis for including their land in any category on the NVR Map or seek a review of their property if they consider their land has been incorrectly categorised.

A new State Environmental Planning Policy (Vegetation in NonRural Areas) 2017 (SEPP) regulates clearing not covered by the *Local Land Services Act 2013* (LLS Act). The SEPP applies to the Sydney and Newcastle metropolitan areas, and to all other land in NSW that is zoned for urban purposes or for environmental conservation/management under the Standard Instrument – Principal Environmental Plan. It regulates clearing of:

- native vegetation above the offset threshold, where a proponent will require an approval from the Native Vegetation Panel established under the LLS Act
- vegetation below the offset threshold, where a proponent requires a permit from council as the vegetation is identified in the council's Development Control Plan (DCP).

For clearing proposals that do not fall under the allowable activities of the Land Management (Native Vegetation) Code, an approval process has been established by the Native Vegetation Panel to enable landholders to offset the biodiversity impacts of developing their land.

Management of native vegetation

Since 2006, the NSW Government has compiled data on native vegetation programs from various agencies to produce the *NSW Report on Native Vegetation* (OEH 2018), including the native vegetation report card. (Updates of this data as they become available can be found on the Office of Environment and heritage website). The report card compiles figures on the range of activities conducted to manage native vegetation in NSW since 2005–06. These numbers are summarised for the period 2005–6 to 2015–16 in **Table 13.5** below.

Table 13.5: Summary of native vegetation management activities undertaken in NSW from 2005–06 to 2015–16

Category	Description	Total area (ha) - Last 2 years (2014–15 to 2015–16)	Annual average (ha) - (2005–6 to 2015–16)	Total area (ha) - (2005–6 to 2015–16)
New conservation areas	New public reserves or additions as well as private conservation areas (see Protected Areas and Conservation topic)	74,560	124,620	1,370,830
New restoration or revegetation of native vegetation	Revegetation or rehabilitation of native vegetation, as part of incentives, wildlife refuges, or retained and improved as a condition to clear under Property Vegetation Plans	234,410	261,250	2,873, 800
New management of native vegetation	Management through Invasive Native Scrub, Thinning and Private Native Forestry Property Vegetation Plans, new areas of public forest, weed removal programs, and management to reduce grazing pressure	1,184,120	783,530	8,618,820
New approvals for clearing of native vegetation	Approved clearing under NSW legislation including the *Biodiversity Conservation Act 2016*; former *Native Vegetation Act 2003* and *Native Vegetation Conservation Act 1997*; *Plantations and Reafforestation Act 1999*	10,120	3,660	40,250

Source:
OEH 2018

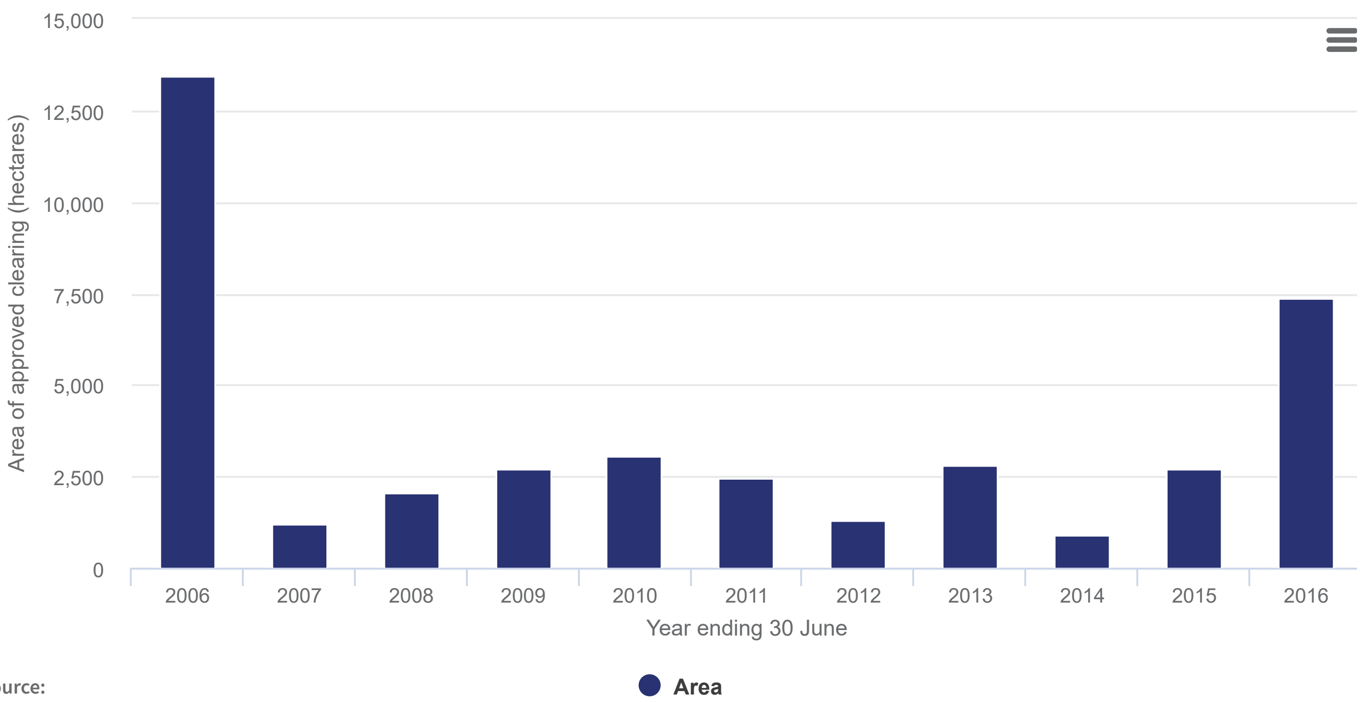
The first three categories describe activities that result in positive changes in the extent or condition (or both), of native vegetation. The last category describes approved losses in the extent of vegetation.

In general, the total area of land being conserved, restored or undergoing improved management is substantially greater than the area approved for clearing. However, it is still too early for many of the measures listed in **Table 13.5** to be detectable as changes in the overall extent or condition of native vegetation, described earlier in this topic.

The new clearing approvals category describes consent for clearing applications. These do not necessarily reflect the actual levels of clearing described in **Figure 13.1** above, as the clearing detected may be approved, exempt from approval, or illegal. Clearing approvals also apply for 15 years, so the clearing may not occur in the year of approval.

Figure 13.2 shows that clearing approvals in 2015–16 totalled about 7,400 hectares. Approvals in the previous nine years to 2014–15, were between 1,000 and 3,000 hectares per annum.

Figure 13.2: New approvals for clearing 2005–06 to 2015–16



Source:
OEH 2018

Future opportunities

More regional programs involving local communities should provide greater opportunities to improve vegetation condition, enhance habitat connectivity and reduce fragmentation. Over time, this should increase the resilience, health and productivity of native vegetation on public and private land.

The pressures that affect vegetation condition are likely to continue in the foreseeable future, due to further weed invasion and new weed incursions, the effects of plant diseases and pathogens, changes to fire regimes and the effects of climate change.

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Protected Areas and Conservation

Protected areas of land and water in original or close-to-original natural condition are the cornerstone of nature conservation efforts in NSW.

Summary

Public conservation reserves

9.5% of NSW

is formally protected in public reserves

Read more

Private land conservation

3.9%

of privately-owned land in NSW is managed for conservation

Read more

Reserve comprehensiveness

39% of bioregions

meet comprehensiveness targets across public reserves

Read more

Reserve representativeness

47% of subregions

within NSW bioregions meet representativeness targets across public reserves

Read more

The public reserve system covers about 7.59 million hectares or 9.5% of land in NSW. Conservation on private land is also important in protecting the natural environment in NSW.

Since 2015, the area of land in national parks and nature reserves has increased by 31,900 hectares. The representativeness and comprehensiveness of protected areas in NSW is improving with significant additions to underrepresented areas, but some bioregions and vegetation classes are still underrepresented, particularly in the central and western regions.

Conservation on Crown and private land supplements the protected area network and provides vegetation corridors linking larger public reserves. Some natural ecosystems protected on these lands are underrepresented or not present in public reserves. The Biodiversity Conservation Trust promotes conservation on private land, encouraging landholders to voluntarily enter into one of three types of private land conservation agreements for environment management and protection to conserve biodiversity.

There has been little change to the management or extent of marine protected areas over the past three years, but the NSW Government is exploring options to enhance marine biodiversity protection in the Hawkesbury Shelf marine bioregion (between Wollongong and Sydney).

The number of parks on land jointly managed or owned by Aboriginal people has increased.

Related topics: Invasive species | Wetlands | Native fauna | Threatened species | Climate change

NSW indicators

Indicator and status		Environmental trend	Information reliability
Area of terrestrial reserve system	MODERATE	Getting better	✓✓✓
Growth in off-reserve protection	MODERATE	Getting better	✓✓
Protected areas jointly managed or owned by Aboriginal people	MODERATE	Getting better	✓✓✓
Area of marine protection	MODERATE	Stable	✓✓

Notes:
Terms and symbols used above are explained in How to use the report

Context

Protected areas of land and water in original or close-to-original natural condition are the cornerstone of nature conservation efforts in NSW.

The State's public land reserve system has a substantial network of protected areas such as national parks and flora reserves that:

- conserves representative areas of habitats and ecosystems, plant and animal species, and significant geological features and landforms
- protects areas of significant Aboriginal and European cultural heritage
- provides opportunities for recreation and education.

Crown reserves can supplement nearby protected areas and may include:

- Crown land reserved for purposes such as environment protection and soil conservation under the *Crown Land Management Act 2016*
- State parks reserved primarily for nature-based recreation and managed by various trusts under the *Crown Land Management Act* 2016
- natural areas administered by trusts under the *Crown Land Management Act*, and managed by local councils
- Local land services travelling stock routes
- former perpetual leases converted to freehold under the *Crown Lands Act 1989* with covenants protecting existing environmental values.

Other important supplements to public reserves are privately-owned areas managed for conservation under legal agreements with landowners and landholders.

The State's marine-protected areas provide a large network of marine parks and aquatic reserves. One objective of marine parks and aquatic reserves is to conserve biodiversity and maintain the ecosystems of bioregions in NSW waters. Other objectives are to:

- enable resources to be used in an ecologically sustainable manner
- enable the park or reserve to be used for scientific research and education
- provide opportunities for public appreciation and enjoyment
- support Aboriginal cultural uses.

Aboriginal people's relationship with Country

The NSW Government and the NSW Constitution acknowledge that Aboriginal people are the original custodians of the lands and waters, and have a spiritual, social, cultural and economic relationship with their traditional lands and waters.

The Office of Environment and Heritage (OEH) commits to involving Aboriginal communities in the management of all national parks and reserves. This is consistent with the OEH principles document *Aboriginal People, the Environment and Conservation*, and the staff of National Parks and Wildlife Service (NPWS) *Statement of reconciliation*.

Through joint management agreements, OEH and Aboriginal people share responsibility for managing national parks and reserves. OEH has 31 joint management agreements with Aboriginal traditional owners, covering approximately 2.1 million hectares. Negotiations for two more agreements will be finalised in 2018 and negotiations for a further nine agreements are planned.

OEH also has an annual funding program for Aboriginal Park Partnership Projects for all parks and reserves across the State. Partnerships between Aboriginal people and NPWS recognise that:

- all parks and reserves are part of Aboriginal peoples' Country and are places where Aboriginal people can care for and access their Country and its resources. NPWS parks and reserves play an important role in maintaining Aboriginal culture and connection to Country
- Aboriginal communities obtain cultural, social and economic benefits through being involved in park management
- OEH, in partnership with the Aboriginal community, can protect and interpret cultural heritage and apply Aboriginal knowledge to land management and the conservation of cultural and natural values
- visitors to parks gain a greater understanding of Aboriginal cultural values and an enriched experience through interaction with Aboriginal people.

The Forestry Corporation of NSW works with Aboriginal communities in some State forests to conserve the qualities and attributes of places that have spiritual, historic, scientific or social value.

Object 1.3(e) of the *Crown Land Management Act 2016* facilitates the use of Crown land by the Aboriginal people of NSW and, where appropriate, to enable the co-management of dedicated or reserved Crown land.

The Marine Estate Management Authority has worked closely with Aboriginal communities over the past three years. This has been to identify threats to Aboriginal culture and heritage in coastal and marine environments and to develop actions to address these threats, for inclusion in a Marine Estate Management Strategy. Employment and improved involvement in the management of Sea Country are key outcomes.

Status and Trends

Land-based formal reserves

Protected areas that meet formal reserve standards under the International Union for Conservation of Nature (IUCN) Protected Areas Categories System are depicted in Map 14.1.

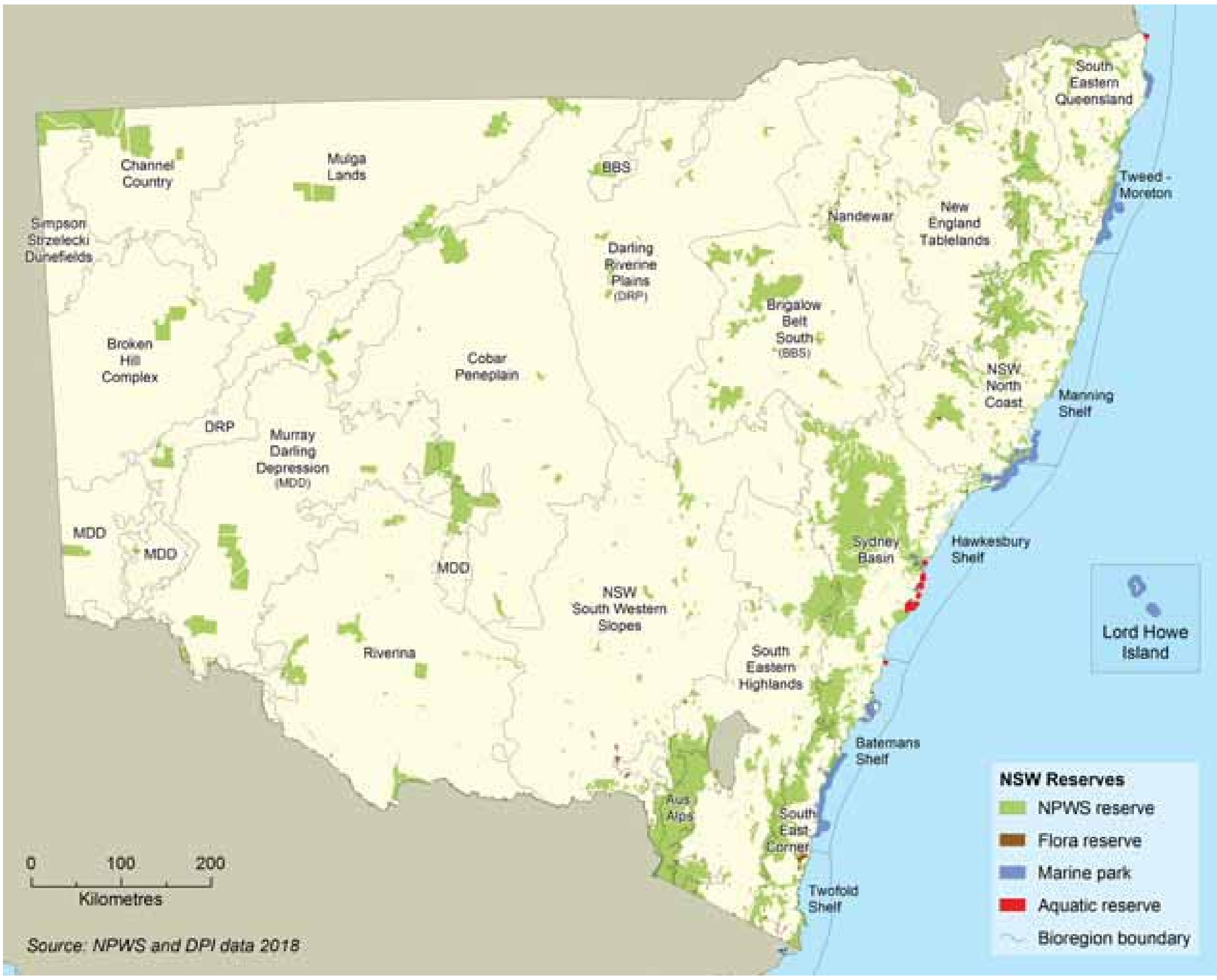
At 1 January 2018, formal reserves comprised at least 9.5% of NSW, and included:

- public reserves protected under the *National Parks and Wildlife Act 1974* (NPW Act), comprising 872 reserves totalling 7,142,675 hectares or approximately 9% of the State
- land reserved for conservation as flora reserves under the *Forestry Act 2012*
- land reserved for environment and heritage protection as formal Crown reserves such as Barigan Heritage Lands Reserve east of Mudgee (25,774 hectares) but not shown in **Map 14.1**.

Reserves established under the NPW Act include national parks, nature reserves, state conservation areas, karst conservation reserves, historic sites and Aboriginal areas. State conservation areas, for example, allow resource exploration and mining as well as protecting natural and cultural values.

Other types of land protected for nature conservation are considered later in this section.

Map 14.1: NPWS reserves, flora reserves, marine parks and aquatic reserves



Source:
NPWS and DPI 2018

Additions to land-based national parks and reserves since 2015

Since the 2015 State of the Environment report (EPA 2015), there were 58 additions to NPWS parks and reserves, totalling 31,900 hectares. The largest areas of additions included:

- Kalyarr National Park (20,240 hectares added)
- Yathong Nature Reserve (4,151 hectares added)
- Culgoa National Park (2,286 hectares added)
- Captains Creek Nature Reserve (1,188 hectares added)
- Oxley Wild Rivers National Park (765 hectares added)
- Dananbilla Nature Reserve (541 hectares added).

Figures 14.1 and **14.2** show additions to national parks and reserves since 2009 by area and number of reserves.

There were fewer additions to the public reserve system from 2015–18 than from 2012–15, due to:

- ending of National Reserve System funding
- lack of available public land suitable for transfer
- a focus on higher value land for purchase in eastern NSW
- consolidation of reserve boundaries to improve management effectiveness and efficiencies

- an increasing focus on private land conservation to complement public reserves.

Figure 14.1: Yearly increase in area (hectares) of national parks and reserves in NSW since 2009

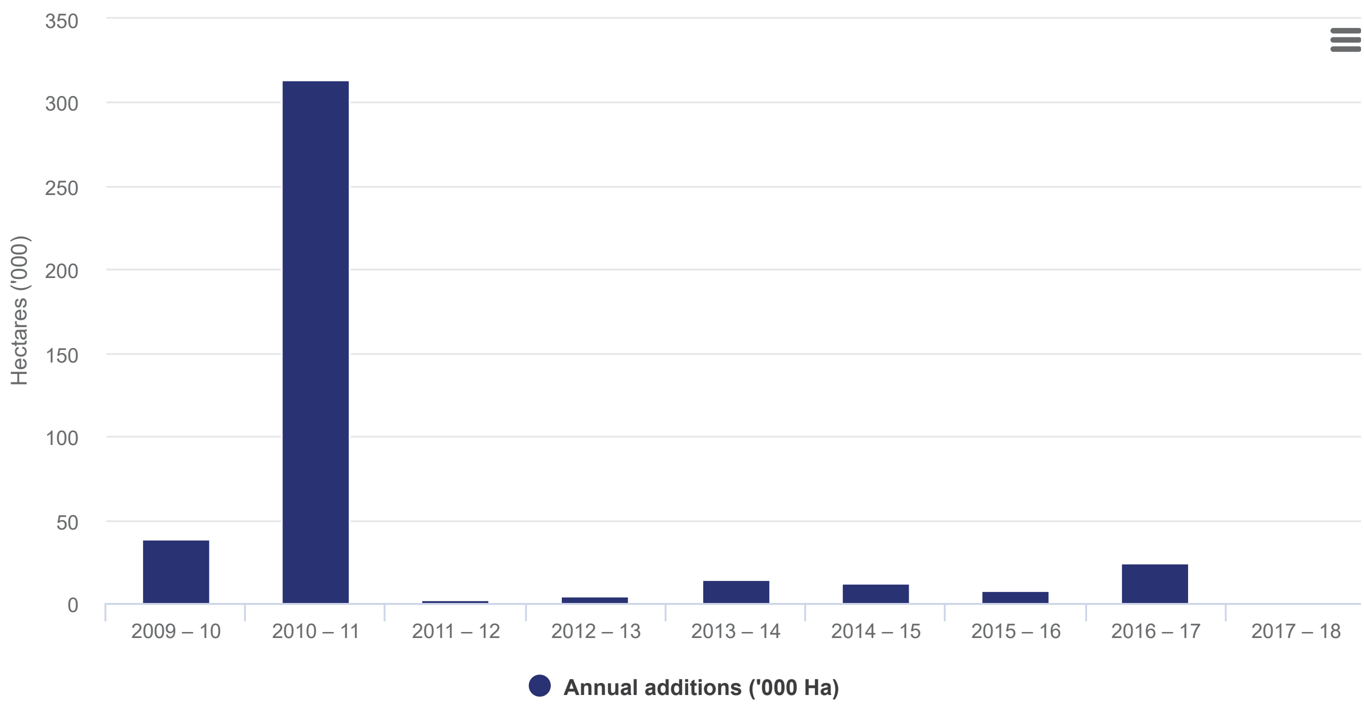
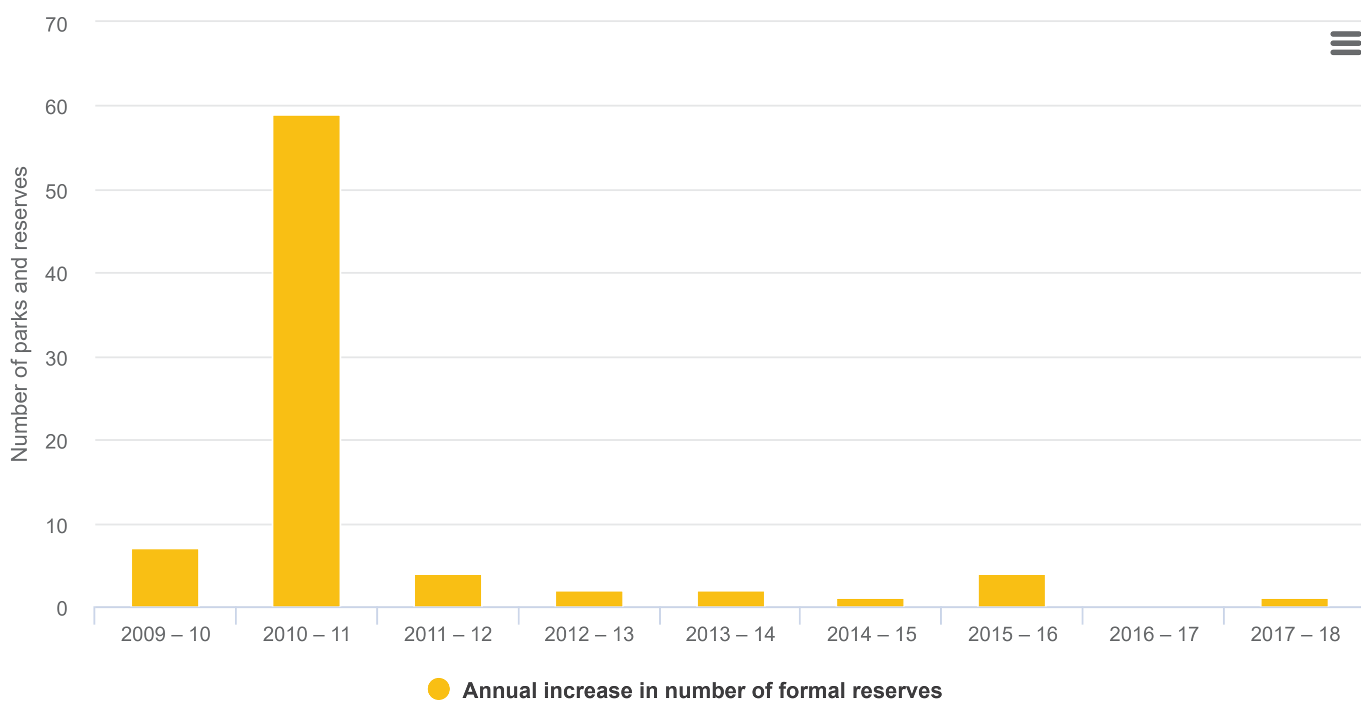


Figure 14.2: Yearly increase in number of national parks and reserves in NSW since 2009



Representation of protected land in NSW bioregions

NSW national parks and reserves are selected according to the conservation principles of comprehensiveness, adequacy and representativeness (CAR):

- **comprehensiveness** refers to conserving samples of each ecosystem and bioregion, in protected areas

- **adequacy** refers to how much of each ecosystem should be protected to provide ecological viability and adequately conserve populations, species and communities
- **representativeness** means protecting the full range of biological variation in each ecosystem's geographic range.

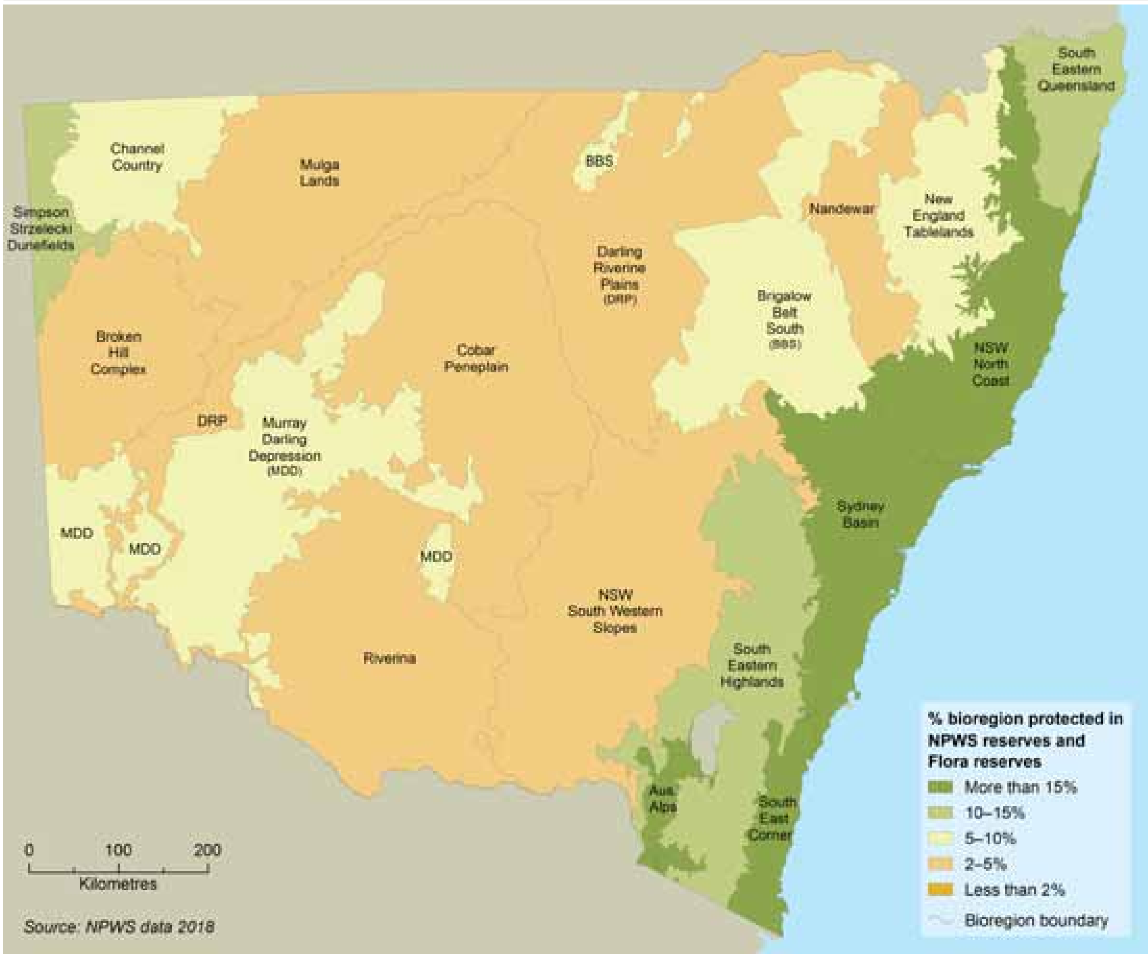
Bioregions are relatively large land areas characterised by natural features and environmental processes that influence the functions of entire ecosystems. Currently in NSW, the most comprehensively protected ecosystems are those on the steep ranges of eastern NSW, parts of the coast, and the Australian Alps. Poorly protected ecosystems include most ecosystems in far western NSW, the northern, central and southern highlands and on the western slopes; and those on the richer soils of the coastal lowlands.

Map 14.2 shows the proportion of land in public reserves in each of the 18 bioregions of NSW. The bioregions of eastern NSW are generally well-represented compared with bioregions in the centre and far west of the State which are mostly underrepresented.

- Of the 18 bioregions, four still have fewer than 50% of their ecosystems included in public reserves.
- Thirty of the 131 subregions in NSW still have under half their ecosystems protected in reserves.
- Many poorly represented bioregions, particularly in central NSW, incorporate large areas of highly fragmented vegetation. With extensive areas used for other land uses, there are limited opportunities to add viable lands to reserves.

Private land conservation can help protect additional ecosystems in conservation priority investment areas.

Map 14.2: Bioregional reservation in NSW



Notes:
The NSW Government's Biodiversity Conservation Investment Strategy is guiding investment in private land conservation to improve outcomes for underrepresented bioregions.

Source:
NPWS 2018

Private land conservation in NSW

With less than 10% of NSW conserved in national parks and reserves and more than 70% of the State under private ownership or Crown lease, private land conservation plays a vital role in conserving additional biodiversity in NSW. Around 3.9% of NSW has some form of private land conservation management in place (see **Table 14.1**).

Table 14.1: Private land conservation in NSW

Conservation mechanisms	Number	Area protected (hectares)
Conservation agreements	467	156,720
Wildlife refuges	687	1,889,135
Nature Conservation Trust agreements	131	56,439
Incentive property vegetation plans	2045	1,003,867
Registered property agreements	317	50,635
BioBanking agreements	92	10,802
Land for Wildlife (Community Environment Network)	1125	87,242
Indigenous Protected Areas	10	16,000
Total		3,128,195

In addition to areas shown in **Table 14.1** are covenants on converted perpetual leases that protect environmental values. There are approximately 3,500 covenants, comprising an area of approximately one million hectares.

Conservation principles on other public land

Forests NSW conservation zones

The Forestry Corporation uses a zoning system in State forests that identifies areas set aside for conservation.

Through this zoning system about 40,000 hectares of State forest are formally protected as flora reserve, 486,000 hectares of State forest (22%) excluded from harvesting for conservation reasons, and a further 544,964 hectares excluded from harvesting for silvicultural reasons. These areas, 47% of the total area of State forests, make a significant contribution to protected areas in NSW.

Travelling stock routes

Travelling stock routes (TSRs) are authorised thoroughfares on Crown land for moving stock from one location to another. On a TSR, grass verges are wider and property fences are set back further from the road than usual, providing feeding stops for travelling stock.

TSRs are often found in environments that are poorly represented in public reserves. Although narrow and modified, TSRs tend to be well vegetated and in better condition than the surrounding land. The conservation values of approximately 700,000 hectares of TSRs in eastern and central NSW are still to be comprehensively assessed. The generally much wider TSRs of western NSW are largely situated on lands under secure Western lands lease tenure.

Table 14.2: Travelling stock routes in NSW

Region	Area in hectares of travelling stock route	Bioregion (hectares)	% of bioregion in a travelling stock route
Australian Alps	272.7	464,297.5	0.06%
Brigalow Belt South	83,767.9	5,624,738.4	1.49%
Broken Hill Complex	151,042.7	3,763,317.7	4.01%
Channel Country	117,549.4	2,340,662.2	5.02%
Cobar Peneplain	230,967.3	7,377,221.2	3.13%
Darling Riverine Plains	474,827.7	9,419,258.4	5.04%
Mulga Lands	242,205.2	6,591,283.3	3.67%
Murray Darling Depression	319,509.0	7,935,880.5	4.03%
Nandewar	24,630.6	2,074,881.9	1.19%
New England Tableland	29,063.2	2,860,297.9	1.02%
NSW North Coast	9,271.1	3,962,537.5	0.23%
NSW South Western Slopes	52,696.5	8,103,373.4	0.65%
Riverina	222,040.5	7,022,691.5	3.16%
Simpson-Strzelecki Dunefields	14,709.7	1,095,796.6	1.34%
South East Corner	821.3	1,153,600.6	0.07%
South Eastern Highlands	7,274.5	4,989,020.1	0.15%
South Eastern Queensland (NSW area)	4,959.6	1,647,040.8	0.30%
Sydney Basin	2,230.5	3,573,565.9	0.06%
Total, and average percent	1,987,839.3	79,999,465.4	2.48%

Marine protected areas

The *Marine Estate Management Act 2014*, which commenced on 19 December 2014, provides for the declaration and management of marine parks and aquatic reserves, which are managed by the Department of Primary Industries. Management rules are contained in the *Marine Estate Management (Management Rules) Regulation 1999*.

The aquatic reserve notification gazetted in 2015 under the *Marine Estate Management Act 2014* sets out the activities prohibited in each aquatic reserve.

Extent and types of marine protected areas

Current NSW marine protected areas (**Map 14.3**) include:

- Six multiple-use marine parks, which cover around 34% (approximately 345,000 hectares) of NSW waters.
- 12 aquatic reserves, which cover around 2,000 hectares of NSW waters.
- National park and nature reserve areas occurring below the astronomical high tide level, which include around 20,000 hectares of estuarine and oceanic habitats.
- The northern and southern regions of NSW, which are well represented by marine parks.
- The central region, which incorporates the Hawkesbury Shelf marine bioregion. The region does not contain a marine park at present but does contain all but one of the 12 aquatic reserves.
- The Twofold Shelf bioregion which only extends into the far south of NSW, being mostly situated in eastern Victoria. There are no marine parks or aquatic reserves on this small section of the NSW coast.

Marine parks in NSW are managed according to zones consistent with the International Union for Conservation of Nature and Natural Resources (IUCN) categories for protected area management. There are four types of marine zones:

- ‘sanctuary’ (IUCN II) – the highest level of protection for biodiversity and natural and cultural features
- ‘habitat protection’ (IUCN IV) - protects physical and biological habitats by reducing high impact activities
- ‘general use’ (IUCN VI) - provides for a wide range of environmentally sustainable activities
- ‘special purpose’ (IUCN VI) – special management arrangements including protection of Aboriginal and other cultural features, or for marine facilities, or for specific park management.

The total area of sanctuary (or no-take) zones is around 65,630 hectares. In June 2018, this area decreased slightly as a result of the NSW Government's decision to rezone 10 sites from 'sanctuary zone' to 'habitat protection zone' to make shore-based recreational line fishing lawful. Overall this decision resulted in a 0.05% reduction in sanctuary zone area, from 6.49 to 6.44% of the NSW marine estate.

Map 14.3: Marine parks and aquatic reserves along the NSW coast

Source:
NSW DPI

Pressures

Threats to national parks and reserves

Weeds

Weeds are a significant problem, endangering threatened species, threatened ecological communities and Aboriginal sites including rock engravings and grinding grooves. It is important to deal with new and emerging weeds before they start threatening native plants and animals and Aboriginal cultural sites. See ‘Responses’ for information about actions being taken.

The most pervasive widespread weeds in reserves are:

- bitou bush
- lantana
- African olive
- scotch broom
- introduced perennial grasses such as serrated tussock
- exotic vines such as madeira vine.

These weeds are listed as key threatening processes under the *Biodiversity Conservation Act 2016*.

Pest animals

Introduced pest animals including foxes, wild dogs, rabbits, deer and feral cats, goats, and pigs are widespread across all of NSW, including in national parks and reserves. Pest animals threaten native flora and fauna, including threatened species, through competition, predation and habitat degradation. As they are present on public and private land, the NSW Government, local councils, and private landowners and landholders must work together to manage them effectively. See ‘Responses’ for information about actions being taken.

Horses, wild deer and cane toads present localised issues in some reserves. For example, some alpine ecosystems of the Snowy Mountains are under significant and increasing pressure from wild horse populations. Hard-hoofed animals cause significant ground and stream bank disturbance, damaging vegetation and threatened species habitat.

Fire

Inappropriate fire regimes may threaten biodiversity in reserves, though planning and hazard reduction burns reduce the severity of impacts and protect life and property.

- In 2016–17, there were 296 fires in national parks, affecting an area of 41,290 hectares. NPWS and Forestry Corporation firefighters also assisted with 97 fires outside parks.
- In 2017–18 (as at 30 May) there had been 482 fires in national parks, affecting an area of 121,530 hectares. NPWS firefighters also assisted with 107 fires outside parks.
- Forestry Corporation reported that the forest estate was broadly protected from fire during 2016–17. Like NPWS, it deployed crews to assist on significant fires on private property and other land as part of NSW’s coordinated firefighting effort.

During the last 10 years, a third of fires in reserves were caused by lightning strike, which burnt 59% of the total area affected by fire. Arson or other suspicious causes accounted for 29% of the fires, or 9% of the area burnt.

Habitat and species isolation

Habitat and species isolation can occur when there are limited vegetation corridors or natural areas between reserves and other key habitats. This can impede movement of animals across landscapes and reduce breeding and genetic variation. Land use changes such as land being developed for housing or agriculture, or land clearing next to reserve boundaries can make it difficult to maintain habitat connectivity.

Illegal activities

The most widely reported illegal activities in NSW national parks are:

- waste dumping
- unregistered off-track trail bike riding
- vandalism
- hunting.

These activities have a negative effect on visitors' enjoyment and safety. They also affect biodiversity, particularly threatened animals, plants and endangered ecological communities; and cultural heritage sites.

Other activities that threaten reserves include timber getting, antisocial behaviour, arson, collecting plants or other materials and stock encroachments from neighbouring properties.

Climate change

Predicted climate change impacts include:

- loss of plant and animal communities and species with a restricted range or diminished capacity to adapt to changes in climate
- increased number and severity of bushfires
- increased impacts on coastal reserves from storms and sea level rise
- increased weed invasion

Some of the natural systems affected or likely to be affected include:

- threatened seabird habitats
- freshwater lagoons
- saltmarsh areas
- sub-alpine habitats
- sand dunes
- rainforests.

Threats to these areas can result in decreased species distribution and abundance.

Threats to marine protected areas

In 2017 the NSW Marine Estate Management Authority completed a statewide threat and risk assessment to the environmental assets of the marine estate, as well as to the social, cultural and economic benefits derived from the marine estate. Lord Howe Island Marine Park was excluded from this assessment.

The top five priority threats identified were:

- urban stormwater discharge

- estuary entrance modifications (affecting water flows)
- runoff from agricultural activities
- clearing riparian and adjacent habitat, including draining wetlands
- climate change.

Community opinion

Surveys of the community conducted as part of the NSW Marine Estate Management Authority's threat and risk assessment identified that the community cares about the health of the State's estuaries and marine waters; and that clean water, healthy habitats and abundant and diverse marine biodiversity underpins the NSW community's social and cultural wellbeing (Sweeney Research, 2014). Priority threats were considered to be:

- littering and marine debris
- oil and chemical spills
- water pollution from sediment or runoff.

Overcrowding, conflicting use and lack of public access were also recognised as potential social threats.

Perceived threats to economic viability were identified as water pollution, loss of natural areas and increasing costs of accessing the marine environment. The diversity and abundance of marine life and the natural beauty of the marine environment were seen as being key economic values for nature-based and regional tourism.

Threats to conservation on private land

The pressures that affect protected areas on private land are similar to those affecting public reserves. These include weeds and pest animals, fire, habitat isolation, illegal activities including clearing of native vegetation, the impacts of stock encroachment and neighbouring land uses.

Land managers may need to address potential threats from other land uses such as agriculture when they are not compatible with conservation values. Unpredictable events, such as bushfires or sustained drought, may exacerbate these threats.

Responses

Legislation and Policy

Review of land-based conservation legislation

In 2014, the NSW Minister for the Environment established an independent panel to review the *Native Vegetation Act 2003*, the *Threatened Species Conservation Act 1995*, the *Nature Conservation Trust Act 2001* and parts of the *National Parks and Wildlife Act 1974*. The aims of the review were to recommend legislation that was simpler, more streamlined and effective. The panel provided 43 recommendations in its report (Byron et al. 2014) including some concerning private land conservation.

The NSW Government accepted all the recommendations, and in 2016 rolled out a program of reforms, including the legislative changes outlined in **Table 14.3**.

Table 14.3: Recent reforms to conservation legislation

Legislation	Change	What's in place now
Threatened Species Conservation Act 1995	Repealed	*Biodiversity Conservation Act 2016*
Native Vegetation Act 2003	Repealed	*Biodiversity Conservation Act 2016*
Nature Conservation Trust Act 2001	Repealed	*Biodiversity Conservation Act 2016* Biodiversity Conservation Trust established
National Parks and Wildlife Act 1974	Animal and plant provisions repealed	*Biodiversity Conservation Act 2016*
Local Land Services Act 2013 Local Land Services Regulation 2014	Amended	*Local Land Services Act 2013* Local Land Services Regulation 2014
	New	State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017

The *Biodiversity Conservation Act 2016* and the *Local Land Services Act 2013* are the main Acts governing land management and biodiversity conservation and commenced on 25 August 2017. Applicants for managing native vegetation under Division 6 of the *Local Land Services Act 2013* have a requirement under the *Land Management (Native Vegetation) Code 2018* to manage land in perpetuity for conservation.

The Biodiversity Conservation Investment Strategy 2018 guides investment in private land conservation.

Other key components are identified below:

Biodiversity Offsets Scheme

The Biodiversity Offsets Scheme replaces a previously fragmented approach to biodiversity conservation and development and updates it with a single framework that captures all types of developments that are likely to have a significant impact on biodiversity. It applies to local developments, major projects, the clearing of native vegetation where *State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017* applies and clearing on rural land that requires Native Vegetation Panel approval. Public authorities can also opt in to use the scheme.

Under the scheme, applicants must avoid impacts on biodiversity if possible, then minimise impacts that cannot be avoided. Impacts that cannot be avoided or minimised may be offset by buying biodiversity offset credits or transferring this obligation to the Biodiversity Conservation Trust by paying into the Biodiversity Conservation Fund. Proponents may also be able to use other agreed conservation measures, such as funding biodiversity conservation actions or mine site rehabilitation (for major mining projects only).

The Biodiversity Offsets Scheme also introduces a new pathway of strategic biodiversity certification to encourage upfront consideration of biodiversity conservation in significant regional development and planning processes. It is intended to address the cumulative impacts of development and deliver more certainty about the development potential and conservation outcomes for an area.

Policy tools, such as Biodiversity Offset Scheme, can be effective mechanisms for balancing the competing demands of conservation and development. Strong public policy, scientific monitoring, and conservation efforts on private land to improve connectivity and protection, are important to bolster the success of biodiversity offset schemes and biodiversity outcomes. See also Hanford et. al. (2017), Maron et. al (2015) and Byron et. al (2014).

Developers may meet their offset obligations by dedicating land for reservation under the *National Parks and Wildlife Act 1974*.

Biodiversity Assessment Method

For all developments entering the biodiversity offsets scheme, specially accredited assessors must apply the Biodiversity Assessment Method to measure:

- the impacts on biodiversity from all developments
- the biodiversity gained at an offset site.

This scientifically-based method helps developers and landholders to identify and measure the potential impacts of their activities on the natural environment, and take appropriate steps to avoid, minimise or offset those impacts.

Private land conservation and the Biodiversity Conservation Trust

Under the *Biodiversity Conservation Act 2016*, private landowners can voluntarily enter into one of three types of private land conservation agreements:

- Biodiversity Stewardship Agreements are for landholders wishing to generate and sell biodiversity credits under the Biodiversity Offsets Scheme. They protect biodiversity on the land in perpetuity.
- Conservation Agreements conserve and manage biodiversity on an area of land and may be in perpetuity or for a stated timeframe.
- Wildlife Refuge Agreements are for landholders who wish to protect the biodiversity on their property but do not wish to enter into a permanent agreement.

These agreements are administered by the NSW Biodiversity Conservation Trust (BCT). The purpose of this statutory body is to protect and enhance biodiversity by:

- encouraging landholders to enter into cooperative arrangements for natural environment management and protection to conserve biodiversity on their land
- seeking strategic biodiversity offsets to compensate for the loss of biodiversity due to development and other activities
- providing mechanisms for biodiversity conservation
- promoting public knowledge, appreciation and understanding of biodiversity and its conservation.

In the first five years of the Biodiversity Conservation Investment Strategy's operation, the NSW Government has invested $240 million in encouraging biodiversity conservation on private land and allocated $70 million thereafter, depending on performance reviews.

Reforms to Aboriginal cultural heritage

The NSW Government has proposed a new system for managing and conserving Aboriginal cultural heritage in NSW, supported by a legal framework.

In February 2018, the NSW Government released the draft *Aboriginal Cultural Heritage Bill 2018* for public consultation. A series of public information sessions and workshops were held from September 2017 to April 2018. The feedback received is being considered in finalising the draft bill.

Programs

Plans of management for national parks and reserves

Plans of management are legal documents that guide how a park or reserve will be sustainably managed. As at 1 January 2018, 387 plans of management had been adopted, covering 591 parks and reserves. More than 6 million hectares are now covered by plans, representing around 85% of protected areas. Parks without a plan generally have a statement of management intent.

A statement of management intent is an interim document outlining the management priorities for a park based on its key values and major threats to these values. They also reference existing strategies that may already be in place for that park, for example, a fire management strategy.

NSW Koala Strategy

On 6 May 2018, the NSW Government released the NSW Koala Strategy, committing $44.7 million to securing the future of koalas in the wild. This was in response to the NSW Chief Scientist and Engineer's 2016 independent review into the decline of koala populations in key areas of NSW.

The NSW Koala Strategy:

- will support a range of conservation actions over three years
- conserves over 24,000 hectares of land with prime koala habitat as koala parks and reserves to ensure the habitat is conserved, key habitat corridors are linked and safe homes are provided for koalas being returned to the wild
- sets a foundation for the government's longer-term vision to stabilise and increase koala populations across NSW.

The NSW Koala Strategy is proposed to deliver:

- $20 million from the NSW Environmental Trust to purchase and permanently conserve land in national parks and reserves that contain priority koala habitat
- $3 million to build a new koala hospital at Port Stephens
- $3.3 million to fix priority road-kill hotspots across NSW
- $4.5 million to improve the care of sick or injured koalas
- $6.9 million to improve our knowledge of koalas, starting with the development of a statewide koala habitat information database
- $5 million to deliver local actions to protect koala populations, including through the *Saving our Species* program
- $2 million to research impacts of natural hazards and weather on koalas.

For more information on actions to protect threatened species, see the Threatened Species topic.

Reintroduction of locally extinct mammals

Since 2015, the NSW Government has been working with the Australian Wildlife Conservancy (AWC) and the University of New South Wales (UNSW) to reintroduce locally extinct mammal species into selected public reserves. See the Threatened Species topic for more information.

Managing threats to national parks and reserves

Weed and pest management

The NSW Government works across agencies to manage weeds and pest animals.

The NPWS has developed 14 Regional Pest Management Strategies to prioritise pest and weed management across reserves. These strategies will be reviewed in early 2019 when the NPWS will revise critical priorities for addressing new and emerging pests, economic impacts, health and disease impacts, and threatened species.

Overall priorities for pest and weed management to protect threatened species are identified in the *Saving our Species* program (SOS). For more information on SOS, see the Threatened Species topic.

In response to statewide reviews of weed and pest animal management conducted by the Natural Resources Commission, the NSW Government has established a State Weed Committee and a State Pest Animal Committee, as well as 11 Regional Weed Committees and 11 Pest Animal Committees facilitated by local land services. The regional committees have developed weed and pest animal management plans, which identify opportunities for working collaboratively with public and private landholders to control pests and weeds.

An important weed management program in NSW is eradicating mouse-ear hawkweed and orange hawkweed from Kosciuszko National Park. These weeds could devastate most of south-eastern Australia, causing major environmental degradation and costs to agriculture. The NSW Government, in partnership with local land services, local councils and other stakeholders, is on track to eradicate these two weeds from NSW.

The NSW Government works closely with stakeholders including local land services and private land managers to tackle wild dog problems across the State under a national wild dog action plan.

The Crown Lands division of NSW Department of Industry manages threats through a pest and weed control program.

Fire management

Over the last five years, NPWS has prevented around 90% of fires that started in parks from spreading beyond park boundaries.

In 2017–18 (as at 30 June 2018), NPWS conducted hazard reduction burns on 95,830 hectares of land. This represents 71% of the NPWS annual target of 135,000 hectares, which is calculated on a rolling five-year average.

Hazard reduction burning strongly depends on weather conditions so there are limited opportunities. Since the start of the Enhanced Bushfire Management Program in 2011, NPWS has undertaken 80% of total hazard reduction burning in NSW, despite managing only 9% of the State's land area.

The Forestry Corporation is a major firefighting authority in NSW and manages fire in more than 2.2 million hectares of native and planted forest. Hazard reduction burning reduces forest fuels that increase the potential intensity of a bushfire. During the fire season, the Forestry Corporation staffs a network of fire towers across the State to detect fires early and respond rapidly to them, giving crews more chance of managing fires while they are still relatively small.

The Crown Lands division manages threats to values in reserves through its bushfire risk mitigation program.

Climate change

The NSW Government conducts research to better understand the impacts of projected climate changes on sensitive ecosystems. Private land conservation is playing an increasingly important role in promoting ecologically sustainable development and building resilience to climate change. The 2018 Biodiversity Conservation Investment Strategy - the NSW Government strategy to guide investment in private land conservation - seeks to optimise biodiversity outcomes, improve landscape connectivity and build resilience to climate change.

See also the Climate Change topic in the present State of the Environment Report with specific reference to the Climate Change Policy Framework.

Managing threats to marine parks and aquatic reserves

The Marine Estate Management Strategy establishes the framework for managing threats to the entire NSW marine estate (including marine parks and aquatic reserves) through to 2028. Initiatives in the strategy detail management objectives, threats, stressors, management actions and resulting benefits. Announced in 2018, the Strategy will focus on the most urgent threats including actions to improve water quality, reduce litter, and deliver healthy habitats.

Funding of $45.7 million over two years has been allocated to achieve this and will also contribute to planning for climate change, protecting Aboriginal cultural heritage, reducing impacts on threatened and protected species, enhancing social, cultural and economic benefits and ensuring good governance. Initiatives will also ensure sustainable fishing and aquaculture, and safe and sustainable boating. The Strategy integrates with other coastal and marine reforms in NSW to achieve a more coordinated approach to management of the marine estate by all levels of government.

The *Marine Estate Management Act 2014* requires the development of a statutory management plan for each marine park in NSW. Statutory management plans are being developed and will replace the current zoning and operational plans in place in each of NSW's six marine parks. The plans will respond to localised threats and will document management objectives and actions, including zoning, compliance, education and communications. The new management planning process will first be piloted in Batemans Marine Park before being rolled out to the remaining marine parks.

Hawkesbury Shelf marine bioregion assessment

In 2018, the NSW Government commenced public consultation on a potential new marine park in the Newcastle, Sydney and Wollongong regions.

The proposal includes 25 distinct sites from Newcastle to Wollongong, or approximately 6.6% of the Hawkesbury Shelf Bioregion, to be protected in either sanctuary, conservation or special purpose zones. The aim is to reduce local or site-based threats while conserving marine biodiversity and allowing for a range of community benefits and uses. Community consultation on the proposal concluded on 27 September 2018 and the NSW Government is currently considering submissions to inform a final response.

Controlling threats to conservation on private land

The NSW Government helps private landholders to manage their land for long-term conservation and sustainable production by:

- providing information and incentive programs
- facilitating State or Federal tax concessions
- developing a support package through the Biodiversity Conservation Trust for landholders who enter into private land conservation agreements.

Future opportunitites

Integrated approach to conservation

The NSW Government is taking an holistic approach to conserving biodiversity in national parks and on private land.

The public land acquisition program builds on the existing network of public land over large areas to help sustain resilient and viable ecosystems.

In regions where remnant vegetation is scarce, private land conservation is critical to prevent further biodiversity loss and improve connectivity in the landscape.

Local land services facilitate access to grants and work with landholders to ensure sustainable environmental, social and economic outcomes.

The government's approach is guided by the Biodiversity Conservation Investment Strategy and the NSW National Parks System Directions Statement.

Review of NSW National Parks System Directions Statement

Every year, the NPWS acquires land for national parks by purchasing private land, and through public land transfers, donations and bequests.

The NSW National Parks Establishment Plan (2008) explains how and why new parks will be established and outlines the government's targets and conservation priorities for acquiring new land and enhancing the parks system.

A new Establishment Plan is being finalised following public exhibition, and will set out the objectives, challenges and opportunities for increasing the national parks system over the next five years.

References

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Biodiversity

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Threatened Species

Efforts to protect species and ecosystems are focused on threatened species as these are at the greatest risk of extinction.

Summary

Number of threatened species

1,025

species are listed as threatened in NSW

Read more

Increase in threatened species

3%

increase (or 26 more species) listed over the past 3 years

Read more

Extinct species

77

species are presumed extinct in NSW

Read more

Key threatening processes

46 KTPs

(Key threatening processes) are listed in NSW

Read more

The number of species considered at risk of extinction continues to rise. There are currently 1,025 species and 112 ecological communities listed as threatened under NSW legislation, including 77 species that are presumed extinct.

In the three years to December 2017 the number of listings of threatened species increased by 26, or 3%, to 1,025. There are also 57 populations and 112 ecological communities listed as threatened.

A total of 46 key threatening processes have been listed as causing these threats – 38 mainly terrestrial threats and 8 aquatic threats.

The main threats to listed species in NSW are habitat loss due to the clearing and degradation of native vegetation and the spread of invasive pests and weeds. The capacity of species to adapt to these pressures is further constrained by climate change.

To help arrest the sustained pattern of decline in species diversity that has occurred over the past 200 years, the Saving our Species program prioritises actions to maximise the number of threatened species that are secure in the wild in NSW for 100 years in a cost-effective manner.

Related topics: Population | Greenhouse Gas Emissions | Native Vegetation | Protected Areas and Conservation | Invasive Species | River Health

NSW indicators

Indicator and status		Environmental trend	Information reliability
Number of threatened species, communities and populations	POOR	Getting worse	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

The NSW landscape is not in pristine condition. Biodiversity has been modified and is constantly changing in response to pressures that are mainly human induced, in particular the clearing of native vegetation and the introduction of invasive species (Byron et al. 2014).

Overall, there has been a general pattern of decline in species diversity since European settlement (EPA 2012; EPA 2015). Conservation of threatened species is important to stabilise this loss of biodiversity.

The NSW approach to conserving threatened species emphasises protecting the species at greatest risk of extinction. Tracking the progress of threatened species in NSW is indicative of overall status of species diversity and may be used as an indicator to understand the effectiveness of programs to conserve biodiversity and save threatened species.

Status and Trends

Threatened species listings

This topic describes the status of native plant and animal species listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) or the *Fisheries Management Act 1994* (FM Act). A broader discussion of outcomes for species, primarily land-based vertebrate animals, which are described as a surrogate for biodiversity, is provided in the Native Fauna topic.

As at 1 December 2017, 1,025 species were listed as threatened in NSW under the BC Act and the FM Act.

Table 11.1: Number of listed threatened species in NSW under the Biodiversity Conservation and Fisheries Management Acts (at 1 December 2017)

Taxon grouping	Total no. of NSW native species	Total no. of species listed	% of species listed	Presumed extinct	Critically endangered	Endangered	Vulnerable
Mammals (terrestrial)	138	83	60%	26	3	15	39
Marine mammals	40	7	18%			3	4
Birds	452	140	31%	13	13	21	93
Amphibians	83	29	35%		5	13	11
Reptiles	230	45	20%	1	1	20	23
Plants (terrestrial)	4677	658	14%	32	63	333	230
Aquatic plants and algae	n/a *	2	n/a	1	1		
Freshwater fish	60	11	18%		3	7	1
Marine fish, sharks and rays	n/a	7	n/a	1	1	2	3
Invertebrates (terrestrial)	n/a	22	n/a	1	6	15	
Aquatic invertebrates	n/a	12	n/a	2	4	2	4
Fungi	n/a	9	n/a			5	4
Total	n/a	1025	n/a	77	100	436	412

Notes:
* n/a - Numbers not available

Source:
Office of Environment and Heritage (OEH) and Department of Primary Industries (DPI) data 2017

Table 11.1a: Number of listed threatened populations in NSW under the Biodiversity Conservation and Fisheries Management Acts (at 1 December 2017)

Taxon grouping	Endangered populations
Mammals (terrestrial)	13
Birds	7
Amphibians	1
Reptiles	1
Plants (terrestrial)	29
Aquatic plants and algae	1
Freshwater fish	4
Invertebrates (terrestrial)	1
Total	57

Notes:
No listings for Marine mammals; Marine fish, sharks and rays; Aquatic invertebrates; and Fungi.

Source:
Office of Environment and Heritage (OEH) and Department of Primary Industries (DPI) data 2017

Over the past three years, an additional 26 species (+3%) have been listed under the BC and FM Acts, including 22 mainly land-based species (+2%) under the BC Act and four aquatic species (+11%) under the FM Act.

Table 11.1 shows the number of listings by threat listing category and by plant or animal group. The groups at greatest risk of extinction are:

- land-based mammal species (60% of all species are threatened)
- amphibian species (35% are threatened)
- birds (31% are threatened).

The 3% increase in threatened species over the three years to the end of 2017 represents a slight increase in the rate of species listings compared to the previous reporting cycle, but this may not reflect an actual change in the outcomes for species.

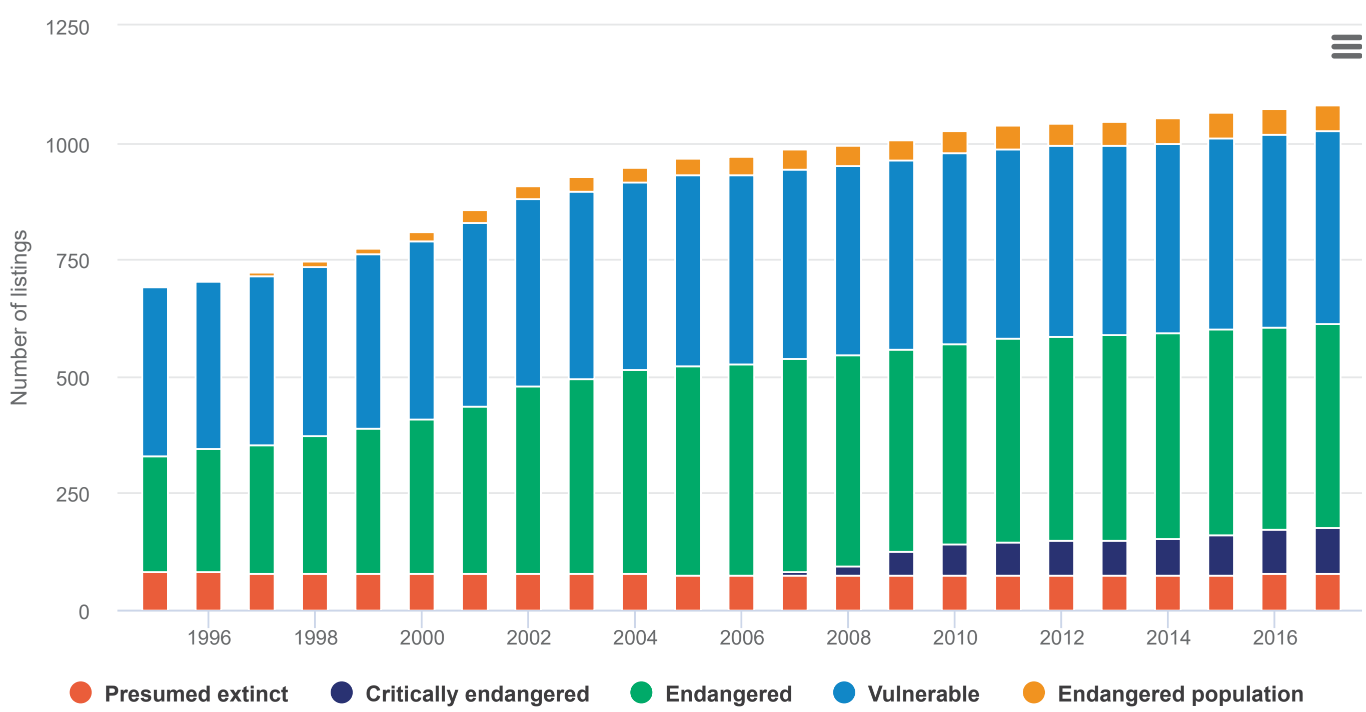
Since 2015, the overall number of species listed as presumed extinct has increased by one, to 77, despite the rediscovery of one plant species previously presumed extinct.

Other changes in the numbers of listings for the period 2014–2017 are:

- the proportion of endangered or critically endangered species increased by 1% from 51% in 2015 to 52% in 2017
- three more endangered populations were listed, bringing the total to 57
- the number of threatened ecological communities increased by four to 112.

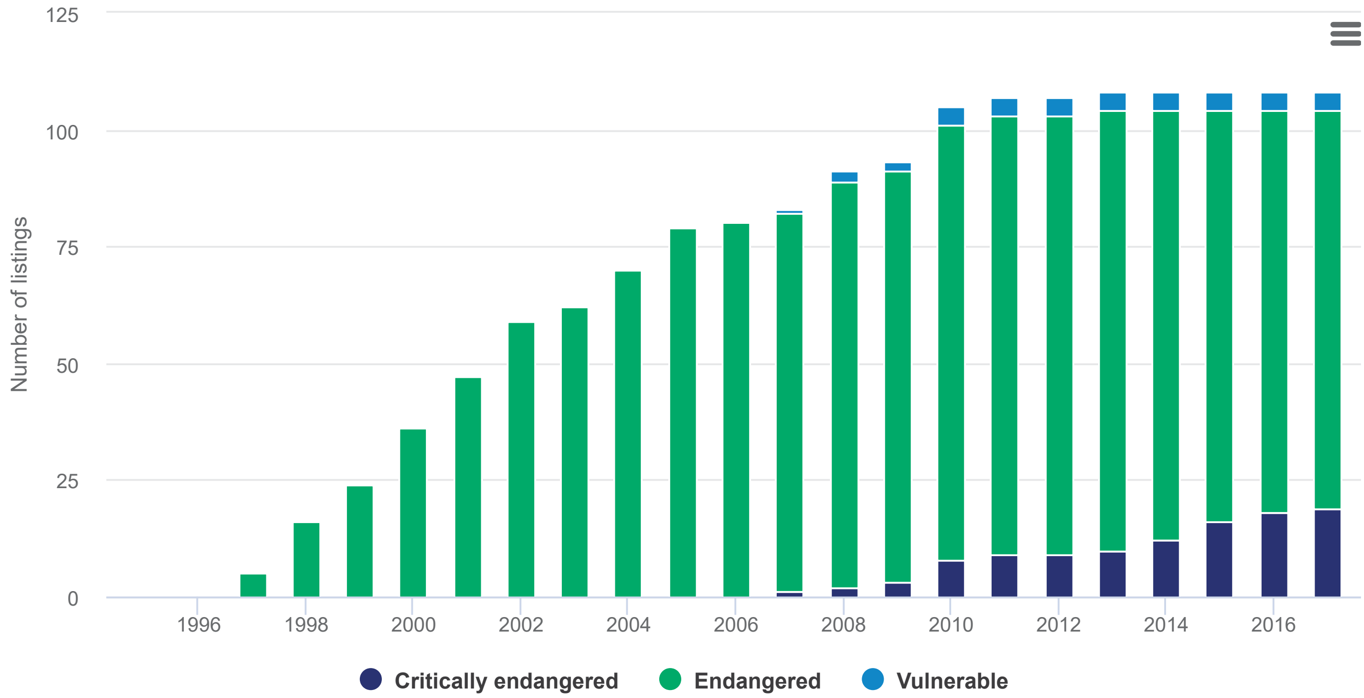
The change in threatened species and community listings from 1995–2017 is displayed in **Figure 11.1.**

Figure 11.1a: Changes in total listings of threatened species 1995–2017



Source:
OEH data 2018

Figure 11.1b: Changes in total listings of threatened species and ecological communities 1995–2017



Source:
OEH data 2018

Reliability of threatened species listings

In the absence of other broad scale data for monitoring changes in species populations, the listings of threatened species have long been used as an indicator to report on outcomes for biodiversity. While this situation has improved, and more data is now available (see the Native Fauna) topic, the listings of threatened species still provide continuity and a stable source of information about the effectiveness of conservation programs to stabilise native plant and animal numbers.

However, the interpretation of species listings, especially trends in the rate of species listings over time is a matter of ongoing debate, as changes in species listings are difficult to interpret (Keith & Burgman 2004). Historically, inconsistency between state, Commonwealth and international threatened species listing criteria and processes has led to potentially incorrect listing or non-listing of species and misdirected conservation efforts (Garnett et al. 2010; EDO 2014).

The criticisms of threatened species listings include:

- bias towards conserving iconic species such as koalas (EDO 2014; OEH 2014)
- over-reliance on public nominations (OEH 2014)
- resourcing constraints on the Scientific Committees that assesses threatened species listing nominations in NSW (OEH 2014)
- Skewed listings due to the allocation of resources to scientific committees for specific purposes
- restrictions on the time, knowledge and skills required to make effective listing nominations
- the numbers and rates of listings not being representative of current outcomes as the listing process only began in 1995, whereas many species have been under threat for much longer.

Pressures

Listing of key threatening processes

The biodiversity of NSW is subject to an increasing number and range of threats. The *Biodiversity Conservation Act 2016* (BC Act) and the *Fisheries Management Act 1994* (FM Act) both list the key threatening processes (KTPs) that impact on listed threatened species. At 31 December 2017, there were 46 KTPs listed for NSW - 38 under the BC Act and eight under the FM Act. There is some overlap, with climate change, shark meshing and changes to river flow regimes listed under both Acts in slightly different ways.

Table 11.2 summarises the types of KTPs listed. Over half of them relate to invasive species, with 24 associated with pests and weeds and a further five pertaining to pathogens and diseases. Ten KTPs relate to the clearing and disturbance of native habitat.

Table 11.2: Key threatening processes listed in NSW, 2017

Issue	Number of KTPs
Invasive species	24
Habitat change	10
Disease	5
Over-exploitation	3
Climate change	2
Altered fire regimes	1
Pollution	1
Total	**46**

Notes:
As at 31 December 2017.

Source:
OEH and DPI data 2017

It should be noted that not all these threats are equivalent in effect and the numbers are not necessarily indicative of the cumulative impact of any type of threat. For example, it is expected that over time climate change will become one of the most significant threats described here.

Main threats to biodiversity and threatened species

When a species, population or ecological community is listed as threatened under the BC Act or the FM Act, the main pressures and threats affecting its conservation status are described in the listing. These threats were analysed for all threatened species listed at the time of analysis under the *Threatened Species Conservation Act 1995*, (the predecessor to the current BC Act), to identify those that have the greatest impact on biodiversity and the environment in NSW (Coutts-Smith & Downey 2006).

The pressures affecting the largest number of threatened species in NSW were the clearing and disturbance of native vegetation (87%), followed by invasive pest and weed species (70%).

Clearing and habitat destruction

The clearing of native vegetation results in the direct loss of species and the destruction of habitat. It is followed by lag effects due to disturbance from subsequent land uses and the fragmentation of remnant vegetation, which impedes regeneration and the movement of species across the landscape and leads to a loss of genetic diversity (Cogger et al. 2007; Taylor & Dickman 2014).

Invasive species

Invasive species have contributed to the decline of many native species. Pest animals, particularly foxes and cats, are likely to have had the greatest impact on native fauna and are considered to be responsible for the majority of fauna extinctions on mainland NSW (Morton 1990; Dickman 1996a; Dickman 1996b). Black rats have had a similar effect on Lord Howe Island, while carp is now the predominant species in most rivers of the Murray Darling Basin.

Climate change

As many Australian species are adapted to highly variable climates, they are likely to have the capacity to cope with some level of climate change. However, the resilience of many species may have been eroded by existing pressures, which have resulted in the declines in numbers or range described in this topic. Climate change is expected to exacerbate the effects of existing threats and introduce additional pressures (Steffen et al. 2009; DECCW 2010a; Hughes 2011). It is likely that climate change will surpass habitat destruction as the greatest global threat to biodiversity over coming decades (Leadley et al. 2010). For further information see the Climate Change topic.

Other threats

Water extraction and altered river flows and cycles have an impact on the critical ecological processes that trigger breeding in a range of aquatic and bird species (see the River Health topic), while altered fire regimes impact on the ability of plant species and communities to regenerate or repropagate.

Most of the main threats to biodiversity in NSW are described in greater detail in other sections of this report, including:

- clearing, fragmentation and the disturbance of native vegetation (see Native Vegetation)
- the introduction and spread of invasive species – pests, weeds, diseases and pathogens (see Invasive Species)
- overgrazing by cattle, sheep and invasive herbivores (see Native Vegetation)
- water extraction and changes to river flows (see Water Resources)
- increasing populations and expanding human settlements (see Population)
- the increasing impacts of climate change (see Climate Change).

Threats not dealt with specifically in other sections of this report include:

- altered fire regimes due to European settlement
- the indirect impacts of development, particularly in new areas where high rates of mortality and injury to wildlife can occur
- disturbance to behaviour and breeding cycles from infrastructure, noise and lighting (Byron et al. 2014).

It should be noted that many of these threats can operate together to have a cumulative impact and hasten the decline of species and communities. Sometimes these impacts may be synergistic, where the cumulative impact is greater than the sum of the individual pressures (Raffaele et al. 2011; Goldman Martone & Wasson 2008; Simberloff & Von Holle 1999).

Lack of information

It is unrealistic to expect that a full range of biodiversity could ever be monitored systematically with available resources. It is, therefore, an ongoing challenge to optimise monitoring information so that it informs decision-making for managing biodiversity effectively.

Although knowledge of the conservation status of species has improved markedly over the past 20 years, especially on the distribution and abundance of land-based vertebrates, less is known about other groups. Patterns of decline that are likely to have been present for many years are still being discovered in the less well-studied groups of species. For most invertebrates, microorganisms and many plant groups, which comprise the vast majority of species, information exists for only a few isolated species and this provides little insight into the broader status and management needs of these groups.

The 2014 Independent Biodiversity Legislation Review panel recommended the development of a comprehensive system for monitoring and reporting on the extent and quality of biodiversity in NSW (Byron et al. 2014). Such a system would improve the availability of information to more effectively track the status of all species in NSW. This recommendation was adopted by the NSW Government and new techniques for monitoring biodiversity are under development.

Responses

Legislation and policies

Biodiversity Conservation Act 2016

Following the Independent Biodiversity Legislation Review, sweeping reforms were made to the legislative framework for land management and biodiversity conservation. Biodiversity legislation in NSW has been consolidated under the *Biodiversity Conservation Act 2016* (BC Act), which replaces the *Threatened Species Conservation Act 1995* (TSC Act), *Nature Conservation Trust Act 2001* and the plant and animal provisions of the *National Parks and Wildlife Act 1974*. A new rural land management framework was also introduced with the *Local Land Services Amendment Act 2016,* which replaced the *Native Vegetation Act 2003*. The laws commenced on 25 August 2017.

Protections for aquatic and marine species remain in the *Fisheries Management Act 1994* (FM Act). Amendments to the FM Act are being progressed during 2018 to make this legislation consistent with the BC Act and the Common Assessment Method for national listing of threatened species.

Policy and guidelines for fish habitat conservation and management

In 2013, an updated policy and guidelines were published to maintain and enhance the habitat of native fish species (including threatened species) in the marine, estuarine and freshwater environments (DPI 2013).

Programs

Saving our Species program

The Saving our Species program (SoS) aims to maximise the number of threatened species that can be secured in the wild in NSW for 100 years. SoS plays a pivotal role in threatened species conservation, and its systematic and pragmatic approach has been formally adopted in the BC Act. Through SoS, land-based threatened species have been allocated to one of six management streams, depending on their distribution, ecology, security and what is known about them. The six management streams are:

- site-managed species: species that can be successfully secured by targeting conservation projects, such as weeding or revegetation, at specific sites (e.g. the smoky mouse, eastern bristlebird and granite rose)
- iconic species: six species that are especially valued by the community – the koala, brushtailed rock-wallaby, mallee fowl, plains wanderer, southern corroboree frog, and Wollemi pine
- data-deficient species: species where there isn't sufficient information to allocate them to another management stream (e.g. Sloane's froglet, finger panic grass and the matted bush pea)
- landscape-managed species: species that are distributed across large areas and threatened across the landscape by habitat loss and degradation (e.g. the green-thighed frog, pale-headed snake, yellow-bellied glider and giant dragonfly)
- partnership species: species that are threatened nationally and have important populations in NSW, that will have conservation projects developed to protect them (e.g. the black-striped wallaby and dwarf bush-pea)
- keep watch species: species that require no immediate investment because they are either naturally rare, have few critical threats, or are more abundant than previously assumed (e.g. Hall's babbler and the spiny mintbush).

Priorities for action under SoS are species in the sitemanaged, iconic, data-deficient and landscape-managed species management streams. Threatened ecological communities and key threatening processes are also priority actions areas.

In 2016–17, SoS conservation projects benefited from approximately $23 million in cash and in-kind contributions from OEH including the Environmental Trust ($16.3 million) and external organisations ($6.7 million). There were 305 active SoS projects across the six management streams, including:

- six iconic species projects
- 239 site-managed species projects
- nine landscape-managed species projects
- one partnership species project
- 41 data-deficient species projects
- two keep watch species projects.

Key actions for these projects include:

- pest and weed control
- habitat and site protection and management
- community and landholder engagement
- translocation and ex-situ conservation (e.g. captive breeding)
- research.

Research on data-deficient species has led to recommendations to move 15 species to a new management stream.

The NSW Government pledged an additional $100 million over five years from 2016–17 to protect the state's threatened species.

Reintroduction of locally extinct mammals

Since 2015, the NSW Government has been working with the Australian Wildlife Conservancy and the University of New South Wales to reintroduce more than 10 species of locally extinct mammals into some public reserves in NSW. The reintroduction of locally extinct mammals is a significant component of the SoS program.

Feral-free fences will protect 180,000 hectares of land from feral predators such as foxes and cats in Sturt National Park, Mallee Cliffs National Park and Pilliga State Conservation Area. Mammals will be reintroduced into these areas following the removal of introduced predators and other pest animals.

In Pilliga State Conservation Area, a 5,900-hectare area of natural habitat will be protected from feral predators and at least six locally extinct mammal species will be reintroduced.

In Mallee Cliffs National Park, an 8,000-hectare area will be protected for at least 10 locally extinct mammal species.

Wildlife licensing

The BC Act established a new risk-based approach to managing wildlife actions through a tiered framework that:

- permits low-risk activities through Biodiversity Conservation Regulations
- allows moderate risk activities under a code of practice
- ensures high risk activities will continue to require a licence
- provides for actions that have direct impacts on biodiversity, including threatened species, to be treated as offences under the BC Act.

The NSW Government has been consulting with stakeholders to identify which actions should continue to require licensing, and which should be regulated by codes of practice and regulations. This process is ongoing.

Identifying areas of outstanding biodiversity value

The BC Act enables the Minister for the Environment to declare Areas of Outstanding Biodiversity Value (AOBVs). AOBVs are special areas that contain irreplaceable biodiversity values that are important to the whole of NSW, Australia or globally. AOBVs will be a priority for investment in private land conservation.

Existing areas of declared critical habitat under the old TSC Act (Wollemi pine and little penguin habitats) became AOBVs when the BC Act came into effect.

Listing of threatened species and communities

The BC Act modernised the process for listing threatened plants and animals. It aligns threat categories with international best practice and provides greater coordination between Australian jurisdictions. The Biodiversity Conservation Regulations prescribes listing criteria for threatened plants and animals which align with standards developed by the International Union for Conservation of Nature.

The Commonwealth, state and territory governments agreed to establish a common method for assessing and listing threatened species. The process of alignment of assessment and listing under the common assessment method is ongoing. This will reduce duplication of effort among governments by allowing jurisdictions to adopt listing assessments undertaken by other jurisdictions and will lead to better conservation outcomes for Australia's species.

NSW public reserves system

The public reserves system is the cornerstone of conservation efforts in NSW. It plays a vital role in protecting habitat and provides a refuge for many threatened species that are sensitive to habitat disturbance.

The NSW public reserves system covers around 7.14 million hectares or about 9% of the state (see the Protected Areas and Conservation topic). It conserves representative areas of most habitats and ecosystems, and the majority of plant and animal species found in NSW are represented in the public reserve system. Under the new BC Act there is an increased focus on conservation measures on private land to supplement land managed for conservation in the public reserve system.

NSW Koala Strategy

The NSW Government recognises the koala as an iconic threatened species and is committed to stabilising and increasing koala populations across NSW. In May 2018 the government released the NSW Koala Strategy, committing $44.7 million towards securing the future of koalas in the wild. The Strategy will support a range of conservation actions over three years.

The NSW Koala Strategy will deliver:

- $20 million from the NSW Environmental Trust to purchase and permanently conserve land that contains priority koala habitat in the national park estate
- $3 million to build a new koala hospital at Port Stephens
- $3.3 million to fix priority road-kill hotspots across NSW
- $4.5 million to improve the care of sick or injured koalas
- $6.9 million to improve our knowledge of koalas, starting with the development of a state-wide koala habitat information base
- $5 million to deliver local actions to protect koala populations, including through the SoS program
- $2 million to research impacts of natural hazards and weather events on koalas.

The NSW Koala Strategy responds to the *Independent Review into the Decline of Koala Populations in Key Areas of NSW* (NSW Chief Scientist and Engineer 2016), which recommended a whole-of-government koala strategy for NSW. An expert advisory committee chaired by the NSW Chief Scientist and Engineer guided the strategy's development along with extensive community and stakeholder consultation.

Management and control of invasive species

Once established, the eradication of invasive species is seldom feasible. Therefore, control of some high-priority invasive species, such as foxes and bitou bush, is specifically targeted at sites of high conservation value. Control is delivered through threat abatement plans which facilitate whole-of-government coordination across agencies and local authorities.

Broad scale rabbit control is being provided through the release of rabbit haemorrhagic disease, while rats, mice and rabbits have been eradicated from some NSW islands. Local Land Service are responsible for identifying priority weeds regionally and developing programs to manage them (see the Invasive Species topic).

Adaptation to climate change

Priorities for Biodiversity Adaptation to Climate Change (DECCW 2010b) was produced in response to the listing of anthropogenic climate change as a key threatening process under the BC Act. This identifies priority measures for dealing with the effects of climate change over the next five years, focusing on four key areas:

- enhancing understanding of the likely responses of biodiversity to climate change and readjusting management programs where necessary
- protecting a diverse range of habitats by building a comprehensive, adequate and representative public reserve system in NSW, with a focus on under-represented bioregions
- increasing opportunities for species to move across the landscape by working with partners and the community to protect habitat and increase connectivity by consolidating areas of vegetation in good condition
- assessing adaptation options for ecosystems most at risk from climate change in NSW.

A key threatening processes strategy has been prepared for the SoS program, that includes adaptation processes in response to climate change following the listing of Climate change as a KTP.

The AdaptNSW website provides comprehensive climate change information, analysis and data to support action to address climate change risks and capture opportunities. It includes information on the causes of climate change and the likely impacts on biodiversity. For further information see the Climate Change topic.

Future opportunities

Measures to improve connectivity across landscapes and build the health and resilience of the land will enhance the capacity of species and ecosystems to adapt to, and cope with, disturbance.

More information about the factors contributing to the resilience or success of some native species and processes, in contrast to the declines of many others, may assist in efforts to maintain sustainable populations of flora and fauna species.

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NSW EPA

Invasive Species

Invasive species are found across all of NSW and displace native species by out-competing them or preying upon them. They are responsible for the extinction of many small to medium sized mammals in NSW.

Summary

Weeds cost the NSW economy

$1.8 billion

each year in lost agricultural production and management costs

Read more

Pest animals and weeds threaten over

70%

of threatened species and endangered ecological communities in NSW

Read more

Introduced fish in NSW

Carp

dominates most freshwater communities

Read more

Pest animal impacts

$170 million

annual cost to the NSW economy

Read more

The NSW environment and community face significant challenges from invasive pests and weeds, and introduced pathogens. Invasive species are widespread across land, freshwater and marine environments in NSW. Ongoing resources will need to be available to manage new outbreaks and biosecurity risks.

Many invasive species have been in NSW for a long time and most parts of NSW are affected by weeds that harm native species, ecosystems and agriculture. Once established, they are difficult to control effectively and remain a significant environmental and economic issue.

Pest animals and weeds are identified as a threat to over 70% of threatened species under the *Biodiversity Conservation Act 2016*. In NSW, weeds account for $1.8 billion a year in lost production and control costs while the estimated annual economic loss to the NSW economy from the impact of pest animals in NSW is estimated to be more than $170 million including the cost of management actions.

Many native animals have become threatened or extinct from being preyed on or out-competed by introduced animals such as cats and foxes. Grazing and browsing by introduced herbivores such as rabbits, goats and deer has led to habitat degradation and a decline in native vegetation diversity and productivity. Pest fish threaten native fish species and aquatic ecosystems, with carp present across most of the Murray–Darling Basin.

New and emerging invasive species pose an additional threat and burden to the environment and the wellbeing of our communities. Invasive pathogens are an emerging threat to both biodiversity and agriculture.

The NSW Invasive Species Plan 2018–2021 (DPI 2018a) sets goals, strategies and guidelines to exclude, eradicate or manage invasive species. These will be monitored and reported on in a new NSW State of Biosecurity Reporting framework.

Related topics: Threatened Species | Native Fauna | Native Vegetation

NSW indicators

Indicator and status		Environmental trend	Information reliability
Number of new invasive species detected	MODERATE	Stable	✓✓
Spread of emerging invasive species	MODERATE	Stable	✓✓
Impact of widespread invasive species	POOR	Stabilising	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Invasive species have been implicated in the decline or extinction of many native plants and animals in land-based and water-based ecosystems. See the Threatened Species, Native Fauna and Native Vegetation topics for more information.

Australian native plants and animals have co-evolved over millions of years. When invasive species are introduced, they can have major negative impacts because native species have not evolved ways to deal with them. Invasive species harm native species and the natural environment in NSW by:

- eating or infecting them
- competing with them for resources
- modifying and degrading habitats
- transmitting disease
- reducing native biodiversity
- disrupting ecosystem processes.

Introduced marine species can threaten marine environments and animals and the industries and communities they support. Fresh water fish, such as carp and tilapia, out-compete native species, disrupt ecosystems and reduce water quality and native biodiversity.

In NSW, many invasive pest animals and weeds were introduced intentionally before people realised how damaging they were to native species and livelihood. Examples include:

- pigs and goats, and various crops, for agricultural production
- pets such as cats, and garden plants
- foxes introduced for fox-hunting
- plants used for erosion control such as bitou bush used for sand dune stabilisation.
- nuisance insect control, such as Eastern Gambusia introduced for mosquito control in the early 20th century.

New invasive species in NSW have been introduced inadvertently in vehicles, equipment, packing material, soil or garden refuse; or through ocean shipping. Emerging threats include:

- pest birds such as Indian mynas
- introduced turtles such as red-eared slider turtles
- insects such as fire ants and yellow crazy ants.

In this report, estimated costs to the economy do not include environmental and social impacts but do include the costs of control in environmental areas.

Definitions of invasive species

Pest animal: an animal (usually non-native) having, or with potential to have, an adverse environmental, economic, or social impact on native plants and animals

Weed: a non-native plant or native plant removed from its natural habitat that has the risk of negative environmental, economic, or social impacts

Invasive species: A general term to include pest animals, weeds or other organisms such as pathogens that are introduced to places outside their native ranges, where they negatively affect local ecosystems and species (IUCN 2014).

Indicators for future reporting

This report adopts similar indicators to previous State of the Environment reports. Development of new indicators to more effectively identify the impacts of invasive species and the effectiveness of management practices were published in the NSW State of Biosecurity Report (DPI 2018b). Following the first publication, a report will be published every four years. Future reports will:

- check progress
- refine the indicators
- report on changes in distribution and population size of invasive species in NSW
- report on the effectiveness of stakeholder and government programs.

Future NSW State of the Environment reports may adopt similar NSW State of Biosecurity indicators.

Status and Trends

Why this topic matters

Invasive species are thought to impact over 70% of threatened plants, animals and insects. Weeds such as Lantana can drive out species and change ecosystems. Invasive animals such as feral cats can directly prey on threatened species, reducing numbers of plants and animals and changing the population dynamics of ecosystems. As well as significantly impacting native species and ecosystems, such invasions can also impact on agricultural productivity, social wellbeing and ecotourism (DPI 2018b).

Since 1788, around 3,000 introduced weeds have established populations in Australia. More than 1,750 of these have been recorded in NSW, with over 340 recognised as threats to native biodiversity (Downey et al 2010). Weeds now make up 21% of the total vegetation (DPI 2018b) and account for $1.8 billion a year in lost production.

Over the same period, more than 650 species of land-based animals have been introduced to Australia, of which 64 terrestrial and freshwater species have established wild populations in NSW (NLWRA 2008). Although a smaller number of these are considered invasive, the annual economic loss to the NSW economy from the impact of pest animals in NSW is estimated to be more than $170 million including the cost of management actions.

Introduced fish species make up around 25% of freshwater fish species in the Murray-Darling Basin (Lintermans 2009).

It is not known how many insects and other invertebrates have been introduced into Australia in general and NSW specifically (Coutts-Smith et al. 2007).

Categories of invasive species

Invasive species are generally widespread, emerging or new, depending on their extent and ability to persist and spread:

- widespread species: invasive species that have been present for some time and have established a broad range across a region, habitat, or state-wide
- emerging species: invasive species that have established a self-sustaining population and are expanding their range or can spread further
- new species: species that have not been recorded in NSW or established self-sustaining populations, but could invade and spread.

Examples of disease-causing pathogens are also included in this report.

Widespread invasive species

Widespread pest animals

Table 15.1 lists the top five widespread land-based pest animals that threaten native plants and animals (Coutts-Smith et al 2007). They are all listed in the *Biodiversity Conservation Act 2016* as key threats to NSW threatened species. Because effective control of established invasive species is rarely feasible, these animals continue to maintain pressure on native species and ecosystems.

Table 15.1: Top five land–based pest animals threatening native animals and plants in NSW, ranked by the number of threatened species affected

Common name	Scientific name
Feral cat	*Felis catus*
Red fox	*Vulpes vulpes*
Feral goat	*Capra hircus*
Rabbit	*Oryctolagus cuniculus*
Feral pig	*Sus scrofa*

Other widespread pest species include animals introduced to NSW as domestic livestock with European settlement. Wild deer populations, for example, are still expanding in range. Wild deer occur along both sides of the Great Dividing Range in NSW. Three species (chital, red and fallow deer) also form significant populations west of the range. Wild deer distribution has increased from approximately 8% of the State in 2009 to 17% in 2016.

Widespread weeds

All parts of NSW are affected by weeds that threaten native animals, plants and ecosystems. Weed species, in terms of extent and diversity, are highest near the coast, particularly around major towns and cities, and in regions with high rainfall (Coutts-Smith and Downey 2006). The number of weeds recorded tend to decline from east to west (Coutts-Smith & Downey 2006). Weeds with the greatest impact on NSW native plants and animals on land have been recorded in Biodiversity Priorities for Widespread Weeds (NSW Government 2011).

Table 15.2 lists the top 20 widespread weeds on land in NSW, based on their level of impact on biodiversity (Downey et al 2010), and shows whether they are listed as a Weed of National Significance and/or as a key threatening process under the NSW Biodiversity Conservation Act.

Table 15.2: Top 20 widespread weeds posing a threat to native animals and plants in NSW

Common name	Scientific name	Weed of national significance (WoNS)	Key threatening process (KTP) listing
Madeira vine	*Anredera cordifolia*	Yes	Yes
Lantana	*Lantana camara*	Yes	Yes
Bitou bush	*Chrysanthemoides monilifera subsp. rotundata*	Yes	Yes
Ground asparagus	*Asparagus aethiopicus*	Yes	Yes
Blackberry	*Rubus fruticosus* species aggregate	Yes	Yes*
Scotch broom	*Cytisus scoparius* subsp. *scoparius*	Yes	Yes
Japanese honeysuckle	*Lonicera japonica*	No	Yes*
Broad-leaf privet	*Ligustrum lucidum*	No	Yes*
Narrow leaf privet	*Ligustrum sinense*	No	Yes*
Cat's claw creeper	*Dolichandra unguis-cati*	Yes	Yes
Salvinia	*Salvinia molesta*	Yes	Yes*
Serrated tussock	*Nassella trichotoma*	Yes	Yes
Cape ivy	*Delairea odorata*	No	Yes
Blue morning glory	*Ipomoea indica*	No	Yes
Balloon vine	*Cardiospermum grandiflorum*	No	Yes

Common name	Scientific name	Weed of national significance (WoNS)	Key threatening process (KTP) listing
Lippia	*Phyla canescens*	No	Yes*
Bridal creeper	*Asparagus asparagoides*	Yes	Yes
Mickey Mouse plant	*Ochna serrulata*	No	Yes*
Turkey rhubarb	*Acetosa sagittata*	No	Yes*
Sweet vernal grass	*Anthoxanthum odoratum*	No	Yes

Notes:
* Relates to 'garden escapes' key threatening process.

Source:
Ranked by Downey et al 2010

Widespread invasive aquatic animals

Invasive aquatic animals:

- alter the composition and function of aquatic ecosystems and habitat, and the diversity of native flora and fauna
- threaten native aquatic and land-based flora and fauna by preying on them or competing with them for food.

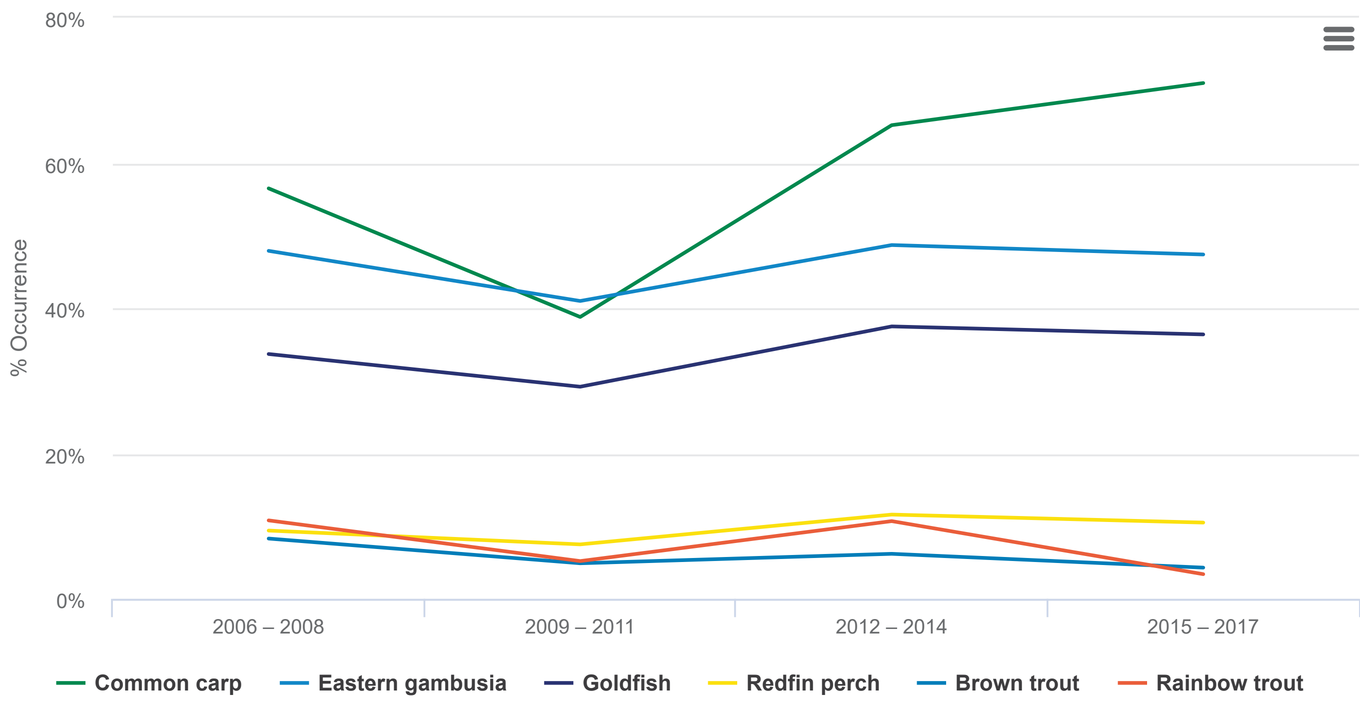
As a result, several key threatening processes have been listed under the *Fisheries Management Act 1994* (FM Act) including: 'Introduction of fish to waters within a river catchment outside their natural range' and 'Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales'.

Introduced freshwater fish compete with native fish and frogs for food and territory. They also prey on fish and frog eggs, tadpoles and juvenile fish.

Surveys of freshwater fish species over 2015–17 have found that few sampled sites are free from introduced fish. Most of the sites sampled have been within the Murray-Darling Basin, which generally comprises fewer native fish species than coastal and inland drainage divisions. In sample plots by DPI Fisheries, only 13% of sites were free of introduced fish and a small number of sites (4%) contained only introduced fish. Averaged across all sites, introduced taxa accounted for 36% of the fish species collected at each site, 37% of total fish abundance and 58% of total fish biomass, see **figure 15.1** below.

There is no evidence of any new introduced fish species becoming established in the freshwater aquatic habitats of NSW during the reporting period.

Figure 15.1: Introduced fish recorded at DPI sampling sites



Notes:
Introduced trout in the sample sites includes brown trout and rainbow trout. Data sourced from over 800 sampling sites in the Murray-Darling Basin and northern coastal rivers.

Source:
DPI Fisheries data 2015–17

European carp

Carp (*Cyprinus carpio*) have been in Australia for over 100 years and are now established in all states and territories, except the Northern Territory. Carp:

- can dominate freshwater fish communities in NSW, affecting water quality, native fish communities, fishing and irrigation
- are distributed across most of the Murray-Darling Basin and many coastal river systems, particularly in central NSW from the Hunter River in the north to the Shoalhaven River (including the Southern Highlands and Tablelands) in the south
- in some parts of the Murray-Darling Basin, comprise up to 90% of aquatic biomass, exceeding 350 kilograms of fish per hectare (DPI 2018b).

New invasive species, and emerging invasive species

New and emerging pest animals

Fire ants: On 28 November 2014, red imported fire ants were detected in Port Botany, possibly coming from Argentina. Although listed as a key threatening process, this was the first record of the ants in NSW.

The single nest at Port Botany was located and destroyed. Despite further surveillance, no further nests or ants have been located since the initial infestation and the population was declared eradicated in November 2016.

Yellow crazy ants: Invasion by crazy ants, *Anoplolepis gracilipes*, is a threat in NSW. Crazy ants are ranked as among the world's 100 worst invading pests. They can disrupt crops, and displace or kill invertebrates, reptiles, hatchling birds and small mammals. Crazy ants spray formic acid, which burns humans and animals.

Crazy ants have spread across parts of the Northern Territory. They have been intercepted in Australian ports regularly since 1988. Approximately 40% of interceptions have been in NSW. The Department of Primary Industries and local land services staff confirmed the presence of yellow crazy ants in Lismore in 2018 after a reported sighting by a member of the public. It is the first time in more than 10 years that the ant has been found in NSW since it was eradicated from Goodwood Island in Clarence River in 2008. The NSW Government has begun a surveillance and eradication operation and a national approach is being pursued under the National Invasive Ant Biosecurity Plan.

Cane toads: Cane toads were reported as an emerging species of concern in 2012 with viable populations established on the NSW far north coast. An isolated population of cane toads was found to be breeding in southern Sydney in 2010. This population has been part of a successful cane toad eradication program led by Sutherland Council, with no cane toads being found in this area since 2015.

New and emerging aquatic pests

Mozambique tilapia: Mozambique tilapia is an internationally recognised pest fish from southern Africa. It is a hardy fish that tolerates both fresh and salty water and was a popular ornamental species before being banned in NSW and other Australian jurisdictions. Tilapia has established populations that dominate native fish in parts of Queensland, including catchments that lie directly adjacent to the Murray–Darling Basin (MDB). In November 2014 a coastal population was detected in northern NSW, which it was found to be not feasible to eradicate. Research has suggested tilapia could become widespread if introduced into the MDB (Murray–Darling Basin Authority, 2011) but at the time of this report, the species has not been detected there. The NSW Government has established targeted local education and advisory programs so the community can identify the fish if it appears and notify their local council.

Red imported slider turtle: This turtle is considered an emerging species in some urban areas around Sydney. It originates from the midwestern states of the USA and north-eastern Mexico. However, non-native populations of wild-living red-eared slider turtles now occur worldwide due to the species being extensively traded as both a pet and a food item. The species is considered an environmental pest outside its natural range because it competes with native turtles for food, nesting areas and basking sites.

New and emerging weeds

Since 2013, six new species of weed known to be invasive in other regions of the world have established in the wild in NSW. Species that are of high risk and listed as State Prohibited Matter under the *NSW Biosecurity Act 2015* include:

Mouse-ear hawkweed (*Hieracium pilosella*)

Mouse-ear hawkweed was first recorded in NSW in January 2015, in Kosciuszko National Park. The infestation was $150m^2$ with dense, heavily matted plants growing over native alpine vegetation. Surveillance around this infestation found another patch of $>200m^2$. The areas were treated and, during 2017–18, only 109 plants were detected over $0.83m^2$, a more than 99% reduction in area infested by this weed. Surveillance and monitoring will continue for the next five years to ensure the seedbank is completely eradicated.

Orange hawkweed (*Hieracium aurantiacum*)

Originating from Europe, orange hawkweed is in the early stages of invasion in Australia in NSW, Tasmania and Victoria, but could invade over 27 million hectares of south-east Australia.

This weed was first located in Kosciuszko National Park after fires in 2003, near Jagungal Wilderness. The NSW Government controlled the weed, and in 2017–18, only $1{,}025m^2$ of orange hawkweed were found and promptly controlled.

Significant advances have been made in developing herbicide controls and new surveillance techniques. Since 2015:

- two weed eradication detector dogs have been trained to detect orange hawkweed through their sense of smell
- the distinctive orange flowers can be quickly detected by drones and algorithms aerially over much larger areas of remote terrain; in 2017–18, over 1,051 hectares were surveyed, compared to 415 hectares in 2016–17.

This increase in area surveyed resulted in the discovery of 35 new sites in 2017–18. All were small and in areas where seeds would not be easily dispersed by wind. The number of new sites detected has also decreased, and the NSW Government is certain this weed will soon be eradicated from the national park. Orange hawkweed had been detected at two sites near the national park in 2015 but these sites were effectively controlled.

In 2017, the NSW Government reviewed orange and mouse-eared hawkweed eradication programs and concluded that eradication of both species remains highly feasible. Full delimitation of these species is now the key and adequate level of resourcing must be maintained to ensure this result.

Pathogens

Pathogens are increasing threats to plant and animal biodiversity in NSW. Pathogens can seriously affect animal and plant production systems and human health.

Four pathogens are listed as key threatening processes under the *Biodiversity Conservation Act 2016*:

- beak and feather disease affecting parrot species
- dieback of native plants caused by the root-rot fungus, *Phytophthora cinnamomi*
- infection of frogs with chytrid fungus, resulting in the disease, chytridiomycosis
- myrtle rust fungi, affecting plants of the family Myrtaceae.

A strain of myrtle rust was first detected in Australia in April 2010 on the NSW Central Coast (Carnegie et al. 2010). From there, it spread rapidly, reaching bushland in south-east Queensland in January 2011. The full impact of myrtle rust is yet to be realised, but the latest research indicates that highly-susceptible species in NSW, such as *Rhodamnia rubescens* and *Rhodomyrtus psidioides* have already considerably declined in response to this pathogen (Carnegie et al. 2015). Other less widespread species in the family Myrtaceae have no natural resistance and a range that coincides with the predicted hotspots for myrtle rust (Kriticos et al. 2013; Berthon et al. 2018).

Pressures

Factors that worsen the effects of invasive species or increase their distribution

Habitat disturbance

Factors stressing the natural environment including the addition of nutrients, altered hydrological regimes, and the frequency and severity of altered fire regimes promote the invasion of introduced species. This, in turn, puts more pressure on native plants, animals and ecosystems (Lake & Leishman 2004).

Introducing weeds through trade

Greater mobility and the globalisation of international trade are significantly increasing the movement of people and goods across borders. This increases the risk of accidentally introducing pathogens, insects and other invertebrate pests.

Greater Sydney currently receives more than 38.5 million international visitors, over 500,000 tonnes of air freight and one million shipping containers every year (DPI 2018).

Many new plant species have already been introduced to NSW via the nursery trade, with many escaping from gardens to become weeds (Groves & Hosking 1998). Of the weed species that threaten endangered species in NSW, 65% were introduced as ornamental plants (Coutts-Smith & Downey 2006).

Other industries that have introduced pests and weeds into NSW:

- the black-market pet trade introduces exotic animals, especially reptiles
- the aquarium industry introduces exotic fish such as goldfish and tilapia, and aquatic plant species that have been released into the wild and flourish
- the ballast water of cargo ships and hull biofouling help spread pests into the marine environment.

Expansions of range

Many invasive species have not yet reached the potential limits of their distribution. For example, weed species such as orange and mouse-ear hawkweed, boneseed, African olive, cabomba and some exotic vines occupy only a small part of their potential range.

Already widespread weeds such as lantana, bitou bush, blackberry and Coolatai grass can spread further without control.

Emerging pest animal species such as deer and cane toads have not yet reached their potential range. While deer are continuing to expand, the spread of cane toads has been contained.

Climate change

The impact of climate change on weed invasion is becoming clearer in Australia. As climate regimes continue to change, it is likely that new invasive plants will emerge (Duursma et al 2013).

The extent of suitable habitat for invasive species has been modelled and predicted under current and future climate change scenarios.

- The alpine eco-region in NSW may be particularly vulnerable to future incursions by weeds (Duursma et al 2013).
- Changing climate regimes may create more favourable conditions for weeds in southern NSW.
- Many native species and ecological communities affected by climate change will become more vulnerable to the threat of pest animals and weeds (NSW Government, 2011).

As a result, climate change scenarios and species distribution models will be useful in predicting future breakouts and spread of invasive plants and to devise suitable management strategies.

Other issues affecting biosecurity

The *New South Wales State of Biosecurity report 2017* (DPI 2018) notes other pressures that are likely to affect biosecurity in NSW, including:

- the need to maintain the willingness of government, industry and the community to share responsibility for controlling invasive pests and weeds

- population growth combined with urbanisation and land clearing for development is providing an increasing biosecurity risk, but also opportunities to engage people in surveillance, detection and control
- the need to embrace new technology and strategies to tackle the changing risk profile of biosecurity in NSW.

Responses

Legislation and policy

The NSW Government determines priorities for control of, and resources to manage, invasive species. The highest priority species for protection are threatened species and other entities listed under the Biodiversity Conservation Act. For cross-tenure impacts, the community can participate through the regional planning process.

All land managers have a duty to prevent, eliminate or minimise the risk of invasive species under the *Biosecurity Act 2015*, including participating in coordinated regional strategies.

NSW Invasive Species Plan

The NSW Invasive Species Plan 2018–2021 (NSW Government 2018) focuses on the four goals to:

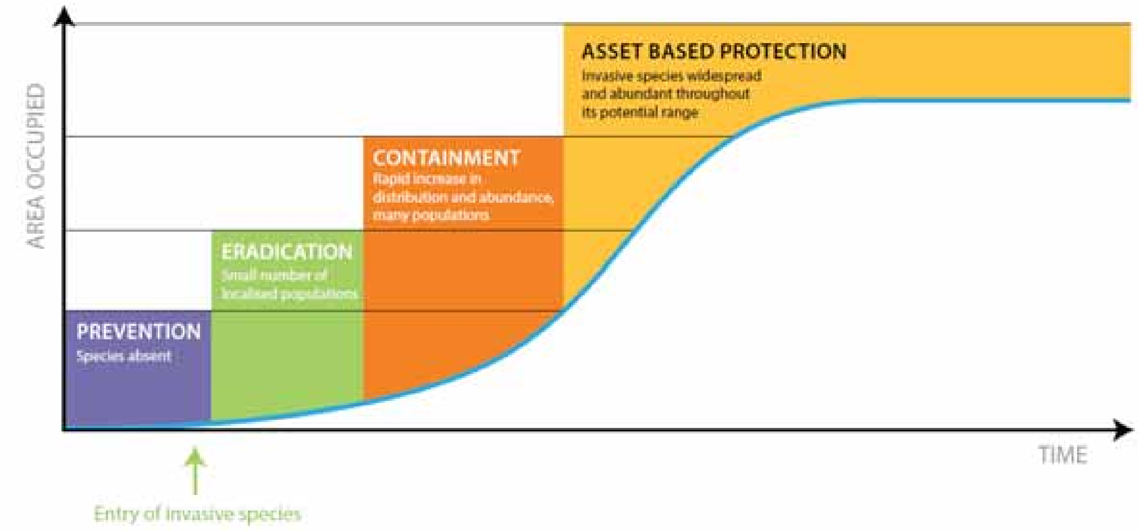
- exclude – prevent the establishment of new invasive species
- eradicate or contain – eliminate, or prevent the spread of new invasive species
- effectively manage – reduce the impacts of widespread invasive species
- capacity building – ensure the NSW Government and community can manage invasive species.

These four goals align with the invasion process from pre-arrival of new invasive species to widespread establishment (as illustrated in **Figure 15.2**). Prevention is the most cost-effective way to minimise the impacts of invasive species. Once an invasive species has appeared, it can colonise areas rapidly. Successful control requires a rapid effective response. Once widespread, the eradication of invasive species over wide areas of different land tenure is rarely practical. Priorities for the control of these species may include focused efforts in areas where the benefits of control will be greatest for environmental, primary production or community benefit.

The plan:

- dedicates resources to manage invasive species
- identifies key responsibilities of the key parties involved in invasive species management in NSW
- supplies critical actions to be undertaken up to 2021.

Figure 15.2: Actions appropriate to each stage of invasive species incursion



Source:
NSW DPI, cited as Biosecurity Victoria, DPI, Victoria

NSW Biosecurity Strategy 2013–2021 and NSW Biosecurity Act 2015

The NSW Government launched the *NSW Biosecurity Strategy 2013–2021* in May 2013. The strategy:

- explains the principles for sharing responsibility for effective biosecurity management
- increases awareness of biosecurity issues in NSW
- outlines ways in which the NSW Government will partner with other government agencies, industry and the community to identify and manage biosecurity risks.

A key component of the strategy is the NSW *Biosecurity Act 2015* and Biosecurity Regulation 2017. The Act and Regulation will provide for the prevention, elimination, minimisation and management of biosecurity risks.

One of the key components of this legislation is the introduction of a General Biosecurity Duty. This duty requires any person dealing with biosecurity matter (such as pest animals or weeds) or a carrier, and who knows or ought to know of the biosecurity risks posed by that matter, to take measures to prevent, minimise or eliminate the risk as far as is reasonably practicable. The occupier of lands (both private and public) is required to take all practical measures to minimise the risk of any negative impacts of pest animals or weeds on their land. The occupier could discharge their duty by complying with control actions outlined in the LLS regional strategic weed plans and regional pest animal management plans.

NSW Authorised Officers undertake regular audits and inspections to ensure implementation of biosecurity practices to enable ongoing market access for trade. In 2016–17, 6,650 compliance and enforcement activities were conducted to protect NSW biosecurity (DPI 2018). Local Land Services and Local Control Authorities also support local land holders to meet their responsibilities.

Land Management (Native Vegetation) Code 2018

The *Land Management (Native Vegetation) Code 2018* is created under section 60T of the *Local Land Services Act 2013*. The Code commenced on 25 August 2017 and facilitates native vegetation management on rural land, enabling landowners to productively manage their land while supporting biodiversity and managing environmental risks. The Code allows the removal of invasive native plant species on private land that have reached unnatural densities and dominate an area. Management of invasive native species promotes the regeneration and regrowth of native vegetation that is not invasive, contributing to positive environmental outcomes.

Programs

Containment lines

To effectively manage new and emerging invasive species, the best method is to eradicate or contain them before they can cause significant environmental impacts.

Establishing strategic containment lines can be an effective method of control. Containment lines are mapped lines, often delineated along a natural feature such as a river or along local government or other management boundaries.

A containment line is placed around the core distribution of the weed or pest, which is eradicated. Any population outside the containment line, and any isolated populations well away from the core distribution area are then fragmented or depleted and can be easily eradicated.

Regional weed and pest committees

The NSW Government has established regional weed committees and regional pest animal committees in each Local Land Services region. The committees coordinate regional pest animal and weed management activities on both public and private land. These committees have developed 11 Regional Weed Plans and 11 Regional Pest Animal Management Plans, which identify actions that can help land managers to manage weeds and pest animals on their land under the NSW *Biosecurity Act 2015*.

Saving our Species program

Biosecurity control measures provide a general level of protection for species and ecosystems. Saving our Species sets specific priorities for ensuring threatened species are secured in the wild. Many of the actions to recover species under Saving Our Species focus on controlling pest animals and weeds, which affect over 70% of listed threatened species, populations and ecological communities.

For more information on threatened species protection and Saving Our Species, see the Threatened Species topic.

National Carp Control Plan and NSW action

The National Carp Control Plan includes all Australian jurisdictions working in partnership to identify safe, effective and integrated measures to control carp populations in Australia, focusing on biocontrol methods.

NSW is a collaborative partner in research being undertaken as part of the National Carp Control Plan and participates in the Science Advisory Group, Policy Advisory Group, Operations Working Group, and Communications Working Group.

Future opportunities

Between 2008 and 2017, the NSW Government spent $107 million on significant biosecurity plant and animal disease and pest incident responses in NSW. It has also made a significant contribution to sharing costs to control incidents in other states and territories. Future opportunities include:

- Continual improvements to surveillance and biosecurity measures can help prevent new and potentially invasive species from threatening natural ecosystems and the productivity of farming systems.
- Development of biological control solutions and other new techniques will help provide opportunities to effectively and affordably manage widespread invasive species.

- Pathogens of native plants and animals continue to emerge as an increasing threat to natural systems and are likely to present challenges for effective management and control.

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Native Fauna

It is important to preserve the full range of biodiversity and maintain healthy ecosystems for future generations.
Fauna populations provide a good indication of our progress.

Summary

Survival of vertebrate species

64%

of terrestrial vertebrate species are not listed as being threatened

Read more

Mammal range contractions

64%

of native mammals have experienced long term declines in range

Read more

The overall diversity and richness of native species and communities in NSW remains under threat of further decline. The conservation status of 64% of land-based vertebrate species is currently not threatened.

A general pattern of long-term decline in biodiversity is evident in reductions to the range or abundance of many native vertebrate species. At the same time, many species less susceptible to current pressures have maintained their distributions, while a small number of adaptable species have flourished.

Over the past 200 years birds have been more resistant to declines in range than mammals, which have experienced substantial declines, especially small- to medium-sized ground-dwelling species. However, over recent decades there is evidence that populations of some bird groups are declining.

The decline in native species is due to the cumulative impact of many diverse pressures and threats. The main threats are vegetation clearing and habitat degradation and invasive species, with vertebrate fauna, in particular, being impacted by foxes and cats on the mainland and introduced rodents affecting species survival on islands. Climate change is likely to be a major threat to the future survival of many species.

The NSW Government has streamlined and integrated legislation for biodiversity conservation and protection.

The main measures to address the decline in biodiversity are conservation of native species in the public reserve system, the Biodiversity Conservation Trust which funds landowners to manage, protect and conserve biodiversity on private land and through biodiversity offsets, and the Saving our Species program which aims to secure as many threatened species in the wild as possible.

Related Topics: Threatened Species

NSW indicators

Indicator and status		Environmental trend	Information reliability
Terrestrial mammals: Loss of distribution - long term (~200 years)	POOR	Stable	✓
Birds: Loss of distribution - long term (~200 years)	MODERATE	Stable	✓
Proportion of vertebrate fauna species that is presently non-threatened	MODERATE	Getting worse	✓✓
Birds: Decline in populations - short term (decades)	POOR	Getting worse	✓✓
Large kangaroos: Populations	GOOD	Stable	✓✓✓
Native fish communities	POOR	Getting better	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Biodiversity refers to the full range of ecosystems, the species and populations they support and the genes they contain. It also encompasses the complex interactions between living organisms and the environment which provide the basis for a range of ecosystem services and maintain the health and productivity of the land.

NSW has a rich biodiversity, much of which is recognised as being internationally significant.

It is not possible to monitor or report on biodiversity across its breadth (Saunders et al. 1998) because of the limited data available and the sheer amount of biodiversity to be monitored. The vast majority of all species are invertebrates or microorganisms, especially bacteria (Larsen et al. 2017). The focus of this topic is limited to describing the status of native fauna, in particular land-based vertebrate species (mammals, birds, reptiles and amphibians). See the Threatened Species topic for a description of the status and prospects of native plants and animals listed as threatened in NSW.

A shrinking distribution is often the first indication that a species is declining in numbers. Declines in many species have been underway for decades or longer but have largely gone unrecorded. Over the past three decades, heightened awareness of the plight of native flora and fauna has revealed the extent of many of these declines and the threats that cause them. For example, the eastern quoll once ranged over most of eastern NSW but is now found only in Tasmania. It became extinct locally in NSW before any population estimates had been undertaken. In western NSW, 24 species of mammals became locally extinct between European settlement in 1841 and Federation in 1901 (Morton 1990; Lunney et al. 2000).

Much effort has gone into arresting declines that largely occurred before 1995 when the NSW Government recognised the need to formally protect native species. A focus on the extent of declines in species has the potential to mask recent achievements in stabilising declines and recovering some species.

The status of species under threat varies regionally and across Australia. Some species lost from NSW, such as the pig-footed bandicoot, are extinct throughout Australia, while others, such as the numbat, are still found in other parts of Australia. A number of species no longer exist on the mainland of NSW but survive on predator-free islands. The brush-tailed rock-wallaby is listed under both the *Biodiversity Conservation Act 2016* (BC Act) and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, but is under greater threat in Victoria than NSW. Conversely, the koala is threatened in NSW but not in Victoria, where it is regarded as over-abundant in some areas.

Status and Trends

Long-term historical surveys

Long-term or wide-ranging monitoring of species and ecosystems based on observations in the field provides the best indication of the status and trends in biodiversity for some fauna groups where such data is available. Such data are complementary to new measures currently being developed, which aim to provide indirect estimates of the status of biodiversity based on remote sensing and modelling techniques. However, such techniques will still rely on field-based observations of biodiversity from relatively intact sites for comparison and validation.

Conservation status of vertebrate species

There are few studies available that have looked at data on the distribution and abundance, or the conservation status of a broad range of native species. The first comprehensive assessment of vertebrate fauna in NSW was undertaken in 1992 (Lunney et al. 2000) to determine which vertebrate species should be listed as threatened under the then newly introduced *Threatened Species Conservation Act 1995* and conversely, those which did not require listing.

Most of the extinctions of native fauna that had occurred in NSW were found to be small- to medium-sized species of ground-dwelling mammals, including small wallabies, native mice, bandicoots and bettongs (Dickman et al. 1993; Lunney et al. 2000). Many of these species inhabited arid shrublands and grasslands in the west of the State and most of them had become extinct by the end of the nineteenth century, largely due to predation by foxes and cats and overgrazing by stock. Other factors that may also have contributed to the decline included altered fire regimes and competition with invasive species, such as rabbits and goats, for habitat and food as well as the general degradation of habitat they cause.

The habitat where the highest levels of mammal extinctions has occurred, by number and proportion, is the semi-arid shrubland in the west of the State, with 18 extinct species (Lunney et al. 2000). Nine of the 12 species of birds that are extinct in NSW were previously found only on Lord Howe Island, with introduced rodents and human settlement being manly responsible for their demise. The other three species were found in central or western NSW.

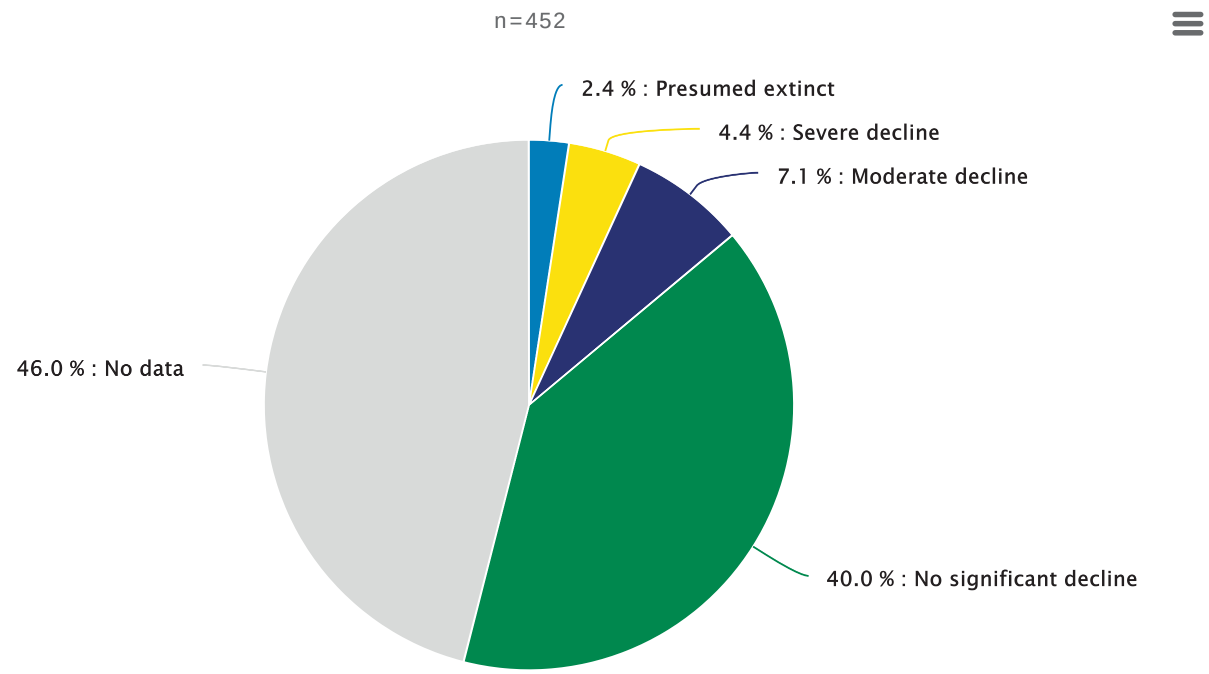
Declines in distribution of vertebrate species

A subsequent study (Mahon et al. 2011; DECCW 2009) conducted under the auspices of the NSW Natural Resources Monitoring Evaluation and Reporting Strategy 2010–2015 (DECCW 2010a), used species survey records to provide further evidence that the decline of NSW species was ongoing and concluded that the long-term prospects of survival for many species were poor.

The study described changes in species distributions since European settlement, specifically losses or contractions in range, for all species with adequate and reliable data. This assessment made use of all available data of sufficient quality from species surveys collected rigorously and continuously, but not necessarily systematically, over the past 200 years. It assessed all records in the Atlas of NSW of Wildlife and the Atlas of Australian Birds. Current records (those collected in the past 12 years) were compared to historical records to build up a cumulative record of patterns of distribution over a 200 year timeframe. As these outcomes are only expected to change slowly and over much longer time frames than the present three-year cycle of State of the Environment (SoE) reporting, the results of the 2009 analysis are still relevant.

The outcomes of this analysis were determined for mammal, bird, amphibian and reptile groups. Of the 897 species of native mammals, birds, reptiles and amphibians assessed, distributional changes could be estimated with a reasonable level of confidence for about half of the species in all groups. The results for birds and mammals are shown in **Figure 12.1** illustrating the biggest and smallest changes for the different vertebrate groups.

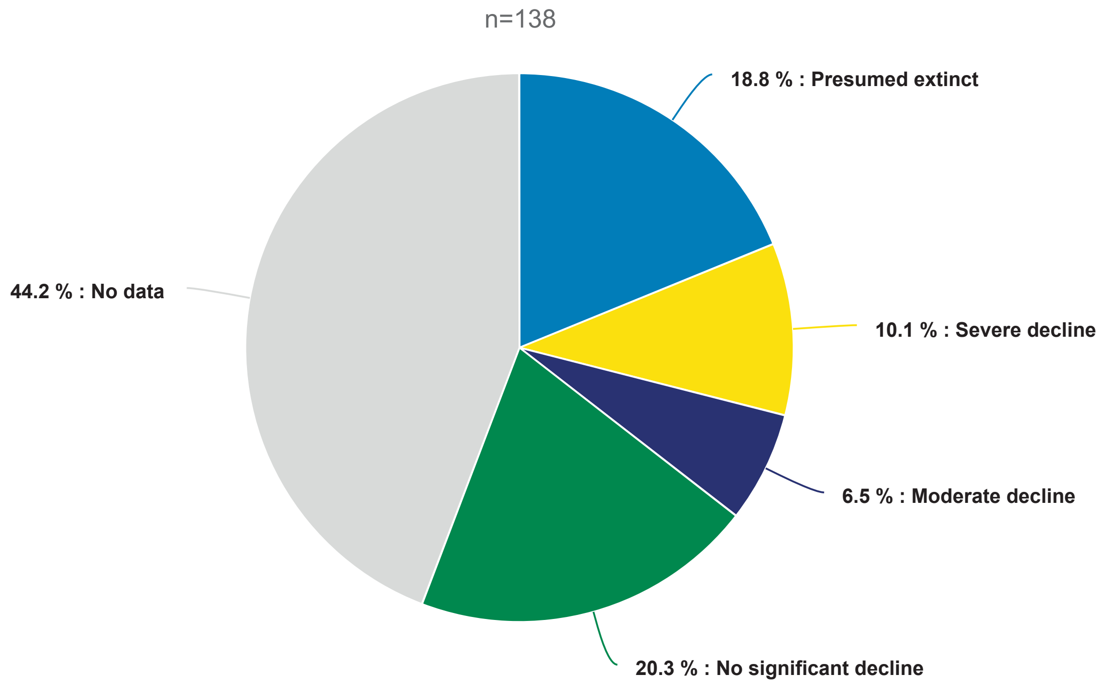
Figure 12.1a: Long-term (200 years) loss of distribution for native birds



Notes:
Presumed extinct – 100% change (contraction) in distribution
Severe decline – 50–<100% change in distribution
Moderate decline – 25–<50% change in distribution
No significant decline – less than 25% change in distribution
n = the total number of species recorded as inhabiting NSW at the time of European settlement, but not including species regarded as ‘vagrants’ (occasional or accidental sightings of species well outside their normal range). Total differs from that used in **Figure 12.6**.

Source:
Mahon et al. 2011; DECCW 2009

Figure 12.1b: Long-term (200 years) loss of distribution for native mammals



Notes:
Presumed extinct – 100% change (contraction) in distribution
Severe decline – 50–<100% change in distribution
Moderate decline – 25–<50% change in distribution
No significant decline – less than 25% change in distribution
n = the total number of species recorded as inhabiting NSW at the time of European settlement, but not including species regarded as 'vagrants' (occasional or accidental sightings of species well outside their normal range). Total differs from that used in **Figure 12.6**.

Source:
Mahon et al. 2011; DECCW 2009

Over the longer term, the described outcomes for birds have been much better than for mammals, with only 2% of bird species (12 out of 452) becoming extinct compared with 19% of mammals (26 of 138 species). Contractions of range of 50% or more (including extinctions) involved only 6% of birds (31 species) compared with 29% of mammals (40 species). Range contractions have been experienced by 64% of all mammals.

The data reveals that, historically, birds have been significantly less susceptible to the pressures resulting in range contraction that have affected other terrestrial vertebrates, particularly mammals. If the figures for bird extinctions on Lord Howe Island (where nine of the 12 extinctions occurred), are excluded, the resilience of bird species on mainland NSW is even more pronounced.

Current field surveys

Most current surveys of change in the numbers or distribution of species over time, tend to be narrower in scope and more constrained in the numbers of species and the areas surveyed than the long-term historical data described previously. However, the greater accuracy of the data from these surveys is useful to corroborate the findings of the broader long-term surveys by providing supporting information that is more reliable and up-to-date. The outcomes of these surveys are quite variable, demonstrating that different species and groups have different responses to environmental disturbances and pressures. A uniform trend does not apply to outcomes for all species. The surveys are mostly limited to selected mammals and birds, which on their own do not provide a sufficient basis for broader generalisations about outcomes for biodiversity.

Bird surveys

In contrast to the relatively good outcomes for birds recorded over longer time frames, more recent surveys indicate that these outcomes may not be sustainable. Shorter-term data on bird populations produced over the previous 15 years shows that the numbers and range of some birds have declined significantly (Garnett et al. 2010; Mahon et al. 2011). Populations of woodland birds have declined the most (MacNally et al. 2009; Paton & O'Connor 2010), due to the extensive clearing of woodlands described in the Native Vegetation topic and the decline in habitat condition due to the Millennium Drought.

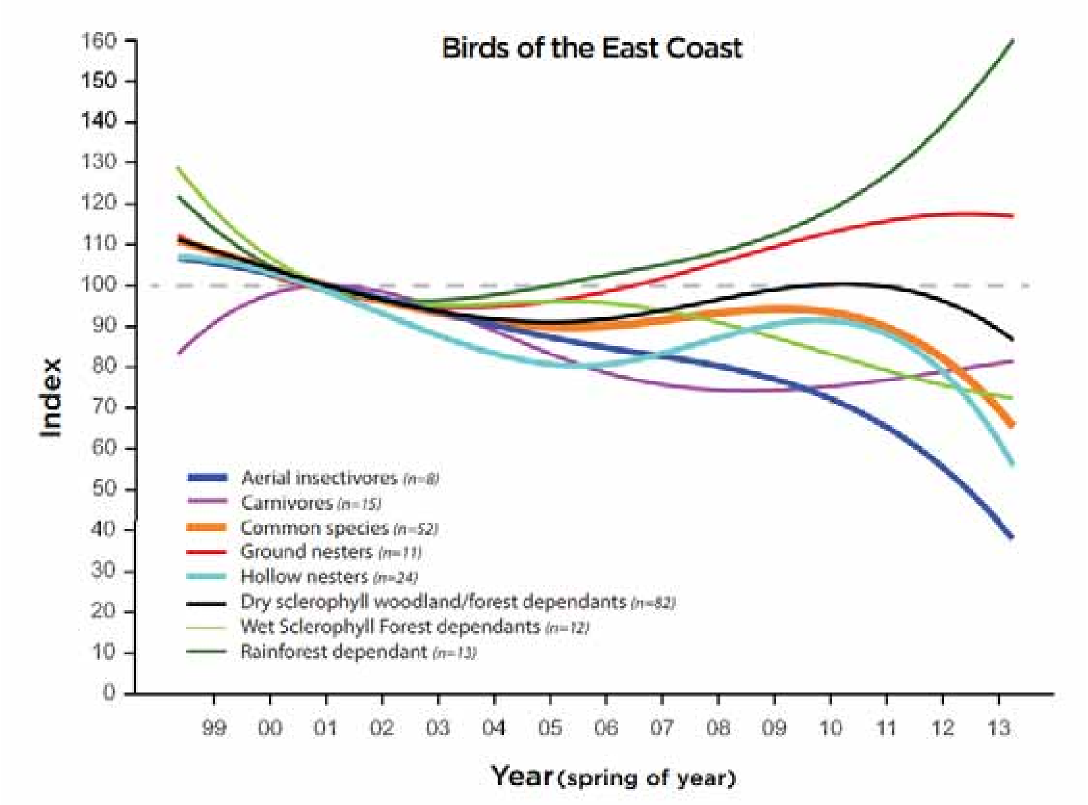
The State of Australia's Birds

The *State of Australia's Birds 2015* (Birdlife Australia 2015) developed indices for terrestrial birds for various regions and bird groups across Australia. The indices were developed from rigorous scientific analysis of Australia's largest dataset of bird sightings, collected by thousands of volunteers across the country.

These indices describe average outcomes for different groups of bird species. The results are quite variable across the different regions defined in the study and across groups (Birdlife Australia 2015). For birds that occur in several regions, quite different trends were often observed across these regions - only 10% of 137 species found across three or more regions showed a consistent overall trend.

Much of the East coast and South-east mainland regions fall within NSW. Indices for groups of East coast birds did not follow a uniform pattern, with two indices in 2013 well above the 1999 baseline and five below (see **Figure 12.2**). While the index value for rainforest birds displayed a marked increase, aerial insectivores and hollow-nesting birds showed clear declines. The patterns were less distinct for South-east mainland birds. Four indices were slightly above the baseline level and two slightly below, with differing outcomes observed for individual species within most of these groups.

Figure 12.2: Indices for east coast birds, 1997–2013



Source:
Birdlife Australia 2015

Part of the Eastern Mallee region also occurs within NSW. All bird indices in this region showed declining values, with the greatest decline in Mallee woodland dependent birds. Only a small part of the Arid Zone occurs in NSW. Four bird indices showed declines in value, while a further two indices remained at around baseline levels.

Threatened Species Index for Australian birds

A collaborative project led by the University of Queensland and Birds Australia is developing a framework for a Threatened Species Index for Australia, based on the Living Planet Index method (Collen et al. 2009). A publically accessible web visualisation app was launched in November 2009 enabling interrogation of the index and data downloads. Indexes for other groups are expected to follow.

To develop the Threatened Bird Index for Australia, an aggregated database was compiled with contributions from more than 130 data government and non-government agencies and citizen science groups. Bird species were grouped into four functional groups depending on the habitats they prefer in order to relate trends to the threats in those habitats:

- marine
- shoreline
- terrestrial
- wetland.

An initial index was calculated for NSW on data for 16 species of threatened and near threatened birds. The year 1985 was chosen as the baseline for this index with the value set to one in that year, but the app allows other baselines to be set. The trend for NSW was a decrease in the index value of 78% compared to the 1985 baseline.

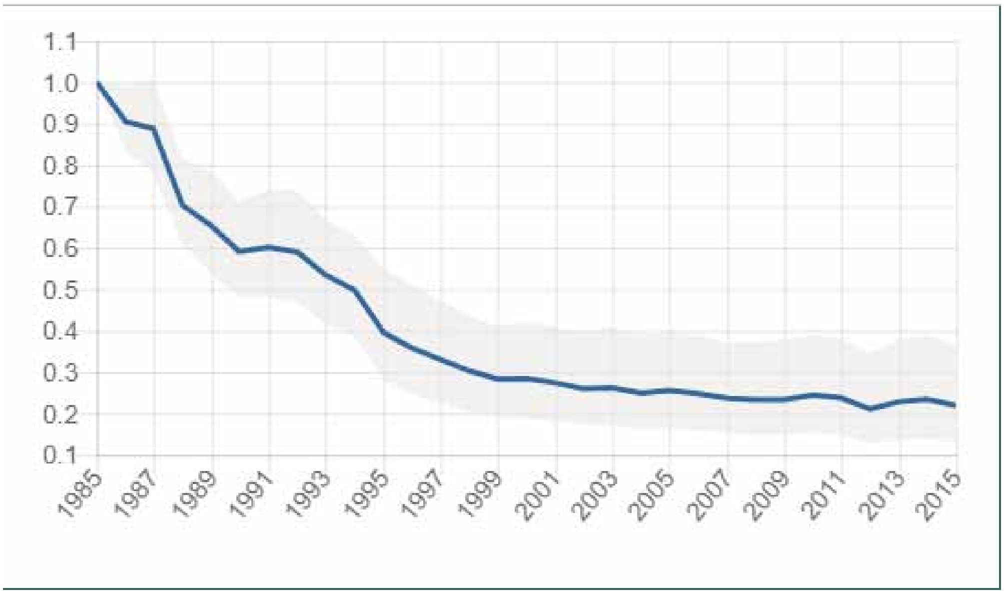
However, great care is needed in interpreting these early results. From the initial baseline set at 1985, the index shows a sharp decline. In 1985, data is only available for about four species of shorebirds known to be strongly declining and this is reflected in the results. The index pattern flattens out from about 2000 when data for about 20 species is available.

It should also be noted that:

- it is likely that a decreasing trend would be observed as all threatened species have been listed due to previously observed declines in their populations
- not all species have sufficient data to be included in the analysis, so the index is not fully representative
- for at least some species, more monitoring effort is likely to have occurred at sites where recovery programs are underway.

As more data for more species is added the index will become more robust in reflecting broader patterns for threatened bird species. It appears that coverage that is more representative of overall outcomes for threatened birds will likely be provided for a shorter period, from a baseline reset to a more recent starting point.

Figure 12.3: NSW index of threatened birds, 1985–2015



Source:
Threatened bird index database 2018

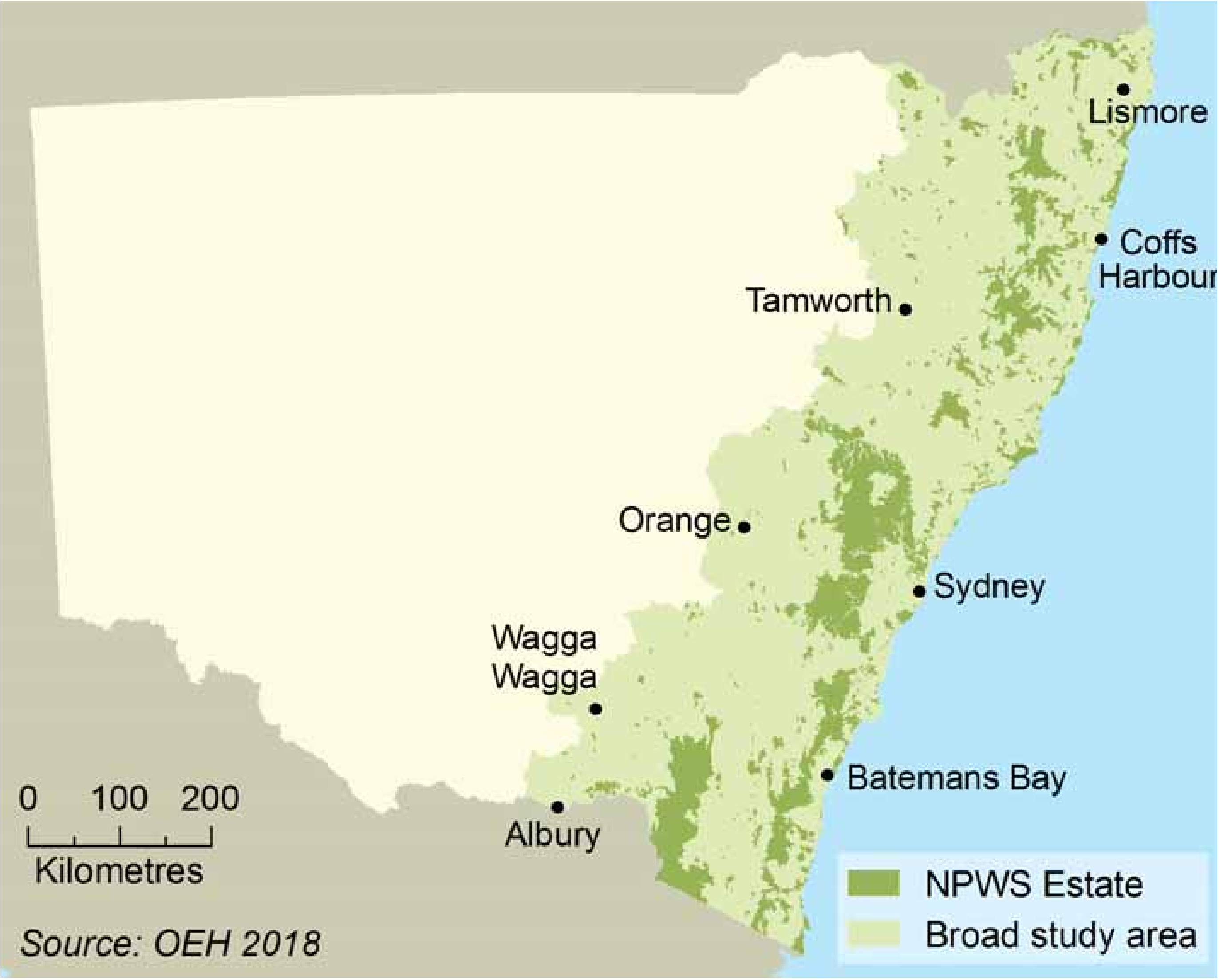
WildCount

WildCount uses photo-trap images captured on remotely deployed cameras (see **Image 12.1**) to monitor species distribution and occupancy patterns of commonly occurring land-based animals in national parks and reserves. The program is monitoring species trends over 10 years from 2012–2022. Monitoring occurs at 200 sites located within the reserve system across eastern NSW, (see **Image 12.2**).

Image 12.1: Long-nosed bandicoot captured by WildCount camera

Source:
WildCount 2018

Image 12.2: WildCount study area



Source:
OEH data 2018

The program aims to identify changes in the presence and absence of species so that species occupancy can be used as an indicator of abundance and the risk of extinction for these species.

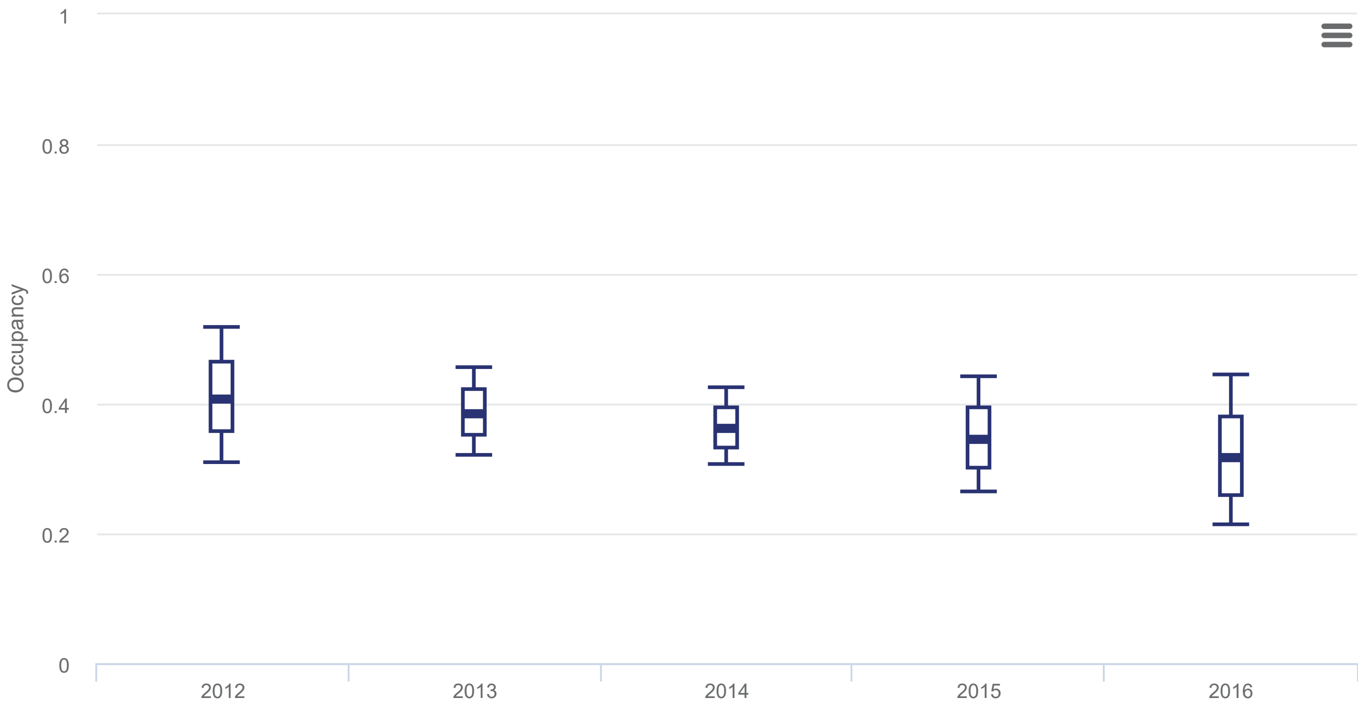
Data are now available for the first five years of monitoring from 2012–2016 (OEH 2017). About 160 species have been recorded and new locations have been identified for more than 15 threatened species.

Species occupancy models (**Figure 12.4**) based on the proportion of sites occupied by a species were developed for 39 of the most commonly found species. These included:

- 17 species of native mammals
- 14 species of birds
- 1 reptile
- 7 feral animals.

The models indicate that two species are likely to be declining - the long-nosed bandicoot and the rabbit; and five species are likely to be increasing -the mountain brushtail possum, satin bowerbird, spotted quail-thrush, wonga pigeon, and feral pig (**Table 12.1**). No trend was identified in the other 32 species monitored. Longer term data across the full 10 years of the program will be needed to confirm the patterns detected in the data to this point.

Figure 12.4: Occupancy model for long-nosed bandicoot



Source:
WildCount data 2018

Table 12.1: WildCount species occupancy estimates

Species	Trend	First (2012)	Last (2016)	Difference	Proportional change (%)
Long-nosed bandicoot	Down	0.409	0.318	0.091	-22.3
Rabbit	Down	0.295	0.141	-0.154	-52.2
Mountain brushtail possum	Up	0.070	0.097	0.027	38.6
Spotted quail-thrush	Up	0.163	0.242	0.079	48.5
Wonga pigeon	Up	0.208	0.319	0.111	53.4
Satin bowerbird	Up	0.108	0.628	0.520	481.5
Feral pig	Up	0.097	0.246	0.149	153.6

Source:
WildCount data 2018

Kangaroo surveys

In contrast to most smaller ground-dwelling mammals, the four largest kangaroo species in NSW (the red, western grey and eastern grey kangaroos and the wallaroo) are among the most abundant mammals in the State.

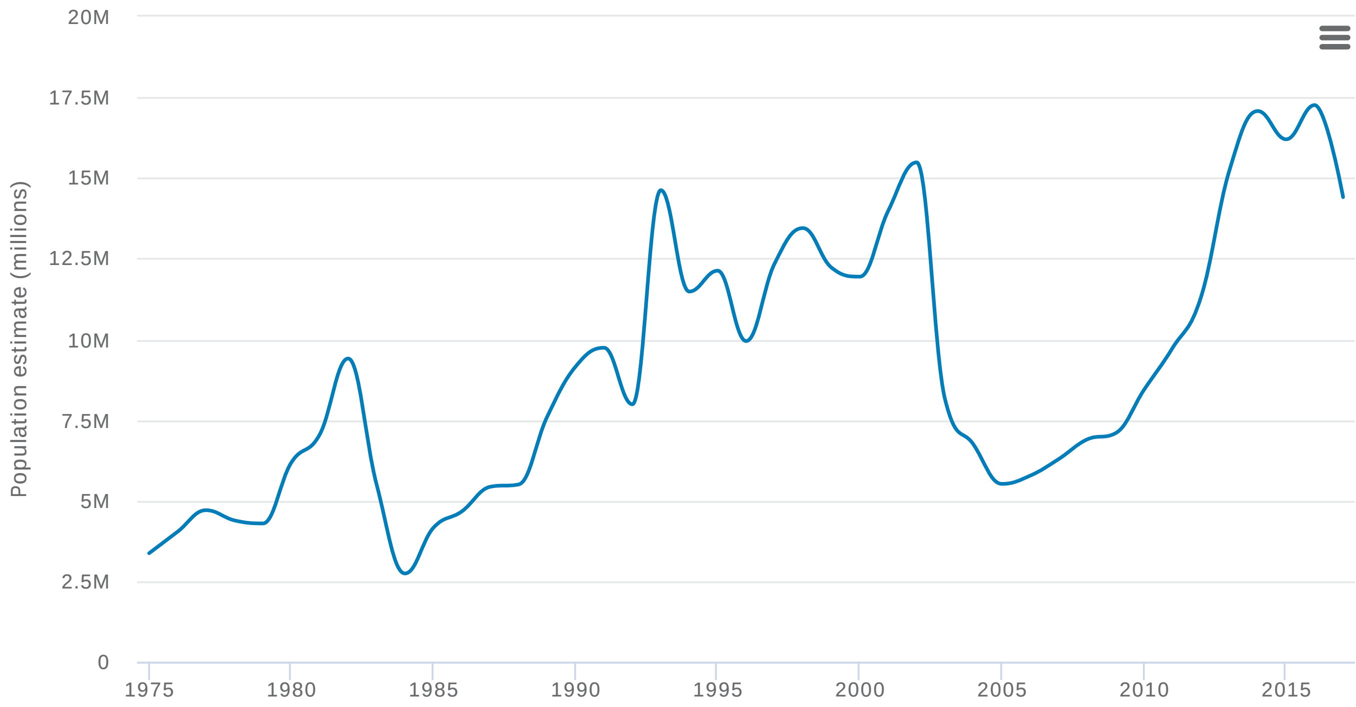
Kangaroo research, monitoring and management has been conducted in the commercial harvesting zones of NSW for more than 42 years, under the NSW Kangaroo Management Program. This is the longest running field monitoring study of wildlife in Australia.

The population sizes of the large kangaroo species in the Western Division of NSW have been estimated by aerial survey every year since about 1975. The Northern Tablelands and South-east NSW regions were added to the monitoring program in 2001 and 2003 respectively, while the Central Tablelands have been monitored since 2010. Tablelands regions

are monitored on rotation, once every three years. The aerial survey methods have improved over time, increasing the precision and accuracy of the population estimates.

Figure 12.5 shows the variation in estimates of total kangaroo population, since 1975. Declines in population are largely consistent with periods of drought and population increases correspond with increased rainfall.

Figure 12.5: Changes in the estimated population of large kangaroo species in NSW, 1975–2017



Source:
OEH data 2018

Freshwater fish surveys

Ten of the 29 native freshwater fish species found in the NSW portion of the Murray-Darling Basin (MDB) are listed as threatened with extinction under the *Fisheries Management Act 1994* (FM Act). The status of native freshwater fish communities in NSW has been monitored on an ongoing basis for over 20 years.

Data are collected on:

- nativeness (the proportion of native versus introduced fish)
- expectedness (the presence of native fish species compared to historic distributions)
- the recruitment of juvenile fish.

This monitoring provides what is probably the most complete picture of the distribution and abundance of any group of native species in NSW, as well as insight into the factors that are driving changes in the populations of native fish species (Riches et al. 2016).

The status of NSW fish communities in 2015 is displayed online for all NSW river basins. Over the past three years data on fish communities were collected from about 800 locations in the MDB and coastal rivers in northern NSW. No new data is available for the remaining coastal rivers over the past three years. The methods for sampling and analysis remain consistent with previous reporting and are described in Muschal et al. 2010; MDBA 2017.

The latest results indicate that the overall condition of native freshwater fish communities has improved within most river valleys of the Murray-Darling Basin, with eight valleys improving, two declining and five valleys remaining the same. Of the 15 MDB catchment valleys, only the Paroo was rated as being in ‘good’ condition, with the Lower Murray and Darling Rivers being in ‘moderate’ condition. Despite the overall improvement, 80% of valleys in the MDB are still in a ‘poor’ or worse condition.

The overall rating for expectedness improved from 'very poor' (index value of 33) to 'poor' (46). The proportion of native to non-native fish also improved from 'very poor' (index value of 38) to 'poor' (55).

These changes represent a return to a slightly better condition than was observed prior to the increase in numbers of common carp following extensive rains in 2010–11. Native fish recruitment was stable, with average index scores of 42 and 44. (For further detail see the River Health topic).

Introduced fish species compete for food and space with native fish and frogs. Over the past three years the surveys found:

- only 13% of the sites sampled (mainly coastal rivers) were free from introduced fish
- 4% contained only introduced fish.

Averaged across all sites, introduced species made up:

- 36% of all the fish species collected
- 37% of total fish numbers
- 58% of total fish biomass (DPI data 2015–17).

It should be noted that most of the sites sampled were within the Murray-Darling Basin, which has much lower 'nativeness' than coastal rivers. (For further detail see the Invasive Species topic).

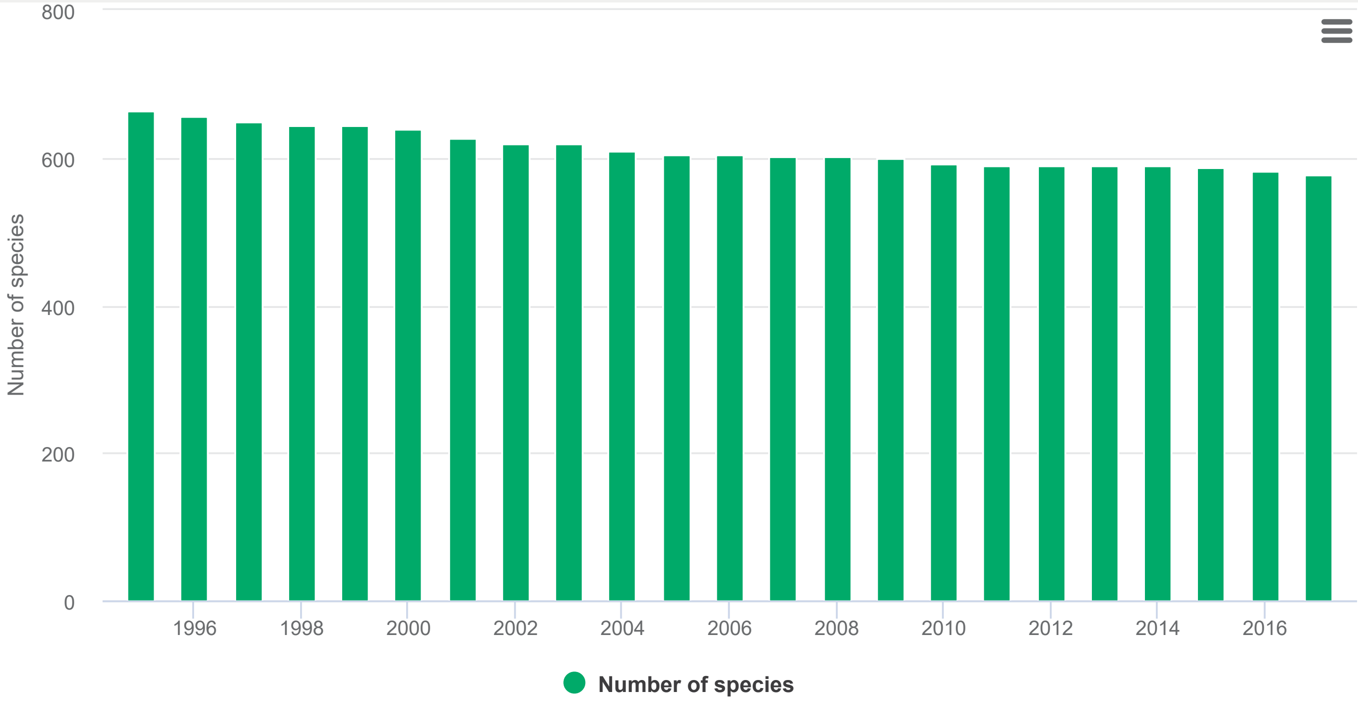
Overall patterns for species

Species that are not threatened

Where the total number of species in a group is known and there is enough information to systematically assess their conservation status, the overall prospects for survival for the group can be described by looking at changes in the proportion of species that are listed as threatened over time. This information is available for terrestrial vertebrates (mammals, birds, reptiles and amphibians) and is shown in **Figure 12.6**.

Of the 903 land-based vertebrate species that inhabited NSW, 664 (or 74%) were not listed as threatened when the *Threatened Species Conservation Act 1995* was introduced, following the first assessment of conservation status (described above). By December 2017, this number had declined to 578 or (64%). The deteriorating conservation status of these species reflects the increasing pressures affecting the biodiversity of NSW and other less well-studied groups are likely to be similarly declining.

Figure 12.6: Changes in the number of vertebrate species not listed as threatened under the Threatened Species Conservation or Biodiversity Conservation Acts, 1995–2017



Notes:
For the purposes of this analysis, 'vertebrate species' refers to mammals, birds, reptiles and amphibians listed under the *Threatened Species Conservation Act 1995*, which was replaced by the *Biodiversity Conservation Act 2016*.
It does not include fish, which are listed separately under the *Fisheries Management Act 1994* or marine mammals about which less is known due to their cryptic lifestyles and habits.

Source:
OEH data 2018

Species with stable populations

Assessments of change in the distribution and abundance of species tend to focus on declines because these are the most common type of change. The Threatened Species topic deals exclusively with species that are declining in numbers as their survival has been assessed to be at risk in the longer term.

However, **Figure 12.6** shows that overall, fewer species are considered to be threatened than not threatened. **Figure 12.1** also shows that most bird species have not experienced contractions in range over the longer term, although more recent surveys of birds indicate that numbers are decreasing in some habitat types or groups. Even in the case of land-based mammals, if the figures for extinctions are excluded, slightly more species now have stable than declining distributions. Therefore, while many species are declining in numbers and range due to a variety of human-caused disturbances, many others have been less susceptible to existing pressures and have maintained relatively stable populations.

Some species are more adaptable and can take advantage of human disturbances to create or occupy new habitat niches, sometimes to the extent that they may be considered a nuisance. The issue may be local, such as:

- brush-tailed possums in the roofs of houses
- ibis near airport runways or at waste disposal sites
- flying-foxes in orchards, or near houses and schools.

Or the issue may be regional, as in the case of kangaroos on rural lands.

There is also some limited evidence that a few native species may be expanding in numbers or range, but such outcomes are rarely studied and difficult to demonstrate conclusively. In a few instances, species of native freshwater fish (eel-tailed catfish, climbing galaxias) and native garden plants (Sweet Pittosporum, Cootamundra Wattle) have become invasive after being translocated from their natural habitats.

Pressures

Listing of key threatening processes

The biodiversity of NSW is subject to an increasing number and range of threats. The *Biodiversity Conservation Act 2016* (BC Act) and the *Fisheries Management Act 1994* (FM Act) both list the key threatening processes (KTPs) that impact on listed threatened species. At 31 December 2017, there were 46 KTPs listed for NSW - 38 under the BC Act and eight under the FM Act. There is some overlap, with climate change, shark meshing and changes to river flow regimes listed under both Acts in slightly different ways.

Table 12.2 summarises the types of KTPs listed. Over half of them relate to invasive species, with 24 associated with pests and weeds and a further five pertaining to pathogens and diseases. Ten KTPs relate to the clearing and disturbance of native habitat.

Table 21.2: Key threatening processes listed in NSW, 2017

Issue	Number of KTPs
Invasive species	24
Habitat change	10
Disease	5
Over-exploitation	3
Climate change	2
Altered fire regimes	1
Pollution	1
Total	**46**

Notes:
As at 31 December 2017

Source:
OEH and DPI data 2017

It should be noted that not all these threats are equivalent in effect and the numbers are not necessarily indicative of the cumulative impact of any type of threat. For example, it is expected that over time climate change will become one of the most significant threats described here.

Main threats to biodiversity and threatened species

When a species, population or ecological community is listed as threatened under the BC Act or the FM Act, the main pressures and threats affecting its conservation status are described in the listing. These threats were analysed for all threatened species listed at the time of analysis under the *Threatened Species Conservation Act 1995*, (the predecessor to the current BC Act), to identify those that have the greatest impact on biodiversity and the environment in NSW (Coutts-Smith & Downey 2006).

The pressures affecting the largest number of threatened species in NSW were the clearing and disturbance of native vegetation (87%), followed by invasive pest and weed species (70%).

Clearing and habitat destruction

The clearing of native vegetation results in the direct loss of species and the destruction of habitat. It is followed by lag effects due to disturbance from subsequent land uses and the fragmentation of remnant vegetation, which impedes regeneration and the movement of species across the landscape and leads to a loss of genetic diversity (Cogger et al. 2007; Taylor & Dickman 2014).

Invasive species

Invasive species have contributed to the decline of many native species. Pest animals, particularly foxes and cats, are likely to have had the greatest impact on native fauna and are considered to be responsible for the majority of fauna extinctions on mainland NSW (Morton 1990; Dickman 1996a; Dickman 1996b). Black rats have had a similar effect on Lord Howe Island, while carp is now the predominant species in most rivers of the Murray Darling Basin.

Climate change

As many Australian species are adapted to highly variable climates, they are likely to have the capacity to cope with some level of climate change. However, the resilience of many species may have been eroded by existing pressures, which have resulted in the declines in numbers or range described in this topic. Climate change is expected to exacerbate the effects of existing threats and introduce additional pressures (Steffen et al. 2009; DECCW 2010a; Hughes 2011). It is likely that climate change will surpass habitat destruction as the greatest global threat to biodiversity over coming decades (Leadley et al. 2010). For further information see the Climate Change topic.

Other threats

Water extraction and altered river flows and cycles have an impact on the critical ecological processes that trigger breeding in a range of aquatic and bird species (see the River Health topic), while altered fire regimes impact on the ability of plant species and communities to regenerate or repropagate.

Most of the main threats to biodiversity in NSW are described in greater detail in other sections of this report, including:

- clearing, fragmentation and the disturbance of native vegetation (see Native Vegetation);
- the introduction and spread of invasive species – pests, weeds, diseases and pathogens (see Invasive Species)
- overgrazing by cattle, sheep and invasive herbivores (see Native Vegetation)
- water extraction and changes to river flows (see Water Resources)
- increasing populations and expanding human settlements (see Population)
- the increasing impacts of climate change (see Climate Change).

Threats not dealt with specifically in other sections of this report include:

- altered fire regimes due to European settlement
- the indirect impacts of development, particularly in new areas where high rates of mortality and injury to wildlife can occur
- disturbance to behaviour and breeding cycles from infrastructure, noise and lighting (Byron et al. 2014).

It should be noted that many of these threats can operate together to have a cumulative impact and hasten the decline of species and communities. Sometimes these impacts may be synergistic, where the cumulative impact is greater than the sum of the individual pressures (Raffaele et al. 2011; Goldman Martone & Wasson 2008; Simberloff & Von Holle 1999).

Lack of information

It is unrealistic to expect that a full range of biodiversity could ever be monitored systematically with available resources. It is therefore an ongoing challenge to optimise monitoring information so that it informs decision-making for managing biodiversity effectively.

Although knowledge of the conservation status of species has improved markedly over the past 20 years, especially on the distribution and abundance of land-based vertebrates, less is known about other groups. Patterns of decline that are likely to have been present for many years are still being discovered in the less well-studied groups of species. For most invertebrates, microorganisms and many plant groups, which comprise the vast majority of species, information exists for only a few isolated species and this provides little insight into the broader status and management needs of these groups.

The 2014 Independent Biodiversity Legislation Review panel recommended the development of a comprehensive system for monitoring and reporting on the extent and quality of biodiversity in NSW (Byron et al. 2014). Such a system would improve the availability of information to more effectively track the status of all species in NSW. This recommendation was adopted by the NSW Government and new techniques for monitoring biodiversity are under development.

Responses

Legislation and policy

Biodiversity Conservation Act

Following the Independent Biodiversity Legislation Review, sweeping reforms were made to the legislative framework for land management and biodiversity conservation. Biodiversity legislation in NSW has been consolidated under the *Biodiversity Conservation Act 2016* (BC Act), which replaces the *Threatened Species Conservation Act 1995* (TSC Act), *Nature Conservation Trust Act 2001* and the plant and animal provisions of the *National Parks and Wildlife Act 1974*. A new rural land management framework was also introduced with the *Local Land Services Amendment Act 2016,* which replaced the *Native Vegetation Act 2003*. The laws commenced on 25 August 2017.

Protections for aquatic and marine species remain in the *Fisheries Management Act 1994* (FM Act). Amendments to the FM Act are being progressed during 2018 to make this legislation consistent with the BC Act and the Common Assessment Method for national listing of threatened species.

Policy and guidelines for fish habitat conservation and management

In 2013, an updated policy and guidelines were published to maintain and enhance the habitat of native fish species (including threatened species) in the marine, estuarine and freshwater environments (DPI 2013).

Programs

Saving our Species program

The Saving our Species program (SoS) aims to maximise the number of threatened species that can be secured in the wild in NSW for 100 years. SoS plays a pivotal role in threatened species conservation, and its systematic and pragmatic approach has been formally adopted in the BC Act. Through SoS, land-based threatened species have been allocated to one of six management streams, depending on their distribution, ecology, security and what is known about them. The six management streams are:

- Site-managed species: species that can be successfully secured by targeting conservation projects, such as weeding or revegetation, at specific sites (e.g. the smoky mouse, eastern bristlebird and granite rose)
- Iconic species: six species that are especially valued by the community – the koala, brushtailed rock-wallaby, mallee fowl, plains wanderer, southern corroboree frog and Wollemi pine
- Data-deficient species: species where there isn’t sufficient information to allocate them to another management stream (e.g. Sloane's froglet, finger panic grass and the matted bush pea)
- Landscape-managed species: species that are distributed across large areas and threatened across the landscape by habitat loss and degradation (e.g. the green-thighed frog, paleheaded snake, yellow-bellied glider and giant dragonfly)
- Partnership species: species that are threatened nationally and have important populations in NSW, that will have conservation projects developed to protect them (e.g. the black-striped wallaby and dwarf bush-pea)
- Keep watch species: species that require no immediate investment because they are either naturally rare, have few critical threats, or are more abundant than previously assumed (e.g. for example Hall's babbler and the spiny mintbush).

Priorities for action under SoS are species in the site-managed, iconic, data-deficient and landscape-managed species management streams. Threatened ecological communities and key threatening processes are also priority actions areas.

In 2016–17, SoS conservation projects benefited from approximately $23 million in cash and in-kind contributions from OEH including the Environmental Trust ($16.3 million) and external organisations ($6.7 million). There were 305 active SoS projects across the six management streams, including:

- six iconic species projects
- 239 site-managed species projects
- nine landscape-managed species projects
- one partnership species project
- 41 data-deficient species projects
- two keep watch species projects.

Key actions for these projects include:

- pest and weed control
- habitat and site protection and management
- community and landholder engagement
- translocation and ex-situ conservation (e.g. captive breeding)
- research.

Research on data-deficient species has led to recommendations to move 15 species to a new management stream.

The NSW Government pledged an additional $100 million over five years from 2016–17 to protect the state's threatened species.

Reintroduction of locally extinct mammals

Since 2015, the NSW Government has been working with the Australian Wildlife Conservancy and the University of New South Wales to reintroduce more than 10 species of locally extinct mammals into some public reserves in NSW. The reintroduction of locally extinct mammals is a significant component of the SoS program.

Feral-free fences will protect 180,000 hectares of land from feral predators such as foxes and cats in Sturt National Park, Mallee Cliffs National Park and Pilliga State Conservation Area. Mammals will be reintroduced into these areas following the removal of introduced predators and other pest animals.

In Pilliga State Conservation Area, a 5,900-hectare area of natural habitat will be protected from feral predators and at least six locally extinct mammal species will be reintroduced.

In Mallee Cliffs National Park, an 8,000-hectare area will be protected for at least 10 locally extinct mammal species.

Wildlife licensing

The BC Act established a new risk-based approach to managing wildlife actions through a tiered framework that:

- permits low-risk activities through Biodiversity Conservation Regulations,
- allows moderate risk activities under a code of practice,
- ensures high risk activities will continue to require a licence,
- provides for actions that have direct impacts on biodiversity, including threatened species, to be treated as offences under the BC Act.

The NSW Government has been consulting with stakeholders to identify which actions should continue to require licensing, and which should be regulated by codes of practice and regulations. This process is ongoing.

Identifying areas of outstanding biodiversity value

The BC Act enables the Minister for the Environment to declare Areas of Outstanding Biodiversity Value (AOBVs). AOBVs are special areas that contain irreplaceable biodiversity values that are important to the whole of NSW, Australia or globally. AOBVs will be a priority for investment in private land conservation.

Existing areas of declared critical habitat under the old TSC Act (Wollemi pine and little penguin habitats) became AOBVs when the BC Act came into effect.

Listing of threatened species and communities

The BC Act modernised the process for listing threatened plants and animals. It aligns threat categories with international best practice and provides greater coordination between Australian jurisdictions. The Biodiversity Conservation Regulations prescribes listing criteria for threatened plants and animals which align with standards developed by the International Union for Conservation of Nature.

The Commonwealth, state and territory governments agreed to establish a common method for assessing and listing threatened species. The process of alignment of assessment and listing under the common assessment method is ongoing. This will reduce duplication of effort among governments by allowing jurisdictions to adopt listing assessments undertaken by other jurisdictions and will lead to better conservation outcomes for Australia's species.

NSW public reserves system

The public reserves system is the cornerstone of conservation efforts in NSW. It plays a vital role in protecting habitat and provides a refuge for many threatened species that are sensitive to habitat disturbance.

The NSW public reserves system covers around 7.14 million hectares or about 9% of the state (see the Protected Areas and Conservation topic). It conserves representative areas of most habitats and ecosystems, and the majority of plant and animal species found in NSW are represented in the public reserve system. Under the new BC Act there is an increased focus on conservation measures on private land to supplement land managed for conservation in the public reserve system.

NSW Koala Strategy

The NSW Government recognises the koala as an iconic threatened species and is committed to stabilising and increasing koala populations across NSW. In May 2018 the government released the NSW Koala Strategy, committing $44.7 million towards securing the future of koalas in the wild. The Strategy will support a range of conservation actions over three years.

The NSW Koala Strategy will deliver:

- $20 million from the NSW Environmental Trust to purchase and permanently conserve land that contains priority koala habitat in the national park estate
- $3 million to build a new koala hospital at Port Stephens
- $3.3 million to fix priority road-kill hotspots across NSW
- $4.5 million to improve the care of sick or injured koalas
- $6.9 million to improve our knowledge of koalas, starting with the development of a state-wide koala habitat information base
- $5 million to deliver local actions to protect koala populations, including through the SoS program
- $2 million to research impacts of natural hazards and weather events on koalas.

The NSW Koala Strategy responds to the *Independent Review into the Decline of Koala Populations in Key Areas of NSW* (NSW Chief Scientist and Engineer 2016), which recommended a whole-of-government koala strategy for NSW. An expert advisory committee chaired by the NSW Chief Scientist and Engineer guided the strategy's development along with extensive community and stakeholder consultation.

Management and control of invasive species

Once established, the eradication of invasive species is seldom feasible. Therefore, control of some high-priority invasive species, such as foxes and bitou bush, is specifically targeted at sites of high conservation value. Control is delivered through threat abatement plans which facilitate whole-of-government coordination across agencies and local authorities.

Broad scale rabbit control is being provided through the release of rabbit haemorrhagic disease, while rats, mice and rabbits have been eradicated from some NSW islands. Local Land Service are responsible for identifying priority weeds regionally and developing programs to manage them (see the Invasive Species topic).

Adaptation to climate change

Priorities for Biodiversity Adaptation to Climate Change (DECCW 2010b) was produced in response to the listing of anthropogenic climate change as a key threatening process under the BC Act. This identifies priority measures for dealing with the effects of climate change over the next five years, focusing on four key areas:

- enhancing understanding of the likely responses of biodiversity to climate change and readjusting management programs where necessary
- protecting a diverse range of habitats by building a comprehensive, adequate and representative public reserve system in NSW, with a focus on under-represented bioregions
- increasing opportunities for species to move across the landscape by working with partners and the community to protect habitat and increase connectivity by consolidating areas of vegetation in good condition
- assessing adaptation options for ecosystems most at risk from climate change in NSW.

A key threatening processes strategy has been prepared for the SoS program, that includes adaptation processes in response to climate change following the listing of Climate change as a KTP.

The AdaptNSW website provides comprehensive climate change information, analysis and data to support action to address climate change risks and capture opportunities. It includes information on the causes of climate change and the likely impacts on biodiversity. For further information see the Climate Change topic.

Future opportunities

Measures to improve connectivity across landscapes and build the health and resilience of the land will enhance the capacity of species and ecosystems to adapt to, and cope with, disturbance.

More information about the factors contributing to the resilience or success of some native species and processes, in contrast to the declines of many others, may assist in efforts to maintain sustainable populations of flora and fauna species.

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Water and Marine

The State of the Environment Report – 2018

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Water Resources

Healthy and secure sources of water are essential to provide for a variety of beneficial water uses including town water supplies and agriculture while maintaining the condition of natural aquatic environments.

Summary

Environmental water share

2,482 GL

in 2016–17, a 50-fold increase from 10 years ago

Read more

Water sharing plans

58

now developed, covering all NSW water sources

Read more

Following high flows in most rivers during 2016–17, conditions have become drier. However, greater amounts of environmental water are now available and being directed to benefit the aquatic environment.

After three years of variability, NSW climatic conditions and surface water availability have now entered a significantly drier climate phase.

Water extraction and flow regulation alter river flows and continue to put pressure on the health of inland river systems.

Demand for the State's water resources remains high, but this demand is being managed through water sharing plans. These plans balance equity of access and productivity for users, while maintaining aquatic ecosystem health.

Water sharing plans have been developed for all water sources in NSW, with a total of 58 water sharing plans commenced by the end of 2018.

The NSW Government's cumulative holdings of environmental water total about 868,000 megalitres (ML) within regulated rivers and about 24,000ML in unregulated rivers. The Commonwealth Government has also recovered substantial volumes of environmental water in the Murray-Darling Basin in NSW with current holdings of about 1,545,000ML in regulated rivers and 46,000ML in unregulated rivers.

During the three years 2014–15 to 2016–17, significant volumes of environmental water were delivered to locations across inland NSW. Volumes ranged from about 506,000ML to 1,420,000ML a year. Substantial releases, averaging 157,000ML a year, have also been made to the Snowy River.

Related topics: River Health | Wetlands | Coastal, Estuarine and Marine Ecosystems

NSW Indicators

Indicator and status		Environmental trend	Information reliability
Proportion of water extraction covered by water sharing plans	 GOOD	Stable	✓✓✓
Environmental share of available water	 MODERATE	Getting better	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Water resources are critical for many human needs, including supplies for towns, household use, stock watering, crop irrigation, and mining and industry. Most of these needs are satisfied by water held in storage or extracted from rivers and groundwater.

Water resources are also vital to conserve the health of aquatic ecosystems in rivers, estuaries and wetlands. (See the River Health, Wetlands, and Coastal, Estuarine and Marine Ecosystems topics.)

An adequate supply of good quality water is vital:

- for a healthy environment
- to secure water resources for human use
- to enable economic growth.

Water use planners must balance water supplies to meet social, economic, cultural and environmental needs. At the same time, they must account for long-term changes in water availability due to climate extremes, such as droughts and floods.

To address these needs, the NSW Government sets out rules in statutory water sharing plans (WSPs). These rules aim to protect water for the environment and provide security of entitlement for all water users. NSW has also committed to work with the Commonwealth Government to implement the Murray-Darling Basin Plan 2012. The Basin Plan sets sustainable diversion limits (SDLs), for both surface water and groundwater sources. These determine how much water can be used in the basin and meet the needs of communities reliant on the basin's water, while making sufficient provision to protect the health of the aquatic environment and river and groundwater systems.

Surface water resources are explored in this topic; for groundwater resources, see the Groundwater topic.

Status and Trends

Despite almost average rainfall in 2015, well above average temperatures contributed to overall dry conditions and low surface water availability in NSW.

For inland NSW, a dry start to 2016 was followed by a significantly wetter winter and early spring. This rainfall caused widespread and prolonged flooding across many inland areas.

On the coast, rainfall generally remained below average over the last three years (2015–17). An exception was in spring 2017 when tropical cyclone Debbie produced widespread flooding and wind on NSW's north coast.

In 2017, dry conditions returned to NSW, with below average rainfall and elevated temperatures. These conditions generally continued statewide to create drought conditions in winter 2018.

Water use and water sources

The NSW Department of Industry website summarises water availability and allocations for each of NSW's major regulated river systems.

For inland NSW, nine water sharing plans cover the regulated river areas of:

- NSW Murray and Lower Darling
- Murrumbidgee
- Lachlan
- Belubula
- Macquarie and Cudgegong
- Namoi
- Peel
- Gwydir
- NSW Border Rivers.

On the coast, four WSPs cover the regulated river areas of:

- Bega and Brogo
- Hunter
- Paterson
- Richmond.

The Department of Industry website also provides detailed reports on basins and catchments, including their climate, hydrology, environmental aspects, land use, water resources, regulating structures and water resource management.

In NSW, the long-term average for annual water use is about 7,000 gigalitres (GL). However, the actual amount of water used each year varies considerably, depending on rainfall and flow conditions.

About 80% of this water comes from regulated rivers, where flows are controlled by large water storages operated by WaterNSW. Of the remainder, about 11% comes from groundwater (see the Groundwater topic), with the balance drawn from unregulated rivers. These estimates of water use include water licensed for consumption and for the environment.

Agriculture is the largest user of bulk water and also the most variable. Agriculture consumes an average of about 60% of total water used, but this ranges from about 70% when water availability is high, to around 45% when availability is low. (These percentages were calculated based on averages for the eight-year period 2008–16 using ABS data [ABS 2017]).

Bulk water for urban water and sewerage services, the second largest user, accounts for about 20% of total water used, on average. This includes water lost to evaporation and leakage during water delivery. Households are large users, consuming about 10%, on average. Industries such as forestry, mining and manufacturing account for the remaining 10% of total water use.

Water extraction

Most water extracted in NSW comes from eight major regulated river valleys:

- Murray
- Murrumbidgee
- Lachlan
- Macquarie
- Namoi
- Gwydir
- Border
- Hunter.

Significant volumes of water are also extracted in sections of the Barwon-Darling River system, which is unregulated.

Runoff from the Snowy Mountains is captured and diverted to the Murray and Murrumbidgee rivers through the Snowy Mountains Scheme. This diverted water flow generates electricity and augments water availability in these inland valleys.

Water is also extracted from the Hawkesbury-Nepean River system. This water is used in agriculture for irrigation; by the tourism, fishing and oyster industries; for various recreational uses; and for urban use in the Greater Sydney metropolitan area. Diversions from the Shoalhaven River system supplement the Greater Sydney urban water supply and parts of southern Sydney are supplied from the Woronora River Catchment. Water sales to supply Greater Sydney were 516GL in 2015, 526GL in 2016 and 557GL in 2017 (Water NSW 2017). See also the Urban Water Supply topic.

Each year, water is allocated to licences in the regulated river valleys on 1 July, the beginning of each water year, and also periodically throughout the year. The quantity allocated reflects the water resources available and the security of the entitlement. The Department of Industry website details the various types of water access licences.

Water licensed for town supply, major utilities, and household and stock use has the highest security of supply. Other high-security licences also receive a high proportion of their water allocations in all but the driest years. These are typically licences for water to irrigate permanent plantings, such as orchards and vines, and for use by industries with a level of investment that warrants assured water supply.

Water allocated to general security licences varies more from year to year; it is mostly used to irrigate annual crops, such as cereals, rice, cotton and pastures. Rules of some water sharing plans permit unused allocations of general-security water to be carried over from year to year.

Water not allocated for extraction each year is considered to be environmental water. Other water is allocated specifically to the environment through the environmental flow rules of water sharing plans and environmental water licences.

Long-term modelling of river flows and extractions

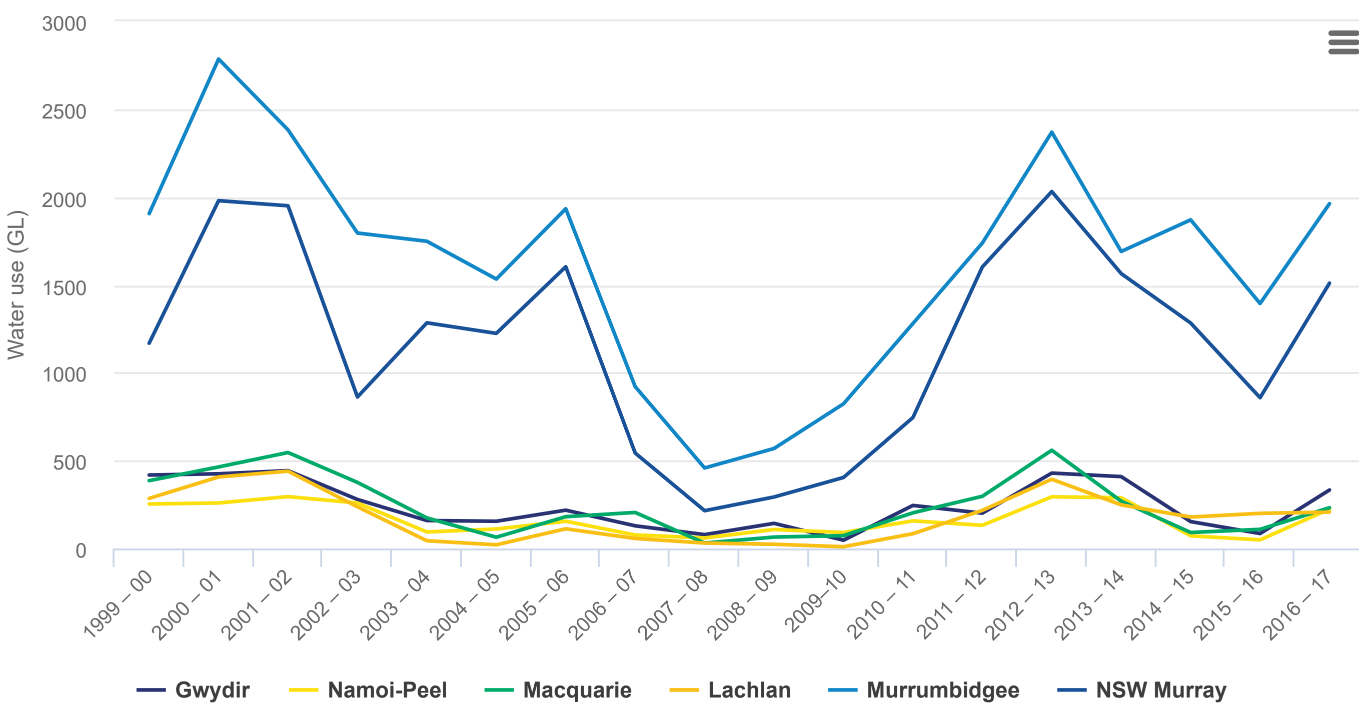
Long-term modelling of river flows provides a basis to set long-term diversion limits for water sharing plans. These models are based on 120 years of historical climate and flow data. They simulate the flow behaviour of river systems, and the impact of water resource development on natural river flows.

The models provide a baseline and context against which to compare actual river flows each year. They generally show the proportion of water remaining for the environment is higher during wetter periods than drier periods. By contrast, when river flows are low, less water is available in total, and proportionally more of it is allocated for consumption. See the Department of Industry website for more on groundwater and surface water models.

Current river flows and extractions

Over the decade prior to 2010–11, water extractions gradually fell due to severe, extended drought conditions. **Figure 16.1** shows how the quantity of water extracted from six regulated rivers rose sharply in 2010–11, as surface water availability increased due to widespread heavy rains. Extractions fell again during another dry period after 2013, before recovering in 2016–17. Yearly rainfall and river flows drive water availability, and directly affect the volumes extracted.

Figure 16.1: Water use by licensed users in major NSW regulated valleys, 1999–2000 to 2016–17



Notes:
Water use is licensed account usage, including general security, high security, conveyance, water utilities, domestic and stock, and supplementary access. These use estimates include licensed water use for both consumptive and environmental purposes.

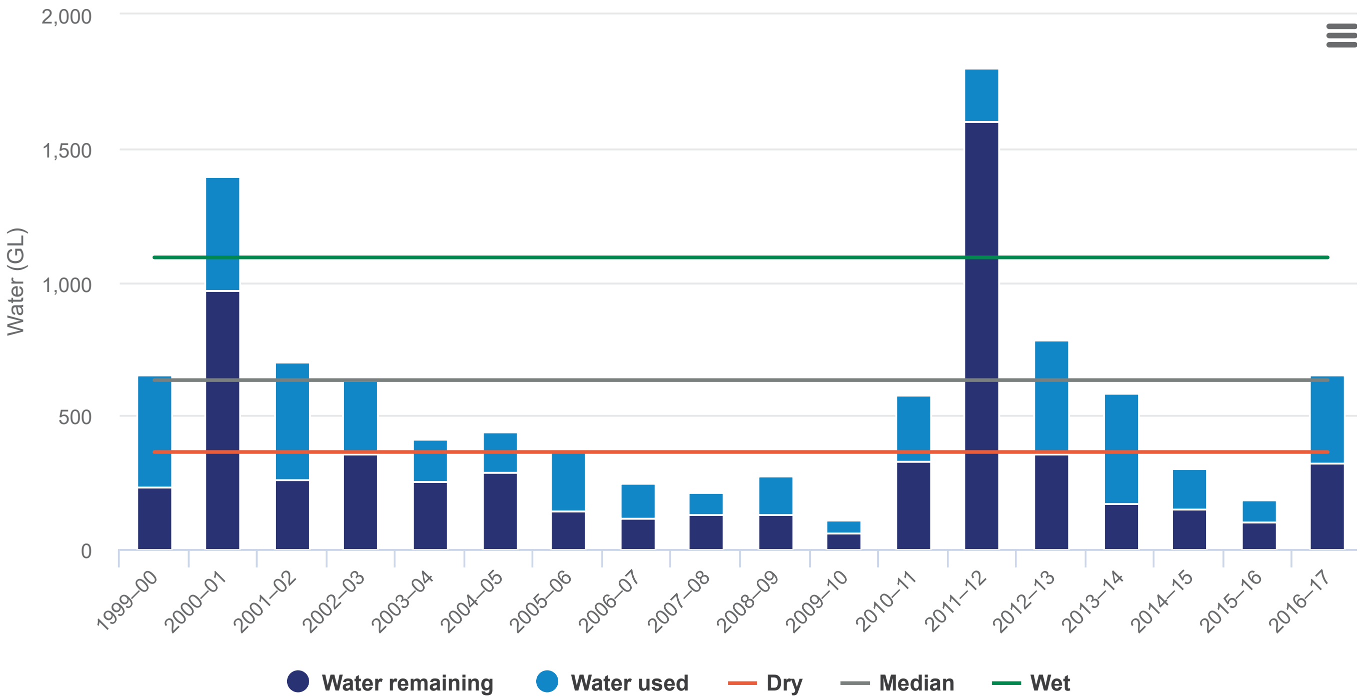
Source:
DoI Water data 2018

Water remaining in-stream

Figure 16.2 shows water extracted from each of five major NSW inland regulated river valleys (in terms of gigalitre quantity extracted, and as a proportion of the total available). It also shows estimates of water remaining in-stream for the environment. In wetter years (2010–11, 2011–12 and 2016–17), the graphs show how a higher percentage of water is typically retained in river systems (and available to the environment) than in drier years.

Environmental flows are protected under water sharing plans, which include rules for low flows. However, as **Figure 16.2** shows, in median and dry years the relative proportion of available water used for consumptive purposes increases, even when actual water volume decreases. Under the Basin Plan, water recovery for the environment is likely to reduce this trend and produce closer to 50% of river flow for the environment in dry years in most inland regulated river valleys.

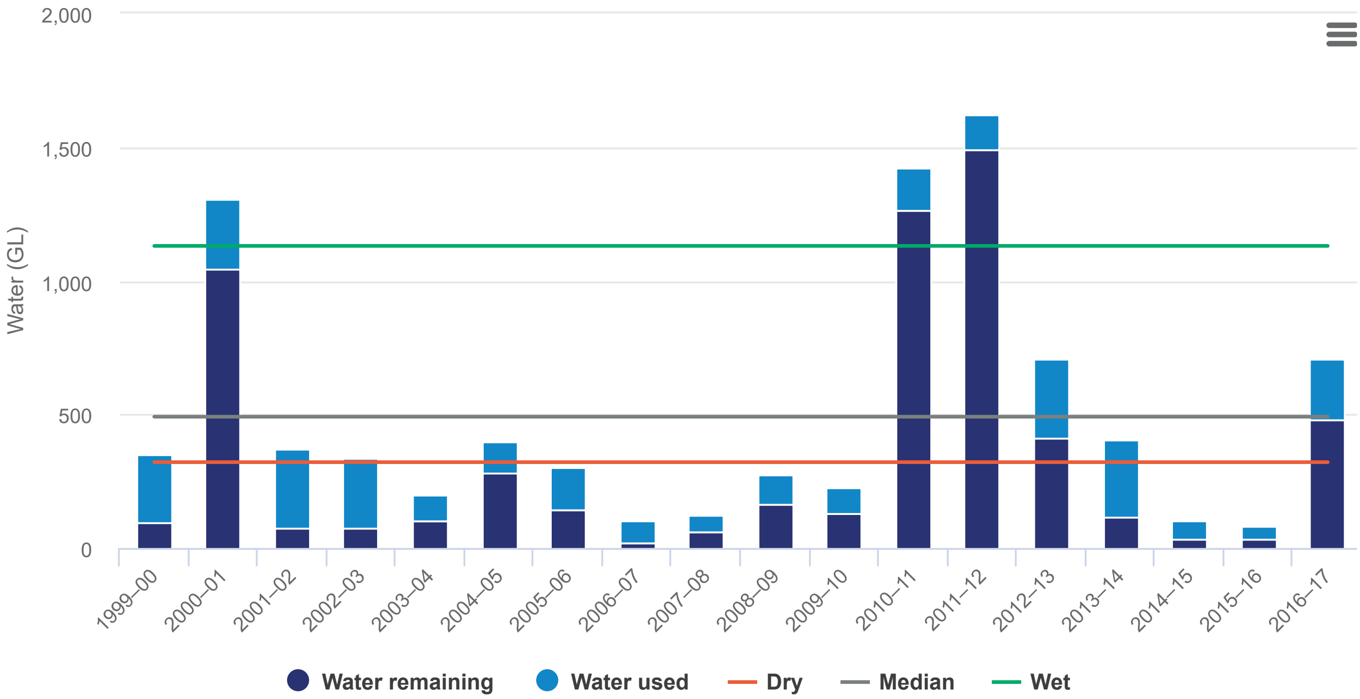
Figure 16.2a: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2016–17: Gwydir



Notes:
Some 'water remaining' is lost to evaporation, seepage and other transmission losses. While in the system, this water has some benefit to the environment, depending on the duration, volume and timing of its flow.
Water use figures are licensed account usage, including general security, high security, conveyance, water utilities, domestic and stock, and supplementary access. These use estimates include licensed water use for both consumptive and environmental purposes. Floodplain harvesting, which is not yet licensed and not included, further reduces the volume of water remaining in the charts. Diversions include licensed environmental water use as well.
The data for each valley represents total water available and is taken from a representative gauging station downstream of major tributary inflows and upstream of major extractions.
Total flow and observed diversions in the Murrumbidgee Valley are influenced by water released from the Snowy Mountains Scheme. In percentage terms the influence is greatest in dry years. Development in the valley reflects this inter-valley transfer.
Wet, median and dry flow levels are sourced from long-term (120-year) hydrological modelling of conditions for water sharing plans.
A dry year is based on the 80th percentile flow, that is in 80 years out of 100, flows will exceed this value. The median year is based on the 50th percentile flow, and a wet year uses the 20th percentile flow.

Source:
DoI Water 2018

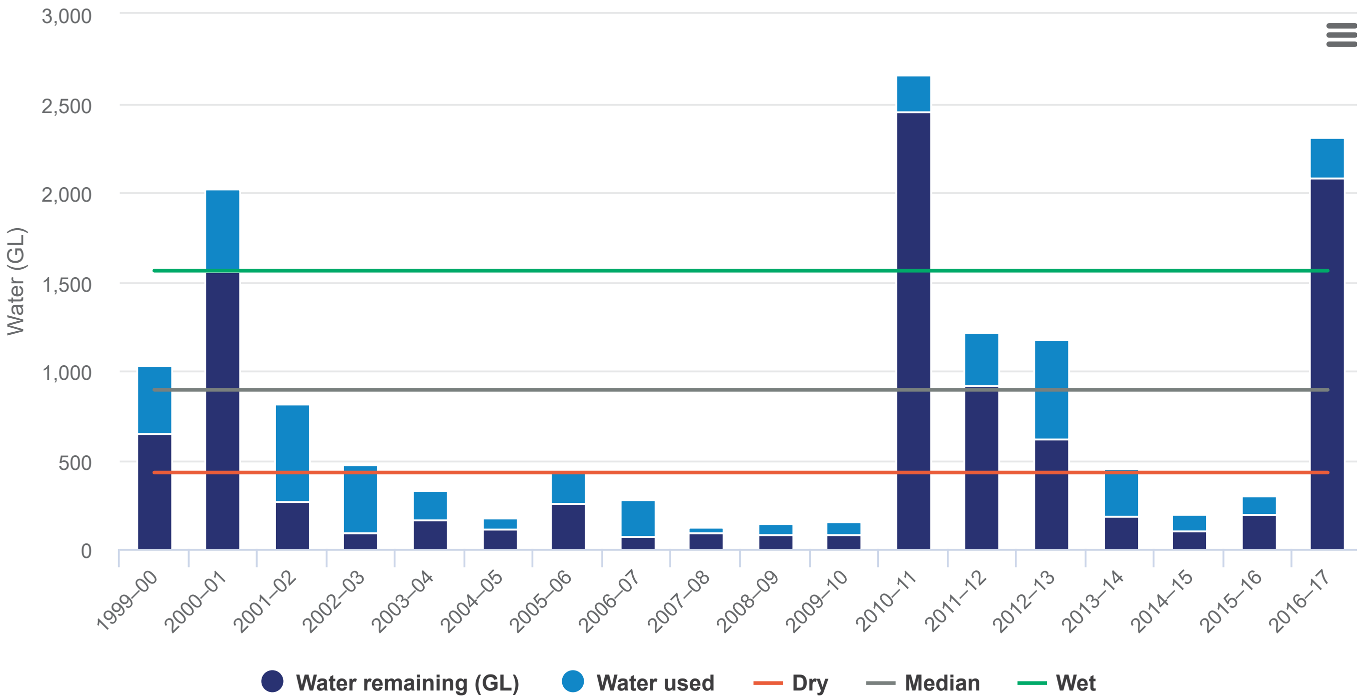
Figure 16.2b: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2016–17: NAMOI



Notes:
See the notes for Figure 16.2a

Source:
DoI Water 2018

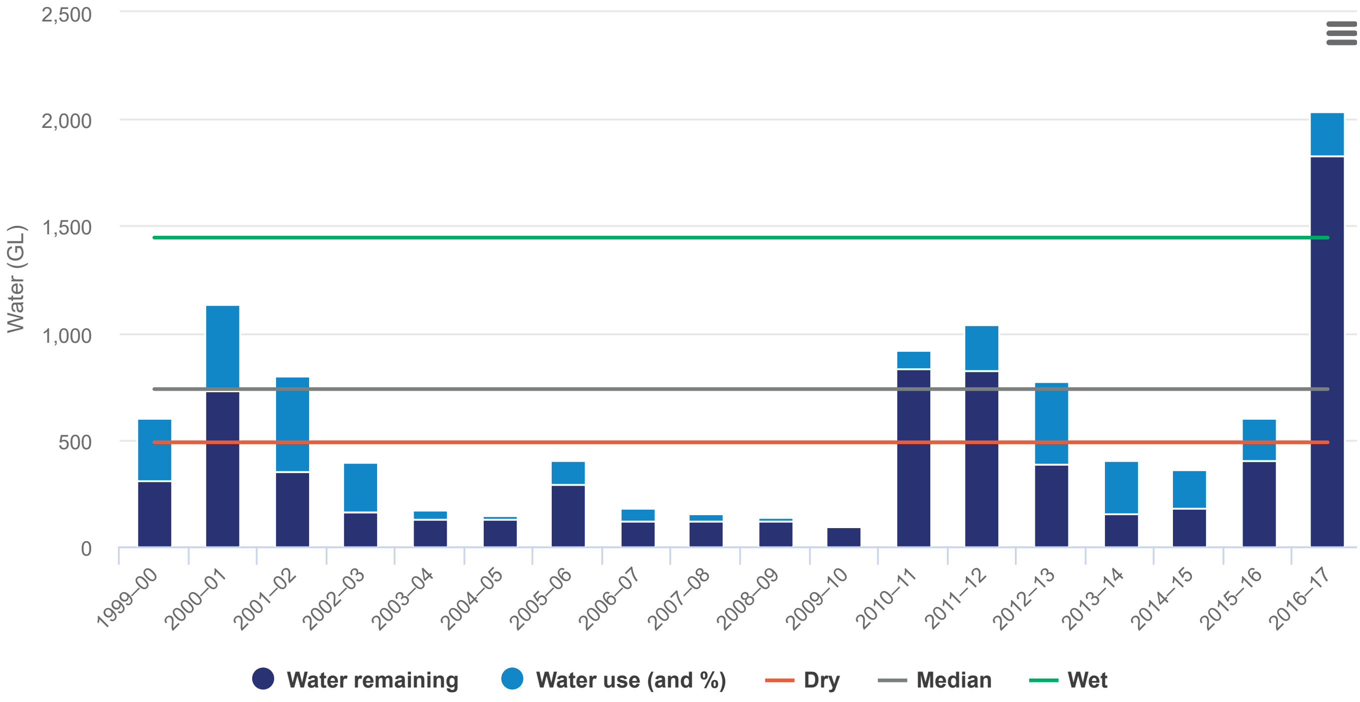
Figure 16.2c: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2016–17: MACQUARIE



Notes:
See the notes for Figure 16.2a

Source:
DoI Water 2018

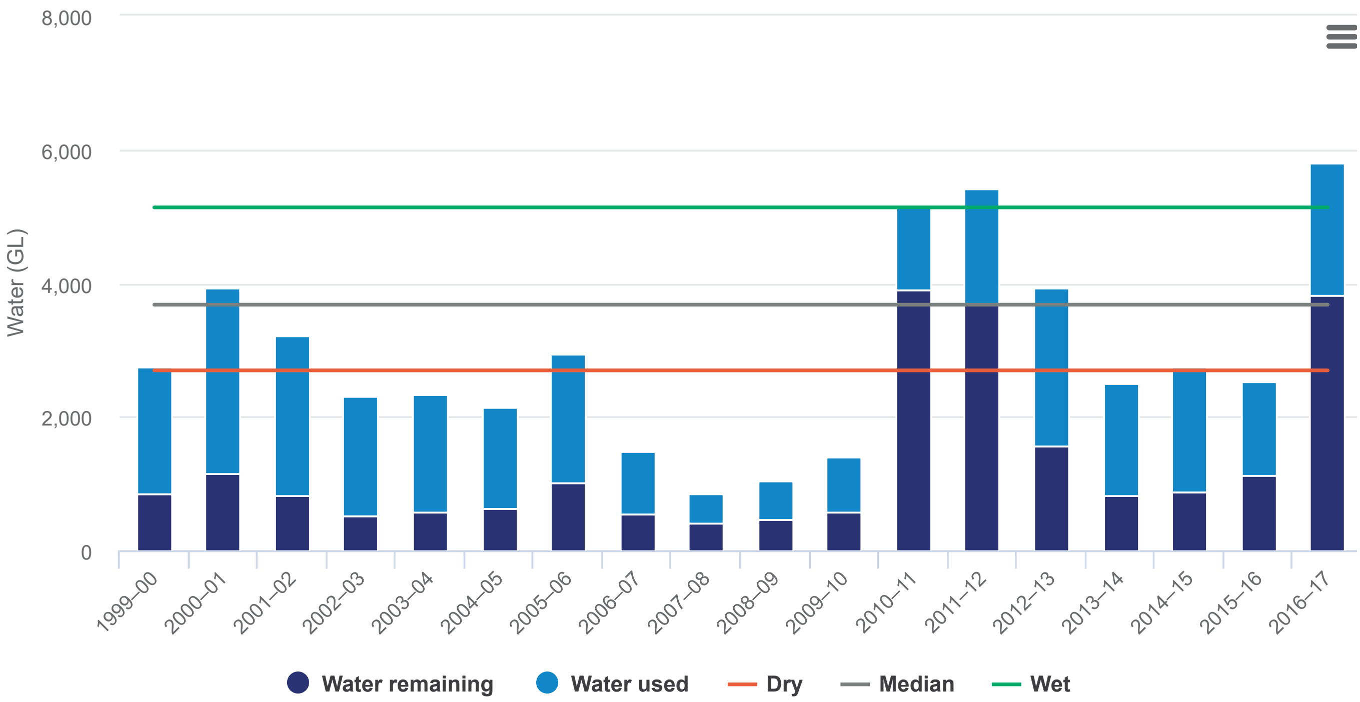
Figure 16.2d: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2016–17: LACHLAN



Notes:
See the notes for Figure 16.2a

Source:
DoI Water 2018

Figure 16.2e: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2016–17: MURRUMBIDGEE



Notes:
See the notes for Figure 16.2a

Source:
DoI Water 2018

Environmental water

Environmental water

To offset the impact of water extraction and structures that regulate river flows, and to maintain the health of natural systems and water sources, a share of the water resource is set aside for environmental purposes. The *Water Management Act 2000* recognises and provides for two types of environmental water in water sharing plans for NSW's regulated rivers:

- planned environmental water
- licensed (or held) environmental water.

Planned environmental water is committed to the environment through rules in water sharing plans. The plans limit overall water extraction to ensure an agreed amount of water remains in the water source. The plans also apply specific environmental flow rules.

Planned environmental water rules are either:

- fixed rules that prescribe 'automatic' actions to release water from storage, such as transparent and translucent releases, and limits on extraction
- discretionary rules that set aside water into environmental water allowances, based on specified trigger conditions.

Environmental water managers can actively manage discretionary water by ordering releases from environmental water allowances. This gives managers the flexibility to determine when and how watering actions should occur, so they can optimise environmental outcomes.

In unregulated rivers, water sharing plans generally rely on rules that limit extraction of river flows to protect a share of water for the environment. In most cases, such rules set out an annual extraction limit and a low-flow cease-to-pump level. This threshold is intended to minimise impacts during low flows and protect water for basic ecosystem health and riparian water uses.

Licensed (or held) environmental water is committed to the environment through water access licences. Corresponding to 'held water' under Commonwealth legislation, it is often called held environmental water. It is generally purchased through entitlements of willing sellers or created through water savings. In the latter case, investment in projects or measures is used to yield more efficient water use, which can be converted into an equivalent licensed entitlement. Licensed environmental water is actively managed to achieve specific environmental outcomes. Often it is aggregated and used along with planned environmental water to make large-scale releases of water to the environment.

Environmental water holdings

Water recovery programs funded by the Commonwealth and NSW governments have purchased or recovered water for NSW's environment. This licensed water contributes to the total environmental water holdings. The cumulative total for all NSW licensed environmental water is about 2,412,000ML for regulated rivers and about 70,000ML in unregulated rivers, 2,482,000ML in total.

Table 16.1 summarises the collective amount of water held by NSW from water recovery programs for seven river valleys or programs. **Table 16.2** describes water holdings acquired by the Commonwealth Government for 11 river valleys in NSW.

Table 16.1: Cumulative holdings of held environmental water recovered by the NSW Government to 30 June 2018 by valley or program (ML entitlement)

Valley/Program	Regulated River Licence Categories	Total Regulated	Unregulated River

	High security	General security	Supplementary allocation	River	
Barwon-Darling	-	-	-	-	2,166
Gwydir	1,249	17,092	3,141	21,482	-
Lachlan	1,795	36,569	-	38,364	-
Macquarie	-	48,419	1,451	49,870	2,916
Murray and Lower Darling	2,027	30,000	-	32,027	-
Murrumbidgee	-	28,508	153,767	182,274	6,162
The Living Murray	5,623.5	187,938	350,000	543,561.5	12,965
Total	**10,694.5**	**348,526**	**508,359**	**867,578.5**	**24,209**

Notes:
Note 1: Conveyance licence holdings for Murray and Murrumbidgee have been included in the general security totals. Murrumbidgee 'supplementary allocation' includes supplementary water (Lowbidgee) entitlement.
Note 2: The Living Murray holdings are part of a multi-jurisdictional program with licences held in the Murray, Murrumbidgee and Lower Darling rivers across a range of entitlement types.

Source:
DoI Water data 2018

Table 16.2: Cumulative holdings of environmental water recovered by the Commonwealth Government by valley as of 31 May 2018 (ML entitlement)

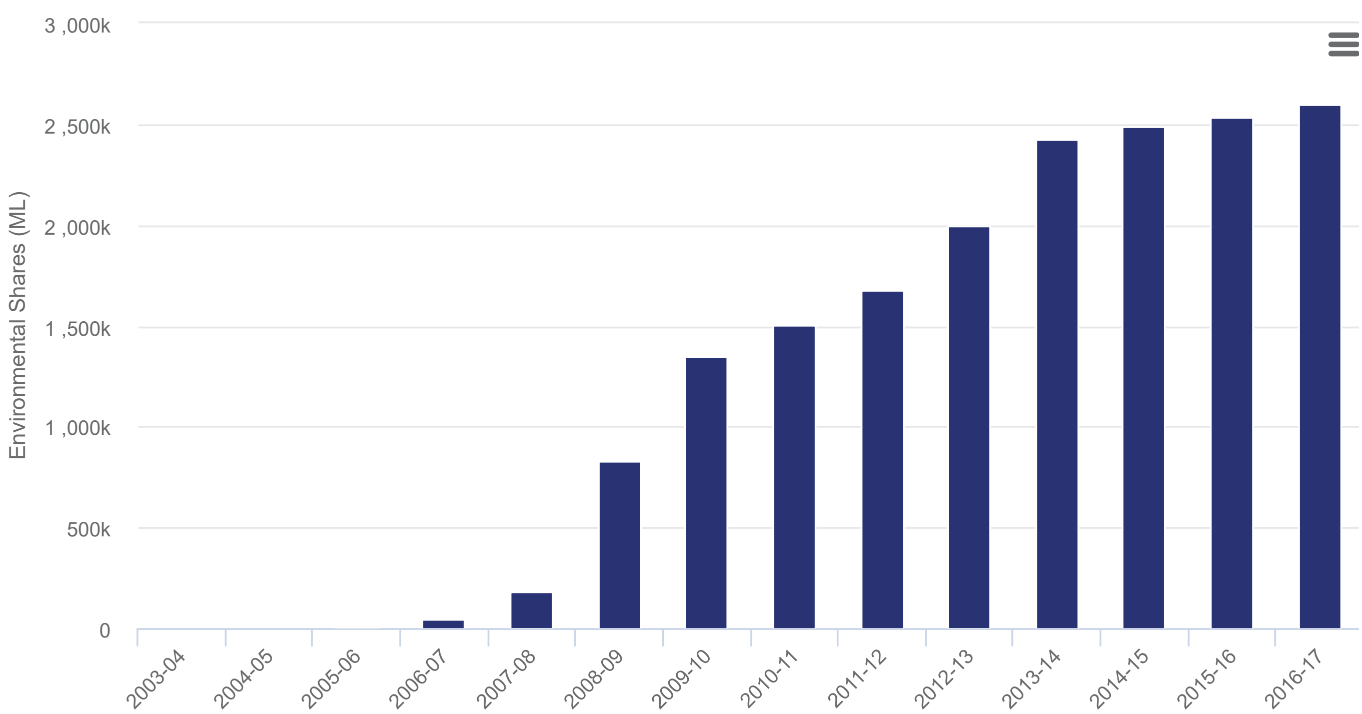
Valley	Regulated River Licence Categories			Total Regulated River	Unregulated River
	High security	General security	Supplementary allocation		
Barwon-Darling	-	-	-	-	28,004
Border Rivers	-	2,598	1,437	4,035	-
Gwydir	4,508	89,525	20,451	114,484	-
Lachlan	933	86,923	-	87,856	-
Lower Darling	3,075	21,564	-	24,639	-
Macquarie/Cudgegon g	-	126,224	8,292	134,516	-
Murray	17,858	400,500	211	418,569	184
Murrumbidgee	10,199	322,753	21,986	354,938	164
Murrumbidgee (Lowbidgee)	-	-	393,117	393,117	
Namoi (Upper) and Peel	-	12,404	-	1,257	11,147
Warrego	-	-	-	-	17,826
Total	**36,573**	**1,062,491**	**445,494**	**1,544,558**	**46,178**

Notes:
Conveyance licence holdings for Murray and Murrumbidgee are included in the general security totals.

Source:
Environmental water holdings, Australian Government Department (as at 11 July 2018), DoI Water data 2018

Figure 16.3 shows the growing volume of NSW environmental water shares. This growth is due to water licence purchases and the creation of new entitlements through water savings infrastructure projects.

Figure 16.3: Environmental water shares in NSW



Source:
Environmental water holdings, Australian Government Department (as at 11 July 2018), DoI Water data 2018; OEH data 2018

Environmental water delivery

The amount of water available for release into the environment depends on annual allocations available for the different types of entitlement. Managers allocate the water according to the priority of these entitlements, while also considering seasonal water availability.

For supplementary flows and unregulated licences, full water allocation is made at the start of each year. However, this water can only be physically diverted if rivers have sufficient flow to allow access to the environments intended. In that sense access is weather-dependent – opportunistic and not guaranteed.

Table 16.3 shows how volumes of water released from storages of different regulated river valleys in inland NSW rose between 2014–15 and 2016–17. These numbers are for releases made through specific environmental allowances, or as a result of licensed environmental water. They do not include water made available to the environment through fixed rules in water sharing plans, such as prescribed end-of-system flows or transparent and translucent releases from storages.

The Snowy Water Initiative has further increased environmental flows each year to the Murray and Snowy rivers. This initiative aims to return 70GL to the Murray; and about 212GL to the Snowy River, or 21% of its long-term average annual flows (that is the level of flow prior to the Snowy Mountains Scheme). The initiative successfully released 148GL into the Snowy River in 2014–15, 142GL in 2015–16, 125GL in 2016–17, and 212GL in 2017–18. The 2017–18 water year was the first time the initiative reached its recovery target since its inception. More information.

Table 16.3: Environmental water delivered in inland rivers of NSW, 2014–15 to 2016–17 (ML)

Water source	2014–15		2015–16		2016–17	
	EWA	HEW	EWA	HEW	EWA	HEW
Border Rivers	-	-	5,940	-	-	-
Gwydir	29,895	56,639	4,750	8,500	21,000	25,847

Lachlan	-	6,471	-	48,114	20,084	35,742
Macquarie	17,745	16,037	36,393	18,661	26,373	62,778
Murrumbidgee	73,068	222,756	103,613	124,282	158,592	371,792
Murray and Lower Darling	5,751	78,022	5,754	200,194	84,032	599,363
Namoi-Peel	-	-	-	-	4,933	9,109
Subtotal	126,459	379,925	156,450	399,751	315,014	1,104,631
Total environmental water	**506,384**		**556,201**		**1,419,645**	

Notes:
Excludes environmental water under water sharing plan fixed rules, such as end-of-system targets or automatic transparent and translucent releases.
EWAs: environmental water allowances.
HEW: held environmental water.

Source:
DoI Water data 2018

Through active management, about 556,000ML of environmental water was delivered to environmental assets in inland NSW valleys during 2015–16. The end of the 2016–17 water year marked the largest delivery year for the NSW Environmental Water Holder, the NSW Office of Environment and Heritage: a total of 54 deliveries of water for the environment. Together, the State, Commonwealth and The Living Murray accounts delivered a total of 1,420,000ML to the environment in 2016–17, with a range of ecological benefits.

In 2016–17, the NSW Office of Environment and Heritage managed delivery of more than 680,000ML of water in the Murray and Lower Darling catchments alone. These strategic environmental flows made it possible for native fish, including golden perch and Murray cod, to move from the Barwon-Darling and Menindee Lakes system into the Murray River. Subsequent releases across the Southern-connected Basin attracted native fish from the lower into the central Murray River system.

In 2016–17, a record 530,000ML was delivered to rivers and wetlands in the Murrumbidgee catchment. These environmental flows supplemented natural flooding, improved habitat and supported breeding of native birds, fish and frogs. One site recorded 6,000 pelican nests.

See the Wetlands topic.

Pressures

Drought

Because droughts are a natural feature of Australia’s climate, aquatic ecosystems are adapted to periods of dryness. However, extensive or prolonged drought can have major repercussions for all water users and the environment.

Water extraction

When water extraction levels are high relative to total river flow, and of extended duration, river health is stressed. Before the Murray-Darling Basin Plan commenced, the total volume of water extracted from the basin's rivers had affected aquatic ecosystem health.

The *Water Act 2007 (Cwth)* provided for the Basin Plan, with its strategy to restore water diversion to within sustainable levels and safeguard the long-term health of rivers and water-dependent ecosystems. The Basin Plan requires a long-term average annual volume of 2,750GL to be recovered and returned to the environment.

River regulation

Structures to store and regulate water are built to increase security of supply. However, their use can also moderate the natural variability of streamflows. This is because these structures can capture and reduce large natural flows and release stored water during naturally dry periods. By regulating rivers, these structures:

- modify natural river flow regimes
- reduce flow variability
- change the seasonality of flows
- change river morphology.

However, aquatic ecosystems, particularly around inland Australian rivers, are adapted to highly variable flow levels. Aquatic species may even depend on this variability to maintain or complete their life cycles. Changes to natural river flow patterns have, over the longer term, contributed to biodiversity loss and declining health in aquatic ecosystems (NSW OEH 2013).

With a much larger portfolio of environmental water now being actively managed, this water can be used to overcome some of these adverse impacts of river regulation, particularly as scientific knowledge in this area continues to grow.

Climate change

Water management across NSW relies on a picture of long-term water availability based on climate data collected since the late 19^{th} century. There is some confidence these arrangements adequately address near-term climate change risks to water security for economic use and environmental flows. However, to ensure plans are resilient in the medium to long term, further analysis will probably be needed. Challenges include representing the increasing natural variability in water supply more completely and simulating future water availability under a range of potential climate change scenarios.

Approaches to incorporate climate change risk are being developed. These use a decision framework that:

- better accommodates increased natural variability
- incorporates changes and outcomes for which there is confidence
- assesses the resilience of existing planning arrangements to such potential changes
- tests alternative arrangements to improve water-related outcomes.

Water pollution

Water quality affects its suitability for human use and the health of aquatic ecosystems. A river catchment's vegetation cover and land management practices significantly affect its water quality. Local, naturally occurring features, such as saltwater intrusion, also play a part. The River Health topic covers river water quality, the effects of catchment disturbance, and diffuse runoff from agricultural activities and urban expansion.

Responses

Legislation and policies

Legislative and policy changes, along with a range of intergovernmental agreements, have made significant progress to enhance the settings for water management in NSW.

Water Reform Action Plan

In December 2017, the NSW Government announced the Water Reform Action Plan. This plan is a response to recommendations by compliance reviews, including those of the Matthews Investigation, the Murray-Darling Basin Water Compliance Review and the NSW Ombudsman. The plan's ambitious water reform program aims to improve compliance and enforcement, increase transparency of water use, and bring about better environmental water management in NSW.

In April 2018, a new independent regulator commenced oversight of the compliance and enforcement of NSW's water law. Called the Natural Resources Access Regulator (NRAR), it aims to act independently as a firm but fair regulator to improve public confidence in water compliance and enforcement. To strengthen joint compliance in the Murray-Darling Basin, NRAR has signed a memorandum of understanding on compliance cooperation with the Murray-Darling Basin Authority.

Other progress under the Water Reform Action Plan includes new policy positions designed to implement the changes required under the plan. The NSW Government is finalising these draft policies, which include a more robust metering network, increased transparency in water management and better management of environmental water, especially in the northern Murray-Darling Basin.

In March and April 2018, road shows throughout key regional areas ensured communities could comment and have input into this water reform policy development. More actions under the Water Reform Action Plan will continue during 2019.

The Water Management Amendment Bill

The recently passed *Water Management Amendment Bill 2018* amends the *Water Management Act 2000* to ensure it complies with the *Water Act 2007 (Cwth)* and the Murray-Darling Basin Plan.

National Water Initiative

The National Water Initiative (NWI) commits NSW to sustainable use of its water resources. To achieve environmental outcomes, it facilitates expanded trade in water resources to promote the highest-value water uses and the most cost-effective and flexible mechanisms of water recovery.

After the National Water Commission was abolished in June 2015, the Productivity Commission assumed the role of tracking progress towards NWI objectives; this includes an evaluation every three years. The most recent evaluation, the National Water Reform Inquiry Report (Productivity Commission 2017a, 2017b) found generally good progress on NWI implementation. The Productivity Commission reported that water reforms have delivered substantial benefits to water users and the broader community. It also provided recommendations on further work and reform priorities.

Murray-Darling Basin Plan

A fundamental role of the Murray-Darling Basin Authority is to oversee implementation of the Basin Plan, scheduled for completion in 2024. This plan is a Commonwealth legislative instrument that sets sustainable diversion limits (SDLs) for both surface and groundwater use in the Murray-Darling Basin, with a target to recover an additional 2,750GL of water to return to the environment. The Commonwealth has committed to bridge the gap to the lower SDLs required by the Basin Plan target by investing in water recovery; these lower SDLs must be met by 2019.

A water recovery program has commenced across the basin, including buy-backs and water savings initiatives. So far, more than 2,100GL of water (about 75% of the 2,750GL target) has been recovered. NSW’s share of this target is 1,312GL, of which 950GL has been recovered.

As part of the Basin Plan’s mechanism to adjust SDLs, the Commonwealth Government has approved a package of projects, developed by NSW, to deliver environmental outcomes using less water.

Floodplain Harvesting Policy

In floodplain harvesting, water flowing across floodplains is collected or diverted. Floodplain harvesting works and water extractions fall under the scope of the *Water Management Act 2000*. However, historically these diversions have not been considered extractions because they are yet to be licensed.

The NSW Government's Floodplain Harvesting Policy, introduced in 2013, signalled important reform in floodplain water management. The policy provides a framework to license and actively manage floodplain harvesting extractions within the long-term average annual extraction limits of water sharing plans. The policy applies across NSW. Work to implement it, as part of the broader NSW healthy floodplains project, is well underway in the five northern valleys where floodplain harvesting is most prevalent:

- Border Rivers
- Gwydir
- Namoi
- Barwon–Darling
- Macquarie.

Planning assumptions

In 2015, State and Commonwealth ministers from the Murray-Darling Basin initiated a process to set out the key planning assumptions they will use to develop their water resource plans under the Basin Plan. In early 2018, NSW and the Murray-Darling Basin Authority agreed on a range of planning assumptions to underpin NSW water resource plans.

Managers use these planning assumptions when they determine how much water to divert under water resource plans. The assumptions inform assessments of whether such plans comply with SDLs, and therefore comply with the Basin Plan.

Extreme events policy

Extreme events with particular relevance for water management are times of severe water shortage (drought), or times when the quality of available water renders it unfit for use. NSW has developed a new policy to manage water during extreme events. The policy’s principles and processes apply in the lead-up to or during an extreme event. They are underpinned by incident response guides for each water source. These propose a suite of management options to give effect to access priorities in the Water Management Act and the Murray-Darling Basin Plan. This policy does not extend to flood management, which falls under separate policy and regulatory frameworks.

Plantations policy

NSW is developing a new policy to manage interception of water by forestry plantations. At their current levels of development and growth, forestry plantations pose negligible risk to water sources. However, the policy includes a process to establish formal growth triggers, at which stage water managers would need to intervene. The policy outlines work to scope the legislative amendments required, and how to bring forestry plantations within the NSW water licensing system should thresholds of growth be exceeded.

Water trading

Water markets help to ensure scarce water resources are efficiently re-distributed. Markets have proven crucial in times of shortage when there is not enough water for all farms to produce a viable crop. With trade, some farmers can buy sufficient water for their crop, while others receive cash flows to support their economic survival.

Water markets also provide incentives to use this resource efficiently; they tend to shift water use towards activities with higher economic returns. Water markets allow users, including environmental water managers, to flexibly adapt to changing conditions and manage risk, making these markets an important management tool.

The *Water Management Act 2000* and water sharing plans enable water trading. The plans establish rules to ensure efficient trade can occur, while also protecting the environment and avoiding impacts to non-trading water users (third-party impacts). Trade has grown substantially from modest levels in 2004 when most water sharing plans were enacted, to annual peaks of over 100GL of (permanent) entitlement trade and several hundred gigalitres of (temporary) allocation trade.

Programs

Water sharing plans

Water sharing plans significantly improve water resource management in NSW. They can apply to rivers, groundwater or a combination of water sources (see the Groundwater topic). As statutory plans, they provide a legislative basis to share water between the environment and extractive users. Over their 10-year lifespan, they bring certainty to both the environment and water users. They also provide the basis for trading water licences and water allocations.

These plans aim to:

- protect the fundamental health of the water source
- ensure sustainable use of the water source over the longer term
- provide water users with long-term certainty about access rules.

Extraction limits in water sharing plans ensure a proportion of the water available is protected for the health of the water source. Explicit environmental flow rules also ensure environmental outcomes are delivered.

Since 2004, water sharing plans have been progressively implemented across NSW. By the end of 2018, a total of 58 plans had commenced, covering all water used in the State.

Floodplain management plans

Prepared under the *Water Management Act 2000,* floodplain management plans help implement the NSW healthy floodplains project. They provide a whole-of-valley framework to assess and determine flood work applications.

The Department of Industry partners with the Office of Environment and Heritage to prepare these plans. Gwydir and Barwon-Darling floodplain management plans are now complete; Upper Namoi, Lower Namoi, Border Rivers and Macquarie valley floodplain management plans are being prepared.

As statutory plans, they must address risks to life and property from flooding. Some features on floodplains with ecological and cultural significance depend on flooding. These plans must also provide connectivity to and from these flood-dependent assets on the floodplain.

Twenty local floodplain management plans already in force were prepared under the *Water Act 1912 (NSW)* and *Water Management Act 2000*. These local plans will be superseded by the whole-of valley plans in the Gwydir, Barwon-Darling, Upper Namoi, Lower Namoi, Border Rivers and Macquarie valleys prepared under the NSW healthy floodplains project.

Environmental water recovery

NSW and the Commonwealth programs have recovered substantial volumes of water for the environment. The Commonwealth will continue this recovery to achieve the Basin Plan's sustainable diversion limits. The Basin Plan's initial water recovery target is a long-term average of 2,750GL per year. As at 31 May 2018 the Commonwealth Environmental Water Office held 2,697GL of entitlement across the basin; expressed as a long-term average, this amounts to 1,852GL of the 2,750GL target (Commonwealth Government 2018), or around 67% of the target.

Future opportunities

Water resource plans

The Murray–Darling Basin covers almost all of inland NSW and the Basin Plan requires the development of water resource plans for both surface water and groundwater sources. NSW is responsible for 20 of the 33 water resource plans required across the entire Basin. NSW continues to invest substantial effort in this water planning, working collaboratively with the Murray-Darling Basin Authority.

Each plan will have:

- the relevant state water sharing plan
- a long-term environmental water plan
- a risk assessment
- a water quality management plan
- an incident response guide to deal with periods of drought and poor water quality.

The water resource plans will also demonstrate how to assess and maintain compliance with the sustainable diversion limit, as prescribed in the Basin Plan. The plans will take into account Aboriginal people's water-dependent cultural values and uses.

Those developing water resource plans have consulted extensively with a range of stakeholders, including nation-by-nation consultation with First Nations of inland NSW.

Sustainable diversion limit adjustment mechanism

By 2015 the Commonwealth Government had invested more than $5 billion to achieve 71% of the 2,750GL target for environmental water recovery required under the Murray-Darling Basin Plan. Just under half of this spend was for purchasing water licences; the remainder was spent on more efficient infrastructure projects.

Remaining Commonwealth Government investment will prioritise more efficient infrastructure, to bridge the remaining gap between current water use and the sustainable diversion limits (SDLs) required to meet the target. A mechanism to adjust SDLs aims to ensure all water is used efficiently, to its full effect. This sustainable diversion limit adjustment mechanism achieves this through:

- supply measures – projects that achieve the Basin Plan's environmental outcomes with less water, thereby reducing the volume of water that needs to be recovered
- efficiency measures – projects that increase the efficiency of water delivery systems for irrigation, so more water may be recovered for the environment
- constraints measures – projects that make environmental water delivery more effective in the future.

The Commonwealth Government has approved a package of projects developed by NSW (and other Murray-Darling Basin states), as part of the Basin Plan's sustainable diversion limit adjustment mechanism. These projects are designed to allow NSW to deliver the required environmental outcomes using less water, allowing valuable water to stay in productive use. NSW's work with our communities to design and deliver these projects will continue, including in-depth consultation and detailed environmental assessments.

Northern Basin Review

The Northern Basin Review is an integral part of the Murray-Darling Basin Plan. This two-year review entailed wide-ranging stakeholder engagement to ensure all perspectives were captured and understood. It also included recommendations to implement a range of toolkit measures designed to improve water management and deliver positive outcomes for the environment and communities in northern NSW.

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River Health

Healthy river ecosystems, comprising rivers, their riparian zones, floodplains and wetlands, are vital to aquatic and terrestrial biodiversity.

River Health

River Condition Index

38

out of 40 NSW river valleys have a 'moderate' or better rating

Read more

Fish communities

80%

of NSW river valleys are rated 'poor' or worse

Read more

The overall condition of rivers across NSW is rated as moderate. Aquatic ecosystems in the major rivers of the Murray-Darling Basin are generally in poorer condition than those in coastal rivers.

The major inland river systems are affected by the ongoing impacts of water extraction, altered river flows, and catchment changes such as vegetation clearing. Generally, the greatest signs of ecosystem stress occur where flow regimes have changed most.

Most coastal rivers are less affected than inland rivers by water extraction and flow regulation. With the exception of their fish communities, coastal rivers are generally in better ecological health.

Fish communities are in poor condition across the state but are improving within the Murray-Darling Basin. The widespread distribution of introduced carp in the Murray-Darling Basin has had a significant impact on the health of fish communities.

Exceedances of water quality standards for the nutrients phosphorus and nitrogen increased slightly during the period 2015–17. The increase is mainly due to the effects of flooding in some inland catchments in 2016. Salinity is relatively stable in most streams surveyed.

Water management initiatives aim to balance human uses of water with environmental water, to maximise the outcomes for river and wetland health. Fifty-eight water sharing plans have been finalised for all water sources in NSW.

In the Murray-Darling Basin, these plans will underpin the development of nine surface water resource plans by 2019, which will detail rules for planned environmental water and 11 groundwater plans.

Related topics: Threatened Species | Invasive Species | Water Resources

NSW Indicators

Indicator and status		Environmental trend	Information reliability
River Condition Index for NSW rivers	MODERATE	Stable	✓
Health of fish assemblages	POOR	Getting better	✓✓
Salinity	GOOD	Stable	✓✓
Nitrogen and phosphorus levels	MODERATE	Stable	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

NSW has approximately 58,000 kilometres (km) of rivers and major streams. They can be categorised as:

- short, high-gradient coastal streams
- long, low-gradient inland rivers.

About 97% of river length in NSW has been substantially modified (NLWRA 2002). Yet healthy river ecosystems, comprising rivers, their riparian zones, floodplains and wetlands, are vital to aquatic and terrestrial biodiversity.

Healthy rivers are also critical for the ecosystem services needed to maintain good water quality and supply. Rivers are vital to support economic growth and enable human activities, including agriculture, aquaculture, fishing, recreation and tourism.

Rivers and aquatic ecosystems are under pressure from:

- regulation of river flows
- extraction of water from rivers
- clearing of riverside vegetation
- diffuse source water pollution, including agricultural runoff and urban stormwater
- sedimentation from runoff and the erosion of land and river banks

- introduction and expansion of exotic species.

A primary objective of river management is to achieve a long-term balance: preserve the integrity of natural systems but also provide for a range of beneficial human uses.

Status and Trends

Ecosystem health

The River Condition Index (RCI), developed in 2012, replaces the Sustainable Rivers Audit (SRA). The SRA was used in earlier State of the Environment Reports, and to consistently assess rivers within the Murray-Darling Basin across states.

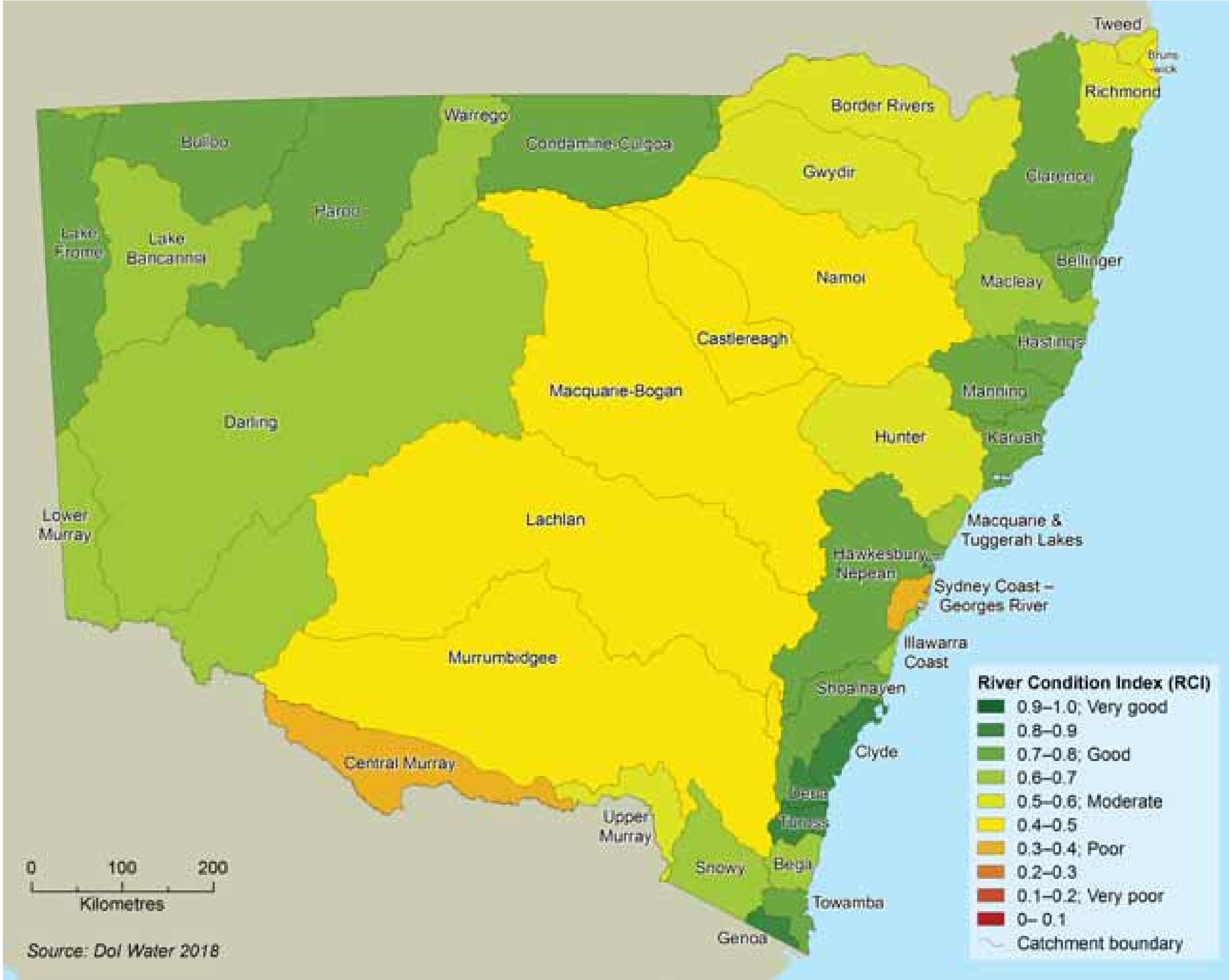
The RCI is a simpler, more readily-available assessment of river condition in NSW. Applicable to all rivers in NSW, the RCI's five component indexes are:

- riparian vegetation cover
- hydrological stress
- biodiversity condition
- geomorphic condition
- catchment disturbance.

The RCI technical manual (Healey et al. 2012) details how the index is determined, its data inputs and its relationship to the SRA's more comprehensive approach. Spatially, the RCI covers all of NSW. However, not all river systems have data for all RCI indexes. In some cases, the RCI draws on data from the SRA.

Map 17.1 shows the RCI values for NSW river catchments. Overall, the RCI rates the condition of NSW rivers health as moderate. Murray-Darling Basin rivers are generally in poorer condition than Eyre Basin or coastal NSW rivers; far south coast rivers are healthiest.

Map 17.1: RCI index value for NSW catchments



Source:
NSW DoI - Water 2018

Fish

Fish community data for 2015–17 is available for significant parts of NSW, including 800 Murray-Darling Basin locations and some northern coastal rivers. This latest data is reported separately here because the RCI determination draws on earlier SRA data on fish condition and macroinvertebrates. No new data is available for macroinvertebrates (larger invertebrates such as shrimp, crayfish or snails).

Health of fish communities in the Murray-Darling Basin improved slightly in the three years since 2012-14, based on scores from a fish condition index that uses three indicator measures:

- **Expectedness** is the proportion of fish species collected at a site compared to the species that would be expected to occur there prior to 1788 (Muschal et al. 2010; Davies et al 2012). Scores on this indicator improved moderately across all valleys over the last three years, from an average of 33 (very poor) to 46 (poor). The main improvements were in Warrego, Paroo, Lachlan and Murrumbidgee river valleys.
- **Recruitment** of native fish, the number of surviving young added to the population, stayed relatively stable over the last three years; scores on this indicator increased slightly from 42 to 44, on average.
- **Nativeness**, the proportion of native species to introduced species, comprises the three metrics of species richness, abundance and biomass (Muschal et al. 2010; Davies et al 2012). Nativeness of fish communities increased across most valleys analysed, from 39 (very poor) to 46 (poor). This reflects moderate progress since the widespread recruitment of common carp during 2012–14.

Table 17.1 provides composite fish condition index values for each of 15 Murray-Darling Basin river valleys. In most, the overall condition of freshwater fish communities improved in the last three years. In eight valleys, it improved by one condition category, and in five valleys it remained the same. However, in two valleys (the Border Rivers and the Bogan River) it declined.

Nevertheless, the Paroo was the only river where fish condition was rated as good. Lower Murray River and Darling River fish communities were in moderate condition, but in five other rivers they were poor, in four rivers they were very poor, and three rivers extremely poor condition. Those river valleys with fish communities in extremely poor condition were (in declining order of condition) the Condamine-Culgoa, Macquarie and Castlereagh.

Despite some improvement since 2012–14, 80% of the fish communities in NSW's Murray-Darling Basin river valleys still remain in poor or worse condition.

Table 17.1: Changes in fish condition index for NSW Murray–Darling Basin rivers, 2009–11 to 2015–17

Valley	2009–2011	2012–2014	2015-17
Border Rivers	Moderate	n/a	Poor
Condamine-Culgoa	Poor	Extremely poor	Extremely poor
Warrego River	Very poor	Very poor	Poor
Paroo River	Moderate	Moderate	Good
Gwydir River	Poor	Poor	Poor
Namoi River	Very poor	Poor	Poor
Castlereagh River	Very poor	Extremely poor	Extremely poor
Bogan River	Very poor	Poor	Very poor
Macquarie River	Very poor	Extremely poor	Extremely poor
Darling River	Poor	n/a	Moderate
Lachlan River	Extremely poor	Extremely poor	Very poor
Murrumbidgee River	Extremely poor	Extremely poor	Very poor
Upper Murray River	Extremely poor	n/a	Very poor
Central Murray River	Very poor	n/a	Poor
Lower Murray River	Poor	n/a	Moderate

Source:
DPI - Fisheries data 2018

Three indicator measures make up the score for the overall fish condition index:

- **Expectedness** is the proportion of fish species collected at a site compared to the species expected to occur at that site or zone prior to 1788 (Muschal et al. 2010; Davies et al 2012). It has improved moderately across all valleys over the last three years, from an average of 33 (Very poor) to 46 (Poor). This is in part due to improvements in the Warrego, Paroo, Lachlan and Murrumbidgee valleys.
- **Recruitment** of native fish has been largely stable over the last three years, with a slight increase in the average from 42 to 44.
- **Nativeness** is the proportion of native species to introduced species for the three metrics of species richness, abundance and biomass combined (Muschal et al. 2010; Davies et al 2012). This increased across most of the analysed valleys from an average of 39 (Very poor) to 46 (Poor), which is slightly better than that observed prior to the widespread recruitment of common carp observed during the 2012–14 period.

Threatened species and endangered ecological communities

Environmental issues of concern are biodiversity decline and the number of species listed as threatened (see Threatened Species topic). Although they may lack the wider awareness the public has for many land plants and animals that are threatened, numerous aquatic species are also under threat (DPI 2016).

Species threatened with extinction can be listed under the *NSW Fisheries Management Act 1994* as vulnerable, endangered or critically endangered. In the NSW portion of the Murray-Darling Basin, 10 of 29 native freshwater fish species and eight freshwater invertebrates are listed under one of these categories.

As well as species, threatened populations of a given species can also be listed under the Act. Populations of four additional species and four aquatic ecological communities are also listed as endangered. See the Threatened Species topic.

Water quality

Targets

The Murray-Darling Basin Plan 2012 (Schedule 11) sets targets for water quality that must be met to achieve the basin's environmental, social and economic outcomes. Toward these targets, monitoring identifies trends and informs actions to stem water quality decline.

Water quality at inland monitoring stations in NSW is now assessed against these Basin Plan targets. The targets replace values formerly used: default trigger values for slightly disturbed ecosystems listed in the National Water Quality Management Strategy (NWQMS; ANZECC & ARMCANZ 2000).

Nutrient data at coastal sites, however, are still assessed using the National Guidelines for Fresh and Marine Water Quality. Over the long term, regionally-specific water quality targets will be developed for all NSW rivers.

Nutrients

Nutrients, especially nitrogen and phosphorus, can significantly affect water quality when they exceed ecosystem needs. **Map 17.2** shows the percentage of NSW stream water samples with nitrogen and phosphorus concentrations that exceed water quality targets.

Since 2012–14, water quality targets were exceeded in slightly more inland sites than coastal sites. That is, during 2015–2017, in slightly more sites 75% of samples taken exceeded the targets for total nitrogen and total phosphorus; and fewer sites had less than 25% exceedances for these two nutrients. This increase is mainly due to higher water flows during the 2015–17 period; some catchments had major flooding in 2016.

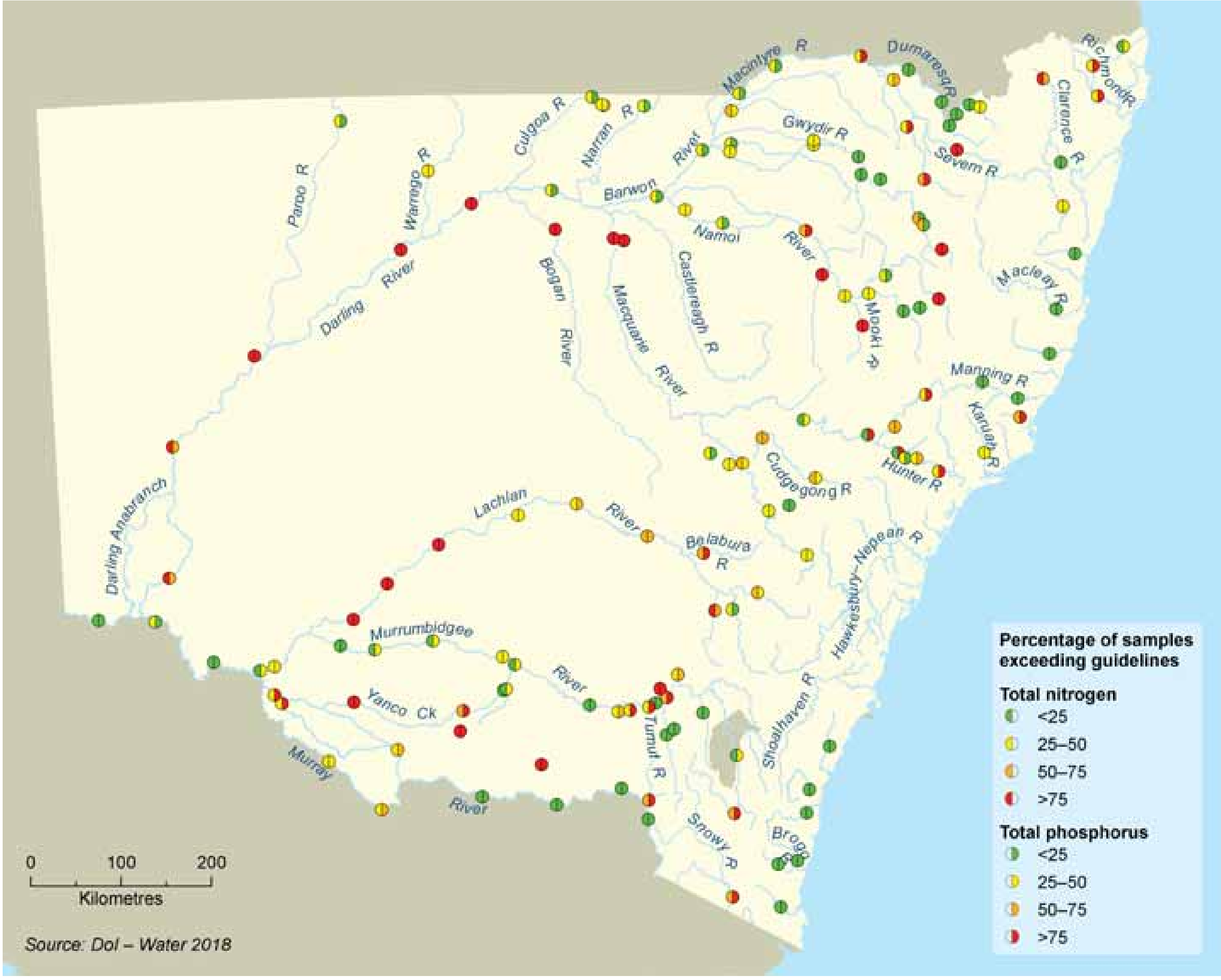
Sites in the Border Rivers, Gwydir and Namoi montane zone all rated poorly for their high total nitrogen and total phosphorus levels. This is largely due to basalt-derived soils which are naturally high in nutrients in the upper reaches of these rivers' catchments. High nutrient levels were also recorded at sites on tributaries draining the Liverpool Plains in the Namoi catchment, the Lower Lachlan River, the lower Macquarie River and Billabong Creek.

Sites in the middle and lower Darling zone also had poor water quality ratings. Due to data deficiencies, the Basin Plan applied more stringent default National Water Quality Management Strategy targets to this zone, which is a priority for developing regionally-specific water quality targets.

On the coast, water quality ratings were generally better, and no sites had greater than 75% exceedances for both total nitrogen and total phosphorus.

Elevated nutrient levels also occur in rivers with catchments affected by urbanisation or used for metropolitan urban water supply, such as parts of the Hawkesbury-Nepean and Shoalhaven river systems (for example Water NSW 2017). These are sourced in runoff from urban and agricultural land and in discharges from sewage treatment plants and can be exacerbated by reduced river flows downstream of major dams (DECCW 2010).

Map 17.2: Exceedance of water quality targets for Total Nitrogen and Total Phosphorus



Source:
DoI - Water 2018

Salinity

The level of salinity in NSW streams is affected by:

- geology
- climate
- the interaction between surface and groundwater
- land use practices.

High salt concentrations can degrade freshwater aquatic ecosystems. Irrigation water with high salt loads can increase soil salinity, degrade soil structure and adversely affect crop health.

Salinity in water is usually measured as electrical conductivity, the ability of dissolved salts to transmit an electric current. Water with electrical conductivity less than 1,000 microsiemens per centimetre (µS/cm) is generally considered safe for irrigation. Electrical conductivity is continuously monitored at many sites in NSW.

Table 17.2 shows average salinity levels for the three-year period 2014–17, and the preceding 10-year period, 2004–2014, at selected mid- and end-of-catchment sites in NSW.

At most measuring points, mean salinity levels are within the World Health Organization (WHO) desirable upper threshold for drinking water, 800µS/cm. Darling River at Wilcannia and Pooncarie, and the Hunter River at Greta are among NSW sites with the highest mean salinity.

Table 17.2 also gives maximum salinity levels measured at each monitoring point during the 2014–17 period. The WHO upper threshold for drinking water was exceeded for short periods at 55% of these locations.

Comparing the two periods (the three- and ten-year averages) shows salinity levels in many streams surveyed are relatively stable, with minor variations. However, salinity levels in the Hunter River at Greta, and the Barwon River at Brewarrina increased somewhat (by more than 110µS/cm); and in the Darling River at Wilcannia and Pooncarie they increased substantially.

The Barwon and Darling river salinity increases likely stem from low river flows, which allowed evaporation to concentrate salts in the area. At the Castlereagh River at Gungalman, where the site was dry for most of the 2014–17 period, the opposite effect was seen: substantially lower electrical conductivity readings.

Table 17.2: Electrical conductivity (µS/cm) in selected NSW rivers (2014–17)

Station Number	Station Name	Daily river salinity levels (µS/cm)		
		Mean *July 2004–June 2014*	*Mean* *July 2014–June 2017*	*Maximum* *July 2014–June 2017*
416012	Macintyre R at Holdfast Crossing	283	301	543
416001	Barwon R at Mungindi*	257	244	457
418058	Mehi R at Bronte*	463	435	1 391
419001	Namoi R at Gunnedah	487	505	1 023
419026	Namoi R at Goangra*	405	404	862
420020	Castlereagh R at Gungalman Bridge*	640	305	592
421127	Macquarie R at Baroona	435	456	850
421012	Macquarie R at Carinda*	574	541	897
421023	Bogan R at Gongolgon*	361	347	786
412004	Lachlan R at Forbes*	493	436	888
412005	Lachlan R at Booligal	573	544	945
410001	Murrumbidgee R at Wagga Wagga	140	148	460
410130	Murrumbidgee R D/S Balranald Weir*	160	166	280
409005	Murray R at Barham	81	85	238
414216	Murray R D/S Mildura Weir	139	144	309
422002	Barwon R at Brewarrina	540	668	3 542
425008	Darling R at Wilcannia*	501	905	6 034
425005	Darling R at Pooncarie	515	1 051	3 040
210002	Hunter R at Muswellbrook	498	446	879
210064	Hunter R at Greta	737	850	1 629

Notes:
* End-of-valley salinity site

Source:
WaterNSW data 2018

Pressures

Water extraction and altered flow regimes

Natural river flows have been modified by:

- water extraction
- dams and other structures.

Water flows in inland NSW and in coastal river systems supplying major metropolitan areas are particularly affected by dams and other structures (see Water Resources topic). Changes to natural river flows, and dampening of their peaks and troughs, affect the critical ecological processes that trigger breeding in birds and fish. These altered flow regimes in rivers are a significant cause of long-term decline in aquatic ecosystems.

River flow regimes also play an important role in creating and maintaining the physical habitat of river channels.

Blockages to fish passage

Many Australian native fish species must access suitable habitat to complete their lifecycles. The *Fisheries Management Act* lists 'installation and operation of instream structures and other mechanisms that alter natural flow regimes and streams' as a key threatening process. These structures:

- disrupt migration of native fish populations
- exclude these fish from large areas of vital breeding and spawning habitat
- restrict their access to food
- limit available shelter for fish, leading to increased predation
- reduce fish population's genetic variability.

A database of all known fish barriers in NSW, compiled by Fisheries NSW, identifies more than 10,000 structures, nearly 5,000 of which are barriers to fish. Among them are more than 2,000 dams, weirs and regulators, the most common type of major barrier. A further 1,800 road crossings and 480 floodgates also impede fish passage (NSW Fish Habitat Partnership 2017).

Infrastructure hazards

Each year irrigators divert a large portion of river water using canals and pumps. Many adult fish are caught in irrigation canals or pumps. If pumping occurs when fish are spawning, this also destroys their eggs and larvae. On the Namoi River some pumping stations remove more than 200 fish daily (Baumgartner et al. 2009). NSW's western-flowing rivers have more than 4,546 pumps greater than 200 millimetres (mm) in size.

In the Murray-Darling Basin, more than 80% of main channel weirs use an undershot (gated) design (Boys et al. 2014) to control water flows. Where undershot weirs are used, fluid shear stress is a common problem that can injure or kill fish. Many fish eggs and larvae die when passing through undershot weirs due to the distortion encountered. Small-scale experiments with golden perch demonstrate high susceptibility to fluid shear stress, with egg mortality rates exceeding 90% (Boys et al. 2014; Baumgartner et al. 2006).

Cold water pollution

When operators discharge water from the bottom of dams, this injects colder water into sensitive downstream ecosystems. This cold water release alters rivers' thermal regimes, sometimes for hundreds of kilometres downstream. Cold water pollution (CWP) affects a range of physiological and biological processes in native fish species, including feeding, spawning, hatching and larval development (Lugg & Copeland 2014).

Nine inland NSW dams cause relatively large and pervasive CWP:

- Blowering
- Burrendong
- Burrinjuck
- Copeton
- Hume
- Keepit
- Khancoban
- Pindari.

CWP is also a medium pressure downstream from some dams supplying major coastal metropolitan areas, including below upper Nepean catchment dams, Warragamba Dam and Tallowa Dam on the Shoalhaven River.

In some cases, discharges from dams cause downstream temperatures to drop more than 15°C below natural summer conditions (Hardwick et al. 2012).

Catchment disturbance

Runoff causing water pollution is affected by:

- the extent of vegetation cover in a river catchment
- local land use and land management practices, such as agriculture and urban development.

Runoff may increase nutrients and sediments in the river or stream. It may even modify the geomorphology of the river. Clearing riparian and land plants and draining wetlands also affect river geomorphology by:

- widening river channels
- leading to head cut incisions in headwater streams
- increasing sediment loads, smothering aquatic habitats (Brierley & Fryirs 2005).

Generally, the more intensive a development, the greater its impact on river ecosystems.

Healthy riparian vegetation is important to maintain healthy aquatic ecosystems. The structure it provides protects riverbanks from erosion and creates complex habitat and sources of food and nutrients, including for aquatic communities. Intact riverbanks are also critical because many species use overhanging banks and their vegetation for habitat.

River health is affected when riparian vegetation is disturbed. Clearing and trampling by livestock destroys or degrades riparian zone vegetation, with significant impacts.

Other forms of disturbance that influence river health include:

- bushfires
- roads
- large dams
- industrial activities such as mining.

Invasive species

Introduced pest fish can compete with native species. They prey on fish and frog eggs, tadpoles and juvenile fish, and fundamentally alter food webs and habitats. Freshwater fish surveys over the past three years found:

- only 13% of all sites sampled were free from introduced fish, mainly in coastal rivers
- 4% of sites contained only introduced fish
- introduced fish taxa accounted for 36% of fish species collected at each site, 37% of total fish abundance, and 58% of total fish biomass, averaged across all sites.

Allowing for the greater proportion of sampling in the Murray-Darling Basin during the latest surveys, these numbers show an improvement compared to results reported in SoE 2015.

No new introduced fish species became established in NSW's freshwater aquatic habitats during the period 2014–2017. See the Invasive Species topic.

Drought

The Australian landscape is adapted to natural drought conditions; many species have lifecycles that rely on natural variability in river flows. Prolonged drought, however, causes major disturbance to river systems and can severely stress aquatic ecosystems.

Where the combined effects of drought conditions and water extraction build up over extended periods, they may exceed critical thresholds for life cycles of species. This stress threatens the recovery of at-risk fish populations. Where long-term changes to river conditions have reduced native fish populations, they are less resilient to further change, such as those imposed by the decade-long Millennium Drought of the 2000s.

Climate change

Climate change is likely to gradually add to existing stressors, particularly water availability pressures and the impacts of altered river flows.

Climate change will affect environmentally beneficial flooding that occurs in most Murray-Darling Basin regions (especially highly-developed regions). However, these climate change effects will be smaller than existing impacts from water resource development, according to the CSIRO Sustainable Yields Assessment (CSIRO 2008a).

Nevertheless, when climate change impacts are superimposed on existing water availability pressures, important ecological thresholds may be crossed. The ecological consequences may be substantial (CSIRO 2008a). By 2030, under a median climate change scenario, expected impacts include:

- extended dry periods between important flood events and reduced flood volumes for Murray icon sites identified in The Living Murray program (CSIRO 2008a)
- a 10% increase in the interval between beneficial flood events in the Macquarie River (CSIRO 2008b)
- a 24% increase in the interval between floods in the Lachlan River (CSIRO 2008c).

Responses

Legislation and policy

NSW Diffuse Source Water Pollution Strategy

Pollution from diffuse sources accounts for most pollution in NSW waterways. The NSW Diffuse Source Water Pollution Strategy (DECC 2009) aims to reduce this pollution in all NSW surface and groundwater, by focusing on sources not currently regulated. It addresses three main pollutants: sediments, nutrients and pathogens. These pollutants come from many sources, including agriculture, sealed and unsealed roads, and urban stormwater.

There is an action in the Marine Estate Management Strategy to clarify NSW Government and local government roles and responsibilities for diffuse source water pollution.

Fish habitat policy and guidelines

Policy and guidelines updated in 2013 aim to maintain and enhance fish habitat in NSW to benefit native fish (including threatened species) in marine, estuarine and freshwater environments (DPI 2013).

Programs

Floodplain management plans (Water Management Act 2000)

Floodplain management plans, prepared under the *Water Management Act 2000*, will help implement the NSW Healthy Floodplains Project. These plans provide a whole-of-valley framework to assess and determine flood work applications.

The Department of Industry Water, in partnership with the Office of Environment and Heritage, is preparing six floodplain management plans for:

- the Gwydir
- Barwon-Darling
- Upper Namoi
- Lower Namoi
- Border Rivers
- Macquarie valley.

These whole-of-valley plans will supersede 20 localised floodplain management plans already in force for areas of these six floodplains. The plans to be superseded were prepared under the *Water Act 1912* and the *Water Management Act*.

As statutory plans, the new whole-of-valley plans must address risks to life and property from flooding. Some features of floodplains with ecological and cultural significance depend on flooding; the plans must also provide connectivity to and from these flood-dependent assets.

Water sharing plans

Water sharing plans are important tools to address river health in NSW. They provide for better management of river flows and water extraction practices and protect a proportion of all flows for the environment. Water sharing plans developed for all NSW water sources were in place by the end of 2018. The plans are reviewed every 10 years, at which time they are either remade or renewed.

Under the Murray-Darling Basin Plan, water sharing plans in the basin will underpin 20 water resource plans (WRPs) to be developed by 2019. See Water Resources topic.

Water resource plans

The NSW Government will develop water resource plans as part of implementing the Murray-Darling Basin Plan. The Basin Plan provides a framework to integrate the basin's water resource management over the long term. Water resource plans will align basin-wide and state-based water resource management. They will recognise and build on existing water planning processes.

Each water resource plan will have:

- the relevant state water sharing plan
- a long-term environmental water plan
- a risk assessment
- a water quality management plan
- an incident response guide to deal with periods of drought and poor water quality.

See Water Resources topic.

Water quality management plans

Under the Murray-Darling Basin Plan, water quality management plans must be developed for all basin areas with water resource plans.

Each water quality management plan will:

- establish water quality objectives and targets for freshwater-dependent ecosystems, irrigation water, and recreational uses
- identify key causes of water quality degradation
- assess risks from water quality degradation
- identify measures that help achieve water quality objectives.

Environmental water holdings

In NSW, water has been purchased or recovered for the environment through a number of water recovery programs funded by the Commonwealth and NSW governments. The cumulative total for all this licensed environmental water for regulated rivers in NSW is about 2,412,000 megalitres (ML), and about 70,000ML in unregulated rivers (see Water Resources topic).

NSW and Australian government agencies work together to release and manage environmental water holdings. They manage environmental water through two types of plans:

- Annual environmental watering plans outline priorities for environmental water use in the coming year, considering climatic factors and water availability.
- Environmental water management plans are strategic plans for wetlands. They link environmental water management with activities of other government agencies. These plans identify environmental assets and values, assess water-use priorities, and outline the water and land management issues that must be addressed to support environmental values.

Environmental flows are also provided by releases from dams on coastal river systems that provide urban water supply for major metropolitan areas. The NSW Government has committed to new variable environmental flows from Warragamba Dam by 2024 that will reintroduce more natural downstream flow conditions and improved water quality (Metropolitan Water 2017).

Fishways

Fishways and remediation work in NSW have re-opened thousands of kilometres of river habitat to fish. Remediation includes replacing low-level road crossings and causeways with larger fish-friendly box culverts. These culverts allow fish to pass, but also improve access for landholders during floods. Recent works include fishways completed at Kyogle and South Dubbo Weir.

The WaterNSW 2017 Fishways Strategy for 46 priority fishway sites is part of a broader strategy to address the state's 90 highest-priority barriers to fish passage (WaterNSW 2018). With funding and implementation, the strategy could open up about 8,200 km of rivers and streams to migrating fish.

Future opportunities

Continued monitoring will shed light on how habitats and ecosystems respond to environmental flows. This information will refine knowledge and guide adaptive management, to better target high-value ecosystems and enhance the benefits of these environmental flows.

Point sources of water pollution are generally well managed. However, scope exists to better manage diffuse-source pollution, mainly from agricultural runoff and urban stormwater. Stormwater harvesting developments, runoff controls, and initiatives to promote revegetation and better land management practices in catchments are being implemented to improve water quality. This includes initiatives being funded under the NSW Government’s $112 million Catchment Action NSW initiative (Local Land Services 2017).

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NSW EPA

Wetlands

Wetland ecosystems support high levels of biodiversity, providing habitat for a wide range of animals including waterbirds, fish, frogs, turtles, invertebrates and water-dependent plants.

Summary

Wetland area of eastern Australia

111,000

ha in 2017, this was below the long-term median of 235,000 ha

Read more

Waterbird abundance

239,000

birds in 2017, below the long term median of 294,000

Read more

A return to drier weather conditions from 2017 has affected some wetland areas and waterbird breeding but has been mitigated in those inland communities receiving environmental water.

Widespread rain and flooding during 2016 inundated many wetlands, increasing waterbird breeding. From 2017, drier weather has reduced the extent of wetland inundation and decreased waterbird breeding.

Inland wetlands that have received environmental water (water held by the government and released in areas that need it) have maintained vegetation condition and waterbird diversity, with many acting as refuges for water-dependent species during dry periods.

Wetland condition is affected by dry weather, decreased water availability, changed patterns of river and tidal flows and surrounding land uses, for example, runoff from agriculture, construction and mining can affect wetland health.

Inland wetland health is being maintained by releases of environmental water and the implementation of the 2012 Murray–Darling Basin Plan. Coastal wetland health is anticipated to have renewed emphasis because of actions being carried out under the *NSW Coastal Management Act 2016* and *NSW Marine Estate Management Act 2014*.

Related topics: Water Resources | River Health

NSW indicators

Indicator and status		Environmental trend	Information reliability
Wetland extent	MODERATE	Getting worse	✓
Wetland condition	MODERATE	Getting worse	✓
Waterbird abundance and diversity	POOR	Getting worse	✓✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Wetlands are areas of land covered or saturated with fresh, brackish or salt water that is generally still or slow moving. The water can also sit just below the land's surface. An area does not need to be permanently wet to qualify as a wetland, but just wet for long enough for its plants and animals to have adapted to – or even depend on – wet conditions for at least part of their life cycles.

Wetlands can be classified into five types:

- **riverine wetlands**, around freshwater rivers, creeks, streams and other waterways
- **lacustrine wetlands**, around freshwater lakes and reservoirs
- **palustrine wetlands**, which are inland freshwater areas with plenty of trees and other vegetation
- **estuarine wetlands**, around estuaries
- **marine wetlands**, along the coast.

In 2004, approximately 5.6% of NSW was mapped as wetland (Kingsford et al. 2004).

Wetland ecosystems:

- support high levels of biodiversity, providing habitat for a wide range of animals including waterbirds, fish, frogs, turtles, invertebrates and water-dependent plants
- contribute to regional economies by providing environments for commercial fisheries, grazing and tourism
- provide habitat for threatened animals including the freckled duck, Australasian bittern, green and golden bell frog and southern pygmy perch (*Fisheries Management Act 1994; Biodiversity Conservation Act 2016*)

- are home to threatened ecological communities such as coastal saltmarsh
- provide important stopover and winter habitat for many migratory birds protected under bilateral international agreements and the Bonn Convention (Convention of the Conservation of Migratory Species of Wild Animals).

Wetlands also play a key role in keeping the environment healthy by:

- contributing to the biogeochemical cycling of gases such as methane and carbon dioxide, and nutrients
- regulating regional hydrological cycles and climate
- reducing the impact of storm damage and flooding
- maintaining good water quality in rivers
- recharging groundwater.

Wetlands are culturally significant for Aboriginal people and provide them with a strong connection to country.

Status and Trends

Long term surveys

The basis for assessing trends in wetland extent and waterbird populations is the long-running (1983–2017) annual Eastern Australian Waterbird Survey. In October each year, 10 aerial surveys covering areas 30 kilometres wide at every two degrees of latitude across eastern Australia are undertaken to monitor up to 2,000 wetlands and provide estimates for 50 species of waterbird (Porter et al. 2017). The survey includes every body of water larger than one hectare in width and length, including estuaries, coastal lakes, rivers, swamps, floodplain wetlands, saline lakes, dams, reservoirs and impoundments.

The wetland area index is the sum of all the inundated wetland areas measured over the 10 aerial survey bands, rather than the actual total area, which is why it is referred to as an index. It is assumed to be a representative sample of all the wetlands and is comparable from year to year since the aerial survey bands are consistent through time. The waterbird abundance index, breeding index and breeding species diversity index are also summations over the 10 aerial survey bands.

Wetland extent and condition

The Eastern Australian Waterbird Survey data shown in **Figure 18.1** reveals that there was a reduction in wetland area across eastern Australia in 2017 to below the long-term median of 235,000 ha (1983–2017). There has been a trend of decline since 1983. In 2017 the wetland area was 111,000 ha.

Figure 18.1: Estimated wetland area in eastern Australia, 1983–2017

Notes:
Data from annual aerial survey in 10 NSW wetland areas, 1983–2017.

Widespread rainfall across 2010–11 and 2011–12 and in 2016 inundated many floodplain wetlands across inland NSW and initiated the recovery of wetland vegetation from the drying effects of the millennium drought of 2003 to 2009 (OEH 2015a). The improvement in wetland vegetation has continued where environmental water can be delivered (OEH 2016; OEH 2017).

Over the past decade, monitoring across inland valleys receiving environmental water has indicated an improvement in the condition of wetland vegetation communities compared with their condition near the end of the millennium drought in 2008 (DECCW 2010b; DECCW 2010c; DECCW 2011a; DECCW 2011b; Wen & Saintilan 2015; Bowen et al. 2018b). This improvement is due to both natural flooding and delivery of environmental water. Where monitoring for the period 2015–17 is available, overall vegetation condition either remained steady or showed some further improvement (OEH 2016; OEH 2017).

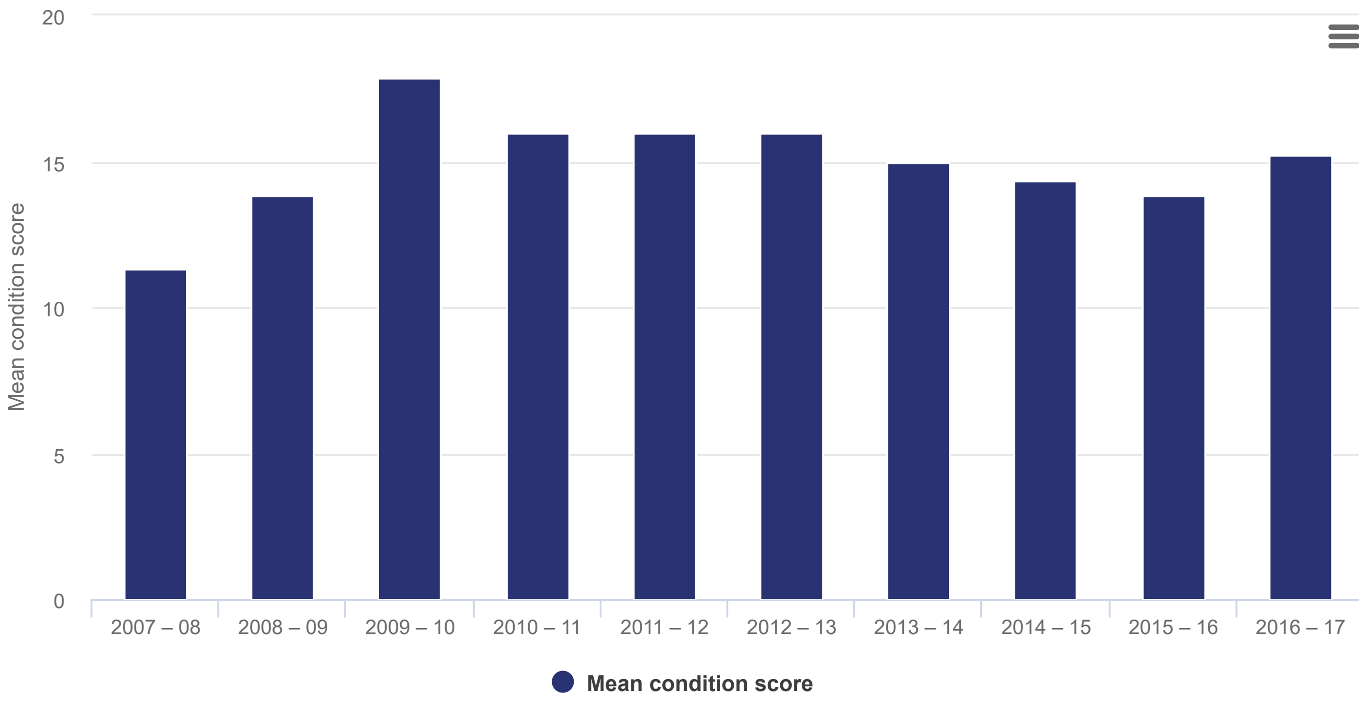
For example, in the Macquarie Marshes, vegetation condition improved between 2015 and 2017, mostly in response to flooding in late 2016 (**Figure 18.2**).

The score for vegetation condition in **Figure 18.2** is determined using a methodology (Bowen et al. 2018a) where the maximum score possible is 20. Scores for vegetation condition in 2015–17 in the Macquarie Marshes were intermediate to good (Bowen et al. 2018b). Vegetation communities that improved in condition during this period included lignum shrublands, river red gum forests and woodlands, and coolabah woodlands. The condition of other vegetation such as mixed marsh, water couch and reed beds remained steady.

Monitoring of vegetation communities in the Gwydir Wetlands indicated steady condition scores overall between 2015 and 2017 (OEH 2017). Marsh club rush and mixed marsh improved while river cooba and coolabah forests showed little change in condition (Spencer et al. 2017, unpublished data).

Despite the improvement in vegetation condition in inland wetland areas receiving environmental water, areas without adequate water have still not recovered to pre-drought conditions (OEH 2015b; OEH 2016; OEH 2017).

Figure 18.2: Condition score for all flood dependent monitoring sites in Macquarie Marshes



The recent threat and risk assessment of NSW marine areas identified statewide priority threats to coastal wetlands, which were:

- clearing riparian habitat, including draining wetlands
- estuary entrance modification (BMT WBM 2017).

The negative outcomes of these threats are water pollution, physical disturbance and wildlife disturbance. In some locations:

- clearing and draining have led to acid runoff and black water (depletion of dissolved oxygen levels) after floods
- entrance modifications have resulted in changes to tidal flow velocity and patterns, altering water tables and connectivity
- both threats have permanently decreased some shorebird habitat through dryness or erosion.

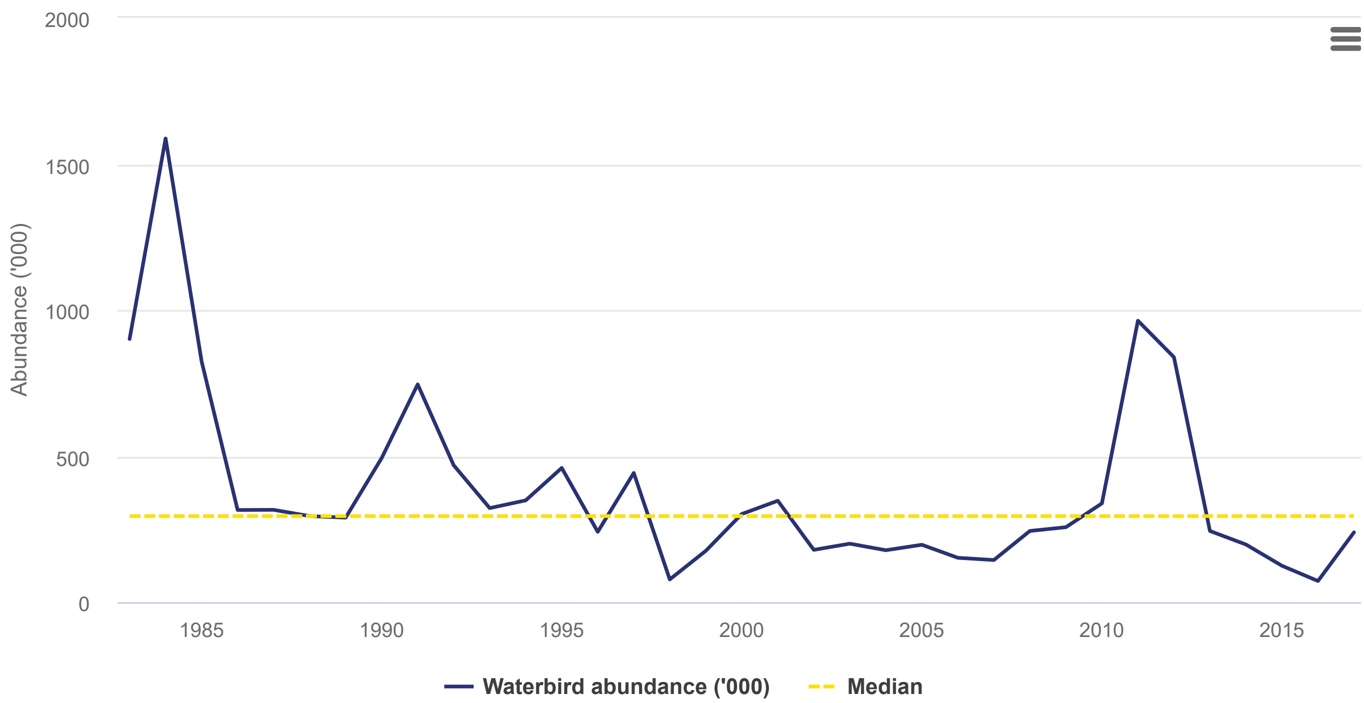
Related topic: Coastal, Estuarine and Marine Ecosystems

Waterbirds

Wetlands provide important waterbird habitat, supporting breeding and foraging. The Eastern Australian Waterbird Survey showed that the total breeding index was low in 2015 and 2017, well below the long-term median, although it increased in 2016 in response to widespread natural flooding (Porter et al 2015; Porter et al 2016; Porter et al. 2017) (see **Figure 18.3a**). May–September 2016 was the wettest period on record across much of south-east Australia, with September 2016 being the wettest period on record for NSW.

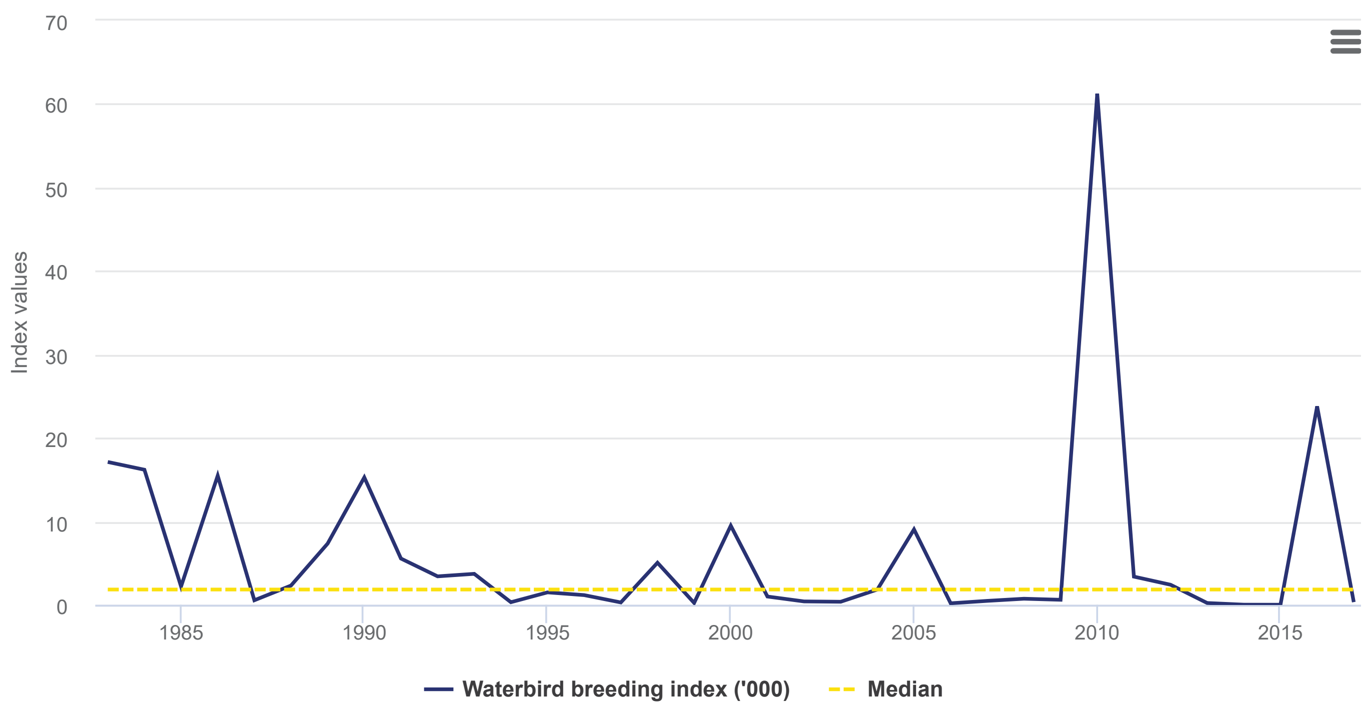
In 2017, the total waterbird abundance index increased considerably from 2016 but remained below the long-term median. The waterbird breeding species richness index was also low, with only six species recorded breeding (**Figure 18.3b**). The number of birds for each game species in 2017 was well below long-term medians, in many cases by an order of magnitude, save for the grey teal which recorded numbers of birds near the long-term median (Porter et al. 2017).

Figure 18.3a: Estimated waterbird abundance index ('000) in eastern Australia, 1983–2017



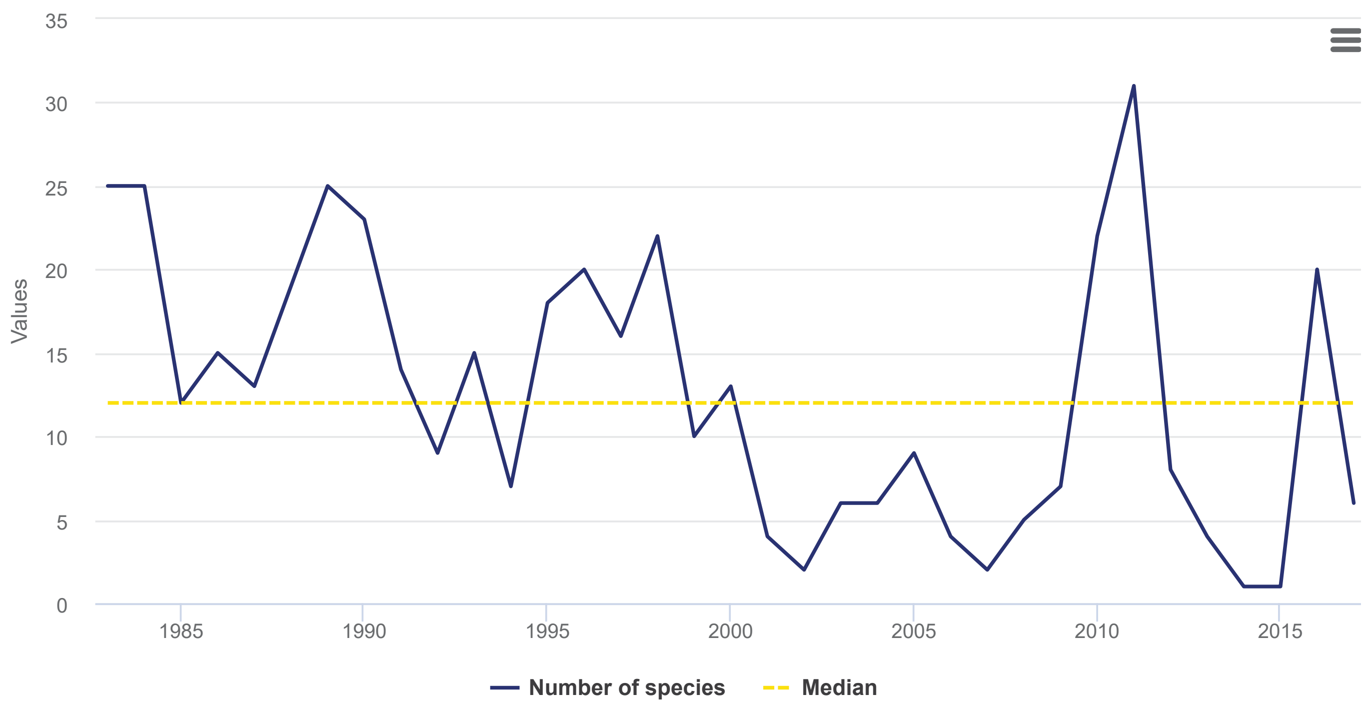
Notes:
Data from annual aerial survey in 10 NSW wetland areas, 1983–2017.

Figure 18.3b: Waterbird Breeding index ('000) in eastern Australia, 1983–2017



Notes:
Data from annual aerial survey in 10 NSW wetland areas, 1983–2017.

Figure 18.3c: Waterbird breeding species diversity in eastern Australia, 1983–2017



Notes:
Data from annual aerial survey in 10 NSW wetland areas, 1983–2017.

Despite some increase in breeding abundance and species diversity for 2015–17, there is a continued long-term reduction in these indices of waterbird populations, reflecting the lack of suitable inundated habitat due to declines in annual river flows across the Murray–Darling Basin. In comparison, there is no long-term decline in waterbird populations in the less developed Lake Eyre Basin (Kingsford et al. 2017).

Recent research also indicates that migratory waterbird habitat is declining across East Asia (a major stopover for many migratory waterbird species en route to Australia) and this is also affecting shorebird populations (Murray & Fuller 2015).

Monitoring results across the State's inland wetlands show that other wetland-dependent animals have benefited from the delivery of environmental water. An example is the nationally vulnerable southern bell frog, with populations expanding into new wetland sites in the Murrumbidgee and Murray catchments (Wassens et al. 2017).

Wetlands added to national parks, regional parks and reserves

Tables 18.1a and **18.1b** summarise the 1,451.7 hectares of wetland that were added to NSW national parks, regional parks and reserves in 2015–17.

Table 18.1a: Extent of wetland types and their inclusion in NSW reserves, 2017: Coastal wetlands

Wetland type	Total area in NSW (ha)	Total area in NSW parks estate (ha) (% of total)	Additions of wetland to NSW parks estate in 2015–17 (ha)	Examples of new areas of wetland declared or added to NSW parks estate in 2015–17

Wetland type	Total area in NSW (ha)	Total area in NSW parks estate (ha) (% of total)	Additions of wetland to NSW parks estate in 2015–17 (ha)	Examples of new areas of wetland declared or added to NSW parks estate in 2015–17
Floodplain wetlands	15,429	4,349 (28%)	68.6	Everlasting Swamp National Park (addition to existing reserve: 66.7ha) Yellomundee Regional Park (addition to existing reserve: 1.0ha) Captains Creek Nature Reserve (addition to existing reserve: 0.9ha)
Freshwater wetlands	2,095	235 (11%)	–	–
Estuarine wetlands	111,527	14,873 (13%)	33.6	Coffs Coast Regional Park (addition to existing reserve: 2.2ha) Hunter Wetlands National Park (addition to existing reserve: 1.8ha) Cobaki Nature Reserve (14.7ha, new reserve gazetted January 2016) Gaagal Wanggaan (South Beach) National Park (addition to existing reserve: 14.7ha) Wolli Creek Regional Park (addition to existing reserve: 0.16ha) Lake Macquarie State Conservation Area (addition to existing reserve: 0.06ha)
Coastal lakes and lagoons	66,590	18,775 (28%)	0.5	Lake Macquarie State Conservation Area (addition to existing reserve: 0.5ha)
Total	**195,641**	**38,232 (20%)**	**102.7**	–

Table 18.1b: Extent of wetland types and their inclusion in NSW reserves, 2017: Inland wetlands

Wetland type	Total area in NSW (ha)	Total area in NSW parks estate (ha) (% of total)	Additions of wetland to NSW parks estate in 2015–17 (ha)	Examples of new areas of wetland declared or added to NSW parks estate in 2015–17

Wetland type	Total area in NSW (ha)	Total area in NSW parks estate (ha) (% of total)	Additions of wetland to NSW parks estate in 2015–17 (ha)	Examples of new areas of wetland declared or added to NSW parks estate in 2015–17
Floodplain wetlands	4,008,839	272,210 (7%)	1,349	Kalyarr National Park (addition to existing reserve 1,105 ha) Culgoa National Park (addition to existing reserve 244 ha)
Freshwater lakes	296,071	21,026 (7%)	–	–
Saline lakes	18,542	–	–	–
Total	**4,323,452**	**293,236 (7%)**	**1,349**	–

Coastal wetlands

In 2015–17, coastal wetlands in the NSW public reserve system increased by 102.7 hectares. Substantial additions included the new Cobaki Nature Reserve and additions to Everlasting Swamp National Park and Gaagal Wanggaan (South Beach) National Park, all located on the NSW North Coast.

Cobaki Nature Reserve lies on the Tweed River estuary and protects important remnants of coastal lowland forest in an area of rapidly expanding urban and infrastructure development. Mangroves and saltmarsh occur on intertidal estuarine mud and cover 11% of the reserve, while swamp sclerophyll forest dominated by stands of swamp oak covers 21%.

Everlasting Swamp National Park, 15 kilometres west of Maclean, lies on the Clarence River floodplain, and is part of one of the largest coastal floodplain wetlands remaining in NSW.

Inland wetlands

In 2015–17, 1,349 hectares of inland wetland were added to the NSW public reserve system. This included an addition to Kalyarr National Park of 1,105 hectares. This park, on the Lachlan River, protects inland freshwater aquatic ecosystems and diverse species including migratory birds. Much of the wetland reserved is listed in A Directory of Important Wetlands in Australia.

Pressures

Water availability

Water availability is the most significant pressure on the health of many wetland ecosystems. Altered flows from water extraction and the building of dams, levees and diversion structures has had long-term and ongoing negative effects on water availability, especially for important waterbird breeding sites such as Macquarie Marshes and Lowbidgee wetlands. Many inland wetlands have had prolonged periods of reduced water availability.

See the Water Resources topic for more information about water resource extraction and diversion.

Climate change

Wetlands in NSW, and the animals and plants that depend on them, are vulnerable to the impacts of climate change. Altered flow regimes and extreme weather such as heatwaves and droughts will decrease water availability through rising temperatures increasing rates of evapotranspiration and altering rainfall patterns. This ultimately impacts on the frequency and duration of wetland inundation.

Coastal freshwater wetlands that rely on rainfall are likely to be negatively affected by climate change. Rising sea levels will alter tidal ranges and inundation in estuaries, reducing water flowing into coastal saline wetlands (DECCW 2010a, BMT WBM 2017).

Water quality

Human activities may adversely affect wetland water quality. Examples include:

- **Vegetation clearing** in NSW is resulting in far more sediment entering wetlands. Sediment can form muddy deposits, reduce light penetration and smother plants and animals.
- **The amount of saline water discharged from mines** is increasing in areas such as the Hawkesbury–Nepean and Hunter regions and is affecting the health of streams and the wetlands they flow into (EPA 2013; OEH 2015c; Price and Wright 2016; Wright et al. 2017).
- **Increased urbanisation** adds more pollutants such as sediments and nutrients to rivers and streams (MEMA 2017).
- **Soil erosion and gullying** have led to declines in water quality in the Wingecarribee, Braidwood, Wollondilly, Mulwaree, Upper Wollondilly and Nattai rivers (Alluvium Consulting Australia 2017).
- **Diffuse pollution** from development, clearing, cropping, grazing, mining and other land uses, and sewage, can lead to increasing levels of nutrients and sediments entering wetlands, resulting in hypoxia or black water (depletion of dissolved oxygen levels), fish kills, excessive plant growth, increased turbidity and siltation.

Physical disturbance

Physical disturbances such as land clearing on the floodplains of inland NSW and mining activity have a major impact on the quality of habitat in, and the extent of, wetlands (see the River Health topic).

Studies have identified impacts linked to longwall mining on upland swamps on the Woronora and Newnes plateaus in the Woronora and Hawkesbury-Nepean catchments (GHD 2013; Alluvium Consulting Australia 2017; Young 2017). Subsidence can fracture the base of swamps and drain groundwater-dependent ecosystems (GHD 2013). Other impacts include changes to site geology through strata fracturing, a reduction in surface water and groundwater quantity and quality, and decreased ecosystem function in wetlands and streams (GHD 2013; Alluvium Consulting Australia 2017; Young 2017). The 2016 Sydney Drinking Water Catchment Audit (Alluvium Consulting Australia 2017) found surface water flows were decreasing, associated with the cumulative impacts of underground coal mining.

Invasive species

The spread of weed and pest species is facilitated by physical disturbances to wetlands, altered flow regimes and drainage and increased nutrient load. Aquatic weed species in NSW wetlands include lippia, salvinia and water hyacinth (see the State of the catchments reports).

Introduced plants can:

- result in poorer habitat value for native animals
- increase sedimentation
- create monocultures which reduce overall biodiversity.

Introduced plants can reflect the degree of degradation or restorability of a wetland.

Invasive pest species also cause problems. Introduced aquatic species such as carp and mosquito fish can decimate native fish populations in wetlands and affect water quality.

Trampling and digging by grazing animals has extensively damaged wetland vegetation, soils and channels and river banks. Many feral animals such as cats, foxes and pigs prey on small native animals and birds, and their young (see the Invasive Species topic).

Responses

Legislation and policy

Key policies and legislation include:

- the NSW Wetland Policy
- protection for some wetlands under the NSW Reserve system (*National Parks and Wildlife Act 1974*) or through conservation agreements with private landholders
- State Environmental Planning Policy - Coastal Management 2018 and the *Biodiversity Conservation Act 2016*, which protects wetlands listed as endangered ecological communities
- The *Coastal Management Act 2016* and the coastal management framework which includes coastal wetlands within its scope of management and grants
- the Ramsar Convention and *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth),* which help protect 13 internationally significant wetlands in NSW
- environmental water holdings in five valleys in the Murray–Darling Basin which help to improve the ecological condition of floodplain wetlands (see the Water Resources topic)
- the *Water Management Act 2000, which* outlines requirements for water-sharing plans and floodplain management plans to manage and protect wetlands along NSW rivers and on their floodplains.

The NSW Wetlands Policy (DECCW 2010a) promotes the sustainable conservation, management and use of wetlands. Some wetlands are protected under the NSW Reserve system (*National Parks and Wildlife Act 1974*) or through conservation agreements with private landholders. Additional significant wetlands in NSW include those mapped under State Environmental Planning Policy – Coastal Management 2018.

The *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) protect threatened species and endangered ecological communities in wetlands.

The Ramsar Convention and Environment Protection and *Biodiversity Conservation Act* help protect internationally significant wetlands. NSW has 12 Ramsar wetlands: Blue Lake, Fivebough and Tuckerbil Swamps, Gwydir Wetlands, Hunter Estuary Wetlands, Lake Pinaroo (Fort Grey Basin), Little Llangothlin Nature Reserve, Macquarie Marshes, Myall Lakes, Narran Lake Nature Reserve, NSW Central Murray Forests, Paroo River Wetlands and Towra Point.

The *Water Management Act 2000* outlines requirements for water-sharing plans for NSW rivers, which are one of the most important mechanisms for protecting wetlands. Floodplain management plans help protect and restore wetlands on floodplains.

To address the potential effects of underground mining activities on wetlands in the Woronora and Hawkesbury-Nepean catchments, the NSW Government places strict controls on mining to protect the integrity of the catchments and its water storages. The Government has also established an Independent Expert Panel to review and monitor existing mining in the catchments, and introduced an Aquifer Interference Policy to protect underground water sources.

Programs

Water to restore and maintain wetlands

The NSW Office of Environment and Heritage manages environmental water in five valleys in the Murray–Darling Basin (Lachlan, Macquarie-Castlereagh, Gwydir, Murrumbidgee and NSW Murray), in part to improve the ecological condition of floodplain wetlands (see the Water Resources topic).

The environmental water management program (EWMP) aims to rehabilitate wetland habitat for significant water-dependent plants and animals, including floodplain eucalypts, waterbirds, frogs, reptiles and fish.

The EWMP evolved from a need to address long-held concerns about the health of floodplain wetlands in the Murray–Darling Basin. The NSW Government purchased environmental water from willing sellers under NSW RiverBank, the Rivers Environmental Restoration Program and the NSW Wetland Recovery Program.

The Commonwealth Government now holds water for the environment across the Murray–Darling Basin to ensure sustainable limits set by the 2012 Murray–Darling Basin Plan are met by 2019.

Water quality

NSW Government initiatives that protect and improve wetland water quality include:

- those being funded under the NSW Government's $112 million Catchment Action NSW initiative
- the $46 million Marine Estate Management Strategy 2018–2028
- coastal management planning and grants for estuarine wetlands under the NSW coastal management framework.

Related topics: River Health | Coastal Estuarine and Marine Ecosystems

Future opportunities

NSW wetlands inventory

While wetland inventories for areas of NSW exist (Kingsford et al. 2004; Powell et al. 2017), many NSW wetlands are not on currently available maps or in spatial data, due to the variety of mapping methods used, the scale of the mapping or the climate regime at the time of assessment. This limits the ability to report on their condition and extent or undertake a statewide vulnerability assessment. As a result, Office of Environment and Heritage is building a comprehensive inventory of all wetlands in NSW to improve the way wetlands are monitored and managed. This information will be then passed to the public.

A wetlands inventory pilot project for the Lachlan River catchment was completed in 2016–17. This region was selected due to:

- opportunities for community engagement
- availability of data
- feasibility, given limited timeframes.

The pilot project showed the value of consistently mapping all inland wetlands to improve available information on their location, extent and condition (Powell et al. 2017). When funding is available, more catchments will be mapped using the tools developed during the pilot project.

Marine Estate Management Strategy

An extensive statewide threat and risk assessment of marine areas in NSW, including coastal wetlands, was completed in 2017 (BMT WBM 2017). The Marine Estate Management Strategy (MEMA 2018) responds to the priority threats identified in the threat and risk assessment, and provides an overarching framework for managing the marine estate as a single continuous system over the next decade. Objectives in the strategy include:

- protecting and rehabilitating coastal wetlands and habitats (BMT WBM 2017)
- understanding ways of managing the threat of sea level rise on estuarine wetlands
- protecting threatened species and ecological communities listed in the *Fisheries Management* and *Biodiversity Conservation Acts* (MEMA 2017).

Related topics: Coastal Estuarine and Marine Ecosystems | Protected Areas and Conservation

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Groundwater

Widely used in agriculture and industry, groundwater is also the primary water source in many NSW regional communities, for drinking and domestic and stock use.

Summary

Water use in NSW:

11%

comes from groundwater sources

Read more

Groundwater dependent ecosystems

>90%

of likely extent in NSW has now been mapped

Read more

Overall extractions from all NSW metered groundwater sources are mostly within the long-term average annual extraction limits. Knowledge of NSW groundwater-dependent ecosystems has improved, but their actual extent and condition remain uncertain.

Groundwater extraction decreased between 2014–15 and 2016–17, reflecting seasonal conditions that reduced demand on groundwater resources during this period.

Water sharing plans now ensure that groundwater is managed at the water-source scale to the long-term average annual extraction limit. Extraction from the major alluvial systems of the Lower Gwydir, Upper and Lower Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and Lower Murray Rivers fluctuates around levels close to the limits for sustainability. However, the overall level of groundwater extracted from all metered sources in NSW is much lower than the cumulative sustainable extraction limit.

Eleven water resource plans (WRPs) focusing on groundwater will be developed by 2019. These will set out arrangements to share water for consumptive use, establish rules to meet environmental and water quality objectives, and take into account potential and emerging risks to water.

Related topic Water Resources

NSW indicators

Indicator and status		Environmental trend	Information reliability
Long-term extraction limit: entitlement	GOOD	Getting better	✓✓
Aquifer integrity	GOOD	Stable	✓
Groundwater quality	MODERATE	Stable	✓
Condition of groundwater-dependent ecosystems	Unknown	Unknown	✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

Where surface water is available, groundwater is often seen as a supplementary water resource. However, in areas beyond the close proximity of rivers, both surface water and groundwater are primary water resources. Widely used in agriculture and industry, groundwater is also the primary water source in many NSW regional communities, for drinking and domestic and stock use.

Those who manage groundwater depend heavily on data from monitoring bores and groundwater extraction data. Managing groundwater is complex because each source is unique in composition and size. Many factors determine how each source functions. This means sources cannot all be managed the same way.

Locally, it is possible to limit groundwater extraction rates from individual bores. This is a way to manage impacts on third parties, such as other users, and on the aquifer system and groundwater-dependent ecosystems (GDEs). If not managed, third-party impacts can be significant.

The many ecosystems that depend on groundwater to survive include:

- highly-specialised and endemic subterranean systems
- surface water systems (wetlands, rivers and lakes) connected to groundwater
- some land-based ecosystems.

When the amount or quality of available groundwater changes significantly, this can degrade ecosystems and affect human uses of this water. Because many groundwater-dependent ecosystems are hidden underground, impacts to them are likely to be less obvious and less well understood.

Status and Trends

Extent and major uses of groundwater

Approximately 11% of all water used in NSW comes from groundwater sources. Together, domestic use (including drinking water) and watering stock consume around 13% of total estimated groundwater used in NSW. For more than 200 towns in NSW, groundwater is the principal water supply source.

Agriculture is by far the greatest user of groundwater in NSW. Most of this water is used to irrigate along inland floodplains underlain by high quality alluvial aquifers.

Although groundwater is also used by some mining operations, for others it is an obstruction or hazard to extract before mining can proceed.

Groundwater resources in NSW

Groundwater, found throughout NSW's landscape, ranges in depth and salinity, and this affects its availability to the environment or extractive users.

The upper groundwater bearing zone, or water table aquifer, is typically the most important groundwater system for GDEs, and for groundwater's connection with surface water. Climate, topography, and permeability of the host geology strongly influence this water resource. In higher rainfall areas in eastern NSW, groundwater tends to be shallower and salinity lower; depth and salinity increase going westward, where evaporation rates are higher and the topography flatter.

The different types of groundwater aquifers in NSW also differ in their yields:

- Unconsolidated sediments in alluvial floodplain and coastal sand beds yield the greatest groundwater supplies because they are more permeable.
- Consolidated porous rocks of the sedimentary basins have varying groundwater yields and salinity, from freshwater in the Great Artesian Basin to higher-salinity groundwater found with some coal deposits.
- Fractured rock groundwater systems typically have low groundwater yields — basalt aquifers on NSW's north coast are among the notable exceptions.

Levels of groundwater extraction and recharge

In large areas of NSW, the potential to extract groundwater is low due to unfavourable hydrogeology or unsuitable water quality. About 98% of all metered groundwater extracted in NSW comes from inland alluvial groundwater sources. These sources include high-yielding aquifers with good-quality water used extensively for irrigation.

Six major inland alluvial aquifers account for about 80% of all metered groundwater use:

- Lower Gwydir

- Upper and Lower Namoi
- Lower Macquarie
- Lower Lachlan
- Lower Murrumbidgee
- Lower Murray Rivers.

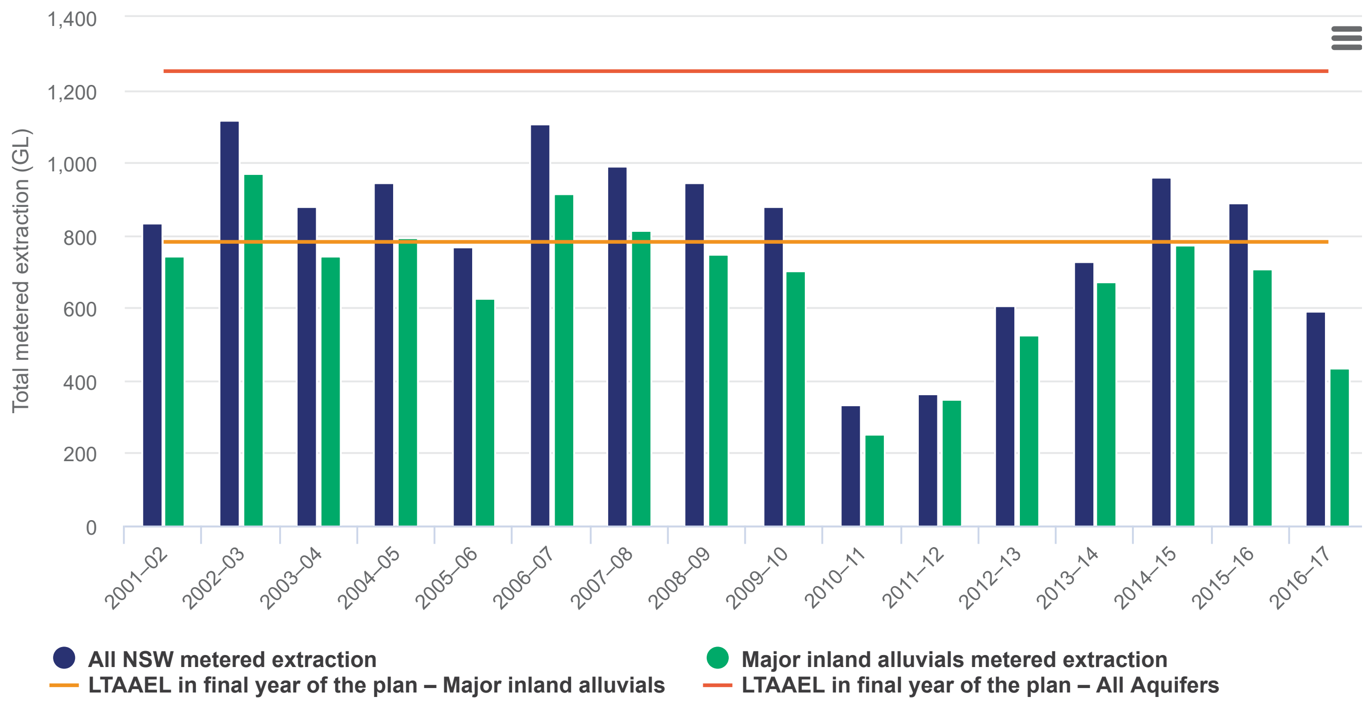
The Upper Lachlan and Mid Murrumbidgee sources make notable contributions to the remaining 20% of metered groundwater use.

Figure 19.1 shows groundwater extraction from all metered aquifers in NSW and the major inland alluvial aquifers, for the 16-year period to 30 June 2017. It reveals two extraction peaks, in 2002–03 and 2006–07, during periods of particularly acute droughts when surface water availability was low.

From 2006–07 to 2010–11, groundwater extraction gradually declined as water sharing plans were introduced and rainfall and surface water availability increased. Then, between 2011–12 and 2014–15, groundwater extraction from all NSW water sources, including major inland alluvial aquifers, gradually increased, from a 2010–11 low. This increase reflects greater demand for groundwater during a period when rainfall and surface water availability were low, particularly in valleys of northern NSW. In the three years to 2017, groundwater extraction again declined as rainfall and surface water availability improved.

The quantity of groundwater extracted from the six major inland alluvial aquifers fluctuates around levels close to the limits for sustainability. Nevertheless, the total quantity of groundwater extracted from all metered sources in NSW is well within the long-term average annual extraction limits.

Figure 19.1: Annual levels of groundwater extraction from metered aquifers in NSW and the major inland alluvial aquifers, 2001–02 to 2016–17



Notes:
The major inland alluvial aquifers are those of the Lower Gwydir, Lower and Upper Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and the Lower Murray rivers.
The green line is the long-term average annual extraction limit (LTAAEL) for these major groundwater sources only. The LTAAEL is the level of water that can be extracted annually on a sustainable basis over a longer time frame.
The purple line is the LTAAEL for all metered extraction in NSW.
Extraction limits were reduced gradually to align with the LTAAEL by the final year of relevant water sharing plans, 2016–17.

Source:
DoI - Water data 2018

Long-term average annual extraction limits

Climate variations affect how much groundwater people use. Groundwater is managed on a long-term average basis, an approach that ensures groundwater systems, with their large storage capacities, provide a buffer to supply water in times of drought. During droughts, groundwater extraction may increase to offset decreases in surface water, and levels decline. In periods of high rainfall, demand for groundwater decreases; this allows levels to recover, sustaining a reliable and secure water resource.

For groundwater sources defined in water sharing plans, the long-term average annual extraction limit (LTAAEL) is the volume of groundwater that can be extracted on an annual average basis over the longer term. It is effectively the plan limit.

To manage compliance with the LTAAEL, each water sharing plan sets rules. These rules aim to prevent annual groundwater extractions, over a set rolling average period, from exceeding the LTAAEL by a set percentage. If extraction exceeds this, the plan allows for reductions in available water determinations (AWDs) for aquifer access licences (AAL). These reduced allocations to licensed groundwater users bring groundwater extraction back to the LTAAEL. In unregulated river systems, joint management rules may be established and used to guide reductions in AWDs.

Managers in some large inland alluvial systems use numeric groundwater models to inform the limits set for extraction. By simulating groundwater flow over years, these models provide insights into how groundwater systems respond to climate variations and pumping stresses. In other inland alluvial areas, previous levels of groundwater extraction are used to set the extraction limit; this limits any growth in groundwater pumping.

In many coastal alluvial systems, the limit simply corresponds to current levels of entitlement.

In the remaining groundwater systems, managers use the estimated rainfall recharge to inform the extraction limit they set. In these systems an extraction volume, equal to a portion of long-term average rainfall recharge, is permitted each year.

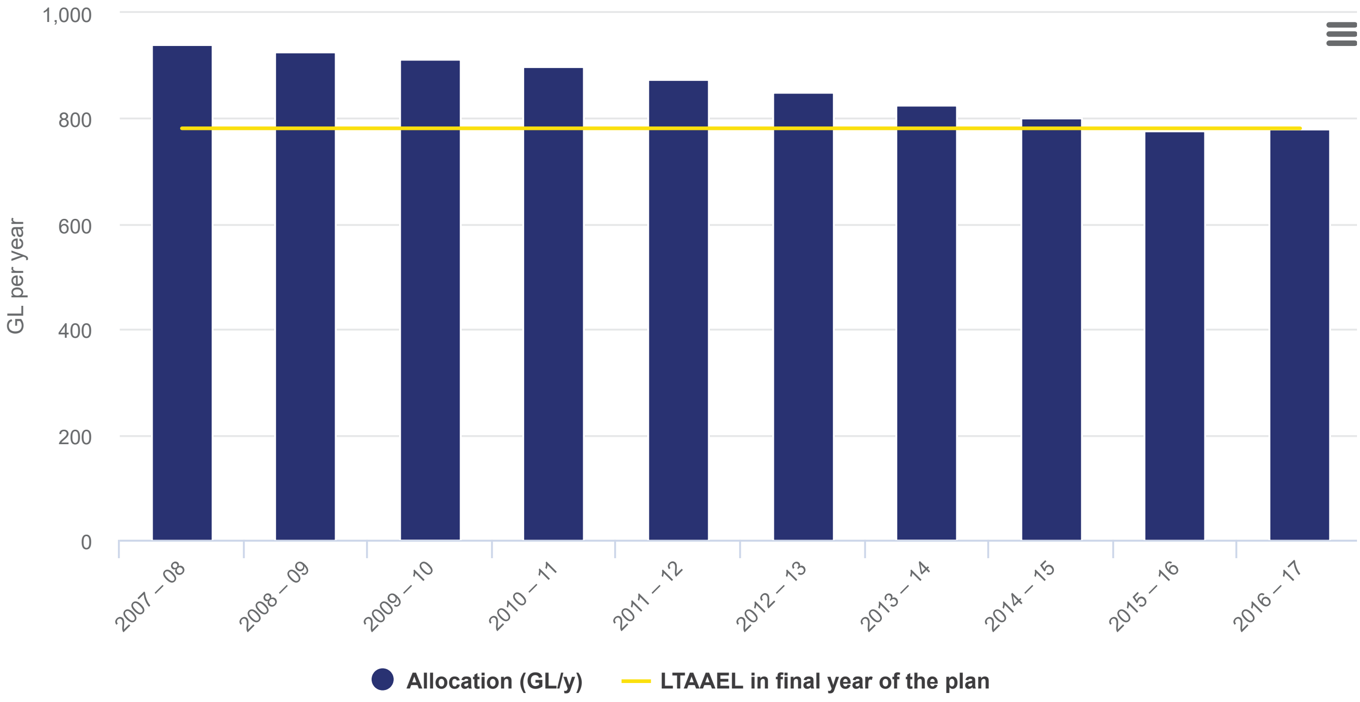
All water not explicitly permitted for extraction is reserved as environmental water. This reserve protects important environmental assets and ensures groundwater sources remain viable over the long term.

Water sharing plans and extraction levels

Water sharing plans allocate water for the environment, town water supplies, basic landholder rights and commercial uses (such as irrigation). These plans manage extraction to the LTAAEL.

By applying progressive allocation reductions over their 10-year plans, managers addressed historical groundwater use above their plans' extraction limit in the six major inland alluvial aquifers (Lower Gwydir, Upper and Lower Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and the Lower Murray). See **Figure 19.2**.

Figure 19.2: Allocations to groundwater under water sharing plans in the six major inland alluvial aquifers

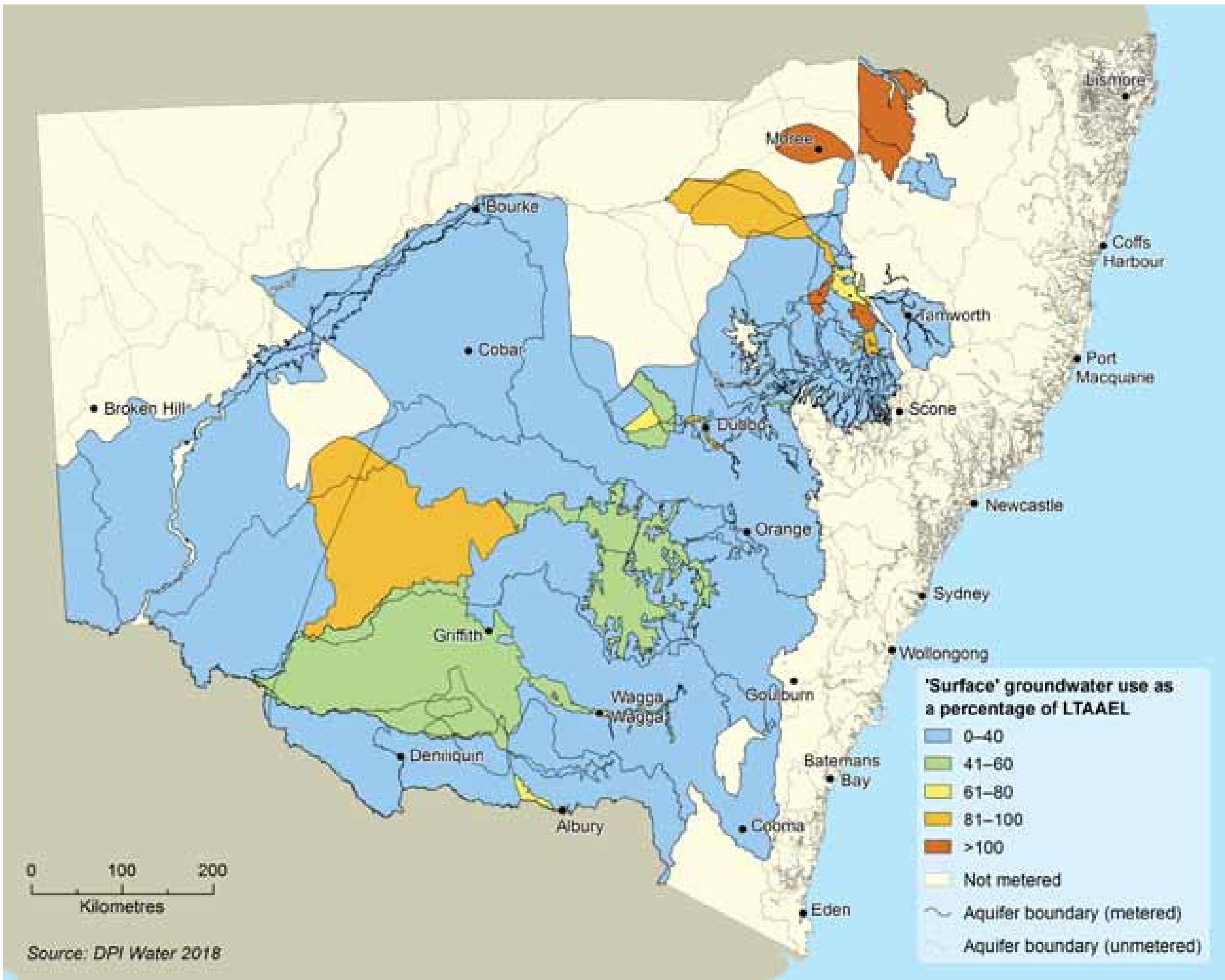


Source:
DoI - Water data 2018

In other over-committed groundwater systems, water use is being managed to water sharing plan extraction limits by annual allocations. In these systems, groundwater was not historically extracted above limits. The focus is therefore to limit future growth in groundwater extraction, rather than reduce access to water that users are economically reliant on.

Maps 19.1 and **19.2** show average groundwater use as a percentage of long-term average annual extraction limits for the period 2015–2017 for surface and buried sources respectively, in areas where groundwater use is metered and monitored.

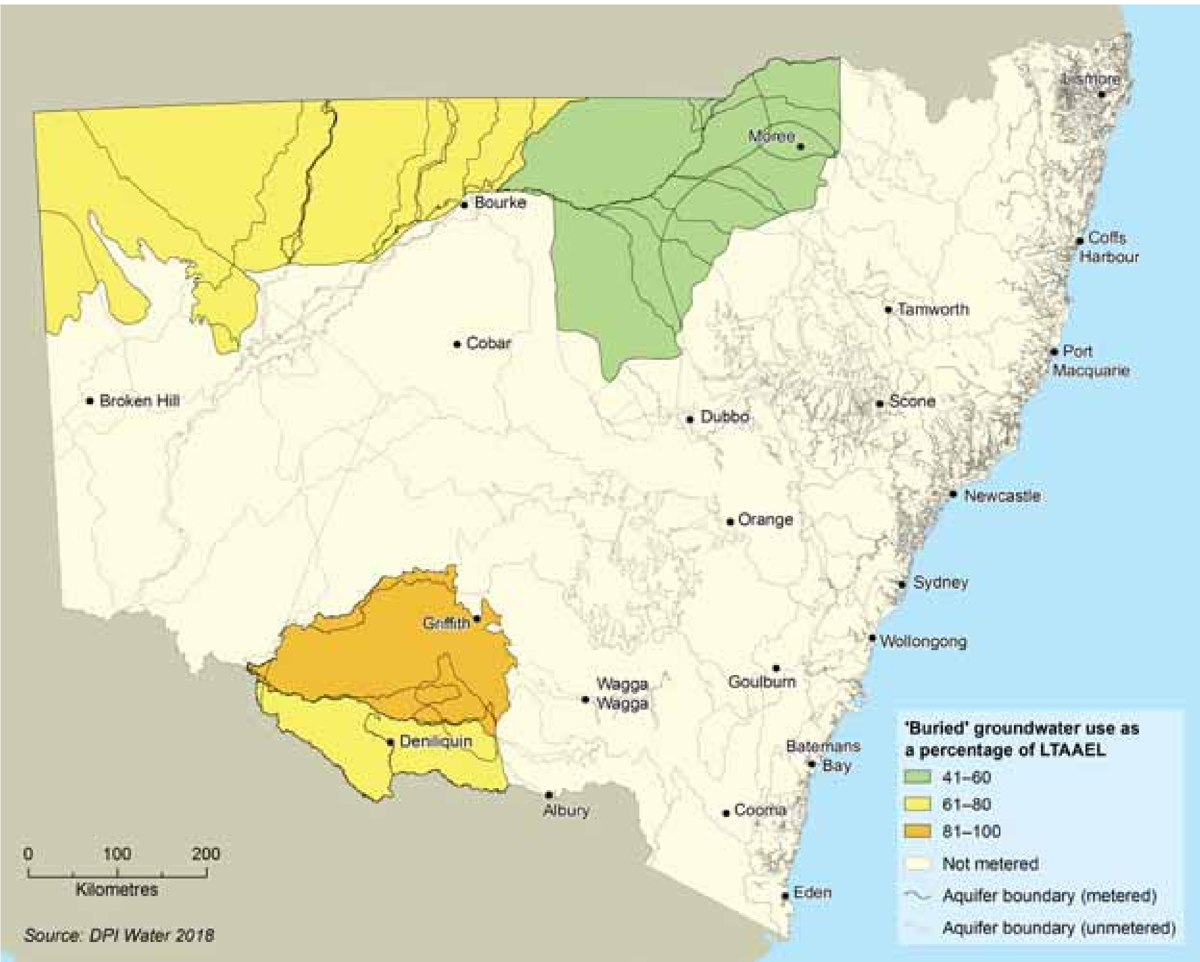
Map 19.1: Extraction from NSW surface aquifers as a percentage of the long-term average annual extraction limit



Notes:
Only areas where groundwater use is metered are shown on the map.

Source:
DoI - Water data 2018

Map 19.2: Extraction from NSW buried aquifers as a percentage of the long-term average annual extraction limit



Notes:
Only areas where groundwater use is metered are shown on the map

Source:
DoI - Water data 2018

All water sharing plans have compliance rules to manage extraction to the LTAAEL over time. If extractions exceed the limit, the plan's compliance triggers, and groundwater allocations may be reduced until extraction is brought back to the LTAAEL.

Water resource plans

The *Commonwealth Basin Plan 2012* requires NSW to develop 20 water resource plans by 2019, 11 of them for groundwater. The water resource plans' fundamental role is to ensure managers implement sustainable diversion limits (SDLs) set by the Basin Plan, from 2019 and beyond.

Water resource plans set out arrangements to:

- share water used for consumption
- establish rules to meet environmental and water quality objectives
- account for potential and emerging risks to water resources.

See the Water Resources topic.

Groundwater-dependent ecosystems

Water sharing plans describe groundwater-dependent ecosystems as, 'ecosystems where the species composition or natural functions depend on the availability of groundwater'. These ecosystems depend completely or partially on groundwater, such as during periods of drought when surface water is not available. The degree and nature of their dependency influences how much these ecosystems are affected by changes to groundwater quality or quantity.

Groundwater-dependent ecosystems are found in a wide range of environments, from highly-specialised subterranean ecosystems to more generally occurring land, freshwater and marine ecosystems. Seven broad types of GDEs, falling into two main groupings are defined according to their ecology, geomorphology and water chemistry.

Subsurface ecosystems:

- subsurface phreatic aquifer ecosystem
- karsts and caves
- subsurface baseflow streams.

Surface ecosystems:

- surface baseflow streams
- wetlands
- estuarine and near-shore marine ecosystems
- groundwater-dependent or phreatophytic vegetation.

Underground springs and cave systems host the most significant, diverse, and potentially sensitive groundwater-dependent ecosystems and organisms.

Identifying groundwater-dependent ecosystems

The NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002) was introduced in 2002, and ongoing work by the NSW Government to identify GDEs across the state has improved knowledge (Eamus & Froend 2008). Current mapping, completed state-wide, is available through the BOM GDE Atlas, which provides the latest dataset of GDEs.

Pressures

Excessive demand and extraction

Reducing an aquifer's storage levels, or consistently mining its water resource beyond the recharge rate, affect its long-term stability and integrity. This has permanent consequences for all dependent ecosystems and beneficial uses. Competition for groundwater resources can place the long-term security of these resources at risk.

Saline intrusion and groundwater quality

Intrusion of salty water into aquifers has detrimental effects on water quality and related uses. Saline intrusion of depleted aquifers is a high risk where:

- groundwater extraction is high
- the aquifer is overlain or underlain by saline aquifers

- the aquifer is near the coast.

Coastal sand beds north of Newcastle exemplify the risk of saline intrusion in this important water source for Greater Newcastle. To manage this risk, bore monitoring sites in the Tomago and Tomaree water sources were constructed along several transects, to monitor for changes in seawater intrusion. Each bore has specific triggers linked to response procedures under Hunter Water Corporation's Sustainable Groundwater Extractions Strategy.

Further north, in the Stuarts Point Water Source, the NSW Government constructed a series of bores aligned in transects to monitor for seawater intrusion. Each bore uses automatic data loggers to collect hourly salinity data.

Studies of risks to groundwater quality from high-volume groundwater extraction in the six major inland alluvial aquifers reveal localised areas of water quality decline. Strategies are being developed to address these risks.

Chemical contamination

Chemical contamination of groundwater reduces its value for users and the environment and increases water treatment costs. Such contamination can even prevent some types of water use altogether. Once polluted, an aquifer is extremely difficult and expensive to restore.

Groundwater contamination is largely associated with areas of long-standing industrial activity (existing or former). Such areas are found around Sydney, Newcastle and Wollongong.

Responses

Legislation and policies

Water Management Act 2000

Under the *Water Management Act 2000*, all groundwater aquifers must be managed sustainably. Statutory water sharing plans for groundwater are used to implement this sustainable management.

NSW State Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (DLWC 2002) has guidelines on how to protect and manage GDEs. Ongoing work seeks to improve understanding of the location of these ecosystems and determine the extent of their reliance on groundwater.

NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (DPI 2012) is part of the NSW Government's Strategic Regional Land Use Policy. The policy details how to assess and license potential impacts to aquifers, such as mining and coal seam gas (CSG) extraction activities. It aims to balance water requirements of towns, farmers, industry and the environment. This policy plays an important role in assessments for proposed mining and CSG developments. Because the Aquifer Interference Approval provisions of the *Water Management Act 2000* have not been enacted, some groundwater-related activities are still administered under the *Water Act 1912*.

Programs

Cap and Pipe the Bores Program

Since the 1990s, various programs have sought to reduce water wastage and improve groundwater pressure by capping and piping bores across the Great Artesian Basin located beneath parts of NSW, Queensland, the Northern Territory and South Australia.

The Cap and Pipe the Bores Program gives landowners financial incentives to offset the costs of replacing uncapped artesian bores and open drains with rehabilitated bores and efficient pipeline systems. These pipeline systems provide water to properties, prevent large quantities of salt from entering drainage systems, and help drought-proof properties. The program's measures have produced water savings of 78,500ML annually in the NSW part of the Great Artesian Basin, and water pressure across the basin has increased. A further joint Commonwealth–NSW Government phase of the program was announced in early 2018.

Future opportunities

Metering

Many groundwater management areas do not yet report meter readings. In these areas, information on groundwater recharge and availability is currently estimated using limited data and conceptual models.

Under a draft NSW metering framework announced in June 2018, the NSW Government proposes to meter approximately 95% of existing licensed water take capacity. Under the framework, groundwater extraction works of 200mm or larger must be metered. The framework proposes a requirement that telemetry be attached to meters. These proposed measures would make water take data capture and reporting more timely and efficient.

Non-metered take of groundwater also presents opportunities for better measuring, modelling, and hydrometrics. As part of agreed actions under the Murray-Darling Basin Compliance Compact, the NSW Government has committed to manage basin water resources using best available data and emerging technology. Better monitoring of water extracted will improve groundwater recharge models and help managers set extraction limits with greater accuracy.

The connections between groundwater and surface water systems is an area where knowledge and understanding could be improved. If closely-linked, such water systems have the potential to be managed holistically as a single integrated resource — another area in which groundwater management could benefit from further development.

Allocation

Some groundwater sources are not yet allocated. A process for controlled allocation of a proportion of this water has been formulated; such allocations are only made if they do not adversely affect surface water flows, other groundwater users, or the environment. Three controlled allocations of these groundwater sources have already been made, and new allocation orders are planned for release in 2019.

Groundwater-dependent ecosystems

Knowledge of groundwater-dependent ecosystems is still emerging. Better understanding of their location, characteristics, and levels of dependency on groundwater is needed. Little is also known about plants and animals living within, or dependent on, groundwater aquifers. These knowledge gaps make it difficult to manage groundwater systems in ways that will protect them.

However, two key stages of work to better identify the state's GDEs are now complete. First, the Department of Industry - Water released comprehensive mapping of high-probability GDEs. Read the report.

Second, GDEs were prioritised so they could be better managed, by assigning an ecological value to high probability GDEs. Methods used to assign them are based on the High Ecological Value Aquatic Ecosystem (HEVAE) framework (Aquatic Ecosystems Task Group 2012). This work identified a subset of high-probability, high-value GDEs across NSW. Going forward, managers can consider the risks to these GDEs posed by water extraction. They can determine whether controls are required to manage these risks, and whether monitoring or more information is needed.

References

References for Groundwater

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Coastal, Estuarine and Marine Ecosystems

The coastal, estuarine and marine waters of NSW contain high levels of biodiversity because of their wide range of oceanic, shoreline and estuarine habitats, and both subtropical and temperate currents.

Summary

Recreational water quality

84%

of monitored swimming sites scored very good or good for recreational water quality in 2016–17

Read more

Marine species

45

marine species are listed as threatened under NSW legislation

Read more

Saltmarsh in estuaries

17%

of estuaries have shown a decrease in areas of saltmash since 1985

Read more

Coastal living

85%

of the NSW population lives within 50 kilometres of the coast

Read more

Water quality and ecosystem health in the marine environment is generally good. Most coastal environments are in good condition, while the condition of NSW estuaries tends to be more variable and not as good.

At 84% of NSW beaches, recreational water quality, based on levels of pollution from stormwater runoff and sewage contamination, is rated as very good or good. The rating for coastal lakes and estuaries is 66%. The condition of individual estuaries and coastal lakes is highly variable and depends on their level of resilience to change and the level of disturbance of their catchment.

Forty-five marine species or populations are currently listed as threatened under NSW legislation including 21 marine seabird species and seven marine mammal species.

The greatest threats to the coastal and marine environment come from land use intensification, resource-use activities and climate change. Most coastal and estuarine areas have been modified to some extent, increasing pressure on the species that depend on them. Coastal development and land use continue to impact the viability of fauna populations, including threatened species. Only about one in five estuaries and coastal lakes retain more than 90% of natural, uncleared vegetation within their catchments, mostly along the south coast.

Related topics: Protected Areas and Conservation | Invasive Species

NSW indicators

Indicator and status		Environmental trend	Information reliability
Percentage of ocean and estuarine beaches with beach suitability grades for swimming of good or better	GOOD	Stable	✓✓✓
Chlorophyll *a* levels in estuaries	MODERATE	Stable	✓✓✓
Turbidity levels in estuaries	MODERATE	Stable	✓✓✓
Distribution of estuarine macrophytes	MODERATE	Variable	✓
Levels of estuarine catchment disturbance	MODERATE	Getting worse	✓✓

Notes:
Terms and symbols used above are defined in How to use this report.

Context

The NSW coastline is about 2,100 kilometres long and the state's marine jurisdiction extends 5.6 kilometres (three nautical miles) out to sea.

The coastal, estuarine and marine waters of NSW contain high levels of biodiversity. This is because of their wide range of oceanic, shoreline and estuarine habitats, and both subtropical and temperate currents.

Common estuary types in NSW are:

- the mouths and tidal reaches of drowned river valleys
- rivers with sand bars at their entrances (wave dominated rivers)
- intermittently closed and open lakes, lagoons and creeks
- large coastal lakes.

The broad characteristics of the NSW coast are:

- the north coast has broad coastal floodplains that have been extensively cleared and settled
- the Sydney Basin is highly urbanised with drowned river valleys cutting through sandstone plateaus

- the south coast is mostly less developed and has many coastal lakes and lagoons with relatively small catchments.

These varied environments and the habitats they support provide many important ecosystem services, such as:

- mitigating coastal and seabed erosion
- maintaining coastal water quality
- acting as critical habitats for fish and other marine life
- maintaining healthy aquatic ecosystems
- providing recreation, visual amenity and food production.

The desirability of coastal lifestyles and increasing settlement along the coast are placing estuaries and coastal lakes under higher levels of stress. The waters and ecosystems near urban, industrial and agricultural areas are particularly exposed to the effects of pollution from urban and agricultural runoff, stormwater and sewage discharge. The main threats to coastal, estuarine and marine waters are:

- land-use intensification, point discharges and hydrologic modification
- resource use activities including shipping, fishing, aquaculture, recreation and tourism, dredging, mining, flow modification and infrastructure
- climate change resulting in altered ocean currents and nutrients, air and sea temperature rise, ocean acidification, altered storm and cyclone activity, sea level rise and flooding and storm inundation (MEMA 2017).

Over the last decade, systematic data has been collected on the condition and long-term health of the coastal, estuarine and marine areas of NSW, and the important ecosystems they support. This data includes information on estuarine ecosystem health including:

- algal abundance
- water clarity
- seagrass depth
- oxygen levels.

There are significant knowledge gaps about threatened species and fish species abundance and variety.

Status and Trends

Water quality

The health of coastal, estuarine and marine ecosystems is heavily influenced by water quality. Water quality is naturally different between different estuary types. However, pressures on water quality over time can lead to reduced ecosystem health including:

- changes in the distribution and abundance of species
- algal blooms
- loss of habitat and biodiversity
- reduced recreational value and amenity.

Marine waters are generally considered to be in good condition as currents, wave action and tides are usually able to dilute and disperse pollution (for relatively small inputs). Marine waters are less vulnerable to degradation than estuaries and coastal lakes, especially those that are only intermittently open to the sea, where lower levels of tidal flushing result in a reduced resilience to pollution (BMT WBM 2017).

Even in well-flushed systems, sedimentation, local pollution from stormwater runoff, urban and industrial development and sewage system overflows can impact on water quality. Pollutants can accumulate in sediments, and bioaccumulation can then lead to adverse effects on ecosystems and human health. For example, contamination of Homebush Bay by dioxins and the Hunter River by per- and poly-fluorinated alkyl substances (PFAS).

Recreational water quality

Water at NSW beaches is mainly polluted by stormwater discharges and sewage overflows after heavy rain and agricultural runoff. Pollution of coastal waters with faecal material can threaten recreational users due to the pathogens (organisms that can cause a range of illness in humans) in the faecal matter. Polluted water may contain pathogens such as enteric bacteria, viruses, protozoa and worms.

The NSW Government administers the Beachwatch program, which monitors recreational water quality at swimming beaches in NSW. Beachwatch provides information on the level of sewage and stormwater pollution at beaches to indicate their suitability for swimming and recreational use, and to inform the community of the effectiveness of stormwater and wastewater management.

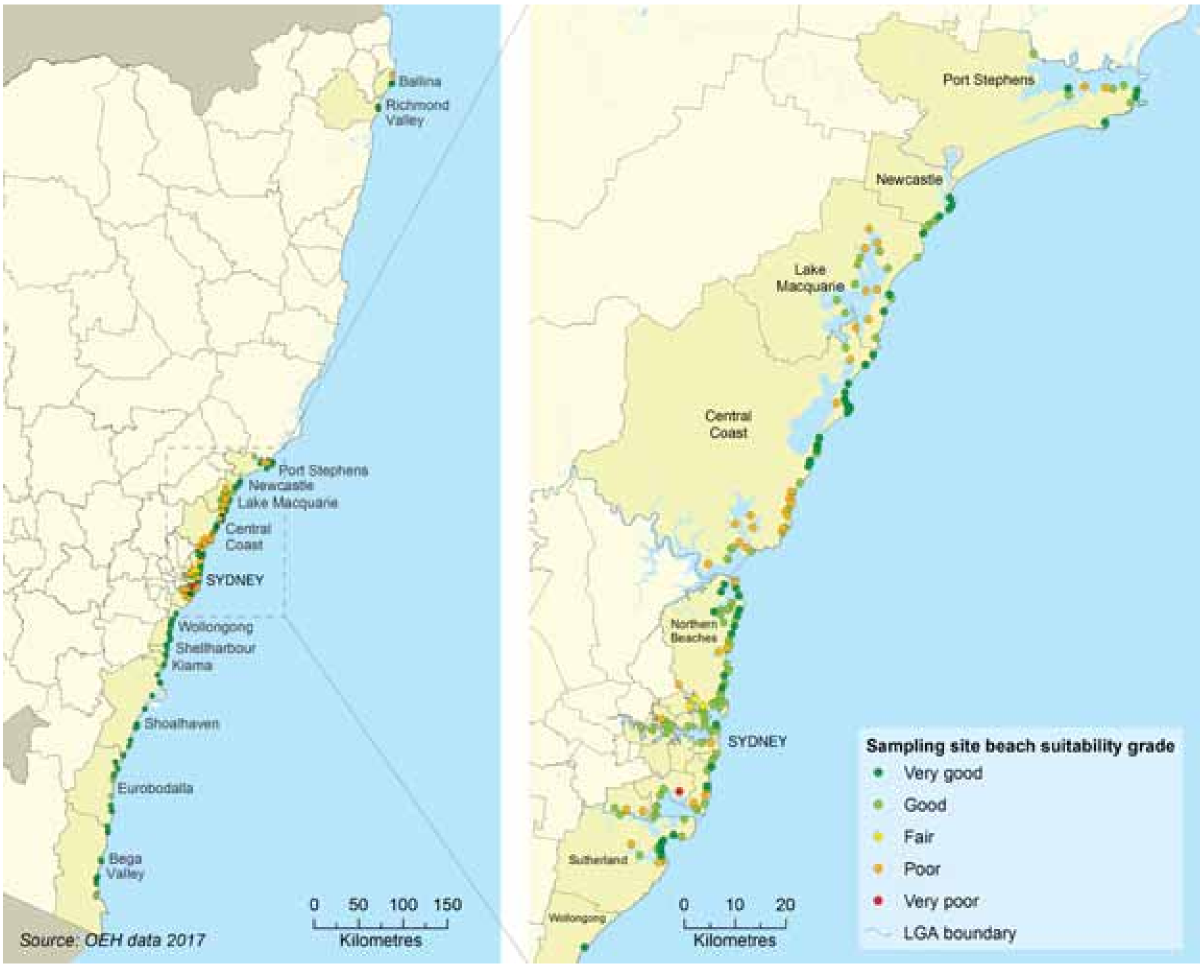
Beachwatch and the Beachwatch Partnership Program monitor 250 swimming sites.

- Beachwatch monitors 132 swimming sites in the Sydney, Hunter and Illawarra regions: 72 ocean beaches, 56 estuarine beaches, three lagoon/lake sites and one ocean rockpool.
- Regional coastal councils monitor beaches under the Beachwatch Partnership Program. In the 2016–17 swimming season, 10 local councils participated in this program, which monitored 118 swimming sites, including beaches, coastal lagoons, ocean baths, estuaries and rivers.

Swimming sites are assigned a beach suitability grade, ranging from 'very good' to 'very poor'. These relate to the Microbial Assessment Category (MAC), which detects levels of bacteria called enterococci to assess the risk of illness as determined in accordance with the Guidelines for Managing Risks in Recreational Water (NHMRC 2008).

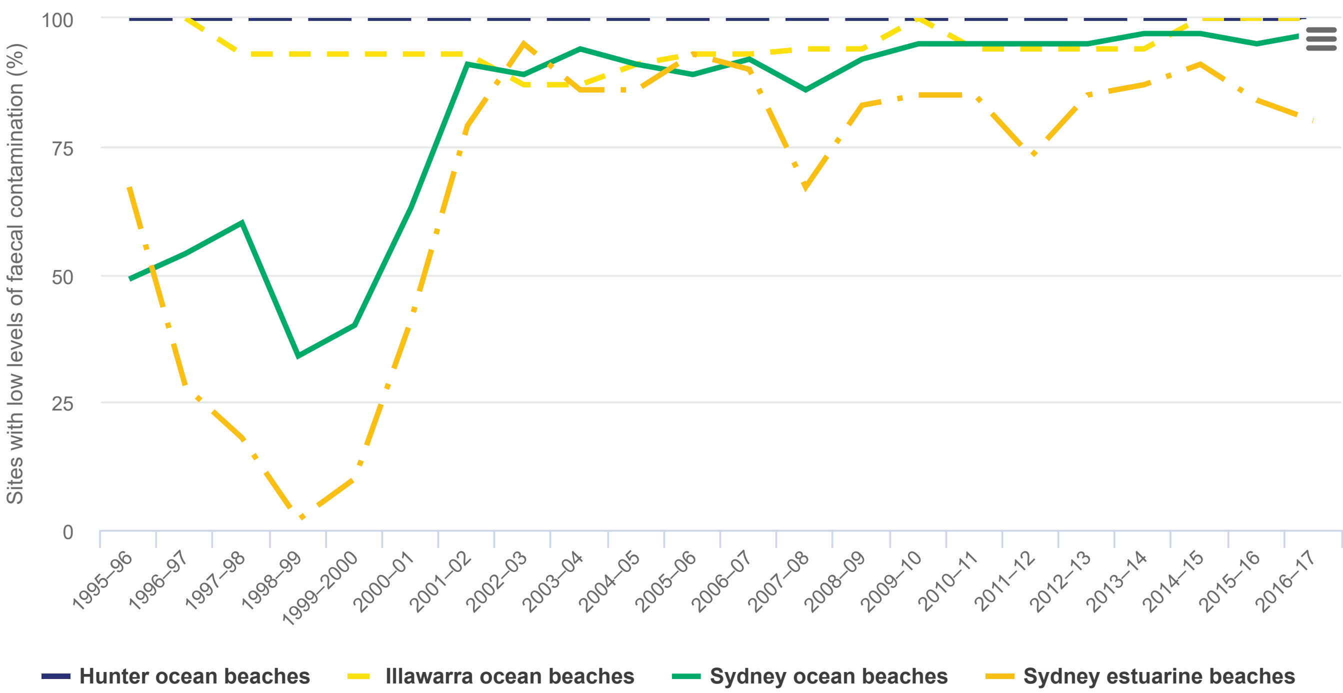
In 2016–17, 84% of the 250 swimming locations monitored were graded as 'very good' or 'good'. Nearly all ocean beaches (98%) and 73% of estuarine beaches achieved these ratings. However, only 43% of lake and lagoon swimming sites and one of the two ocean baths were graded as 'very good' or 'good,' reflecting their lower capability to dilute and flush pollution (**Map 20.1**).

Map 20.1: Beach suitability grades at coastal and estuarine swimming sites in NSW, 2016–17



Source:
OEH 2017

Figure 20.1 Percentage of Sydney, Hunter and Illawarra beach and estuary monitoring sites graded as having low levels of faecal contamination 1995-96 to 2016-17



Notes:
Includes Beachwatch data. Data from the Beachwatch Partnership Program is not included.

Source:
OEH 2018

Figure 20.1 shows the percentage of sites with low levels of faecal contamination over the past 22 years at ocean and estuarine beaches in Sydney, Hunter and Illawarra. It includes data from the Beachwatch program but not the Beachwatch Partnership Program. Microbial Assessment Categories are used to determine level of faecal contamination and have been applied to historical enterococci data. Microbial Assessment Categories A and B indicate generally low levels of faecal contamination are part of the assessment for a swimming site to achieve a 'very good' or 'good' beach suitability grade.

In 2016–17, 80% of Sydney estuarine beaches had low levels of faecal contamination, compared with the 91% of beaches with low levels in 2014–15 and despite variable rainfall conditions.

The longer-term trend shows there has been significant reduction in bacterial levels at swimming locations in the Sydney region since 1998–99 with most fluctuations due to rainfall patterns and the associated variation in the frequency and extent of stormwater and wastewater inputs.

Before about 2002, wet weather had a much greater impact on swimming locations in Sydney. While 1998–99, 2007–08 and 2010–11 were all wetter years, the levels of enterococci show great improvement over the years:

- **2%** of Sydney estuarine beaches had low levels of enterococci in 1998–99
- **67%** of Sydney estuarine beaches had low levels of enterococci in 2007–08
- **85%** of Sydney estuarine beaches had low levels of enterococci in 2010–11.

The significant reductions in bacterial levels at swimming locations in the Sydney region may be attributed to improvements in stormwater and wastewater management over the past 18 years. The latest results from 2016–17 indicate the need to improve the management of stormwater inflows to estuaries in urban catchments by continuing to adopt a risk-based approach to reduce the impacts of wet weather overflows from the wastewater network.

Estuarine water quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) provides default values and criteria for physical, chemical and biological factors related to water quality and recommends that local values be determined. Estuarine water quality is reported on using data collected through the NSW Government's Estuary Health monitoring program and is based on local values for NSW estuaries.

Eutrophication occurs when nutrients and organic matter lead to an excessive growth of plants, including algae, in estuaries. Consequences include:

- reduced water clarity leading to submerged aquatic plants and animals struggling to get the light they need to grow
- loss of oxygen in waters leading to death of animals
- toxins produced by some algae that threaten fish, shellfish and humans coming in contact with the water.

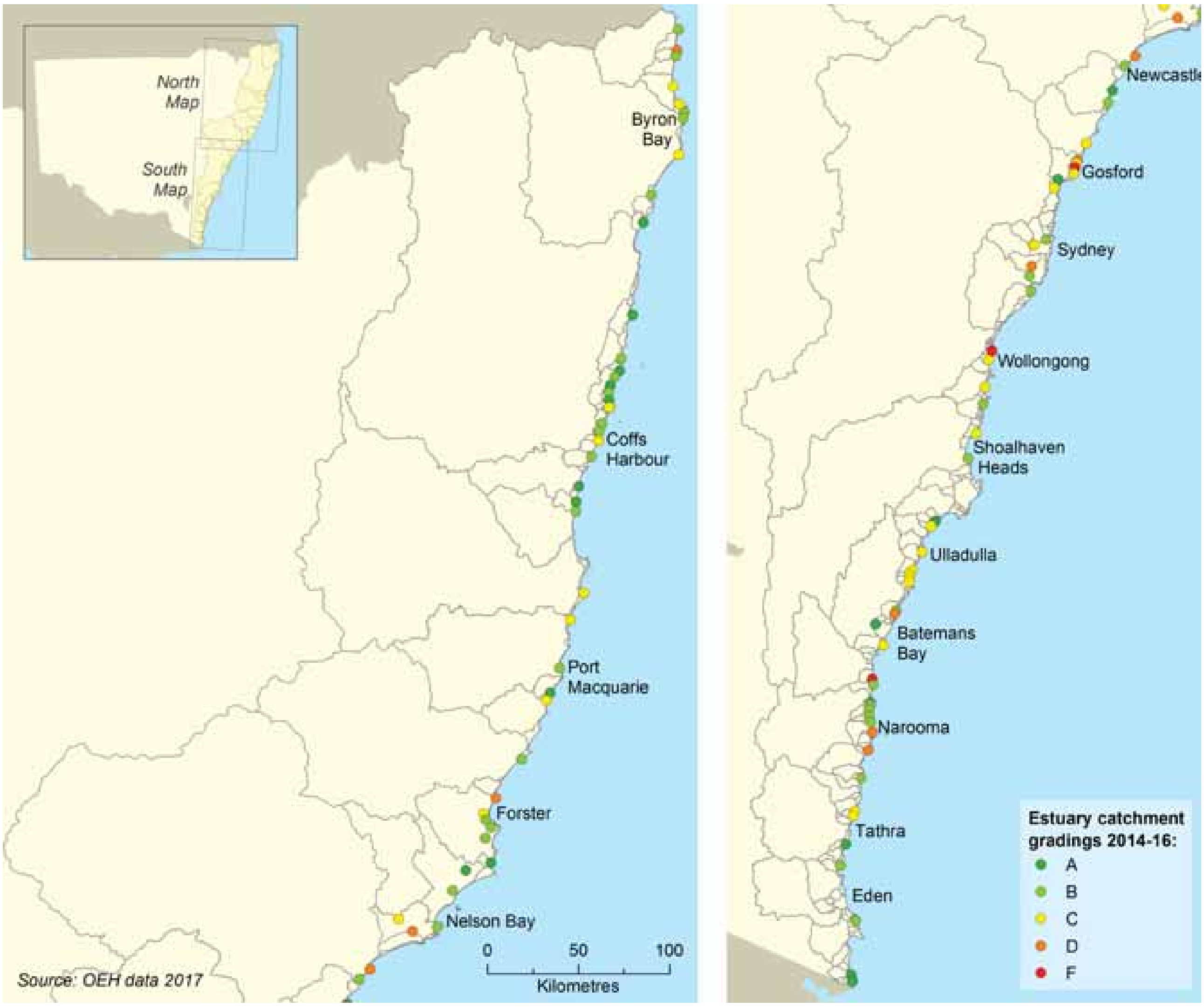
Abnormally high turbidity (poor water clarity) or high levels of chlorophyll *a* (indicative of high phytoplankton levels or algal blooms) can mean that a water body is experiencing eutrophication. Sometimes this can be attributed to natural causes (ocean upwellings, which have a close association with El Niño cycles, can lead to natural algal blooms), but often it is human-induced. High and moderate levels of disturbance result in significantly increased turbidity and chlorophyll *a* (OEH 2016).

The NSW Estuary Health Monitoring Program (OEH 2016, Hallett et al 2016) monitors waterway health by measuring chlorophyll *a* concentration, turbidity and oxygen content. The program has been collecting data from NSW estuaries since 2007, using the sampling design set out in Roper et al. (2011). The data have been used to calculate an Estuary

Health Index, with levels for estuaries ranging from A (very good) to F (very poor) (OEH 2016). Data on low oxygen content have not been included in the index as no chronic problems have been found, with the exception of infrequent low oxygen levels from flood events in the Hunter and Richmond Rivers that the program is not designed to detect.

Data on estuarine turbidity and chlorophyll *a* are available from July 2007 to March 2017 (MEMA 2017). The result of the turbidity and chlorophyll analyses have been combined into an overall score for each estuary for every year sampled. Estuaries with greater levels of catchment disturbance have had poorer results for both chlorophyll *a* and turbidity, as can be seen by the many grades for estuaries in the 2014–2016 period from Newcastle to Wollongong in **Map 20.2**.

Map 20.2 Estuarine Catchment Gradings 2014-2016



Source:
OEH 2017

Some estuaries have consistently poor or very poor grades, for example, Hunter River, Wamberal Lagoon, Terrigal Lagoon, Hawkesbury River, Manly Lagoon, Parramatta River, Cooks River, Towradgi Creek, Fairy Creek. These are all located in extensively developed catchments with large amounts of stormwater and some are subject to sewage discharges.

On the north and south coasts there are some consistently poor scores (e.g. Brunswick River, Belongil Creek (sewage), Salty Lagoon (sewage), Evans River (sewage), Flat Top Point Creek (sewage), Coffs Creek (urban and agricultural), Tilligery Creek (agricultural), Karuah River (agricultural), Tilba Tilba Lake (agricultural). Other systems have shown an improving trend such as Wallamba River (agricultural), Durras Lake and Nadgee Lake (both natural cycles) or intermittent rainfall-driven variation (Myall Broadwater).

Aquatic vegetation

Along the NSW coast, aquatic vegetation falls into two broad categories:

- Biota attached to rocky features such as reefs and headland plants rooted in sediments, mostly the estuarine macrophytes such as seagrass, mangroves and saltmarsh.
- Coastal vegetation, such as dune, coastal heath and woodland, and back-beach swamp ecosystems, are also important for the overall health of coastal environments.

These types of vegetation have not been systematically monitored. Trends in marine vegetation can be seen by analysing aerial photos from the late 1970s, although most of the major stressors due to land use changes and poor pollution practices occurred decades earlier.

Saltmarsh

Saltmarshes occur in 81% of NSW estuaries, with the dominant species being *Sarcocornia quinqueflora* (samphire), *Suaeda australis* (salt-couch), *Sporobolus virginicus* and *Paspalum vaginatum*.

The distribution of saltmarshes has been mapped at least twice in most estuaries in NSW. The results show there have been consistent declines in 17% of estuaries (23 out of 135) containing saltmarshes (MEMA 2017).

- The northern region (Tweed River to Port Stephens) contains 64% of the state's saltmarsh. Large areas of saltmarsh occur in Port Stephens, Wallis Lake, Clarence River and Macleay River. Saltmarsh has been re-mapped in 14 estuaries in the northern region over the last six years. There have been steady declines in area of saltmarsh in two estuaries and increased areas in three estuaries.
- Saltmarsh habitat in the central region is in 17 estuaries, with the largest areas in the Hunter River, the Hawkesbury River, Botany Bay and Brisbane Waters. Only Lake Macquarie has been re-mapped during the last six years. Saltmarsh had decreased in area by six hectares since 2009, but this is similar to the area of saltmarsh mapped in 1985.
- Saltmarsh has been mapped in 63 estuaries in the southern region of NSW. The largest area is in the Shoalhaven River, followed by Jervis Bay and the Clyde River. Between 2005 and 2015, only eight estuaries in the southern region were re-mapped. Of these, the area of saltmarsh had decreased in two. In 2017, saltmarshes were mapped in an additional six estuaries in the Eurobodalla Shire. Decreased areas of saltmarsh were reported in two estuaries, with increased areas in four estuaries (Finley & Yee 2018)

Mangroves

Six mangrove species occur in NSW, with the two most common being the grey mangrove (*Avicennia marina*) and the river mangrove (*Aegiceras corniculatum*).

Mangroves occur in 60% of NSW estuaries, being largely absent from intermittently open lagoons, lakes or creeks. The spread of mangroves may be related to human activities and is often associated with declines in saltmarsh (Mitchell & Adam 1989, Saintilan & Williams 1999).

The distribution of mangroves has been mapped at least twice in most NSW estuaries since 1985 (MEMA 2017).

- Mangroves are found in most northern region estuaries, with significant increases in area mapped between 1985 and 2012. Mangroves have been re-mapped in 14 estuaries in the northern region over the last seven years. In all, mangrove area has remained relatively stable, except for an increased area of mangroves in two rivers.
- Mangrove habitat in the central region is present in 72% of estuaries. The largest areas of mangroves are in the Hunter River, followed by the Hawkesbury River and Botany Bay. Only Lake Macquarie has been re-mapped over the last six years, where mangrove area remained relatively stable.

- Many (62%) mapped estuaries in the southern region do not contain mangroves. The estuaries with the greatest area of mangrove are the Shoalhaven River, the Clyde River and Jervis Bay. Between 2005 and 2012, eight estuaries were mapped, and mangrove area had increased in all of them except for Tuross Lake. In 2017, mangrove areas were mapped in six estuaries in the Eurobodalla Shire and all had increased areas since 2012, including a recovery of mangroves in Tuross Lake (Finley & Yee 2018).

Seagrasses

Seagrasses are found mainly in shallow waters of protected estuaries and bays. Dominant species are *Posidonia australis* (strapweed) and *Zostera muelleri ssp. capricorni* (eelgrass). Populations of *Posidonia australis* are listed as endangered in six NSW estuaries due to recent population declines (*Fisheries Management Act 1994*). *Posidonia australis* in the Manning-Hawkesbury bioregion is also listed as an endangered ecological community (EPBC Act).

Abundance of smaller species of seagrass (*Zostera*, *Ruppia*, *Halophila*) can fluctuate greatly over time due to variation in salinity in estuaries with large catchments and other reasons. It is often not possible to attribute declines in total seagrass area to human activities (BMT WBM 2017).

- Seagrasses have been recorded in 80% of mapped estuaries in the northern region. The greatest areas of seagrass are in Wallis Lake, Port Stephens and Camden Haven. *Posidonia* occurs only in Wallis Lake and Port Stephens, and in both estuaries this species has increased in area over the last 10 years. Between 2004 and 2017 there was a decline in total seagrass area (primarily driven by *Zostera*) in the Lower Myall River of around 91 hectares or 61% of area loss, although this magnitude of decline is not uncommon in many NSW estuaries.
- Seagrass is in 84% of mapped estuaries in the central region. The largest areas of seagrass are in Tuggerah Lake, Lake Macquarie, Lake Illawarra, Brisbane Waters and Botany Bay. Only Lake Macquarie has been re-mapped over the last 10 years, with areas of *Posidonia* remaining relatively stable from 2009–2013, while total seagrass area declined by 336 hectares (22% loss), due primarily to losses in *Zostera*. In the mid-2000s, an entire *Zostera* meadow 6.5 hectares in size, which had been present since at least 1978 (West & Williams, 2008), was lost from Rose Bay in Port Jackson, and there are still no signs of recovery.
- Seagrass occurs in 85% of estuaries in the southern region, with *Posidonia* in only eight of these. The largest areas of seagrass occur in Jervis Bay. Seagrasses have been mapped in eight estuaries in the southern region over the last six years. Of these, *Posidonia* occurs in only one (Batemans Bay) and its area has remained relatively stable. Total seagrass area increased in two estuaries between 2004 and 2012, while there was a large reduction in total seagrass area in Tuross Lake. In 2017, seagrasses were mapped in six estuaries in the Eurobodalla Shire (Finley & Yee 2018), with seagrass areas remaining stable in all six estuaries since 2012, with the exception of Tuross Lake where the seagrass area declined substantially.

Threatened species

Forty-five marine species or populations are currently listed as threatened (up from 41 reported in 2015) in the *Fisheries Management Act 1994* (FM Act) and the *Biodiversity Conservation Act 2016* (BC Act). These include:

- 21 marine seabird species (there are also 16 other marine birds including shorebirds, waders, eagles and hawks)
- seven marine mammal species
- seven fish species
- three reptile species
- four marine invertebrate species
- two macroalgae species
- one marine vegetation species.

Little is known of the status of many marine organisms, particularly invertebrates. The number of species listed will probably grow as pressures on the marine environment increase. Species such as sharks, tuna and whales remain the most vulnerable to threats.

Poorly located or inappropriate coastal development is threatening the viability of fauna populations including threatened species. For example, studies have found adverse impacts from artificial lighting, including street lighting, on turtle hatchings and breeding patterns (Truscott et al 2017) and a reduction in migratory seabird and shorebird habitat due to foreshore hardening and disturbance from recreational activity (Umwelt 2017, DEC 2006).

See the Threatened Species topic for more information.

Pressures

Catchment disturbance

More than 85% of the NSW population lives within 50 kilometres of the coast and most coastal catchments in the marine estate have some level of land-use activity or development (MEMA 2017). Only 12 of the 184 main catchments in NSW remain undeveloped, and these are mostly in the south towards the NSW and Victorian border (MEMA 2017).

The most developed catchments, where over 80% of land is developed, are predominantly urbanised. Typically, urban areas are adjacent to main waterways; while agricultural areas, forestry and mining operations are in the upper parts of the catchment.

The top four threats to coastal and marine environments are associated with land-use intensification (BMT WBM 2017) and are:

- urban stormwater discharge
- modifications at the entrance of estuaries to enable access
- agricultural runoff in estuaries
- clearing riparian and adjacent habitat, including draining wetlands.

The extent of land use activity in all coastal catchments has been summarised by a catchment disturbance index, which ranges from very low disturbance (5) to very high (1). The index was derived for the NSW Monitoring, Evaluation and Reporting Strategy 2010–2015 (DECC 2010, Roper et al 2011), and contains pre- and post-European pollution levels modelled using the NSW Government's Coastal Eutrophication Risk Assessment Tool.

The sensitivity of estuaries to impacts resulting from land use intensification varies due to the type of estuary, likelihood of intensification and pollutant removal efficiency (Roper et al 2011). There are 93 estuaries identified as sensitive to impacts from land use (OEH 2017) including:

- 25 in the northern region
- 21 in the central region
- 47 in the southern region.

Table 20.1 (MEMA 2017) shows that the population has increased faster on the north and south coasts – 36–40% of catchments have population increases of over 20% – while there is an increase of only 10% in central NSW.

- In the north region 44–45% of estuaries are situated in areas with the highest population density and nutrient export from runoff and overflows. This region has the greatest hydrological modification of estuary function.
- The central region has the greatest levels of urbanisation, so 85% of estuary catchments with the highest population densities, and high levels of nutrients and sediment are exported to 70% of estuaries.
- The south region has just 17–18% of estuary catchments in areas of high population density and nutrient categories.

Table 20.1: Proportion of NSW estuary catchments in the two highest disturbance ranks (statewide) for population density, nutrient increase and commercial fish catch

Factor	Number of estuaries with a high disturbance[a]	Number of estuaries	Percent[b]
Northern			
Population density	24	55	44%
Nutrient increase	25	55	45%
Commercial catch	5	55	9%
Population increase (>20%)	20	55	36%
Central			
Population density	34	40	85%
Nutrient increase	28	40	70%
Commercial catch	1	40	3%
Training walls	7	40	18%
Population increase (>20%)	4	40	10%
South			
Population density	16	89	18%
Nutrient increase	15	89	17%
Commercial catch	3	89	3%
Training walls	9	89	10%
Population increase (>20%)	36	89	40%

Notes:
[a] Estuaries with a disturbance rank of 1 or 2.
[b] Percentage of estuaries with training walls (modifications) and proportion of estuaries with a more than 20% increase in population between 1996 and 2006 in the northern, central and southern regions.

Source:
Source: MEMA 2017, all data from Roper et al (2011)

Pollution

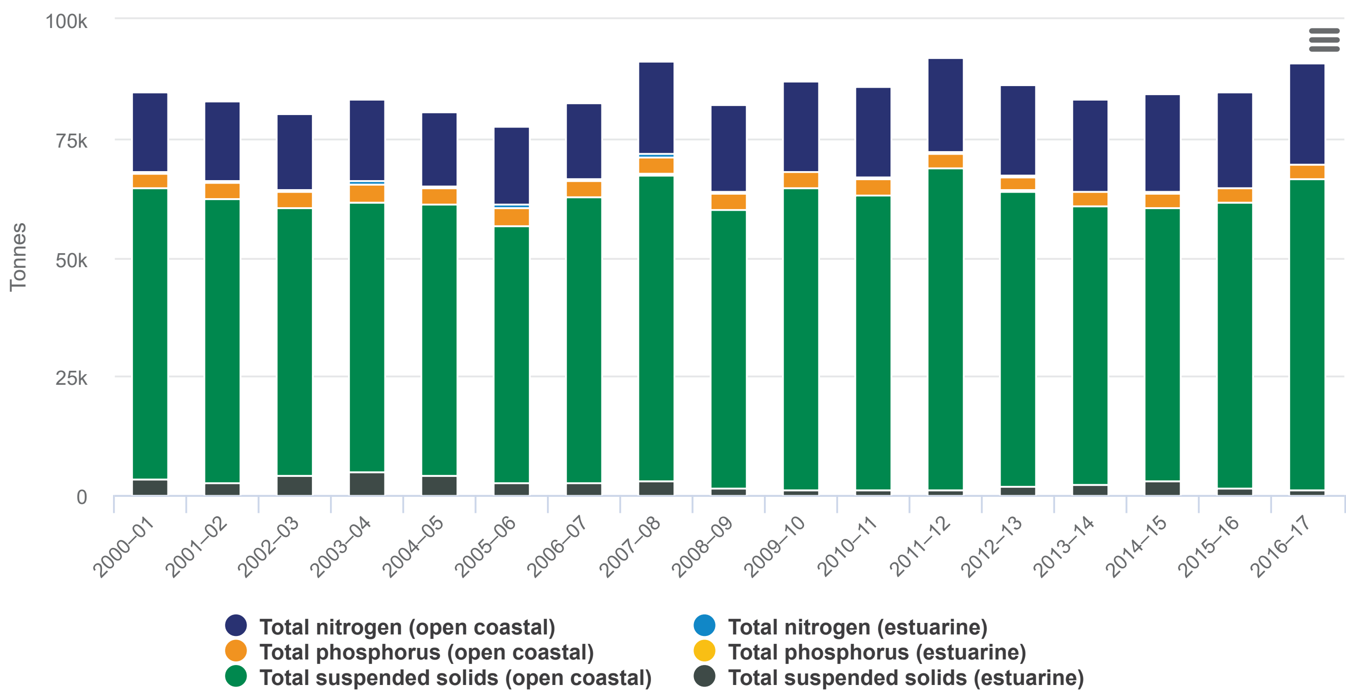
The most significant priority threats for water pollution on environmental values are urban stormwater discharge, agricultural diffuse source runoff and solid waste, marine debris and microplastics.

Discharge of nutrients, sediments, metals, toxins, and other chemicals and pollutants into coastal waters also occurs from the many small catchments that front the coast. This often involves untreated urban stormwater and agricultural runoff. Some catchments will also have licensed discharges from industries such as those dealing with minerals production and refining; and sewage treatment plants.

Figure 20.2 shows licensed discharge loads of total nitrogen, phosphorus and suspended solids to open marine waters and estuaries.

Loads discharged to estuarine environments have been generally decreasing over this period. Discharges of suspended solids tend to reflect wet and dry periods, such as El Niño cycles, and are relatively stable, although these discharges have increased in open coastal waters in 2016-17, but have generally remained stable.

Figure 20.2: Licensed discharges to NSW open marine waters and estuaries, 2000–01 to 2016–17



Notes:
Data covers all licensees discharging into the marine environment under the Load-based Licensing Scheme.

Source:
EPA data 2018

Urban stormwater and agricultural runoff are recognised as significant contributors of nutrients to marine waters. Refer to the status and trends section of this topic for detail on nutrients and water quality. Additional sources of coastal and marine pollutants include:

- garbage washed or blown from land
- discarded commercial and recreational fishing gear
- material from shipping operations and incidents, such as ballast water discharges and sewage released from vessels, and oil or chemical spills.

No major shipping-related pollution incidents have been recorded in NSW marine waters over the last three years. However, in Commonwealth Waters in June 2018 cargo loss from the Liberian-flagged ship, YM Efficiency, approximately 30 kilometres off the coast of Port Stephens resulted in debris in NSW waters and on the Mid North Coast and Nelson Bay peninsula.

Entanglement and ingestion of debris can be fatal to marine species, particularly threatened species such as seabirds, turtles and whales. The NSW Government's *Biodiversity Conservation Act 2016* lists 'entanglement in or ingestion of anthropogenic debris in marine and estuarine environments' as a key threatening process. Recovery in the populations of threatened species, such as humpback whales, is likely to result in more accidental entanglements.

As much debris is plastic, which both floats and is slow to degrade, the impacts are multiple and long-lasting. See the Waste topic in this report for more details.

Climate Change

‘Human induced climate change’ is listed as a key threatening process under the *Fisheries Management Act 1994* and 'anthropogenic climate change’ under the *Biodiversity Conservation Act 2016*. Key components of climate change that are considered to have potential impacts on the NSW marine environment (MEMA 2017) are:

- altered storm and cyclone activity, flooding, storm surge and inundation
- altered ocean currents and nutrients
- climate and sea temperature rise
- sea-level rise
- ocean acidification.

Sea level rise, major storms and floods are having adverse impacts on coastal geomorphological processes including the cyclic accretion of sand onto beaches. The loss of sand from beaches and other changes to the NSW coast due to sea level rise, storm surges and inundation will continue to impact on coastal amenity.

Predictive studies show that the change in the movement of the East Australian Current could greatly affect future species distributions in NSW estuaries (Cetina Heredia et al 2015), though this is an area that requires further research.

Climate change can result in increased water temperatures, often known as ‘marine heat waves’ with extreme consequences for survival of marine and estuarine animals, and changes in ranges for many species. Changes in tidal levels from estuary entrance modifications or sea level rise has major consequences for critical marine habitats such as beaches, mudflats, seagrasses, mangroves and saltmarsh, with flow-on consequences for all the organisms that rely on them (MEMA 2017).

The long-term impacts of climate change will magnify effects on the NSW marine environment. Significant effects are expected to occur across south-east Australia (Hobday et al 2006, Wernberg et al 2011, Verges et al 2016), including changes to:

- marine species distribution and abundance
- variations and timing of life cycle events
- physiology, morphology and behaviour (e.g. rates of metabolism, reproduction, development)
- biological communities via species interactions.

Further specific studies have identified that increases in temperature are likely to result in:

- spread, establishment and virulence of pathogens and exotic species (Wernberg et al 2011, Campbell et al 2011, Harvell et al 2002)
- changes in range and distribution of harvested species (Pecl et al 2011)
- composition and interactions in aquatic communities and the structure and dynamics of communities (Verges et al 2016)
- disease in seaweeds and invertebrates (Campbell et al 2011, Sweet et al 2016)
- poleward contraction of marine organisms and habitats (Smale & Wernberg 2013, Fowler et al 2017)
- a reduction in kelp habitat and associated change in community composition and ecosystem function, particularly in northern NSW.

Ocean acidification may emerge as an important pressure in future decades with evidence of impacts on calcifying immobile animals (Parker et al 2013, Ross et al 2011, Havenhand et al 2008). A particularly vulnerable group is marine molluscs (e.g. oysters, abalone and whelks) in their reproductive stages (Parker et al 2010, Scanes et al 2014). Acidification already interacts with temperature to reduce fertilisation success in Sydney rock oysters, resulting in their smaller size, longer time to develop and increased abnormality of larval stages (Parker et al 2010) and with other stressors to limit survival (Scanes et al 2017).

See the Climate Change topic in this report for more details.

Invasive species

Marine invasive species are plants or animals, often introduced from overseas, that can take over habitats and directly compete with native species for food. Some marine pests are native to other regions of Australia but have been transported into NSW through shipping or the aquarium trade.

The main invasive marine species in NSW are:

- *Caulerpa taxifolia* (green alga)
- *Carcinus maenas* (European green crab)
- *Sabella spallanzanii* (European fan worm).

Other marine pests found in NSW include:

- *Tridentiger trigonocephalus* (Japanese goby)
- *Maoricolpus roseus* (New Zealand screw shell).

The introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW is listed as a key threatening process under the *Fisheries Management Act 1994*.

There is no statewide monitoring program for invasive species in NSW, although much research and monitoring was undertaken after the green alga *Caulerpa taxifolia* was introduced in 2000 and ad hoc surveys have been done for different species in particular locations.

Caulerpa taxifolia was particularly abundant in Burrill Lake and Lake Conjola but has not been seen in either lake since 2013. Wallagoot Lake was officially declared free of Caulerpa in 2013 when surveys failed to detect the presence of the marine pest following significant control efforts. Over recent years, Caulerpa has been reported in 14 estuaries or lakes from Lake Macquarie to Wallagoot Lake in the south. *Caulerpa taxifolia* in Lake Macquarie continues to persist, with a new highly populated creek area confirmed during 2018.

There are historical reports of *Carcinus maenas* from estuaries as far north as Port Jackson, but there have been no recent sightings of Carcinus in any estuaries north of Narawallee Inlet. Surveys since 2011 have documented the presence of Carcinus in 27 estuaries south of Narawallee Inlet to the Victorian border (DPI 2017a).

Sabella spallanzanii was known only in Twofold Bay until April 2013 when it was discovered in Botany Bay (Murray & Keable 2013).

Resource use

Marine resource use, including shipping, recreation and tourism, dredging, modified and freshwater flows, are identified as sources of threats (BMT WBM 2017).

Fishing has potential impacts on the natural food chain. Commercial and recreational fishing is undertaken in the coastal, estuarine and marine waters of NSW. Three commercial fisheries operate in NSW estuarine waters:

- estuary general fishery

- estuary prawn trawl fishery.

Commercial fishing is permitted in only 86 of the 184 estuaries along the NSW coast, with recreational fishing only permitted in many estuaries. Of those commercially fished, 18 estuaries account for over 95% of the total estuarine commercial catch, which was around 4,500 tonnes in 2013–14.

The following fisheries operate in coastal and marine waters:

- ocean trap and line
- ocean trawl
- ocean hauling
- rock lobster
- sea urchin
- turban shell and
- abalone
- southern fish trawl.

In 2013–14 commercial catch in NSW coastal and marine waters was around 8,585 tonnes (excluding Southern Trawl Fishery). There were more catches for some species in Commonwealth waters.

Recreational fishing occurs throughout estuarine, coastal and marine waters of NSW. Most recreational fishers use line fishing to catch different species. The composition of the recreational catch varies along the coast, mostly reflecting differences in the distribution of the key harvested species, with many of the same species also harvested in the commercial fisheries.

Commercial and recreational fishing place pressures on fish numbers as well as the broader environment by:

- reducing the abundance of species and interfering with the natural food chain
- causing incidental by-catch, including species of conservation concern
- disturbing wildlife and the marine environment.

Impacts on fish populations vary considerably and are strongly influenced by:

- the number, type and population status of harvested species
- levels of fishing
- type of specific management arrangements.

Several threatened and protected species managed under the *Fisheries Management Act 1994*, particularly grey nurse shark, white shark and black cod, are threatened by:

- illegal fishing
- injury due to accidental capture by fishers
- entrapment in shark mesh nets.

Hook and line fishing in areas important for the survival of threatened fish species is listed as a key threatening process under the *Fisheries Management Act 1994*. The shark meshing program in NSW is also listed as a key threatening process under the *Fisheries Management Act 1994* and the *Biodiversity Conservation Act 2016*.

Responses

Legislation and policy

Marine estate management framework

The *Marine Estate Management Act 2014* (MEM Act) provides for the strategic and integrated management of the marine estate in NSW. The MEM Act mandates an environmental, social and economic threat and risk assessment (TARA) to be undertaken for the entire NSW marine estate, including coastal waters, lakes and lagoons, estuaries and coastal wetlands.

The TARA (BMT WBM 2017) assesses the pressures on the environmental assets and the social, cultural and economic benefits derived from the NSW Marine Estate (all estuarine, coastal and marine waters up to the tidal limits). It considers how activities create pressures (defined as stressors) on natural assets, and the threat this poses to benefits. The TARA has informed the development of nine new management initiatives in the *Marine Estate Management Strategy 2018–2028* and will inform new marine park management plans and related coastal management programs.

Coastal management framework

The *NSW Coastal Management Act 2016* (CM Act) establishes the new framework and objectives for coastal management in NSW. The framework comprises the:

- *Coastal Management Act 2016*
- State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP)
- NSW Coastal Management Manual
- Coastal Management Programs (see following section)
- NSW Coastal Council
- Coastal and Estuary Grants Program.

The CM Act defines the coastal zone which is made up of four coastal management areas. The CM SEPP includes maps of the coastal zone and coastal management areas according to the definitions in the CM Act and establishes development controls to be applied in each area to achieve the objectives of the CM Act. Coastal management in NSW supports the objects of the *Marine Estate Management Act 2014*.

Environment protection legislation

The *Environmental Planning and Assessment Act 1979* sets the framework for land use planning decisions. It is complemented by state environmental planning policies (SEPPs) that deal with planning issues for the coastal zone, including matters arising under the CM SEPP, SEPP No. 50 – Canal Estate Development and SEPP No. 62 – Sustainable Aquaculture.

The *Protection of the Environment Operations Act 1997* regulates point source discharges into coastal, estuarine and marine environments.

Fisheries management legislation

The *Fisheries Management Act 1994* and supporting regulations aim to conserve, develop and share fishery resources for the benefit of present and future generations by:

- conserving fish stocks and key fish habitats
- protecting threatened species, populations and ecological communities of fish and marine vegetation

- promoting ecologically sustainable development.

Programs

Coastal management programs

Coastal Management Programs (CMPs) set the long-term strategy for coordinated management of the coast, with a focus on achieving the objects of the CM Act. They are prepared by local councils in consultation with their communities and relevant public authorities. The coastal management manual provides mandatory requirements and guidance for CMPs by local councils. CMPs are key mechanisms in the implementation of actions identified in the MEM Strategy.

The Marine Estate Management Strategy

The Marine Estate Management Strategy 2018–2028 (MEM) proposes nine initiatives to address the priority and cumulative threats to the environmental assets and community benefits derived from the NSW marine estate. The MEM Strategy provides an overarching framework to manage the marine estate as a single continuous system over the next 10 years. The initial stage will focus on dealing with threats posed by water pollution and marine litter, with complementary activities to:

- deliver healthy coastal habitats and sustainable land use
- protect Aboriginal cultural values
- reduce threats to marine wildlife
- deliver safe and sustainable fisheries and recreational boating
- enhance social, cultural and economic benefits.

The Strategy's marine litter initiative is being assisted by current NSW litter programs, including a container deposit scheme – see the Waste and Recycling topic.

The Risk-based Framework

The Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (Dela-Cruz et al 2017) is a protocol to help decision-makers manage the impact of land-use activities on the health of waterways in NSW. It enables decision-makers to determine management responses, which meet waterway health outcomes that reflect the community's environmental values and uses of waterways.

Marine Water Quality Objectives

The Marine Water Quality Objectives for NSW Ocean Waters (DEC 2005) describe the water quality needed to protect the community's values for, and uses of, the marine environment and are used in coastal planning and management planning strategies covering land use and catchment management.

AdaptNSW

The NSW Government AdaptNSW program is developing information and tools to help government, businesses and communities build resilience in the face of future extreme events and hazards. The Coastal Processes and Responses node researches risk to and management of the impacts of climate change on coastal and estuary zones.

Regional plans

Regional plans are being developed to plan for future population needs for housing, jobs, infrastructure and a healthy environment. These plans set a strategic direction for rapidly growing coastal regions.

Commercial Fisheries Business Adjustment Program

The Commercial Fisheries Business Adjustment Program has provided enhanced management structures to promote sustainability and viability throughout NSW commercial fisheries. The program has provided significant reforms including introduction of additional direct catch and effort quota management structures and measures to rationalise potential fishing effort. The new management arrangements will result in increased certainty for the management of key commercial species and allow effective and efficient controls for the management of commercial harvest. Implementation of the new arrangements commenced in 2017 and will conclude in 2019.

Harvest Strategies

Harvest strategies provide best practice frameworks for assessment and management of fisheries resources. The NSW Government is in the process of developing a policy framework and harvest strategies that will provide improved assessment, monitoring, and management objectives with an initial focus on commercial harvest.

Sustainable Aquaculture Strategies

Sustainable aquaculture strategies have been developed to guide sustainable seafood production to support future demands of food security for the state.

The NSW Land Based and Oyster Industry Sustainable Aquaculture Strategy outlines industry best practice, a streamlined approvals process, secure oyster leases for future generations and highlight protection of water quality. It is complemented by the Healthy Estuaries for Healthy Oysters - Guidelines, prepared to meet the requirements of the NSW Diffuse Source Water Pollution Strategy. The Guidelines aim to not only protect environmental conditions required for healthy oyster production, but also to improve estuarine water quality to benefit recreational users, tourism, and recreational and commercial fisheries.

A NSW Marine Waters Sustainable Waters Aquaculture Strategy has been drafted to set the overarching strategy for the NSW Government to co-ordinate development of the marine aquaculture industry. It provides regulatory and industry best practice framework for development of the NSW marine waters aquaculture industry in an ecologically sustainable and socially responsible manner.

Fisheries Compliance

NSW DPI Fisheries Compliance works to reduce the risks to fish stocks and aquatic habitats in NSW. Fisheries officers operate from 28 strategically placed locations along the coast and inland to ensure compliance in all recreational fishing, commercial fishing, aquaculture, and marine protected areas programs in NSW (including marine reserves and marine parks).

Using a risk-based approach the group strives to optimise compliance with fisheries and marine estate management rules by maximising voluntary compliance and creating effective deterrence against illegal activity.

Each year fisheries officers detect around 6,000 offences and seize more than 40,000 illegally obtained fish and 3,000 items of illegal fishing gear.

Non-government initiatives

Teaching and research facilities contribute data and information to Government initiatives. The Sydney Institute of Marine Science (SIMS) is a partnership between the four main universities in the Sydney region and several research institutes including the Australian Museum. SIMS has over 100 scientists and graduate students associates with the Institute and represents a broad array of projects. It provides information directly to policy makers and managers in NSW. Flagship projects run through SIMS include the World Harbour Project, the NSW node of the Integrated Marine Observing System (IMOS), and the Sydney Harbour Research Program.

Australian Government activities

The National Water Quality Management Strategy (NWQMS) is a joint national approach to improving water quality in Australian and New Zealand waterways. The NWQMS involves development and implementation of management plans for estuaries, coastal waters and other water bodies by the community and government. These plans focus on the reduction of pollution released into coastal pollution hotspots and other aquatic ecosystems around the country. The Great Lakes (Wallis, Smiths and Myall Lakes), Botany Bay, and the Hunter River estuary and its catchment have been identified as hotspots in NSW.

Local government, community organisations and other agencies carry out these plans using the NWQMS to protect agreed environmental values.

Future opportunities

The NSW Government will need to continue to develop and implement suitable management and adaptation strategies to prevent a decline in the quality of coastal, estuarine and marine environments. The poor condition of water quality in some highly urbanised estuaries suggests that stormwater runoff and new urban development can be managed better to maintain the health of estuaries and coastal lakes and the desirability of coastal lifestyles.

Vulnerability to inundation and coastal erosion should be a significant consideration in the location and planning of future developments for an expanding population.

Areas of further improvement could include:

- collaboration between the community, local, state and national governments and research institutions to make the most efficient use of available marine resources
- strengthening comprehensive ecosystem health monitoring programs to provide sound scientific input to decision making
- further developing and expanding risk assessment methods to help protect and rehabilitate the environment in the most resource efficient manner
- consistently applying the risk-based framework across NSW as a best-practice protocol for managing the impacts of land-use change activities on waterway health.
- clarifying agency roles and responsibilities for diffuse source water pollution in NSW.

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