New South Wales

State of the Environment 2015

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2015

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FOREWORD

Nature has both an intrinsic value in and of itself and an instrumental value as the environmental infrastructure that underpins our economy and sustains our community. That is why the state of the 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 for ourselves, for future generations and for the environment.

I am pleased to present the Environment Protection Authority's ninth *NSW State of the Environment*. This report supports the work the EPA already undertakes by outlining the status and condition of major environmental resources and the associated environmental trends and implications for the environment and human health. The report uses the most up-to-date information from a range of government agencies and authorities.

This latest report explains the challenges we have overcome, notes the issues we are still working on, and explores emerging challenges.

Air quality continues to be generally good overall, with low concentrations of lead, carbon monoxide and sulphur dioxide. Ozone and particle pollution levels require ongoing attention.

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

Since 2012, the area of public land reserved under the *National Parks and Wildlife Act 1974* has increased by about 26,600 hectares. This includes significant reservations in the South Coast (Dharawal National Park), Sydney (Berowra Valley), Darling Riverine Plains (Warrambool) and near Moree (the Gwydir wetland). The Conservation Partners Program has helped encourage and support conservation on private land, which is of growing importance to restore connected, resilient landscapes.

There are several challenges that we are working to address, such as the decline of NSW threatened species and our greenhouse gas emissions.

The government's *Saving our Species* program was established to protect all threatened species over the next century and has been bolstered with $100 million over the next 5 years, and the legislative reform we are undertaking will help safeguard biodiversity at a bioregional scale.

The government is also implementing its Renewable Energy Action Plan and the Energy Efficiency Action Plan in order to increase the use of sustainable energy sources and improve energy efficiency, to continue the downward trajectory of NSW emissions.

NSW State of the Environment 2015 reminds us that challenges also present opportunities. They present the opportunities to improve our economy, our environment, and our health and amenity at the same time, through ecologically sustainable development. The government is committed to working with communities, industry and other stakeholders to better protect and conserve the environment, to enhance our wellbeing, and to meet the challenges ahead.

Mark Speakman

Minister for the Environment

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PREFACE

In November 2011, the NSW Government passed legislation to strengthen and reinvigorate the Environment Protection Authority (EPA). One of the principal requirements of the reforms to the EPA was to increase its transparency through clear reporting and thus improve the community's access to information.

The New South Wales State of the Environment (SoE) Report is prepared every three years by the EPA in accordance with the requirements of the *Protection of the Environment Administration Act 1991*. This is the ninth SoE report in NSW and continues to build on the valuable time-series data of previous reports.

The *NSW State of the Environment 2015* (SoE 2015) provides an overview of the NSW environment using the best information available. As required under section 10 of the Act, the report assesses the status and condition of major environmental resources and examines environmental trends. The report also describes the pressures that affect the environment and the responses to those pressures.

SoE 2015 reflects the continuing trend of improvement and refinement of reporting shown over the previous eight iterations of the report. It assembles a wide range of information from a large array of sources into a format that is accessible to the wider community, yet still provides scientific rigour.

For SoE 2015 20 themes are presented in two parts: Environmental Drivers and Environmental Resources. The report provides ratings of the status and trend for 65 indicators across the 20 themes.

Preparation of SoE 2015 has relied on extensive contributions from many other NSW Government departments and agencies and within the EPA. The data and information provided was appraised and validated by the contributing organisations through an extensive process of review. My sincere thanks to all of those concerned in providing information and advice during its compilation. I would especially like to express my appreciation to the independent experts listed in the Acknowledgements who provided a range of perspectives, additions and helpful advice.

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

Barry Buffier AM

Chair and Chief Executive Officer
Environment Protection Authority

ACKNOWLEDGEMENTS

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ABOUT STATE OF THE ENVIRONMENT 2015

Purpose

NSW State of the Environment 2015 (SoE 2015), 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 ninth SoE since 1993.

SoE 2015 aims to provide credible, scientifically based, statewide environmental information to assist those involved in environmental policy and decision-making and managing the state's natural resources.

Preparation

Although SoE 2015 has been prepared by the EPA, the scope of state of the environment reporting is too broad to be covered by just one agency. SoE 2015 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 an inter-agency SoE Steering Committee.

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

Section 10(3)(f) of the *Protection of the Environment Administration Act 1991* states that the SoE Report is to include a statement on the performance of environmental education programs. This statement is to be prepared by the NSW Council on Environmental Education (s.27). However, the council has not been in existence since 2009 and therefore no such statement is available.

Structure and linkages

SoE 2015 is structured differently from previous SoE reports. To simplify and streamline the report each issue is reported as an independent 'Theme' with extensive cross-referencing highlighting the relationships between themes.

The report has been produced in two parts:

Environmental drivers

The first part of the report describes key environmental drivers that influence our environment: population growth, economic trends, energy use, transport trends, greenhouse gas emissions, urban water use and waste and recycling.

The population of NSW is continually growing and trends in population growth, settlement patterns and residential densities are described in **Theme 1: Population.** Growth in population helps to drive economic growth and prosperity for the people of NSW. Responding to the environmental challenges presented by a growing NSW economy requires a better understanding of how the economy and the environment interact. New economic instruments and accounting systems are discussed in **Theme 2: Economics and the environment.**

The growth in population and the economy also 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 transport and electricity generation responsible for the majority of these emissions. Energy production and use is described in **Theme 3: Energy consumption**, while trends in the use of public and private transport are described in **Theme 4: Transport.** Overall levels and trends in greenhouse gas emissions are described in **Theme 5: Greenhouse gas emissions.**

Communities, industry, and agriculture require access to reliable sources of water. Drinking water quality and patterns of potable water use are described in **Theme 6: Urban water.** Trends in waste generation and recycling are described in **Theme 7: Waste and recycling.**

Environmental resources

The second part of the report describes the condition of important environmental resources such as: air quality, soils and land management, native species, vegetation, and reserves and conservation, and water resources, rivers and wetlands. It also reports on specific issues such as invasive species and contaminated sites.

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. While air quality is generally good in NSW the levels of major pollutants and the issues that can arise in some situations are discussed in **Theme 8: Air quality.**

The contamination of land by pollutants is covered in **Theme 9: Contaminated sites**. Healthy soils provide the essential ecosystem services and the primary productivity supporting natural ecosystems and the economic prosperity of the state. The health of soils in NSW and changes in condition over time are described in **Theme 10: Soil condition**, while current land management practices and their effects on soil health are discussed in **Theme 11: Sustainable land management.**

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 the current status and trends in threatened species are discussed in **Theme 12: Threatened species**. The main threats to the survival of species are habitat destruction through the clearing of native vegetation, discussed in **Theme 13: Native vegetation,** and competition and predation by invasive species. The preservation of ecosystems and habitats is described in **Theme 14: Protected areas and conservation**, while invasive species are discussed in **Theme 15: Invasive species**.

One of the greatest challenges facing NSW is continued access to reliable sources of 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 an increase in the share of water for the environment is described for surface water in **Theme 16: Water resources**, and for groundwater in **Theme 19: Groundwater.** The ecological health of rivers and the effects of water availability and extraction are described in **Theme 17: River health**, and the relationship to wetland health in **Theme 18: Wetlands.**

Most rivers flow to the sea through estuaries and the final theme in this report covers the health and impacts on estuaries and the coastal and marine environments of NSW, in **Theme 20: Coastal, estuarine and marine ecosystems.**

Linkages

The linkages introduced above are presented graphically at the beginning of each theme, with the topics most strongly linked to that theme highlighted in the banner; the example below highlights the linkages to Theme 3: Energy consumption.

Indicator summaries

SoE 2015 assesses the current status and trends since SoE 2012 for each of 65 environmental indicators, and the availability of the information used to make these assessments. The information availability rating signifies the level of information used to make the assessment.

Key to the indicator summaries

Indicator and status		Environmental trend	Information availability
Indicator status refers to the environmental condition of the indicator.		The environmental indicator trend describes the direction of significant change in environmental condition and is generally judged over the reporting period, between the previous report (SoE 2012) and the current report. The trend reported, using the descriptors below, may have an impact on the overall status of the indicator in the future.	Information availability describes the statewide extent, condition and 'fitness for use' of the data used for assessing the status and trend for the indicator. It is represented by the symbols below.
Green – Good: the data shows positive or healthy environmental condition		**Decreasing Impact** – The trend in environmental condition for the indicator is getting better (environmental impacts are decreasing)	✓✓✓ = Good
Yellow – Moderate: the data shows that the environmental condition is neither good nor poor, or results may be mixed across the state		**Stable** – No significant change for the indicator **Stabilising** – The rate of environmental deterioration is slowing	✓✓ = Reasonable
Red – Poor: the data indicates poor environmental condition or condition under significant stress		**Increasing Impact** – The trend in environmental condition for the indicator is getting worse	✓ = Limited
Grey – Unknown: insufficient data to make an assessment		**Unknown** – Not enough information is available to determine a trend for the indicator	

SUMMARY

Environmental drivers

Humans and their activities have a profound effect upon the landscapes within which they live, as well as the broader environment that surrounds them. The first part of this report describes seven drivers of environmental issues that provide the broad context for assessing the condition of environmental resources in the second part of the report.

1: Population

The population of NSW is continually growing and by June 2014 had reached 7.52 million people

As population increases, population density in urban areas has also risen. By June 2014 Greater Sydney had 390 people per square kilometre, 27 more than in 2009. Population has continued to rise in NSW since June 2014 and by March 2015 had increased by about 78,000 people. It is predicted that by 2031 9.23 million people will live in NSW, with the majority of the growth expected to be in Sydney. Increasing population and urbanisation can present environmental challenges through a greater demand for housing, energy and water and increased waste generation.

2: Economics and the environment

Since 1990 the NSW economy has experienced annual growth of around 2.5% per annum

The economy is intrinsically linked to the natural environment. While economic growth may be related to increases in population and increased resource use, the shift to a services based economy and improved efficiencies in the use of resources mean that growth can be achieved without increasing impacts on the environment. Economic instruments such as levies, subsidies, tradeable permits and performance-based regulatory charges are increasingly being used to achieve environmental quality objectives more flexibly and at lower cost.

3: Energy consumption

Environmental benefits from reduced electricity demand and growing renewable electricity supply are being offset by continued strong growth in fossil fuel demand by the transport sector

Over 90% of energy demand is being met by non-renewable sources – mainly coal, gas, and petroleum products. Around one-quarter of final energy demand is met by electricity, but demand for electricity has been falling over the past six years. At the same time supply has experienced strong diversification, with renewable (non-hydro) electricity generation growing five-fold between 2008 and 2014. Diversification of other energy supplies has been limited. Transport has now become the largest sector for final energy demand with strong growth in fossil fuel use, and minor use of renewable energy.

4: Transport

Use of public transport continues to rise; however, the dominant mode of transport for Sydney residents is still the car, accounting for 69% of all trips

The number of trips per person dropped by 4.8% for the decade to 2012–13. Changes in lifestyles and technological advances are likely to have influenced this outcome, with a 148% increase over the decade to 2012–13 in employees who have working from home arrangements in place. Transport is the main source of NO_x emissions in the Greater Sydney Region and was responsible for 19% of NSW greenhouse gas emissions.

5: Greenhouse gas emissions

Annual greenhouse gas emissions in NSW peaked in 2007, and are now 1% below the 1990 baseline. The stationary energy and transport sectors make up 59% of all emissions

Emissions have declined across most economic sectors since 1990. In contrast, emissions from transport have undergone almost uninterrupted growth, with forecasts indicating continued growth. Overall, stationary energy emissions (primarily electricity generation) also rose from 1990, peaking in 2007 and then declining quickly.

6: Urban water

The quality of urban water supplies continues to improve. At the same time demand is continuing to grow slowly, maintaining pressure on the state's water resources

Overall water use is much lower than in the 1990s. However water demand by NSW cities and large towns over the past seven years has had an annual average growth rate of 1.35% (inclusive of recycled water). Sydney Water and Hunter Water are both maintaining per person water use below water licence targets, while per property consumption from regional water utilities is almost half of 1990 levels. The quality of this water is excellent and in 2013–14 all large water utilities had 100% compliance with microbiological and chemical standards. Demand for urban water is having ongoing impacts on aquatic ecosystems.

7: Waste and recycling

The proportion of waste that is recycled continues to rise and reached 62.5% in 2012–13

In NSW waste generation rose steadily from 2002–03 until 2010–11, but appears to have stabilised over the last two years to 2012–13. Over the same timeframe waste generation per person has decreased by 3%. The uplift in the housing market has led to construction and demolition waste increasing, and the amount of waste being recycled in this sector fell to 69% in 2012–13.

Environmental resources

The second part of this report describes the condition of important environmental resources of NSW: Air quality; Soils and land management; Native species, vegetation and reserves and conservation; Water resources, rivers and wetlands; and some specific issues such as invasive species and contaminated sites.

8: Air quality

Most key air pollutants have remained at low levels, but microscopic particles (e.g. dust) and ozone (a component of smog) continue to impact air quality across metropolitan areas and some regional centres

The concentrations of a number of the most common air pollutants, including carbon monoxide, lead, oxides of nitrogen and sulfur dioxide, are now low (especially compared to the 1980s), as are air toxics. Oxides of nitrogen and volatile organic compounds have reduced, but as these contribute to the formation of ground-level ozone (a key component of photochemical smog) they remain of concern within the Sydney region. There is growing evidence about the adverse health impacts of airborne particles. Depending on the location, bushfires, agricultural burning, dust storms, mine dust and wood heaters can be key sources of particulate pollution.

9: Contaminated sites

More potentially contaminated land continues to be identified with an additional 166 sites reported in the eighteen months to June 2014

The EPA currently regulates 332 contaminated sites and 130 sites have been remediated. In addition 860 sites reported prior to the end of 2014 are still awaiting assessment. To address the backlog the EPA set up a Backlog Program in late 2014.

10: Soil condition

The soil resources of NSW are generally in a moderate condition despite a broad but largely historical decline since the arrival of European settlers

While in a moderate condition overall, some soil degradation issues remain, with 74% of priority soil units being rated as poor or very poor for at least one soil degradation hazard. The loss of organic carbon and topsoil loss due to sheet erosion are the main causes of declines in soil condition over time. The widespread use of conservation farming practices is now helping to maintain soil condition and counteract land-use pressures.

11: Sustainable land management

Current land management practices are broadly sustainable, with only a moderate risk that they will lead to soil degradation

Most land in NSW is being managed within its capacity to support current management practices. However, some localised areas are at risk of soil degradation where land use is marginal for the area. The greatest risk is from soil acidification and wind erosion. Intensifying land use and unpredictable weather extremes are factors increasing these risks.

12: Threatened species

The number of species considered to be threatened, or at risk of survival over the longer term, continues to rise, but at a slower rate

Native species remain under threat in NSW, with 999 species presently listed as having a threatened status. Ten additional species have been listed as threatened since 2012. The greatest risks to biodiversity are from habitat destruction, in particular the clearing of native vegetation and the impacts of invasive species, particularly predation by foxes and cats. A major process of reform is underway to simplify legislation and improve outcomes for biodiversity.

13: Native vegetation

Clearing rates for native vegetation in NSW have remained relatively stable for most of the past 10 years, but the overall condition of vegetation is deteriorating

Due to new technology that provides a higher resolution for the monitoring of clearing of woody vegetation, the rate of clearing is now recognised to be lower than previously reported, presently at around 11,000 hectares per year. Changes in the condition of vegetation are harder to monitor. While about 61% of the state has not been cleared of native vegetation, its condition is considered to be good in only 9% of the state. The main pressure on vegetation condition is due to land use, but this is increasingly being addressed through better land management practices. Fragmentation due to clearing, weed invasion and climate change are factors maintaining the pressure on vegetation condition.

14: Protected areas and conservation

About 8.9% of NSW is reserved in the public reserve system, and around 3.9% of land in NSW is currently subject to some form of management under a private land conservation program

Since 2012 the area of the reserve system has increased by about 26,600 hectares. This includes significant reservations in the South Coast (Dharawal National Park), Sydney (Berowra Valley) and the Darling Riverine Plains (Warrambool) as well as several thousand hectares of the Gwydir wetland, near Moree. While many ecosystems in NSW are well represented in parks, some ecosystems are poorly protected. To supplement the public reserve system a range of measures has been developed under the Conservation Partners Program to encourage and support conservation on private land.

15: Invasive species

Invasive species, including pest animals and weeds are widespread across NSW and have significant impacts on native species, ecosystems and agriculture

Many invasive species are listed as key threatening processes in NSW, with pest animals and weeds identified as a threat to over 70% of all threatened species. Pathogens and diseases are an emerging threat to both biodiversity and agriculture and are becoming increasingly prevalent. A revised NSW Invasive Species Plan 2015–2022 will provide better guidance to help prevent and manage the introduction and spread of invasive species.

16: Water resources

Much of NSW is returning to drier conditions, so the variability of river flows has been reduced and less surface water is available for use

As conditions become drier across much of NSW, less surface water is available for use and more water is being extracted from rivers. Seventy water sharing plans covering about 95% of water use have now been implemented, with plans for the remaining water sources to be completed soon. Greater amounts of environmental water are being stored and released to maintain or improve the health of rivers and wetlands. Over the past three years, around 600,000 megalitres of water per year, on average, have been targeted to priority aquatic ecosystems.

17: River health

The overall condition of rivers in NSW is moderate, but rivers in the Murray–Darling basin are generally in poorer condition than coastal rivers

While the overall condition of rivers is considered to be moderate, the condition of fish communities remains poor and continues to decline in the Murray–Darling basin. Most major inland river systems are affected by the ongoing impacts of water extraction and altered river flows, so they are in poorer condition overall. Coastal rivers are less affected by these pressures, so with the exception of fish communities, are in better ecological health.

18: Wetlands

Overall waterbird abundance has reduced, but targeted delivery of environmental water has helped maintain the health of some priority wetlands

Over the past three years the return to drier conditions has seen a reduction in the extent of wetland inundation and a decrease in waterbird abundance and breeding activity. The condition of wetland vegetation and waterbird diversity at some sites that received environmental water has been maintained.

19: Groundwater

Groundwater use has risen over the past three years as conditions dry out in most parts of the state

While use of groundwater has risen, extraction from most groundwater sources is below the long-term sustainable extraction limit. When water sharing plans commenced, extraction was above the sustainable yield for some groundwater sources, but is being reduced to align with long-term sustainable extraction limits over the life of these plans. Water sharing plans have now been completed for all sources in the NSW Murray–Darling Basin and will be completed for all coastal sources by 2016.

20: Coastal, estuarine and marine ecosystems

Although the majority of coastal, estuarine and marine systems in NSW are in moderate or good condition, most have been modified to some extent and continue to come under increasing pressure from coastal development

Overall, the water quality and the ecosystem health of the NSW marine environment are considered to be good, as they are in most coastal waters, although a wide range of threats and risks are present. Conditions in NSW estuaries are typically more variable, generally reflecting the level of disturbance locally and across their catchments, and their level of resilience to change. Recreational water quality is good at most ocean beaches, but water quality is lower in the more enclosed waters of coastal lakes and estuaries.

1 POPULATION

The population of NSW continues to grow. By June 2014, 7.52 million people were living in NSW, 64% of whom were located in the Greater Sydney area. NSW gained more than 867,000 people between June 2004 and 2014 and has grown at an average rate of 1.2% annually over the decade.

As population has risen, so has population density. In NSW in June 2014 there were 9.4 people per square kilometre, a 6% rise since 2009. In Greater Sydney at June 2014, there were 390 people per square kilometre, 27 more people per square kilometre than in 2009.

A rising population, increasing urbanisation and an ageing population (15% of the NSW population were 65 or over in June 2014) leads to greater demand for housing, energy and water as well as an increase in waste being generated. The increasing demand for land can also lead to loss of green spaces and greater pressure to develop the urban-rural fringe.

By 2031 the population of NSW is expected to grow to 9.23 million people with the majority of this growth anticipated to be in Sydney. A Plan for Growing Sydney is the NSW Government's 20-year plan for the Sydney Metropolitan Area, a plan for a sustainable and resilient city with a balanced approach to the use of land resources while protecting the natural environment.

Context

Population growth and urbanisation contribute to environmental challenges in NSW that relate to biodiversity, air quality, water resources, natural hazards and climate change. Increasing populations also lead to greater demand for public transport, more traffic on roads and more goods moving around NSW. Population also drives demand for food, the production of which can impact on the environment. In densely populated areas, waste products, such as solid waste, sewage, hazardous waste and atmospheric emissions place increased stress on natural ecosystems. Planning responsibly for this growth can avoid or minimise these impacts.

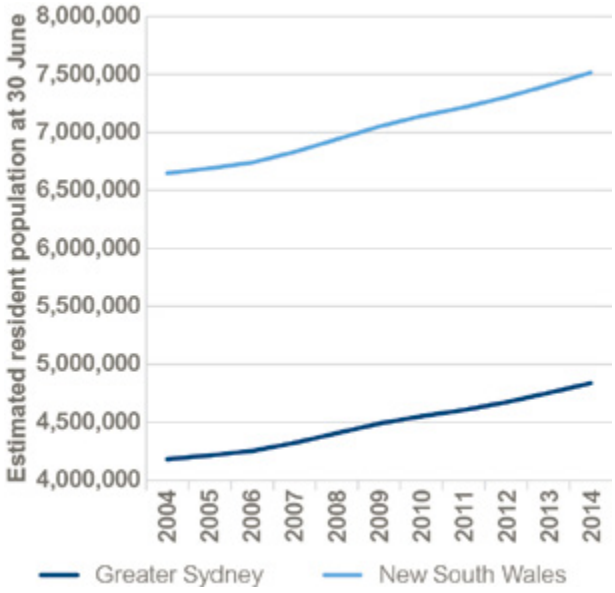
Population changes are a critical factor to inform strategic environmental planning. How many of us there are, how fast the population grows or declines and ages, where we live and how we live together, all drive the need for careful use of resources and influence our footprint on the environment.

Status and trends

Population change

The population of NSW continues to grow, as depicted in Figure 1.1. Between June 2013 and June 2014 there was an increase of 109,100 people (up 1.5% to 7.52 million), with 77% of this growth occurring in Greater Sydney. The NSW population reached 7.6 million people in March 2015 (ABS 2015a). In comparison to other states and territories in Australia this was the greatest growth (to June 2014) in terms of number of people, but the rate of growth was slightly below the average for Australia of 1.6% (ABS 2015b).

Figure 1.1: Population growth in Greater Sydney* and NSW for the last decade



Source: ABS 2015b

Notes: *Greater Sydney extends from Wyong and Gosford in the north to the Royal National Park in the South; towards the west the region includes the Blue Mountains, Wollondilly and Hawkesbury.

By 2031 the NSW population is projected to grow to over 9.23 million people, with the majority anticipated to live in Greater Sydney, which may put pressure on the demand for resources including energy and water.

Population distribution

Table 1.1 depicts a 5% increase in population from 2010–11 to 2013–14 for Greater Sydney, a 2.6% increase for coastal areas and 2.7% for regional NSW.

Table 1.1: Populations June 2011 to June 2014

Area	June 2011	June 2014
Greater Sydney	4,608,949	4,840,628
Coastal*	1,684,900	1,728,338
Regional NSW	1,247,300	1,280,555

Source: DP&E 2014b; ABS 2015b

Notes: *Coastal includes the local government areas of Ballina, Bega Valley, Bellingen, Byron, Clarence Valley, Coffs harbour, Eurobodalla, Gosford, Great Lakes, Greater Hume Shire, Kempsey, Kiama, Lake Macquarie, Nambucca, Newcastle, Port Macquarie-Hastings, Port Stephens, Richmond Valley, Shellharbour, Shoalhaven, Tweed, Wollongong, Wyong

Greater Sydney

About 4.84 million people lived in Greater Sydney at June 2014, representing just under two thirds of the state's population. Map 1.1 shows population change between June 2013 and June 2014. The largest growth in Greater Sydney between 2013 and 2014 was in Parklea – Kellyville Ridge (up by 2700 people). Large growth also occurred in Waterloo – Beaconsfield (up by 2000 people), Parramatta – Rosehill (1900), Concord West – North Strathfield (1600) and Cobbitty – Leppington (1500). Population decline has also occurred in Greater Sydney, between June 2013 and June 2014 the largest decline was in Claymore – Eagle Vale – Raby (Sydney's south-west) down by 140 people and Springwood – Winmalee in the Blue Mountains down by 80 due to the bushfires of late 2013 (ABS 2015b).

In the last decade the largest population increases have been recorded in the local government areas (LGAs) of Blacktown (+61,000 people), Sydney (+45,450) and Parramatta (+41,050).

Rest of NSW

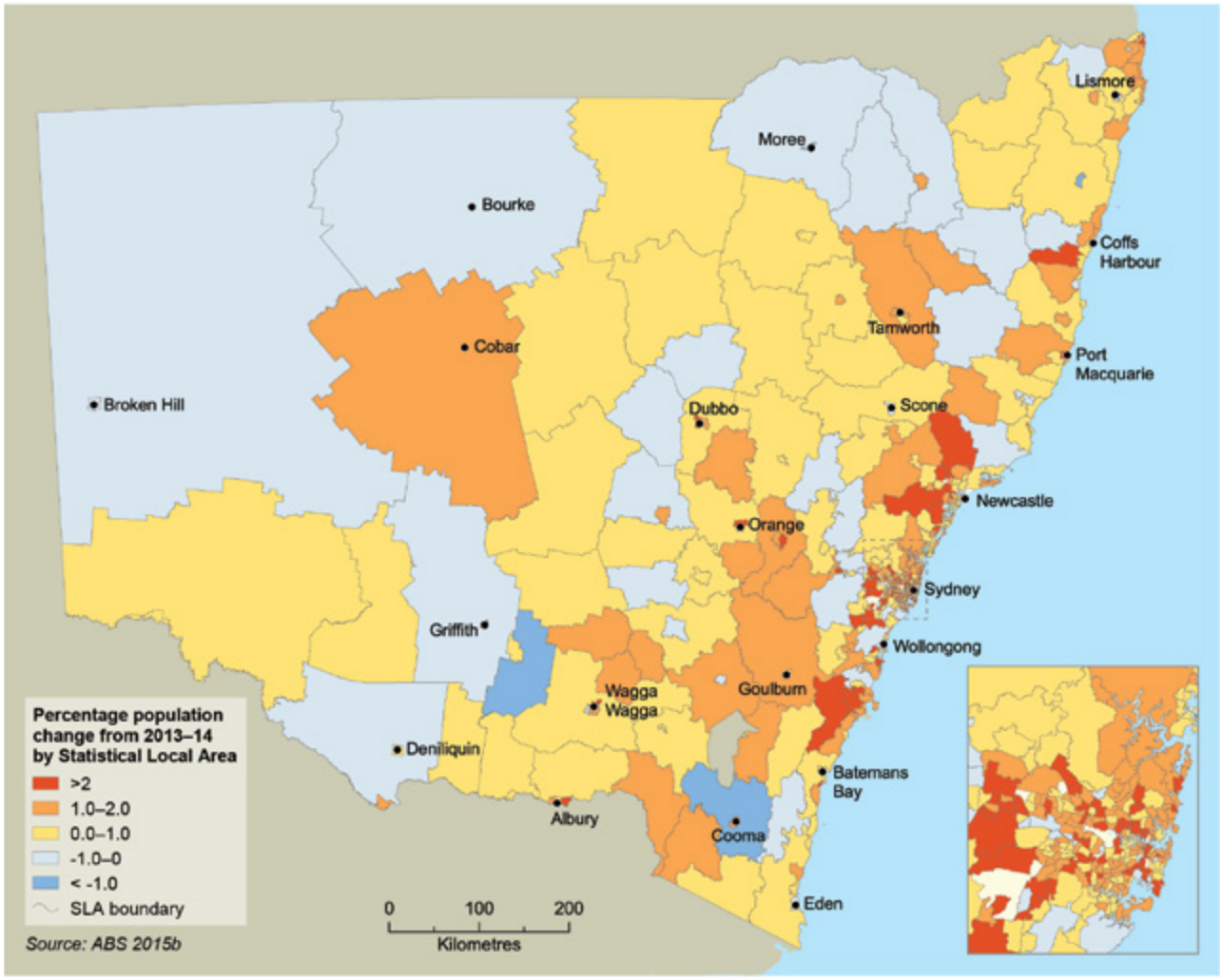
The population of the rest of NSW (outside Greater Sydney) increased by 24,900 people between June 2013 and June 2014 to reach 2.6 million. Map 1.1 shows that in that period the largest and fastest population growth occurred in the Hunter Valley (excluding Newcastle) which rose by 3700 people (1.4%). Substantial growth also occurred in Newcastle and Lake Macquarie (up by 3500 people), Illawarra, just south of Sydney (2800) and Richmond – Tweed on the far north coast (2200). The biggest decline in population was in Grafton on the north coast which experienced a loss of 180 people (ABS 2015b).

In the last decade the largest declines have occurred in the LGAs of Broken Hill (1050 people) and Moree Plains (950 people).

Population density

At June 2014 the population density of NSW was 9.4 people per km^2 (this was a 6% increase when compared to the 2009 figure of 8.9 people per km^2). The highest population densities outside Sydney as at June 2014 were in Newcastle – Cooks Hill (2800 people per km^2), Waratah – North Lambton (2500) and Wollongong (2800) (ABS 2015b).

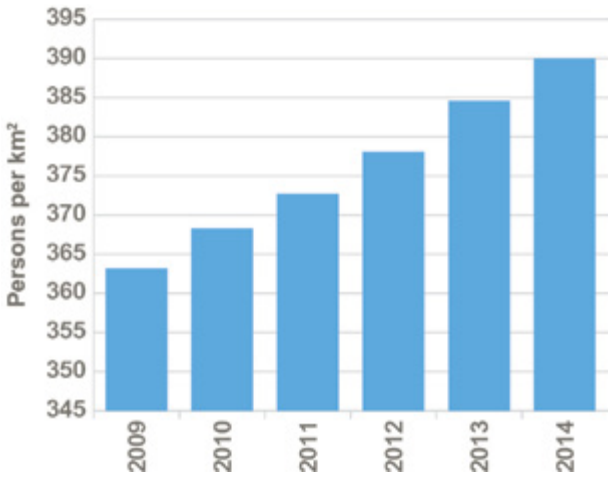
Map 1.1: Population change, NSW, 2013–14



In Greater Sydney, as shown in Figure 1.2, the population density has continued to rise since 2009. At June 2014 the population density was 390 people per km^2 which is an extra 27 people per km^2 in comparison to 5 years earlier (2009). The highest population densities at June 2014 were in Pyrmont – Ultimo (15,000), Potts Point – Woolloomooloo (13,700), Darlinghurst (13,400) and Surry Hills (13,300) (ABS 2015b).

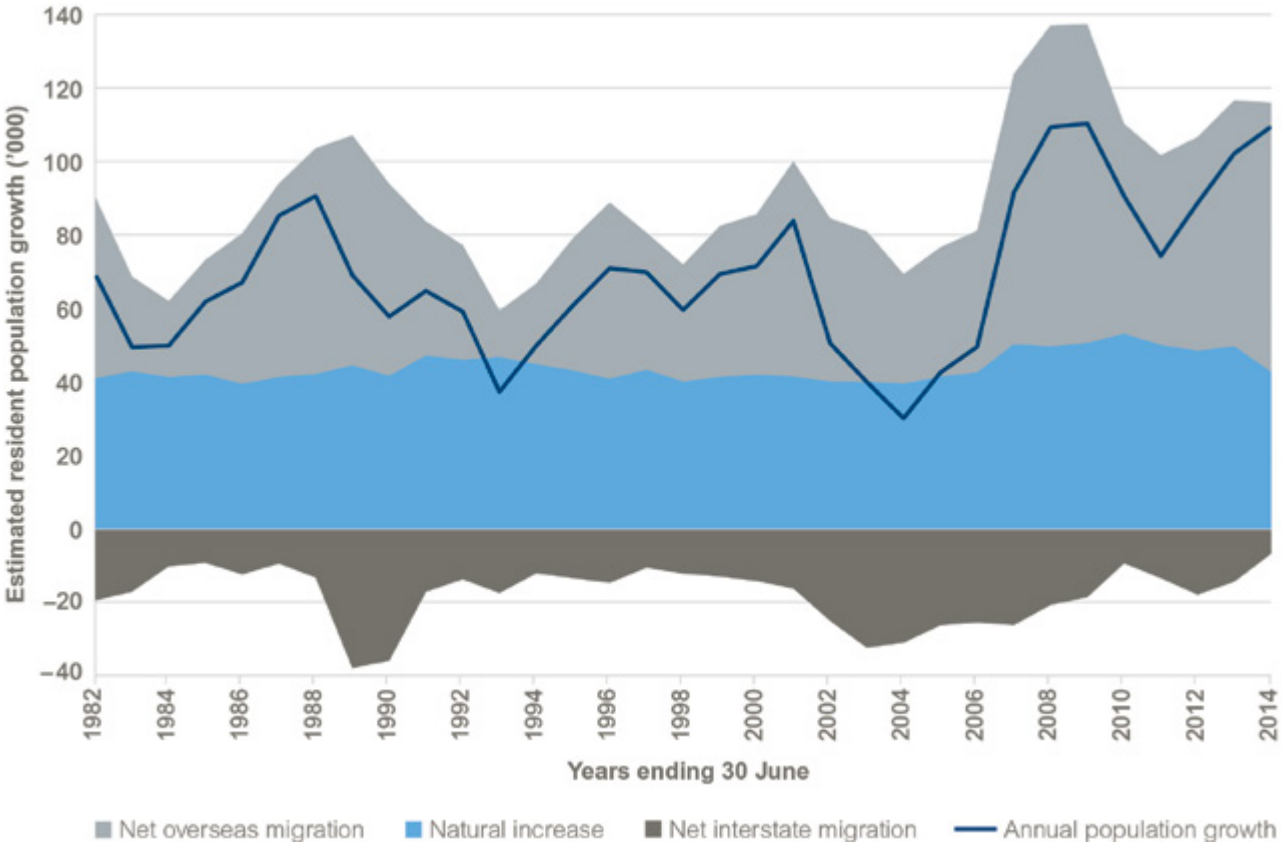
Increased population density concentrates demand for energy, water and waste removal services (see Theme 3: Energy consumption, Theme 6: Urban water, Theme 7: Waste and recycling); this can be offset by a more efficient and healthy built environment (see Responses below).

Figure 1.2: Population density within Greater Sydney, 2009 to 2014



Source: ABS 2015b

Figure 1.3: Components of population growth in NSW, 1982–2014



Source: ABS 2015a

Size of residential properties

Table 1.2 shows that the average floor area of residential properties has substantially increased since 1984–85. Bigger homes can have negative impacts on the environment as more energy is required to light, heat and cool properties. In the process of constructing homes more waste may be generated, while the demand for more housing and larger housing can lead to conflict with other land uses and encroachment into the urban–rural fringe.

Table 1.2: Average residential floor area

Type of property	Floor area m²	
	1984–85	2012–13
New house (detached) in NSW	159.3	266.2
New other residential (not detached) in NSW	96.6	151.1

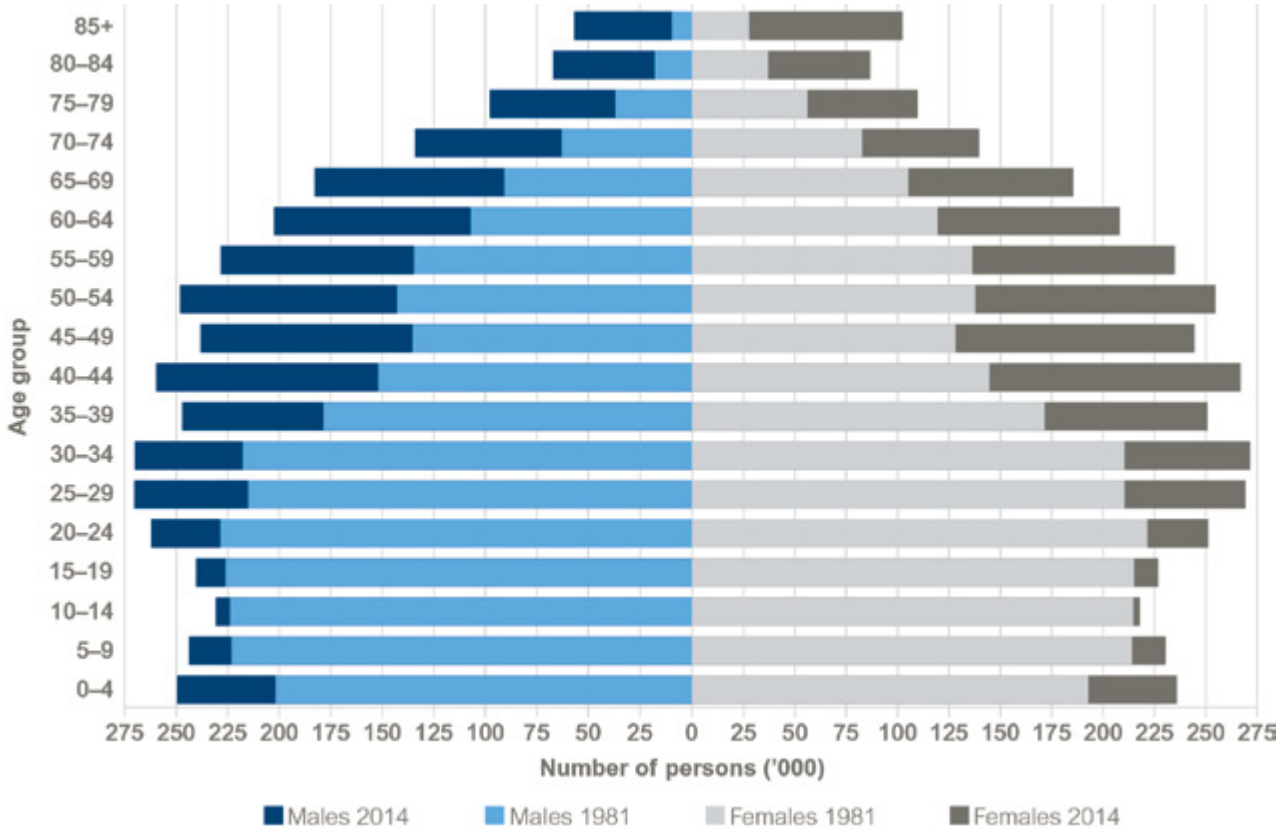
Source: ABS 2005; ABS 2013

Reasons for population growth

Population growth in NSW is driven by natural increase (the difference between births and deaths) and by net overseas migration. As seen in Figure 1.3, natural increase has been relatively stable over time. Figure 1.3 shows that net overseas migration has been an important factor influencing annual changes in population size. In 2008, net overseas migration reached a peak of 87,389 persons, which was attributed to international students arriving in the state, as well as temporary work visa holders and working holiday makers. A fall in net overseas migration saw a drop to 51,675 persons in 2011 which has since risen to 73,300 persons in 2014. Net overseas migration gains are offset by net interstate migration losses, with more people leaving NSW than arriving.

The drivers of population growth differ across the state. Population is growing faster in urban areas and regional centres than elsewhere. People move to regional centres from surrounding areas; young people move to the cities; workers and their families move to regional centres; and retirees move to popular areas on the coast,

Figure 1.4: NSW age profiles in 1981 and 2014



Source: ABS 2014; ABS 2015a

along the Murray River and in locations within easy commuting distance of metropolitan areas (DP&E 2014a). The relatively younger age profile of populations in urban areas means natural increase is also an important driver of population change.

Age profile and population ageing

The age distribution of the NSW population continues to shift as a result of changes in fertility rates, increasing life expectancy, and age-specific migration. The population pyramid in Figure 1.4 shows that in June 1981 10% of the population of NSW was over 64 years old and by June 2014 this had grown to 15% of the population. As a result of the ageing population in NSW, household compositions are also changing with older people more likely to live alone or with only one other person. This has environmental implications caused by the need for more housing and flow-on effects from demand for housing materials and energy, water and waste consumption (see Theme 3: Energy consumption, Theme 6: Urban water and Theme 7: Waste and recycling).

Pressures

Larger populations create an increased demand on housing supply and increase the demand on potable water, energy and wastewater treatment. They also generate greater urban water runoff and waste. The construction of new residential homes increases construction and demolition waste and can result in the loss of green spaces and wildlife habitats. As urban areas become too densely populated pressure is put on urban fringes, which can encroach onto environmentally sensitive or potentially hazardous areas. For instance, many settlements are located in flood-prone river catchments, with tens of thousands of properties located within a floodplain. A significant portion of these are in the Hawkesbury–Nepean Valley in Sydney.

NSW experiences a range of natural hazards, including bushfires, severe storms and floods. These events cause great financial hardship for individuals and communities, and can sometimes result in loss of life. As our population grows, there is potential for more people, buildings and

infrastructure assets to be exposed to natural hazards. While some of the impacts of natural hazards can be mitigated or avoided, risks cannot be completely eliminated.

NSW is now home to greater numbers of older people than ever before. This means a greater demand for aged care facilities and health care services which are often in places outside the main urban areas of the state. An ageing population also poses increased risks from the environment. For example, extreme temperatures can lead to illness and loss of life and increase the cost of transport, agriculture, energy and infrastructure. Heatwaves are also becoming more common and are a significant cause of mortality. This is particularly the case for the vulnerable sectors of society, such as the elderly, the unwell and children.

The growing population of NSW has more complex interactions with the environment that are specifically discussed further in other sections of this report.

Responses

A Plan for Growing Sydney

A Plan for Growing Sydney (NSW Government 2014) was released in December 2014. It is the NSW Government's 20-year plan for the Sydney metropolitan area. It provides direction for Sydney's productivity, environmental management, and liveability; and for the location of housing, employment, infrastructure and open space. It will be implemented through collaboration between a new Greater Sydney Commission and local government.

Regional plans

Regional plans will guide how a region can achieve sustainable growth and will be developed in partnership with communities, councils and businesses to set the long-term vision and actions needed to achieve the vision.

The regional plans will 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.

These are long-term strategic planning documents that will consider the population trends for NSW. They also articulate a vision and plan for a range of housing, jobs and infrastructure to meet the needs of a changing population. Importantly, each regional plan will include actions that relate to the environment, tailored to suit each region. Local government and the community will be central to the development and content of the regional plans.

Ageing

The NSW Office for Ageing published the NSW Ageing Strategy (OA 2012) in 2012. Through this strategy, the NSW Government will work with local councils and Local Government NSW to plan ahead and work strategically in response to population ageing.

The strategy seeks to facilitate greater housing choice and age-friendly local communities, encourage active, independent lives and safe transport, and greater participation and connectivity in civil society.

A growing population also places greater demands on interment facilities such as crematoria and cemeteries. Population projections indicate a need for the NSW Government to manage and provide for interment facilities. This is reflected by Action 1.11.5 in *A Plan for Growing Sydney*.

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2 ECONOMICS AND THE ENVIRONMENT

Since 1990, the NSW economy has sustained positive annual growth of around 2.5% per annum, with gross state product increasing by approximately $18,000 per capita over the same period.

The NSW economy is intrinsically linked to the natural environment. It is shifting from more resource intensive industries based on extraction and primary industries, to a service based economy that has lesser environmental impacts.

The NSW Government employs a range of economic tools to analyse environmental issues, 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 offer a flexible way to meet environmental quality objectives with lower cost, by facilitating market responses to address environmental concerns.

Environmental accounts which supplement traditional economic accounts are emerging as a focal point for the systematic collection of integrated environmental-economic information, to guide sustainable decision-making and enable environmental considerations to be incorporated into decisions that have traditionally been based predominantly on economic factors.

Context

Economic growth (the increase in the production of goods and services in an economy over time) is influenced by a variety of factors, including population growth, improved productivity, new technologies, and growth in human capital (e.g. education). Economic growth is intrinsically related to the natural environment. This interaction is not simple, with different aspects of economic growth having different environmental impacts.

Population growth results in increased consumption, resource use and waste production (see Theme 1: Population), whilst 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.

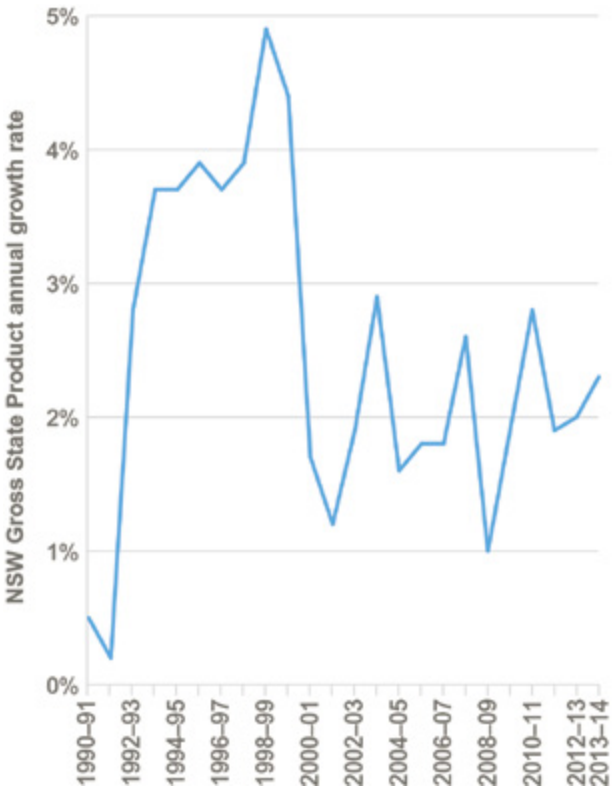
As the incomes of the NSW population increase, society's willingness to pay for better environmental outcomes can be expected to increase.

Status and trends

NSW has the largest economy in Australia, contributing more than 30% to national economic output in 2014. The economic output of NSW has grown by more than 80% over the past 25 years. Since 1990, the NSW economy has sustained positive average growth of around 2.5% per annum (see Figure 2.1, overleaf). Gross state product (GSP) per capita increased by approximately $18,000 over the same period, reaching $65,320 in 2014 (ABS 2014a, Table 1).

NSW is primarily a service-based economy with services contributing more than 70% of GSP in 2013–14 (ABS 2014a, Table 2).

Figure 2.1: Economic growth (annual growth in real GSP), 1990–91 to 2013–14



Source: ABS 2014a, Table 1

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

- finance and insurance (13.5%)
- professional, scientific and technical services (7.8%)
- manufacturing (7.5%)
- health care and social assistance (6.7%)
- construction (5.5%).

The NSW economy is shifting from more resource-intensive industries, often with larger environmental impacts, to rapidly expanding sectors less dependent on the use of natural resources. For example, while manufacturing remains a major industry in NSW, it has not kept pace with the rest of the economy. It has grown by only 9.6% in real terms over the last 25 years. The next slowest-growing industry was utilities, with electricity, gas and water services growing by only 17.5%. In contrast, over the same period the financial and insurance services sector has grown by almost 200%, overtaking manufacturing as the state's largest sector in the year 2000. The information, media and telecommunications sector was the second fastest growing industry, with real growth of 189%. Agriculture, forestry and fishing grew by 45%, while mining grew by 137% (ABS 2014a, Table 2).

Population growth in NSW has occurred at a slower rate than economic growth, averaging 1.1% since 1990 (ABS 2014b, Table 4). Over the same period, real GSP grew by an average annual rate of 2.5%, suggesting that affluence levels in NSW have increased. If NSW continues to experience economic and population growth similar to recent decades, by 2020, the state will have annual GSP of around $550 billion and a population of 8.1 million.

For the period covered by the current SoE reporting cycle the average annual increase in economic growth was 2.1%, business investment 1.1% and employment 1.3% (all recorded from July 2011 to June 2014; ABS 2014a, Tables 1 & 2; ABS 2015a, Table 4).

Pressures

Because of the inherent linkages between the environment and the economy, economic growth is likely to be achieved through the use of some additional natural resources, so there is a need to manage natural resources better in order to maintain or improve the condition of the environment.

Economic growth and the environment

The production of most goods and services in an economy is inefficient to some degree so waste is an inherent by-product of production processes. Economic growth can increase pressure on the environment's capacity to receive and break down waste without causing significant ecological harm (see Theme 7: Waste and recycling).

Waste products such as solid waste, sewage, hazardous waste, and atmospheric emissions, place stress on the environment. Such impacts have been observed in the Hunter region, where population growth and industrial expansion have created the need for interventions to track changes in air quality and reduce the impact of saline discharges on waterways (Newcastle Lower Air Quality Monitoring Network; Hunter River Salinity Trading Scheme).

While drivers of economic growth and certain industrial processes can place pressure on the natural environment, it is important to note that environmental pressures are not necessarily proportionate to growth rates. Policy changes, technological progress and changing behaviour can effectively reduce the rate of environmental harm over time as population and economic growth continues. Figure 2.10 in SoE 2012 (EPA 2012a) shows an improvement in measures of air quality (e.g. 40% reduction in VOCs) between 1992 and 2008 while population increased by 18% and GSP grew by 68%.

Sustained economic growth relies on a continuous supply of energy. Fossil fuels currently meet around 93% of the state's primary energy demand (see Figure 3.2 in Theme 3: Energy consumption).

The energy consumed by NSW households and businesses may not be growing quite as fast as the economy, but the state's demand for large amounts of energy is unlikely to diminish. NSW consumption of petroleum products grew by 24% between 2002–03 and 2012–13, while the NSW economy grew by 25% over the same period (BREE 2014; ABS 2014a, Table 1). Despite the growth in renewable sources of energy, the NSW economy is likely to continue to source most of its energy from high-carbon non-renewable resources into the foreseeable future (Wood et al. 2012).

Responses

Current use of economic analysis

Economic analysis is used to support appropriate policies and to make decisions that either improve environmental outcomes at least-cost or provide the greatest net benefit to the NSW community. These assessments help the NSW Government meet its commitments to reduce the costs of regulation to industry and the community and provide conditions that increase the competitiveness of doing business in NSW. In addition, economic instruments can provide policymakers with an alternative to traditional regulation for delivering environmental outcomes at minimal cost to businesses and the community.

Economic analysis is currently used by the NSW Government to:

- assess the costs and benefits of proposed environmental standards, policies or investments, to identify the least-cost options to achieve specific environmental outcomes
- change the behaviour of industry or the community via market-based instruments and economic incentives
- assess the economic impacts of environmental programs.

Cost–benefit analysis: regulatory review and environmental evaluation

All environmental regulations in NSW undergo a cost–benefit analysis to ensure the regulatory options adopted deliver the greatest net benefits to society. This is a legislative requirement (*Subordinate Legislation Act 1989*) that requires NSW agencies to develop regulations and environmental standards that have well-defined objectives and that consider the compliance and administration costs to industry and government along with the economic and environmental benefits to the broader community.

However, there are challenges with quantifying the environmental impacts of policy decisions. The economic values of environmental goods and services can be estimated using a range of techniques, some of which incorporate established market values while others may provide upper or lower bounds for non-market values.

In its Environmental Policy Analysis: A Guide to Non-Market Valuation (Baker & Ruting 2014) the Australian Productivity Commission provides an overview of revealed and stated preference measures for environmental valuation. Stated preference techniques (e.g. choice modelling) can be used to identify consumers' preference for non-market goods, such as the value of species preservation.

Revealed preference techniques, such as the travel-cost method, can be used to estimate the costs that visitors incur while travelling to a particular location as a proxy for the amount they are willing to pay for recreation. Likewise, the damage-cost approach can be used to estimate people's revealed health costs from exposure to air pollution, allowing the benefits from reducing pollution to be quantified.

Table 2.1: Summary of recent cost–benefit analyses conducted by the EPA

Instrument	Benefits	Costs	Net benefit	Sources
Radiation Control Regulation	$68.3 million	$4.9 million	$63.4 million	EPA 2012b, p.29
Waste Regulation	$38.9 million	$24.9 million	$13.9 million	EPA 2014a, p.7
UPSS Regulation	$485 million	$303 million	$130 million	EPA 2014b, p.26
Contaminated Land Management	$0.4 million	$0.4 million	$0 million	EPA 2013, pp.23–4
Environmental Penalties	$12.5 million	$0.8 million	$11.7 million	(unpublished)

Notes: Costs and benefits are over five years, discounted to present values

The process of cost–benefit analysis improves our understanding of the links between economic activity and environmental outcomes and ensures that policies explicitly take environmental factors into account to achieve optimal outcomes for current and future generations. Table 2.1 summarises some recent assessments of the costs and benefits of proposed changes to NSW environmental legislation.

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.

A range of economic instruments are used currently in NSW 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
- BioBanking, which allows developers to clear native bushland for a new development, as long as they conserve a comparable piece of bushland elsewhere
- biodiversity offsets (OEH 2014) encourage prospective developments at the same time as conserving nature
- 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 NSW 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 was recently initiated by the EPA to match 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 ultimate goal of economic instruments is to provide incentives for businesses and the community to consider the wider social impacts of their behaviour, thereby encouraging economic growth at the same time as achieving more efficient resource allocation.

Program evaluations

Economic analysis is also used in NSW to evaluate the success of environmental programs and to identify possible improvements. In addition to identifying program improvements that reduce costs or increase benefits, evaluations can identify efficiencies and competitive advantages for participants. The waste levy was recently reviewed (KPMG 2012) resulting in a number of recommendations for program improvement.

Economic reviews are currently underway for load-based licensing, the Hunter River salinity trading scheme and NSW biodiversity legislation. The pending review of NSW Aboriginal heritage regulations will be based on achieving better outcomes for the community while minimising costs to businesses and the Government.

Emerging use of economic analysis

Emerging uses of economic analysis by the NSW Government include:

- strategic planning of new national park purchases
- predictive modelling to identify drivers of land clearing
- the potential mapping of biodiversity to strengthen offset markets
- stricter penalties to reduce the financial incentives from illegal behaviour
- measures to make it easier for people to obey laws related to illegal dumping.

Most of these emerging analyses would benefit substantially from having better access to spatially available integrated socioeconomic data that would help guide forward-looking policies. Integrated environmental-economic accounts are likely to be a key source of this information.

Environmental-economic accounting

Rationale and history

The System of National Accounts (SNA) tracks the changes in an economy over time in terms of industry production, income, investment, household consumption, among others. However, economic indicators tell only part of the story of how a society is progressing over time. There are also social and environmental measures of progress that may be developing at faster or slower rates, or perhaps even declining.

Focusing only on changes in economic activity can ignore hidden pressures on land and other environmental assets, often called 'natural capital', which includes renewable and non-renewable resources as well as ecosystem services. As an example of non-renewable natural capital, growth in the NSW mining industry depends on access to the state's mineral resources, which form a part of the NSW natural capital stock. In mid-2014, the NSW mining industry's gross value added was $13 billion – an increase of 137% over 1990 levels (ABS 2014a, Table 2). While mining activity generates economic benefits for business and the community it depletes the stock of natural capital available for future generations.

Wild fisheries (a renewable resource) supported commercial fishing revenues of more than $90 million in 2013, charter fishing added value worth $23 million in 2012, and recreational fishing at least $1.03 billion in 2012 (McIlgorm & Pepperell 2013; McIlgorm & Pepperell 2014). If managed sustainably the natural capital (fisheries stocks) is not depleted and is available for future generations.

Environmental accounts seek to supplement the market-based information in the System of National Accounts, thereby allowing stakeholders to compare and contrast aggregate measures, indicators and trends across a broad range of environmental and economic issues. Environmental accounts data includes trends in the use and remaining stock of natural resources and the amount of pollution and waste discharged to the environment. This helps decision-makers explore relationships between the economy and the environment (UN 2012, p.4).

The integrated approach came from the need to form decisions about current and future social welfare and environmental health using not just the standard (economic) information in national accounts, but also information from 'real-world' accounts of available natural resources.

System of Environmental-Economic Accounting: International application

Developed by the United Nations, the System of Environmental-Economic Accounting (SEEA) provides a framework for collating the statistics and data necessary to monitor interactions between the economy and the environment in order to better inform decision-making. The SEEA reflects the realisation that economic prosperity depends on the capacity of the natural environment to supply resources and to absorb pollution, and that environmental policies impact economic activity (ABS 2015b). The SEEA Central Framework was adopted by the UN Statistical Commission as an international statistical standard in 2012.

The SEEA Central Framework uses a systems approach to organise environmental and economic information that covers the stocks and flows of natural resources that are relevant to the analysis of a set of specific environmental and economic issues. The approach used by

the SEEA Central Framework applies the same accounting concepts, structures, rules and principles as the SNA.

Environmental accounts deliver an important extension to the national accounts. In practice, these accounts can include physical supply and use tables, functional accounts (e.g. environmental expenditure), and asset accounts for the management of natural resources (UN 2012).

Adoption of SEEA in Australia and NSW

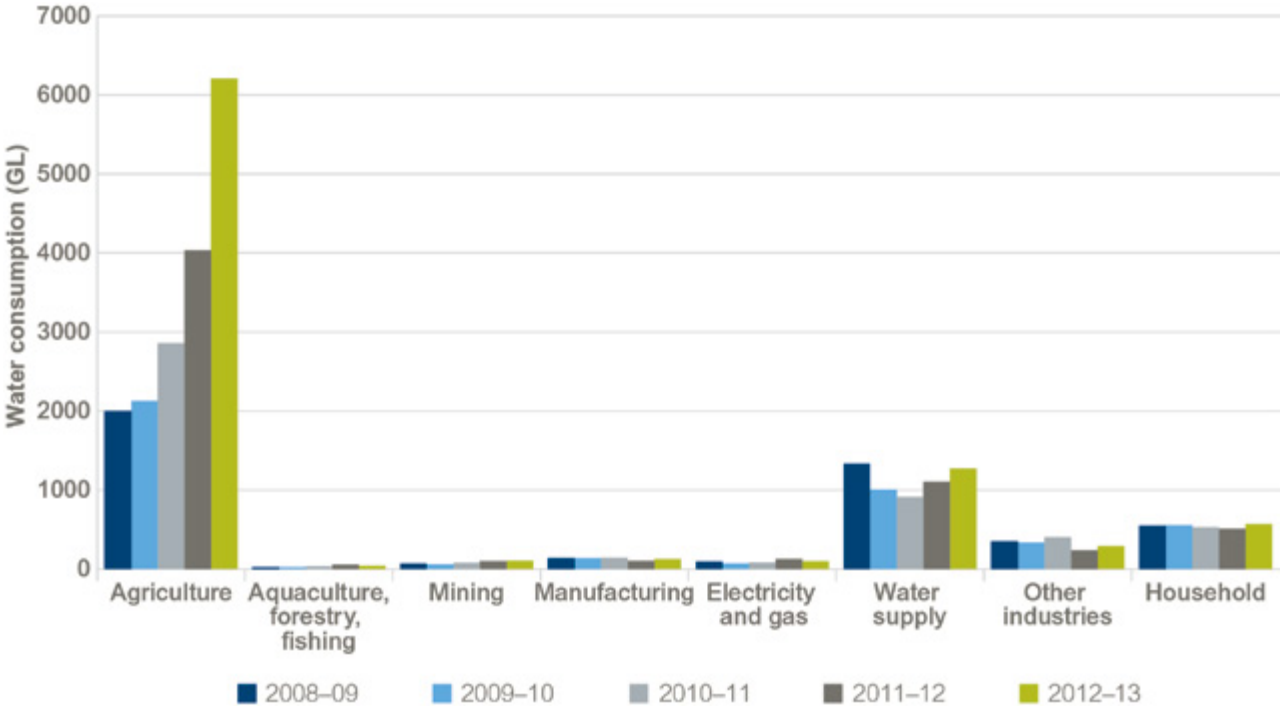
Because a diverse range of government agencies would be involved in collecting the information needed for a national (and statewide) SEEA, it is important that special attention is paid to standardising the metrics and methods by which they are measured. At the national level, the Australian Bureau of Statistics (ABS) is taking 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 tradable assets like timber and water, while following stages will expand the system to include the value of ecosystem services (flows of environmental values) (ABS 2015b).

The ABS has already produced experimental environmental 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 2015b). These reports generally contain aggregate national statistics, with little to no state-level data.

The information contained in environmental accounts can provide a continuous measure of the extent and condition of stocks of natural capital, flagging the sustainability of different activities and the resource efficiency of various industries. This will allow public agencies to develop policy responses to environmental trends as they are identified.

While no state-level environmental accounts have been produced, the ABS has released national water accounts that include some broad state-level data (ABS 2014c). These data were also reproduced in the first Australian Environmental-Economic Account in 2015 (ABS 2015b). Figure 2.2 shows the scale of annual water consumption (GL) by various NSW industries and by households.

Figure 2.2: NSW water consumption over time, by major industries and households



Source: ABS 2014c, Table 2

It is clear that agriculture is by far the largest consumer of water resources in NSW. By contrast, the amount of water consumed by the mining, manufacturing and electricity production sectors in NSW is relatively small.

While there are no obvious trends in water consumption by other sectors the consumption of water by agriculture is rising over the period covered by regular annual water accounts (2008 to 2013), depicted in Figure 2.2.

However, care needs to be exercised in interpreting this data on water use. There are a number of different water entitlement types in NSW. Town and industrial users receive more secure entitlements than agriculture, which effectively receives the water left after other uses have been met.

The use of water by agriculture is highly variable and average annual consumption is actually falling when considered over the longer term (see Theme 16: Water resources). Water use by agriculture is strongly dependent on climatic conditions and the seasonal availability of water. The start of the period covered by this data coincides with extremely dry conditions in NSW, whereas much wetter conditions prevailed by the end of this period.

The environmental information needed to produce viable statewide environmental accounts is not currently being collected in a sufficiently systematic fashion across NSW. The NSW Government has started a dialogue with the ABS, to explore partnership opportunities whereby a system of integrated environmental and economic accounts can be tested for smaller regions of NSW, or statewide accounts developed for specific values or issues such as land or waste management.

Future opportunities

Responding effectively to the environmental challenges presented by a growing NSW economy requires a better understanding of how the economy and the environment interact, and will need to be supported by the collection of appropriate environmental data to enable better evaluation of the outcomes of environmental policies and investment decisions.

Potential uses for environmental-economic accounts include the ability to evaluate the impact of policies implemented in different spatial locations, such as regional or facility-based pollution control measures, the socioeconomic impacts of biodiversity conservation, or measures to improve the socioeconomic impacts of new conservation areas.

Environmental-economic accounts are intended to be publicly accessible, including to researchers who can add value to information that may otherwise have been inaccessible or unavailable. This can reduce the need for costly publicly funded research and can empower local communities by providing access to environmental and economic information at regional or local scales.

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3 ENERGY CONSUMPTION

The production and use of energy causes significant environmental impacts, including being our main source of greenhouse gas emissions. The electricity sector's performance is improving while transport emissions continue to grow.

NSW meets most of its demand for energy from non-renewable sources (about 94% in 2012–13), mainly coal, gas, and petroleum products.

Around one-quarter of final demand is met by electricity. Total electricity consumption from the grid peaked in 2008–09 and has been falling over the past six years with the current demand close to 2001–02 levels. Electricity consumption from the grid per person peaked in 2007–08 and has recently been well below 1997–98 levels.

Diversification of NSW electricity supplies is growing strongly with an increase in renewable-based capacity and generation. Electricity generated from renewable sources (including Snowy Hydro) has increased from 6.1% in 2008 to 10.8% in 2014, driven mostly by the contribution of new, non-Snowy, renewable energy sources (from 1.6% in 2008 to 7.5% in 2014).

Diversification of other energy supplies has been limited, with continued strong growth in fossil fuel use by transport. This is now the largest sector for final energy demand in NSW and proportionally has the lowest use of renewable energy.

To help meet its goal of increasing use of sustainable energy sources and improving energy efficiency, the NSW Government is implementing the NSW Renewable Energy Action Plan and the NSW Energy Efficiency Action Plan. It continues to support a national Renewable Energy Target and has established a Renewable Energy Advocate; along with a suite of other actions to improve energy efficiency and lower power emissions. The NSW Government maintains biofuels mandates as a means of increasing use of sustainable energy sources in the transport sector.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Total NSW energy use	P	Stabilising	✓✓✓
NSW non-renewable energy production	P	Stabilising	✓✓✓
NSW renewable energy production	M	Decreasing impact	✓✓✓
Electricity use per capita	M	Decreasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

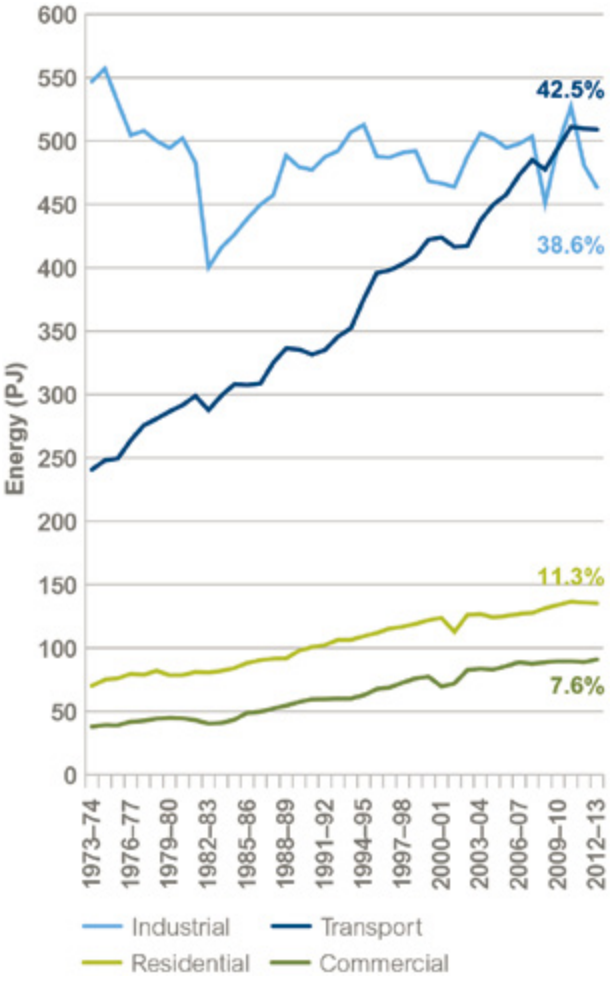
Context

Economically and environmentally sustainable energy is essential to the functioning of an advanced industrial society. NSW uses approximately one-quarter of Australia's total energy. It possesses large reserves of black coal and gas, as well as substantial renewable energy resources. As a result, NSW enjoys a reliable and secure energy supply – important factors underpinning the stability and growth of the economy. These energy sources are also important as feed stock into industrial processes, which help support the industrial sector of the local economy.

To support sustainable development of all NSW energy resources (coal, gas and renewable), a strong regulatory framework around planning, environmental controls and industry operations is in place. This involves managing surface water and groundwater pollution, mine site rehabilitation, dust and noise pollution, and disruption to landscapes, flora and fauna.

Energy production and conversion, such as coal and gas to electricity in power stations and energy used in the transport and industrial sectors, are the main emission sources of greenhouse gases as well as local and regional air pollutants (see Theme 5: Greenhouse gas emissions and Theme 8: Air quality). Energy conversion losses in electricity generation are also very significant.

Figure 3.1: Final energy consumption by sector, NSW and ACT, 1973–74 to 2012–13



Source: Derived from BREE 2014

Notes: The data includes NSW and the ACT, as source data cannot be disaggregated.

'Industrial' includes agriculture, mining and manufacturing.

'Commercial' includes general commercial, construction, and water, sewerage and drainage industries.

Status and trends

Final energy consumption

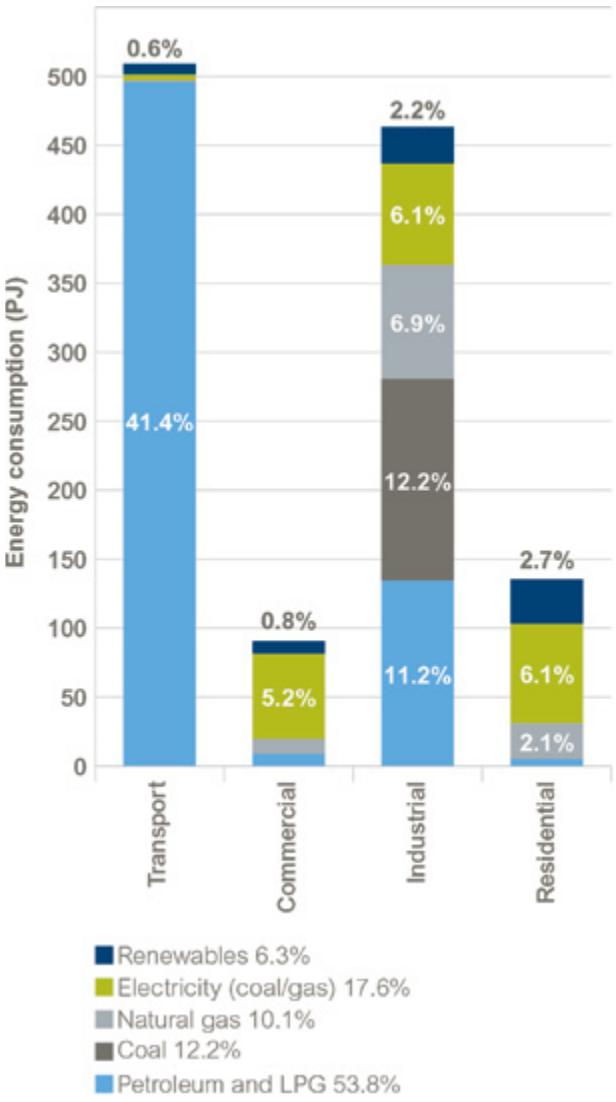
'Final energy' is the energy supplied to the end user. Final energy consumption includes secondary energy, such as electricity, and therefore excludes the coal and gas used to generate electricity.

Over the past three years, total NSW energy consumption has been decreasing at around 2.6% per annum. This is distinctly different from the trends of the previous four decades. The key reason for this recent change is reduced industrial energy use.

Figure 3.1 shows the sectoral trends in final energy consumed for the NSW and ACT economies. In 2012–13, final energy consumption was 1199 petajoules (PJ). The share of the industrial sector has been declining. In addition, four decades of strong growth in energy use in the transport sector (i.e. all residential and commercial/industrial transport fuel use) has led to industrial use falling below that of the transport sector (38.6% and 42.5% respectively in 2012–13), while the residential and commercial sectors used 11.3% and 7.6%, respectively. Over the past three years the transport, residential and commercial sectors have had relatively stable levels of energy use.

Not included in the final consumption are heat and conversion losses in power plant facilities and refineries, as well as network losses. In 2012–13, for example, waste heat from power

Figure 3.2: Final energy consumption by fuel and sector, NSW and ACT, 2012–13



Source: Derived from BREE 2014

Notes: Data re-analysed by NSW Department of Industry to avoid double-counting and better allocate energy use to sectors.

'Coal' excludes fossil fuel inputs to electricity generation.

'Renewables' includes wind, bagasse, solar, wood waste and hydroelectricity. However, this data source does not include estimates for wind, solar photovoltaic (PV), solar water heating, solar thermal and other biomass sources such as ethanol, biodiesel, landfill gas, black liquor (pulp mill by-product), sewage gas, food waste and municipal solid waste.

plants amounted to around 411 PJ, equivalent (and additional) to 34.3% of final energy consumption in NSW.

Figure 3.2 shows final energy consumption by sector for 2012–13. Petroleum comprises the largest component of final energy used in NSW and the ACT. The transport sector was the major user of petroleum in 2012–13, with some used in the other sectors. Electricity use was highest in the industrial and residential sectors.

Gas consumption has been fairly level in NSW over the past five years. Most of the gas used in NSW is for manufacturing and electricity generation. Excluding the latter, gas accounted for 10.1% of final energy consumption in 2012–13.

Total NSW use of gas (excluding bottled LPG) was 19,541 MJ per person in 2012–13. In terms of residential use of gas (mainly for heating, hot water and cooking), average annual consumption was around 22,143 MJ per household (NSW Department of Industry data 2014), based on an average household size in NSW of 2.6 persons.

Energy generation

The supply mix

NSW is largely self-sufficient in terms of electricity supply, meeting about 90% of local demand. The remaining electricity is purchased from other states (in particular, Victoria and Queensland) through the National Electricity Market (NEM).

Partly due to declining electricity demand, the non-renewable component of electricity generation has been decreasing since 2008. Conversely, renewable electricity generation (excluding Snowy Hydro) has been increasing, helped by the Renewable Energy Target (RET) and other government policies supporting the use of renewables (see Responses below).

In 2014, NSW generated 66,066 gigawatt-hours (GWh) of electricity. This included:

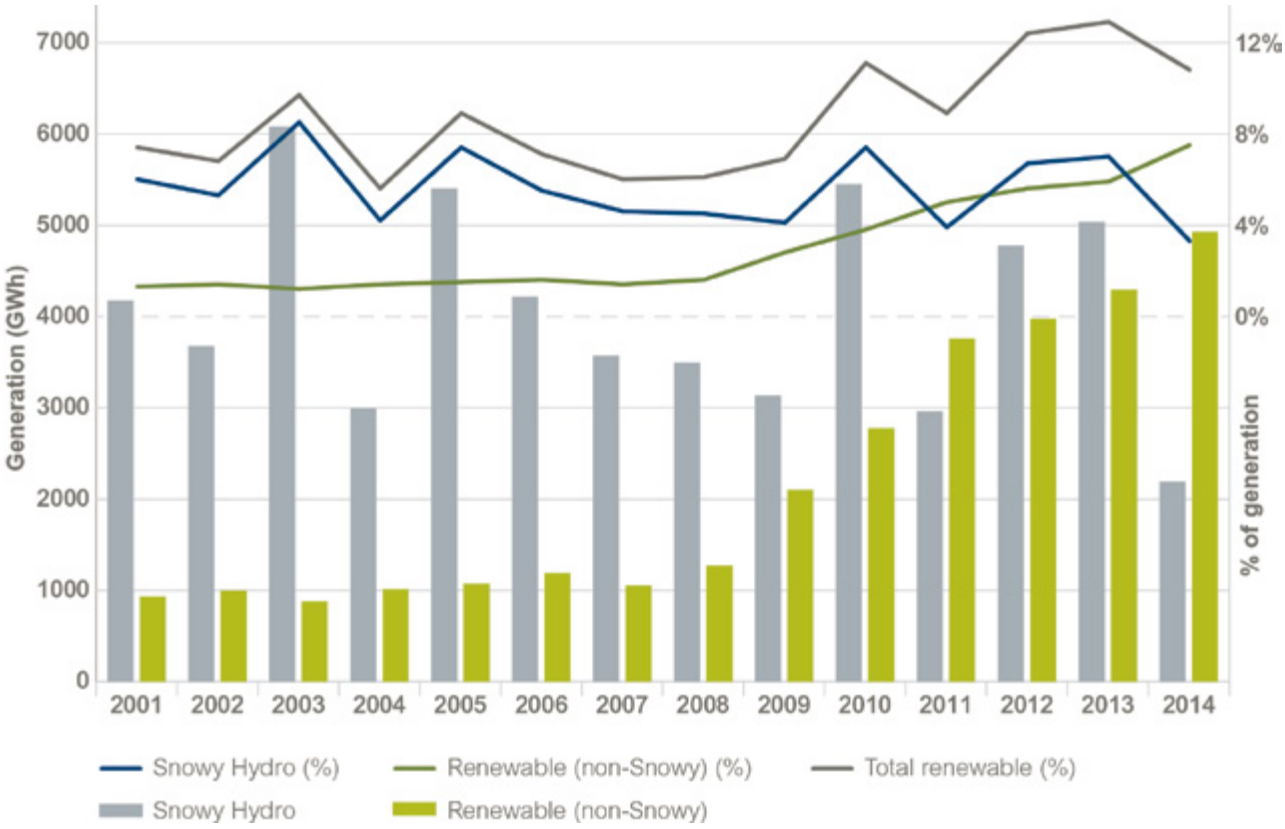
- coal – 82.3% (down from 91% in 2008)
- gas – 6.9%
- renewables – 10.8% (up from 6.1% in 2008).

Renewable energy generation and growth

Although more than 30% of current installed electricity generation capacity is powered by renewables, actual generation is lower and varies from year to year (e.g. due to weather-related water availability for hydroelectricity).

Electricity generation from renewable energy sources peaked at 12.9% of the state's total in 2013 (Figure 3.3, overleaf). Snowy Hydro is the largest renewable energy source for NSW, but can be quite variable.

Figure 3.3: Electricity generation from renewable sources, 2001–14



Source: NSW Department of Industry data 2015

Notes: 'Total renewables' includes total Snowy output.

In 2014, renewable energy sources provided 10.8% of the state's total electricity generation; with Snowy Hydro accounting for 3.3% of total NSW electricity generation. Shares of the remaining 7.5% non-Snowy, renewable energy sources are:

- solar photovoltaic (PV) systems – 31%
- wind – 20%
- biomass – 12%
- solar water heaters (which displace electricity use from electric hot water systems) – 17%
- landfill gas – 9%
- other hydro – 11%.

The growth in non-Snowy renewable generation capacity is reflected in the trend in electricity generation from other renewable sources since 2008 (Figure 3.3).

Solar, wind and biomass resources have increasingly been developed over the past six years, largely due to the RET. Since 2008, wind generation has jumped 25-fold, and solar PV generation 50-fold. In 2014, wind plants in NSW (566 MW installed capacity) generated 975 GWh of electricity, and solar PV systems, 1456 GWh (about 5.2 PJ) (NSW Department of Industry data 2015). Over 1030 GWh of electricity was also generated from bagasse, landfill and other bioenergy sources.

Pressures

The strongest growth in energy consumption in NSW has been in the commercial sector (about 140% growth over the past 40 years), while the residential and transport sectors have grown by 112% and 93% respectively. The industrial consumption in NSW has declined by about 15% (Figure 3.1).

Petroleum

NSW has the largest number of vehicles of any Australian state (ABS 2014a). It is also the largest market for petroleum. As clean and efficient combustion of fuels is more difficult to achieve in mobile engines (compared with stationary engines, power plants, etc.), the environmental and health impacts of energy use

in transport tend to be more pronounced (see Theme 8: Air quality).

Compounding the issue, transport has had a slow rate of uptake of alternative fuel sources (the sector represents only 1.9% of NSW electricity consumption). Although electric vehicles show considerable promise for improved environmental performance – especially if supplied from renewable energy sources – they are in a similar position to that of solar PV systems a decade ago, in that they are currently too expensive for widespread adoption.

Gas

Gas demand in NSW is forecast to decrease at an average rate of 1% per annum over the next 10 years. But as more than 95% of NSW gas needs are met by imports from other states, the surge in demand for liquefied natural gas exports from Queensland, which is expected to grow at an average annual rate of 60% over the next decade (AEMO 2014), means NSW will be buying gas from an increasingly internationally-exposed market as long-term low-cost gas contracts come to an end over the next two to three years.

Electricity

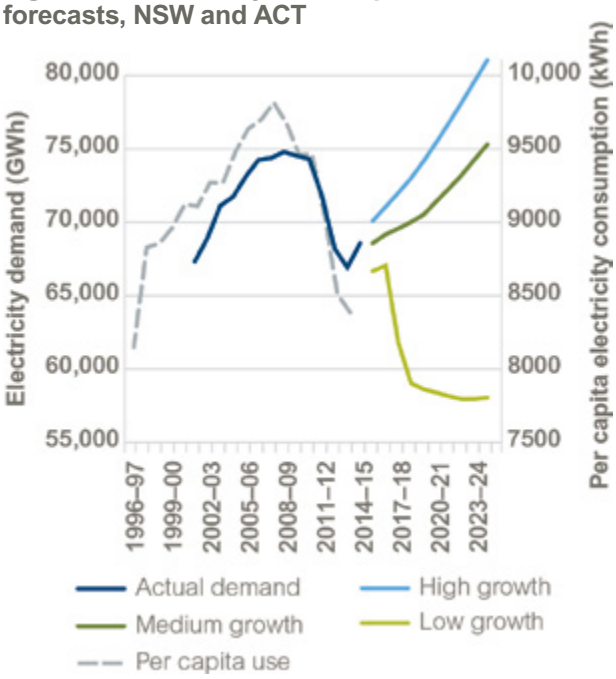
In 2013, NSW generated 66,066 GWh of electricity. The major sources of fuel for this electricity were non-renewable sources, such as coal and gas (89.2%). Renewable sources provided 10.8% of the state's total electricity generation. Heavy reliance on the combustion of fossil fuels has environmental and health impacts, including greenhouse gas emissions (see Theme 5: Greenhouse gas emissions) and air pollution (see Theme 8: Air quality).

The industrial and residential sectors use 34.6% and 34.3% respectively of the state's total electricity consumption, followed by the commercial sector at 24.7% (BREE 2014); thus, changes to economic conditions and population strongly influence demand.

Since 2008–09, consumption of electricity from the grid has been falling at an annual average rate of 2.2%. The AEMO electricity demand forecasts are also being regularly revised downwards. Factors behind these reductions include:

- decreasing demand by the industrial sector due to lower global demand and closure of large industries, such as the Kurri Kurri aluminium smelter, Kurnell and Clyde petroleum refineries
- increasing deployment of rooftop solar PV systems due to lower system prices and other incentives
- growth in energy efficiency due to federal and state government programs and consumer thrift in reaction to higher retail electricity prices.

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



Source: TransGrid 2011; ABS 2014b; Energy Supply Association of Australia data 2014; AEMO 2015a

Notes: The data includes NSW and the ACT.

There is a slight increase in the latest forecasts released in 2015 (AEMO 2015a) as compared to the 2014 forecasts. The population and economics growth from 2014–15 to 2024–25 is projected to be sufficient to grow electricity demand at 1.0% per annum (medium growth scenario, Figure 3.4). Over that period, summer and winter peak demands are also forecast to increase at an average annual rate of 0.9% and 1.1%, respectively.

Total electricity consumption per person has grown since the early 1990s. It peaked in 2007–08 and has been declining since then, and has recently been well below the levels of 1997–98 (Figure 3.4). Residential electricity consumption peaked in 2008–09 and has been falling since then, with the current consumption close to 1999–2000 levels.

Responses

Renewable energy developments

The NSW Government is promoting the development and use of alternative and renewable energy by:

- implementing the NSW Renewable Energy Action Plan (NSW Government 2013) (REAP) to increase renewable generation in NSW and help meet the national Renewable Energy Target (RET) at least cost to the energy consumer and with maximum benefits to the state
- establishing the Renewable Energy Advocate – a position that acts as a single, cross-government, point of contact for industry – helping address network, planning and financial constraints faced by renewable energy proponents
- reiterating its support (during the 2014 Review) for the Australian Government's 2014 RET of 41,000 GWh of renewable generation by 2020)
- managing the National GreenPower Accreditation Program, which helps residential and business electricity users purchase renewable energy – in 2014 sales in NSW stood at 377 GWh, about 30% of the total (NGPSG 2015)
- continuing gas pricing oversight by the Independent Pricing and Regulatory Tribunal (IPART) (regulation of the electricity retail market was removed from 1 July 2014 due to improved market competitiveness)
- continuing to support solar feed-in-tariffs (in line with annual IPART determinations)
- investigating ways to provide a sustainable and predictable future for the solar industrysupporting the Regional Clean Energy Program (RCEP), which is helping communities with the regional development of renewable energy resources – both by fostering community engagement and awareness-raising with respect to large-scale developments, as well as helping communities use renewable energy sources to generate their own electricity locally.

The Renewable Energy Advocate has identified several priority areas under the REAP, such as:

- addressing challenges associated with network connection for renewable energy projects (such as mid-scale solar PV)
- conferencing and promoting Environmental Upgrade Agreements legislation and their application to renewable energy deployment
- developing an information package for small-scale solar PV, solar hot water, and wind generation systems.

Energy efficiency developments

The NSW Government released the NSW Energy Efficiency Action Plan (OEH 2013) (EEAP) in August 2013. The plan aims to reduce household energy use and improve energy productivity for business and government by removing the barriers that prevent the uptake of energy efficiency. Key actions include:

- enhancing the Energy Savings Scheme (ESS) to encourage a broader range of energy efficiency actions
- providing incentives to encourage new, innovative behaviour change programs that save energy
- implementing a digital information-sharing platform for households, businesses, and service providers – this will enable the sharing of: usage data; information on energy efficiency opportunities; and case studies, guides and tools.

In 2013–14, energy savings of 4649 GWh accrued from the ESS, appliances standards, building ratings, and other state and national efficiency programs active in NSW. The NSW Government is investigating expanding the ESS to support natural gas users to adjust to recent price rises and boost gas efficiency.

Funding

The NSW Climate Change Fund, established in 2007, is a key funding mechanism for EEAP, the NSW Government Resource Efficiency Policy (GREP; see Using energy wisely below) and RCEP.

Diversifying energy supply and lowering coal use

The NSW energy supply is dominated by coal (locally produced, but highly carbon-intensive), and petroleum and gas (mostly imported and also carbon-intensive). Therefore, there are sound strategic, economic and environmental reasons to diversify the mix of energy supplied.

Increasingly, individual industries, companies and households can make their own choice on which energy supply they want. However, government and industry can drive this on a broader scale by supporting the diversification of electricity generation sources and developing alternative transport fuels and new vehicle technologies.

The NSW Government is also committed to reducing greenhouse gas emissions from coal. Through the $100 million Coal Innovation NSW Fund (CINSW Fund), the Government is carrying out research, development and demonstration of low emissions coal technologies, and improving public awareness. Trials include:

- investing directly into the Delta Carbon Capture and Storage Demonstration Project and the NSW CO_2 Storage Assessment Project
- funding a further seven research and development projects and other initiatives in low emissions coal technologies (see Future opportunities below).

Electricity

Whether NSW has sufficient electricity supply to meet demand depends on the balance between demand changes and the addition and retirement of generation capacity. According to the latest demand–supply balance outlook NSW has sufficient electricity supply to meet demand for the next six to eight years depending on the demand scenario (AEMO 2015b). This is largely due to:

- the recent retirement of Wallerawang and Redbank coal fired power plants (1150 MW capacity)
- the upcoming retirement of Liddell, the state's oldest coal fired plant (2000 MW)
- the upcoming retirement of a 170 MW gas fired power plant at Smithfield.

As AEMO demand–supply forecasts incorporate 'committed' projects only, the supply-side deficiency may only be nominal. Projects which currently have planning approval (but do not yet have financial backing), or are awaiting NSW planning approval, will improve supply capacity, as will any new investment under the RET.

Replacement capacity is coming from both conventional and renewable sources. New and large-scale renewable generation proposals, with a total capacity of 2700 MW, have development approval (2350 MW wind and 350 MW solar). A further 5100 MW wind generation proposals are seeking planning approvals. Around 8600 MW has also been approved for new coal and gas generators.

However, depending on future economic and regulatory conditions, not all of these proposals (conventional or renewable) may progress to completion.

With a growing proportion of new generation facilities being reduced or zero-emission designs, these proposals will reduce the state's reliance on coal and gas for power generation and aid the move to lower emission energy sources. Moreover, changes to demand, efficiency, along with other factors, may facilitate faster retirement of older fossil-fuelled power stations and the more rapid development of renewable generation capacity in preference to proposed coal or gas plants.

It is also forecast that residential roof-top solar PV generation is likely to grow to over four times the current level in the next 20 years. NSW is leading in commercial solar PV generation, which is likely to grow 13 times to 2600 GWh by 2035 (AEMO 2015a).

Gas

Given strong local and international demand for gas, ensuring security of a cost-effective supply is a key aim of the NSW Government. As NSW has traditionally had minimal local production, the new development of local supplies has been associated with significant environmental issues and community concerns.

In November 2014, the NSW Government released the NSW Gas Plan (NSW Government 2014). It aims to secure gas supplies for NSW households and businesses by establishing a safe, sustainable industry. To do so, the Government will:

- make better science and information available to decision-makers and the community
- introduce a strategic release framework for gas exploration, enabling up-front consultation with the community when determining the most appropriate areas for exploration
- appoint the independent Environment Protection Authority as the lead regulator for compliance and enforcement of conditions of approval for both gas exploration and gas production activities
- undertake policy and regulatory reform leading to strong and certain regulation and introducing worlds' best practice environmental and regulatory standards for gas development activities
- ensure additional water monitoring and reporting
- share the economic benefits of gas development with landholders and local communities by establishing a community benefits fund to fund local projects in communities where gas exploration and production occurs
- secure gas supplies by studying all supply options.

The NSW Gas Plan also adopts in full the recommendations of the NSW Chief Scientist & Engineer's Final Report of the Independent Review of Coal Seam Gas Activities in NSW (CS&E 2014). This includes the establishment of a whole-of-environment data repository for all state environment data including all data collected according to legislative and regulatory requirements associated with water management, gas extraction, mining, manufacturing, and chemical processing activities.

In addition, the NSW Government is developing and implementing policies to reduce land-use conflict between resource industries (including CSG), agriculture and the environment.

Alternative transport fuels and new vehicle technology

The NSW Government is supporting the development of a market for cleaner new motor vehicles and cleaner and alternative fuels. This will improve air quality and reduce fuel consumption and greenhouse gas emissions.

Biofuels, such as ethanol and modified vegetable oil (biodiesel), create jobs in regional NSW, help farmers and reduce reliance on foreign fuel imports. Since 2007 NSW has mandated that ethanol comprises 6% of the total volume of petrol sold in NSW and for diesel 2% must be biodiesel (rising to 5% when there is sufficient local production). Approximately 30% of all petrol and diesel sold in NSW now contains biofuel.

Electric vehicles present significant opportunities to reduce the environmental impacts of road vehicle use. They do not cause air pollution when driven and emit slightly less CO_2 than internal combustion engine vehicles, even when charged through the electricity grid.

As well as technological advances, the uptake of electric vehicles may be assisted by infrastructure, policy and legislation changes. For example, the Australian Energy Market Commission has published a review of Energy market arrangements for electric and natural gas vehicles (AEMC 2012).

Using energy wisely

The Building Sustainability Index

The Building Sustainability Index (BASIX) was introduced by the NSW Government in 2004 to ensure that new homes, residential alterations and additions costing more than $50,000 are designed and built to high energy and water efficiency standards. Each new home in NSW must meet a greenhouse gas emission reduction target compared with the average home built before the scheme's introduction. For Sydney and coastal NSW, this target is 40%. For houses approved between July 2004 and December 2011, the commitment to energy savings for BASIX-compliant dwellings translated to a cumulative reduction of greenhouse gas emissions of more than 1.5 million tonnes CO_2-equivalent.

The National Australian Built Environment Rating System

The National Australian Built Environment Rating System (NABERS) expands on a NSW program that rates buildings using measured environmental impacts. NABERS Energy ratings are available for commercial office buildings, hotels, shopping centres, homes, NSW schools and NSW hospitals. Office buildings using NABERS under Commercial Building Disclosure (CBD) have improved their greenhouse gas emissions performance by an average 11.5%.

Most office buildings over 2000 square metres in size are required to disclose their NABERS Energy rating at the point of sale or lease under the CBD program. In addition to this, NABERS ratings are crucial to a number of industry and government programs, such as the CitySwitch Green Office program, the NSW Energy Savings Scheme, Melbourne's 1200 Buildings program, the National Green Leasing Policy and Green Star ratings.

The NSW Government Resource Efficiency Policy

The NSW Government Resource Efficiency Policy (GREP) (OEH 2014), released in July 2014, encourages the NSW Government to lead by example by saving energy and electricity costs in its own operations through implementing energy efficiency projects across government facilities. The policy contains a range of measures that will ensure NSW Government agencies meet the challenge of rising costs for energy, water, clean air and waste management.

Key actions on government agencies include:

- undertaking energy efficiency projects at sites representing 90% of billed energy use
- introducing minimum efficiency standards for water and energy using appliances purchased
- development of waste reduction plans to further decrease or divert waste from landfill
- introduction of air emission standards for mobile non-road diesel plant and equipment owned or contractor supplied.

Agencies will report annually on performance with whole-of-government progress being reviewed every two years.

The Energy Efficient Government Program (EEGP) was established in 2013–14 in direct response to the Energy Efficiency Action Plan with the aim to achieve energy bill savings of up to $27.5 million a year from energy efficiency upgrades initiated at government sites.

The EEGP provides government agencies with access to the following range of tools and knowledge to ensure that energy efficiency projects are successful:

- a team of dedicated energy efficiency specialists with the expertise to identify and implement viable energy efficiency projects and operational experience in risk-reduction
- a panel of pre-qualified energy service companies (ESCos) to streamline the procurement process
- repayable capital advances to fund energy efficiency upgrades through a Government Finance Facility with a total net liability of $95 million.

Smart meters and grids

When coupled with appropriate price signals or other incentive measures, effective end-user metering of consumption can encourage better user-management of electricity use.

The NSW Government has announced electricity smart meters in NSW will be installed through a market-led rollout; supported by proposed new rules that provide for a competitive metering regulatory framework.

Both the NSW policy and the proposed national framework will encourage competition by allowing metering providers, such as electricity retailers or other new entrants, to offer smart meters to customers as part of retail energy packages that include the meter, installation, and options for time-of-day tariffs.

The Greenhouse and Energy Minimum Standards

The Greenhouse and Energy Minimum Standards (GEMS) is the national program for equipment and energy efficiency. Established in 2012 under Australian Government 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, reduced energy use due to the program could save households and businesses an estimated $60 billion between 2012 and 2030.

Energy market reform

The COAG Energy Council, through its Power of Choice Reforms, is looking at three elements to improve competition and support new products and services:

- cost reflective price signals, i.e. higher prices at the times of high cost for operating the network
- enhanced and more accessible information for consumers to allow them to better manage their energy use; this includes a rule change in late 2014 to provide minimum requirements for information provision to consumers and better tools
- metering changes to complement the above initiatives by facilitating timely information flows and enhancing the products available to customers.

In regards to gas policy, the COAG Energy Council has commissioned the Australian Energy Market Commission to review the design, function and roles of facilitated gas markets and gas transportation arrangements in the context of rapid transition in Australian gas markets.

Future opportunities

As a means of maintaining the security of energy supply while reducing emissions, research and development in NSW is currently examining suitable cost-effective technologies that can be added to conventional energy systems. These include the following.

Carbon capture and storage

The feasibility of retrofitting post-combustion capture and oxy-fuel combustion to existing NSW power stations is being evaluated. The CO_2 storage potential of the state's geological structures is also being investigated, with an initial drilling and testing program in the Darling Basin indicating positive preliminary results.

Combustion efficiency improvement technology

To accelerate the deployment of low emissions coal technologies, the CINSW Fund is supporting research and development of chemical looping air separation technologies to produce oxygen for use in oxy-fuel combustion power stations. The direct carbon fuel cell is also being funded by the CINSW Fund.

Reducing emissions from mines

The CINSW Fund is sponsoring a collaborative project with Centennial Coal trialling a new technology to mitigate ventilation air methane from underground mines; a source that is difficult to abate as standard mining operations greatly dilute the methane, making it difficult to capture.

Active smart meters

Moving beyond the data monitoring capabilities of 'passive' smart meters, active smart meters have the potential to manage energy consumption in real time. These programmable switches can assist in electricity demand management by switching off selected circuits or devices depending on factors such as periods of high electricity demand or low supply. Depending on the supply contract, they can be programmed by the consumer and/or the electricity supplier.

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4 TRANSPORT

The demand for transport has increased as population grows. However the number of trips per person reduced by 4.8% and the vehicle kilometres travelled per person have slightly reduced (2.1%) between 2002–03 and 2012–13. It is likely that a variety of factors, including changes in lifestyle and technological advances have influenced this. From 2002–03 to 2012–13 there was a 148% increase in employees with working from home arrangements.

In 2012–13, over four and a half million Sydney residents made a total of 16.7 million trips by all modes of transport each weekday and 14.6 million trips each weekend day.

Public transport trips increased at a faster rate than population growth in the decade to 2012–13. However, the car is still the dominant mode of transport, accounting for 69% of all trips by Sydney residents.

The transport sector is the main source of NO_x emissions in the Greater Sydney region and in 2012–13 was responsible for 19% of NSW greenhouse gas emissions.

The NSW Long Term Transport Master Plan 2012 establishes a framework to guide the development of transport decisions over the next 20 years, including initiatives to manage and minimise the environmental impacts of our transport systems.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Vehicle kilometres travelled (total)	P	Increasing impact	✓✓✓
Vehicle kilometres travelled (per person)	M	Stable	✓✓✓
Public transport use overall trips	M	Decreasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Transport plays a key role in allowing people and goods to get from one place to another. There are a variety of reasons why people travel, including commuting to and from work, socialising, recreation, education, childcare, shopping, personal reasons and work-related business.

While transport is critical to move people and goods between locations, it also has impacts for the environment. Transport typically uses non-renewable resources, produces greenhouse gas emissions and generates noise and air pollution.

Reducing congestion, improving accessibility between homes and work and service centres (especially by making public transport a more attractive option) is relevant to all metropolitan and regional centres. Definitive information is available for the Newcastle, Sydney and Wollongong metropolitan areas.

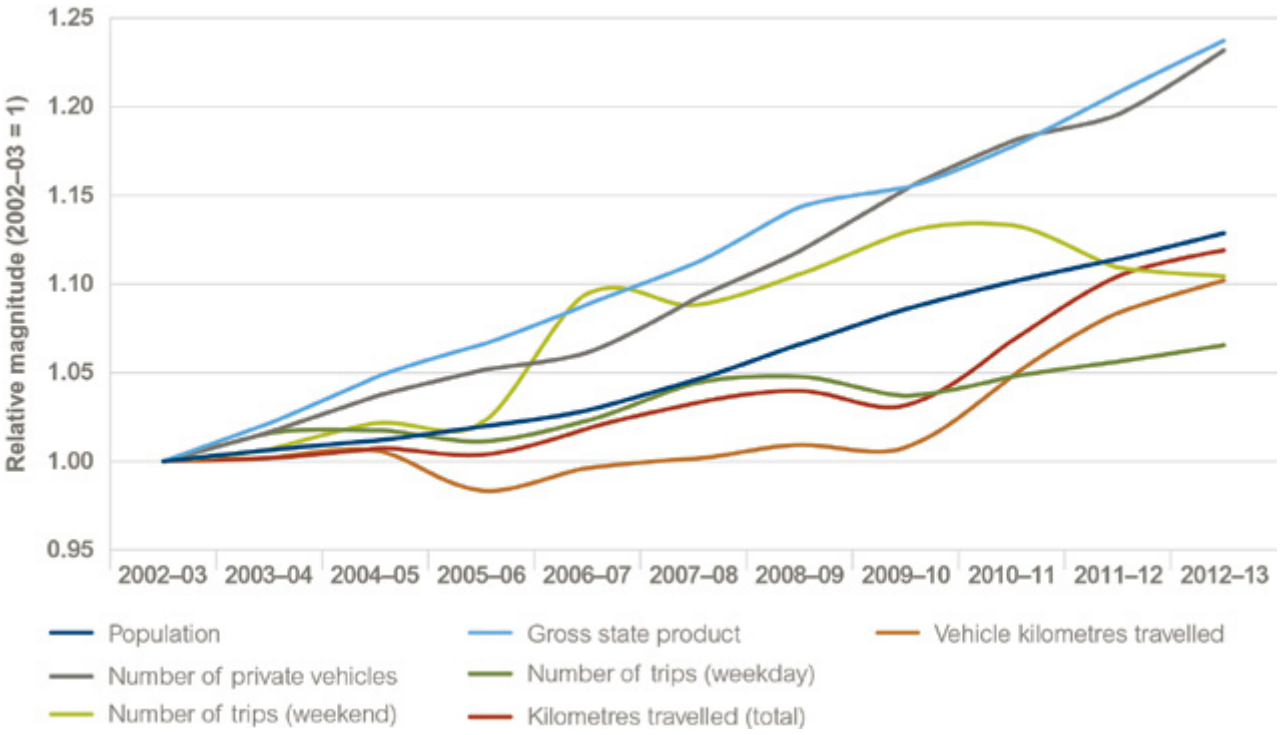
Status and trends

In-depth transport data has been collected for the Sydney Greater Capital City Statistical Area (GCCSA) under the annual Household Travel Survey conducted by the Bureau of Transport Statistics (BTS). The most recent information for 2012–13 is presented below.

Total trips

Sydney residents took 16.7 million trips across all modes on an average weekday in 2012–13. This reflects a 10% increase over 2002–03 figures (Figure 4.1). Weekday trips have gradually increased since 2002–03, however there was a slight decline between 2008–09 and 2009–10 from 16.4 million to 16.2 million. Weekend trips of Sydney residents have grown 10% over the last decade, more recently though there has been a decline from the peak of 14.9 million in 2010–11 to 14.6 million in 2012–13 (BTS 2014).

Figure 4.1: Travel trends 2002–03 to 2012–13 in the Sydney Greater Capital City Statistical Area*



Source: BTS 2014

Notes: *Sydney Greater Capital City Statistical Area extends to and includes the Central Coast (north), Helensburgh (south) and Blue Mountains (west).

The total number of trips for both weekdays and weekends has increased and this could be correlated directly to population growth. The impacts of transport use on the environment are greater greenhouse gas emissions and increased noise and air pollution (see Theme 8: Air quality and Theme 5: Greenhouse gas emissions).

Trips per person

Daily trips per person portray a different story. Weekday trips have experienced a continual steady decrease of 5.7% from 2002–03 to 2012–13. Over the same time period weekend trips have reduced by 2.1%. The reduction in trips was also reflected in personal business trips and work-related business trips, which decreased 23% and 14% respectively (BTS 2014).

Technology and the effect on the number of trips

This continued decline of per person trips coincides with the rise in smart phone and information technologies, which may have led to the reduction in these travel requirements as online shopping and working from home become more popular (BTS 2014).

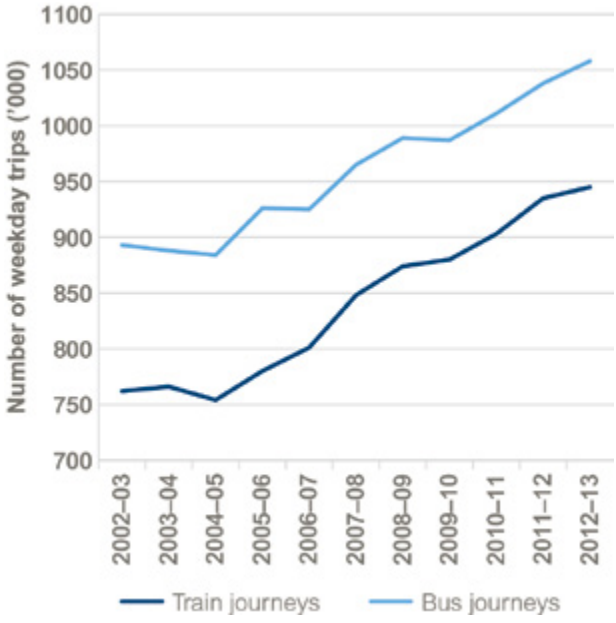
Shopping trips grew by 7% over the decade, which is slower than population growth (13%). The Australian Bureau of Statistics (ABS) estimated that 75% of internet users in NSW engaged in online shopping (BTS 2014).

Technological trends could be further supported as a contributor to the reduction in trips by the number of employees working from home rising from 89,000 in 2002–03 to 221,000 in 2012–13, a 148% increase (BTS 2014).

Vehicle ownership

Vehicle ownership in Sydney has steadily risen by 23.2% from 2002–03 to 2012–13, which is at a similar rate to gross state product (24%), and at almost double the rate of population growth (13%). Over the same time period, bicycle ownership has increased by 30.9% (BTS 2014).

Figure 4.2: Number of train and bus trips on an average weekday for the Sydney Greater City Capital Statistical Area, 2002–03 to 2012–13



Source: BTS 2014

Notes: Based on unlinked trips.

The number of vehicles per household increased from 1.4 in 2002–03 to 1.6 in 2012–13, though this is not reflective of the VKT per person, which in the same decade, dropped by 2.1%. This would indicate that, while people own more vehicles, they don't necessarily drive more. Vehicle ownership and vehicle travel are influenced by a variety of factors including income, fuel prices and environmental consciousness (BTS 2014).

Public transport

Train trips increased by 24% between 2002–03 and 2012–13, while bus trips increased by 18% (Figure 4.2); the rise in public transport trips far exceeded the number of car trips, which was 5%. The proportion of trips made by train on an average weekday in 2012–13 was 5.4%, and 6% by bus (BTS 2014).

While public transport has numerous social, economic and environmental benefits, travel by car remains the dominant mode choice for Sydney residents, accounting for 69% of trips (BTS 2014). This has environmental implications such as the production of greenhouse gases along with the pressure on non-renewable resources due to the demand for fuel.

Extra vehicles on the roads may lead to increased congestion and ultimately result in more air and noise pollution. Runoff from roads affects water quality, while the construction of roads in bushland may have an impact on biodiversity where it fragments natural ecosystems.

In NSW transport is the fastest growing component of greenhouse gas emissions. In 2013 transport accounted for 19% of greenhouse gas emissions; it is the second largest contributor in the state with stationary energy being the main contributor (see Theme 5: Greenhouse gas emissions). In the Greater Sydney region, transport emissions continue to be the main source of NO_x and VOC emissions (see Theme 8: Air quality).

Walking as a mode of travel on an average weekday has risen by 11% from 2002–03 to 2012–13 and while this is encouraging, it is slower than population growth (13%). Younger age groups (below 40 years) are walking more and using public transport, while over 60 age groups rely more on travel by car (BTS 2014).

During 2012–13, 48% of Sydney commuters reported that they used public transport to avoid parking problems. For approximately a third of public transport commuters, speed and cost were also important reasons for their mode choice. Just under a fifth said they used it due to the proximity to their home and workplace. In 2012–13 only 5% of public transport commuters gave environmental factors as a reason for using public transport.

Amount of time travelling

The amount of time spent travelling per person, on an average weekday has remained relatively constant over the 2002–03 to 2012–13 period, ranging from 79 minutes to 81 minutes for a Sydney resident. The average trip duration has risen from 21 minutes to 22 minutes over the same time frame, and has been consistently at 22 minutes since 2010–11 (BTS 2014).

Pressures

The NSW population is expected to grow to around nine million by 2031. Continued growth brings with it an increase in passengers for trains, light rail, buses, ferries, more traffic on the roads and more goods moving around the state. Where the growth in traffic leads to increasing congestion, the pressures on the environment are also exacerbated, whereas if traffic is able to flow smoothly the environmental impact is lessened.

There are also many factors which can ease the pressure that transport generates on the environment:

- the frequency, reliability and quality of public transport and the areas it serves
- the availability and quality of pedestrian and cycling facilities
- advances in transport technologies, particularly increases in fuel efficiency, low emission vehicles and the use of cleaner fuels
- reducing the distance people need to travel to their places of work or essential facilities.

Fluctuations in the price of fuel can lead to the car being seen as a more or less favourable alternative to public transport.

Responses

Strategic direction

The NSW Government released the NSW Long Term Transport Master Plan (NSW Government 2012) in December 2012, which establishes the overarching framework to guide the development of transport planning, policy, reform and funding decisions to support sustainable growth for metropolitan and regional NSW over the next 20 years.

In June 2014 the Government announced Rebuilding NSW. This plan will invest $20 billion in new productive infrastructure, including a second harbour rail crossing and a third harbour road crossing. To support Sydney's anticipated population growth, $8.9 billion is also reserved for urban public transport.

A series of regional, corridor and mode specific plans were progressively released over 2012 and 2013. These plans set out the initiatives that will improve the performance of the transport

network, in a way that integrates transport and land use while minimising the impacts on the environment.

Mode specific plans include:

- Sydney's Rail Future (TfNSW 2012b) – a long-term plan to increase the capacity of Sydney's heavy rail network through investment in new services and upgrading existing infrastructure
- Sydney's Light Rail Future (TfNSW 2012a) – a plan to reduce congestion and revitalise Sydney
- Sydney's Bus Future (TfNSW 2013a) – a 20-year plan to redesign the city's network of over 600 bus routes to sustainably meet customer needs
- Sydney's Ferry Future (TfNSW 2013c) – outlines short and long-term initiatives for the ferry network
- Sydney's Cycling Future (TfNSW 2013b) – coordinates planning and investment in infrastructure and projects thus resulting in a safer and connected network of bicycle paths.
- Sydney's Walking Future (TfNSW 2013d) – sets out actions to make walking the transport choice for quick trips under two kilometres and will help people access public transport.

These transport plans deliver the critical transport infrastructure components of the State Infrastructure Strategy 2012–32 (Infrastructure NSW 2012), which was updated in 2014 (Infrastructure NSW 2014), and support land-use planning for Sydney's future population and employment outlined in the Government's Plan for Growing Sydney (NSW Government 2014).

Major projects

Six major projects have been completed or are underway to help improve public transport and reduce congestion.

Inner West Light Rail Extension was completed in 2014. It includes a 5.6 kilometre extension of the light rail from Lilyfield to Dulwich Hill, nine new light rail stops: Leichhardt North, Hawthorne Marion, Taverners Hill, Lewisham West, Waratah Mills, Arlington, Dulwich Grove and Dulwich Hill, and 12 new light rail vehicles. It improves access to public transport and connections between where people live, work and visit.

South West Rail Link was completed in 2014. It includes the major upgrade of Glenfield Station and bus/rail interchange and a new twin track passenger rail line from Glenfield to Leppington. Benefits include increased and more reliable train services and increased commuter car parking services, thus improving access to public transport for the people of South West Sydney.

Sydney Metro Northwest, which will be the first fully-automated metro rail system in Australia. When completed in 2019 it will deliver eight new stations at Cherrybrook, Castle Hill, Showground, Norwest, Bella Vista, Kellyville, Rouse Hill and Cudgegong Road, five upgraded stations and 4000 commuter car parking spaces. It will provide 15 rapid transit trains an hour. Working together with major upgrades to the Western Line, Sydney Metro City and Southwest will deliver the capacity to increase the number of trains entering the CBD across the entire Sydney railway system from 120 to about 200 in the busiest hour of the day.

Sydney Light Rail when completed in 2019 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. It is an integral part of the NSW Long Term Transport Plan and aims to reduce congestion.

WestConnex is Australia's largest urban road project and will link western and south-western Sydney with the city and airport in a 33 kilometre continuous motorway. The project is to be delivered in three stages and will be complete in 2023. It is anticipated that it will ease congestion and save commuters 40 minutes when travelling from Parramatta to Sydney Airport and create 10 kilometres of bus lanes, halving the bus travel times from Burwood to the CBD.

NorthConnex is a nine-kilometre tunnel motorway which will link the M1 Pacific Highway at Wahroonga to the Hills Motorway at West Pennant Hills. The tunnel is expected to be open in 2019. The NSW Government's State Infrastructure Strategy and NSW Long Term Transport Master Plan recognise the link as important infrastructure for freight and the wider connectivity within NSW to reduce congestion and improve traffic flow along Pennant Hills Road.

More public transport services

New public transport timetables in October 2013 delivered an additional 1190 rail, 6900 bus and 220 ferry services each week across the metropolitan area.

Making journey planning easier

Apps that provide real time information about public transport timetables and service disruptions are now available, along with improvements to the journey planning website.

Opal card, a pre-pay card launched in December 2012, can be used on trains, buses, ferries and light rail. It has reduced queues at stations, encouraged people to use public transport and reduced paper ticket waste.

Walking and cycling

There are a range of pedestrian and cycling initiatives being implemented. These will encourage people to leave their car at home and use alternatives to help reduce carbon pollution, improve air quality and maximise the capacity of the existing road network. Major work commenced on Wynyard Walk in 2012; when completed in 2016 it will provide a fully accessible pedestrian link between Wynyard Station and the developing CBD western corridor and Barangaroo.

Future opportunities

Integrated coordinated strategic approaches to planning are required to help reduce the impacts of population growth on both metropolitan and non-metro areas of NSW. Planning of new residential areas should take into account the ease and viability of public transport to key services and various CBDs in the Sydney region.

Raising public awareness of the environmental benefits of using public transport could increase its use.

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5 GREENHOUSE GAS EMISSIONS

Annual greenhouse gas emissions for NSW – excluding emissions and removals from land usages – were 146.7 million tonnes in 2013, based on the accounting methodology of the *United Nations Framework Convention on Climate Change*. This is a decrease of 1% since 1990, 4% since 2000, and 11% since emissions peaked in 2007.

NSW emissions are about 19.6 tonnes per capita. This is below the national average of 23.2 tonnes per capita.

Across most economic sectors emissions have declined since 1990, including mining, industrial processes, agriculture, land clearing and waste. In contrast, emissions from transport have undergone almost uninterrupted growth, with forecasts indicating continued growth. Overall, stationary energy emissions (primarily electricity generation) also rose from 1990, peaking in 2007 and then declining quickly. Together, the stationary energy and transport sectors represent 59% of total NSW emissions, and forecasts indicate the emissions from both will grow in the future.

To help meet its goal of increasing use of lower emissions energy sources and improving energy efficiency, the NSW Government is implementing the NSW Renewable Energy Action Plan and the NSW Energy Efficiency Action Plan. It continues to support a national Renewable Energy Target and the Greenhouse and Energy Minimum Standards initiative; along with a suite of other actions to improve energy efficiency and lower power emissions. The NSW Government maintains biofuels mandates as a means of increasing use of lower emissions energy sources in the transport sector.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Atmospheric concentrations of greenhouse gases	P	Increasing impact	✓✓✓
Total annual NSW greenhouse gas emissions	P	Decreasing impact	✓✓✓
Annual NSW per capita greenhouse gas emissions	P	Decreasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

The global mean temperature has risen by 0.85°C (± 0.2°C) since 1880. All of the warmest 20 years on record have occurred since 1990.

Temperatures in the Australasian region are already rising quickly to their highest levels in more than a thousand years (Figure 5.1). Since 1910 Australia's climate has warmed by 0.9°C, extreme fire weather has increased and rainfall patterns have changed (BOM & CSIRO 2014).

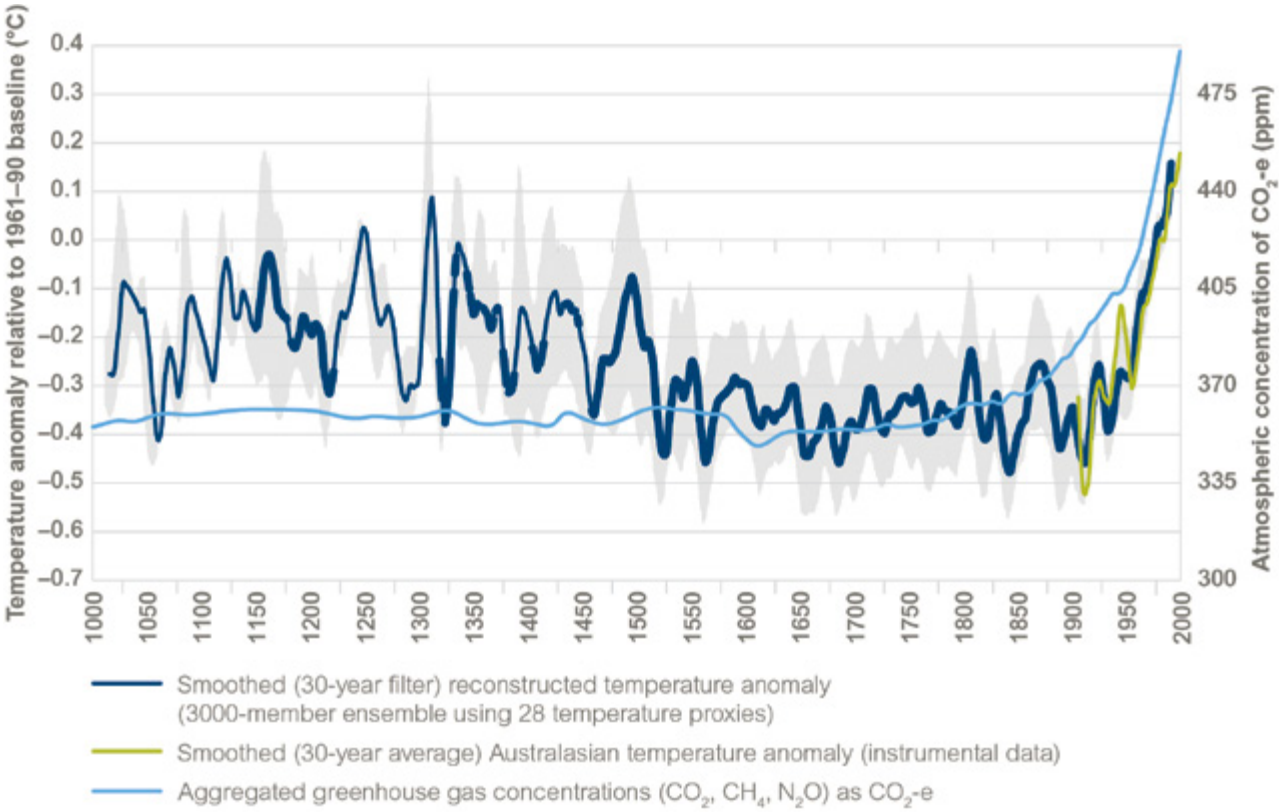
It is the view of most scientists that the dominant cause of recent warming has been human-induced greenhouse gas emissions and not natural climate variability (BOM & CSIRO 2012).

Greenhouse gases in the atmosphere, along with physical processes such as solar heat absorption by vegetation, oceans, atmospheric dust and other dark materials, act to maintain an average global surface temperature of about 14°C, which would otherwise be about –20°C (IPCC 2007, p.946).

Changing greenhouse gas concentrations will alter the heat balance of the atmosphere. For most of the past 2000 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 5.1).

The increased use of fossil fuels since the mid-18th century, along with agricultural and land-use changes, and other activities, have led to a build-up of greenhouse gases, such as carbon dioxide (CO_2), methane, nitrous oxide, ozone and

Figure 5.1: Australasian summer temperature reconstruction, temperature observations, and CO_2-e, since AD 1000



Source: Gergis et al. in revision; CSIRO data; Hartmann et al. 2013, Table 2.1

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, N_2O; as measured in ice cores from Law Dome, Antarctica) multiplied by their individual radiative efficiencies relative to CO_2.

manufactured gases like chlorofluorocarbons (IPCC 2007; CSIRO 2011). This has resulted in extra heat being trapped by the atmosphere, showing up as an increase in global surface temperatures (IPCC 2007, p.4). In terms of both volume and effect, CO_2 is the largest single contributor, being responsible for approximately 63% of the change in the climate observed since pre-industrial times (CSIRO 2011).

Concentrations of 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).

Across the international Greenhouse Gas Reference Network concentrations of CO_2 are observed to be about 2–3 ppm higher in the northern hemisphere (e.g. at Mauna Loa in Hawaii) compared to those in the southern hemisphere (e.g. at Cape Grim in north-west Tasmania). Mauna Loa data shows carbon dioxide concentrations are now increasing at about 2 ppm per year, with monthly mean values exceeding 400 ppm in 2014.

The last time that 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).

Status and trends

Global greenhouse gas emissions

In 2010, global anthropogenic greenhouse gas emissions reached 49 ± 4.5 $GtCO_2$-e (gigatonnes of CO_2 equivalent) (IPCC 2014). Fossil fuel (coal, oil and gas) combustion and industrial processes contributed about 78% of the increase in emissions of CO_2 from 1970 to 2010 (IPCC 2014). Economic and population growth continued to be the key drivers of increases in CO_2 emissions around the world (IPCC 2014).

Australian greenhouse gas emissions

Using the same accounting methodology as the Intergovernmental Panel on Climate Change (IPCC) and United Nations Framework Convention on Climate Change (UNFCCC), 549 Mt CO_2-e of greenhouse gases were emitted in Australia during 2013 (DE 2015a). This makes Australia one of the highest per capita emitters of greenhouse gases in the world (IEA 2011, pp. 97–99). Australia's per capita emissions for fuel combustion (16.7 tonnes CO_2-e per person in 2012), were significantly higher than the Organisation for Economic Cooperation and Development (OECD) average and the non-OECD average of 9.7 and 3.2 tonnes CO_2-e per person respectively (IEA 2014, p.84).

NSW greenhouse gas emissions

According to the UNFCCC accounting methodology, total NSW greenhouse gas emissions for 2013, excluding emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) activities, were 146.7 Mt CO_2-e (27% of the national total) (DE 2015b). This is a decrease of 1% since 1990; it is also a decrease of 4% since 2000 and 11% since emissions peaked in 2007. NSW's mix of economic activities and energy policies helps to keep its annual per capita emissions (19.6 tonnes in 2013) below the national average (23.2 tonnes) (DE 2015a, p.33).

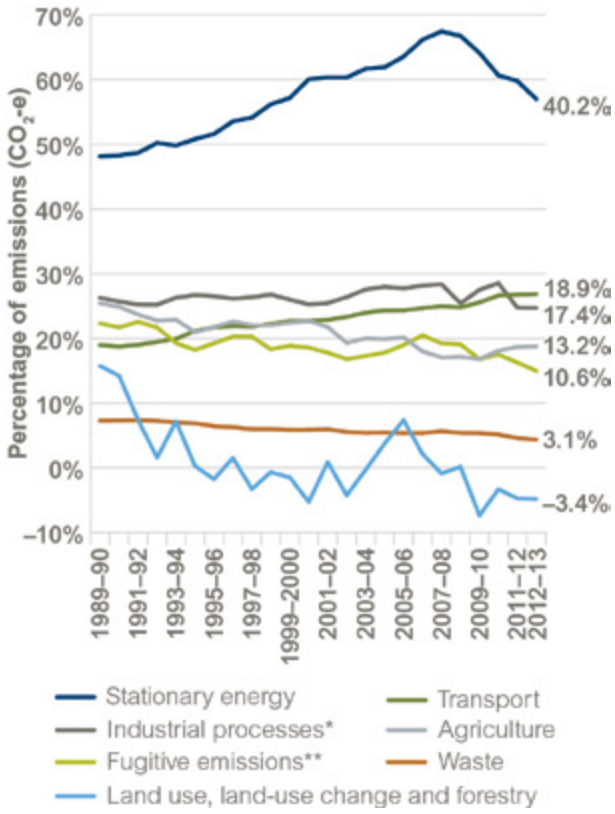
NSW emissions components

Emissions from the combustion of fossil fuels account for 66% of NSW emissions, with a further 10% from coal mining emissions (Figure 5.2, overleaf).

Stationary energy emissions (primarily fuel combustion for electricity and other gas use) increased by 9% since 1990 in NSW, which reflects population and economic growth. This increase is tempered by:

- energy efficiency improvements
- the deployment of gas-fired and renewable power stations sources
- reduced demand due to the impacts of the global financial crisis.

Figure 5.2: NSW greenhouse gas emissions components, 1989–90 to 2012–13

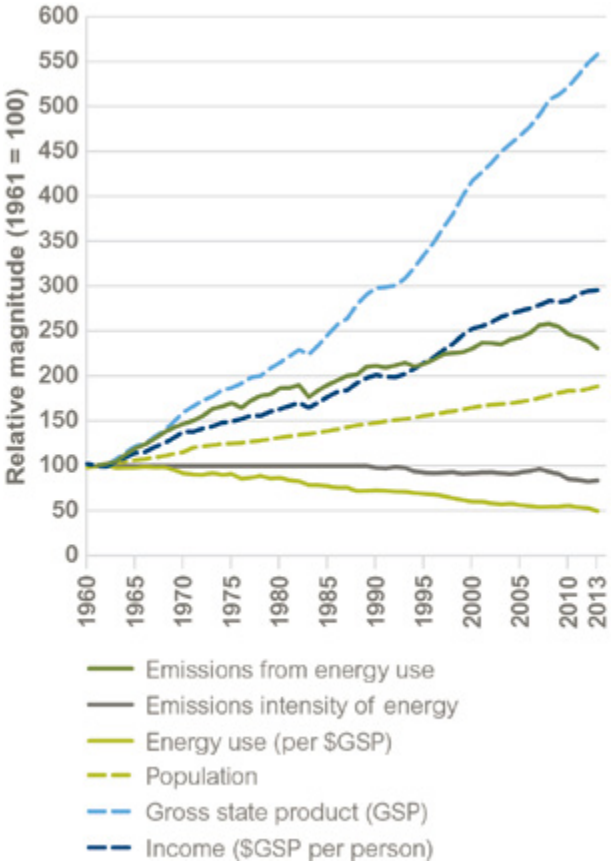


Source: DE 2015b

Notes: *Includes fuel combustion for manufacturing industries and construction, etc.

**97% of NSW fugitive emissions come from coal mining.

Figure 5.3: Trends in NSW energy use, compared with key NSW statistics, 1960–2013



Source: OEH analysis based on ABS 2008; ABARES 2011; ABS 2011a; ABS 2011b; DCCEE 2011

Electricity generation and use in NSW is expected to resume growing, albeit slowly (see Figure 5.3, and Figure 3.4 in Theme 3: Energy consumption).

The transport sector is the fastest growing component of NSW-generated greenhouse gases. This reflects the importance of motor vehicles for both passenger and freight transport within the state. Although transport energy consumption was relatively stable from 2010–11 to 2012–13 (see Theme 3: Energy consumption), the transport sector is, nevertheless, 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 18.9% in 2013.

With the first Kyoto Protocol commitment period (2008–2012) at an end, emissions estimates from LULUCF activities have been finalised. This has involved accounting for (for example) reafforestation undertaken since 1990, but re-cleared before 2012. This reveals that this sector has gone from being a net generator of emissions, to a net sink for emissions.

Pressures

Global emissions

The Copenhagen Accord declared that deep cuts in emissions are required to hold the increase in global temperature below 2°C (UNFCCC 2009). In effect, world-wide emission reductions of around 5% per year would be required. This corresponds to limiting cumulative, post-1750, emissions to the equivalent of one trillion tonnes of carbon (Raupach et al. 2011). Business-as-usual activities will see the trillion tonne level exceeded in about 35 years (CSIRO 2011, Ch. 2).

NSW emissions

Historically, NSW emissions have been strongly correlated to population growth and economic activity (Figure 5.3). As economic activity relies heavily on energy, emissions from energy consumption are the most significant and the largest contributor to NSW emissions (40%).

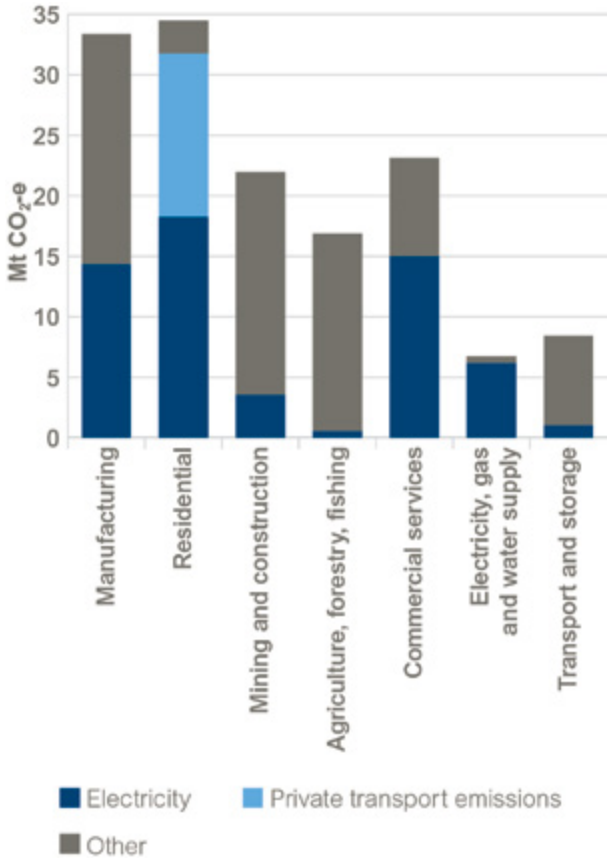
In recent years, electricity consumption has declined in NSW due to a variety of economic factors, such as increased local generation by residential and commercial users and improvements to energy efficiency (see Theme 3: Energy consumption). If these factors continue they should produce a gradual disconnect between emissions from the energy sector and economic and population growth (Figure 5.3). Nevertheless, population and economic growth from 2014–15 to 2024–25 is projected to be sufficient to grow electricity demand at 1% per annum (see Figure 3.4 in Theme 3: Energy consumption).

A large part of the emissions expected over the next few decades are already locked in, as much of the energy generation infrastructure has a decade-long economic lifespan (Davis et al. 2010); unless the (as yet unproven) carbon capture and storage technologies can be reliably and economically implemented. However, the early decommissioning of older, less efficient, power stations may be facilitated by the rate with which end-users adopt new (low or zero emission) generation capacity, as well as energy efficiency improvements.

Conversely, economic and policy factors can conspire to increase emissions. For example, NSW imports about 10% of its power from other states via the National Electricity Market (NEM). Compared with NSW, the other members of the NEM commonly use brown coal for power generation, which is cheaper, but more emissions-intensive than black coal. Following the abolition of the federal carbon price, early indications are that the NEM's average carbon-intensity has increased (Pitt & Sherry 2015; Hannam & Arup 2015).

Demand for gas is forecast to decrease at an average annual rate of 1.8% over the next five years (AEMO 2014a). With residential gas consumption growing, the decrease in total gas demand is driven by industrial closures and declining gas-fired electricity generation.

Figure 5.4: NSW greenhouse gas emissions by end use sector, 2012–13



Source: OEH estimates based on Australian Department of the Environment data

NSW emissions by economic sector

Greenhouse gas emissions produced during electricity generation can be attributed to the final consumer of the generated electricity. This shows the residential sector is making the largest contribution to greenhouse gas emissions in NSW (35 Mt CO_2-e, about 24%), closely followed by manufacturing (33 Mt CO_2-e, about 23%) (Figure 5.4).

Responses

Using energy more efficiently

The NSW Energy Efficiency Action Plan (EEAP) (OEH 2013) aims to implement measures that will reduce the cost of consumers' power bills and improve economic performance. The EEAP contains 30 actions to grow the market for energy saving products and services, and to position the NSW Government to lead by example. Actions include:

- enhancing the Energy Savings Scheme – over the next decade, energy efficiency projects are expected to deliver 11,000 GWh of energy savings and $1.6 billion in bill savings
- leading by example by implementing the NSW Government Resource Efficiency Policy (GREP) (OEH 2014) – this 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 (e.g. through energy efficiency projects, encouraging renewable energy development such as mid-scale solar development, and reducing waste generation).

The NSW Climate Change Fund, established in 2007, has been a key funding mechanism for EEAP and related programs (see also Theme 3: Energy consumption).

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 Theme 3: Energy consumption)
- 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.

Lower emissions energy

Renewable energy sources are increasingly being used for electricity, almost doubling between 2008 to 2013 to 12.9% (9335 GWh) of total energy consumption in NSW (dropping to 10.8% in 2014, see Theme 3: Energy consumption).

As at July 2015, around 325,000 households and small businesses across NSW had solar photovoltaic (PV) systems with a capacity of more than 960 MW (Clean Energy Regulator data). Wind power is also expected to be the main new source over the next decade, with 3.98 GW of new wind generation forecasted to be connected to the NEM power grid by 2020, half of which is planned for installation in NSW (AEMO 2014b).

The NSW Renewable Energy Action Plan (NSW Government 2013) (REAP) will position 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, such as:

- providing $64.9 million to Solar Flagships, which will deploy two large-scale solar PV power stations with a total generation capacity of 155 MW, including the largest solar power station in the Southern Hemisphere at Nyngan
- establishing the Regional Clean Energy Program, which is helping communities to produce renewable energy locally.

The NSW Government also has policies beyond these plans that help reduce greenhouse gas emissions from energy, which 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 to reduce energy use and greenhouse gas emissions from the transport sector (see Theme 4: Transport).

NSW also supports the Australian Government's 2014 Renewable Energy Target (RET) of 41,000 GWh of renewable generation by 2020. Progressing this national target links with the NSW REAP.

Carbon capture and storage

Through the $100 million Coal Innovation NSW Fund, the Government is carrying out research, development, demonstration, and public awareness raising of low emissions coal technologies. Research and development projects funded include:

- retrofitting existing power stations to enable post-combustion capture and storage of carbon dioxide (e.g. the Delta carbon capture and storage demonstration project)
- the NSW CO_2 storage assessment project which is identifying potential geological CO_2 storage basins for permanent storage of CO_2 (Darling Basin is showing early indications of good storage potential)
- capturing and using methane emissions from 'gassy' coal mines.

Carbon sequestration

In addition to carbon capture from electricity production, careful land management can avoid greenhouse gas emissions or sequester (store) 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 LC 2013).

The Australian Government's Emissions Reduction Fund provides incentives for storing carbon in the agriculture and forestry sectors as well as emissions avoidance across the economy. This program now integrates the former Carbon Farming Initiative that ran between September 2011 and December 2014.

Future opportunities

Research and development into cost-effective technologies continue to help reduce emissions, 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 being are being funded by the Coal Innovation NSW Fund)
- improving light and heavy vehicle efficiency
- enabling systems and technologies for very high penetration renewable energy generation
- capturing and using methane emissions from 'gassy' coal mines

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 DPI in conjunction with the Australian Government include:

- increased soil organic carbon
- increases in perennial vegetation in agriculture
- reduced livestock methane emissions
- reduced emissions from nitrogenous fertilisers
- utilisation of agricultural and forestry residues for bioenergy and biochar.

Additional opportunities include capturing fugitive emissions, e.g. methane from landfill waste decomposition; and waste heat from industrial processes.

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6 URBAN WATER

Demand for the state's water resources is high, with urban water use having ongoing impacts on river flow in areas of significant population density, which places pressures on the health of some river systems. Water supplied to NSW cities and large towns has an annual average growth rate of 1.35% (over 7 years), but with recycled water use growing strongly for several of the larger water utilities.

Water supplies for NSW metropolitan areas and regional cities and major towns are being managed by the water utilities via drinking water management systems established under the requirements of the *Public Health Act 2010*. These are based on the Australian Drinking Water Guidelines and are overseen by NSW Health. In 2013–14 Sydney Water, Hunter Water and all large regional water utilities had 100% overall compliance with the microbiological and chemical standards of the guidelines.

Statutory water sharing plans covering about 95% of water use in NSW have been developed. These plans provide better security of entitlement for all water users as well as the environment; this process helps meet the NSW Government's goal of securing long-term potable water supplies for urban communities.

Although water demand has risen with population growth across the state, actions to reduce water consumption continue, with Sydney Water and Hunter Water both maintaining per person water use below licence targets. Median per property consumption for regional water utilities has been relatively stable for the past seven years. Regional local water utilities have reduced average annual residential water use by 48% over the last 23 years (a saving of about 90 GL annually).

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Proportion of the metropolitan and regional water supply meeting reliability standards for water quality	G	Stable	✓✓✓
Total and per person water consumption for metropolitan and regional centres	M	Increasing impact	✓✓✓
Water recycling	M	Decreasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

The security of water resources depends on an adequate supply of good quality water. Water resources are critical for the supply of town water, stock and domestic water, the irrigation of crops, mining and industry. Meeting these needs will help to enable future economic growth.

Conversely, water resources are needed to preserve the health of riverine, estuarine and wetland ecosystems, and to maintain the food chains that support fish and other aquatic species.

Sustaining human use of water can only be achieved by also maintaining healthy aquatic systems, as degradation and overuse of our waterways will lead to societal costs and economic constraints.

Across NSW agriculture accounts for up to 80% of water use (depending on conditions, e.g. drought). While urban consumption is generally less than 10% on a statewide basis, extraction for urban consumption can have ongoing impacts on river flow in areas of significant population density (see Theme 16: Water resources).

Maintaining high levels of water extraction relative to total river flows over an extended period places stress on river health. Water storages and regulating structures have been built to provide greater security of supply by moderating stream flow variability. In Australia, aquatic ecosystems, particularly inland rivers, are adapted to highly variable flow levels. To a significant extent, aquatic species are dependent on this variability to maintain or complete their life cycles. Over the longer term, modification of natural flow patterns contributes to a loss of biodiversity and declining health in aquatic ecosystems.

Status and trends

Urban drinking water quality

Across the greater metropolitan area (not including the Central Coast) water is supplied by Sydney Water and Hunter Water. Across the Central Coast and the rest of NSW, drinking water is supplied by 95 local water utilities (LWUs), mostly local government councils. (Here, supply relates to areas where the utilities have more than 10,000 connected properties.)

The NSW Government has endorsed the Australian Drinking Water Guidelines (NHMRC & NRMMC 2011) as the benchmark for providing water to the people of NSW. These guidelines include the Framework for Management of Drinking Water Quality which sets out a preventative risk management approach for drinking water quality, considering the whole supply system from the catchment to the household.

Water quality monitoring compliance data collected by the NSW Health Drinking Water Monitoring Program shows that NSW drinking water quality in metropolitan areas and regional cities and towns meets the Australian guidelines.

Over the past three years drinking water quality from both Sydney Water and Hunter Water have met the microbiological and chemical quality criteria of the *Australian Drinking Water Guidelines* (NOW 2015a, Table 12).

Outside the main metropolitan areas, 2013–14 was the first year in which all 95 LWUs had 100% overall compliance with the guidelines (NOW 2015a, Table 12) – up from around 92–93 of the 95 LWUs in earlier years.

In both 2012–13 and 2013–14, the public drinking water supply for 99.9% of the urban population in regional NSW complied with the guidelines for both microbiological and chemical water quality.

For each of the past three years, about 20,000 water samples are tested for microbiological compliance from across the 95 LWUs operating in NSW. More than 99.7% of the individual samples have complied. Around 4250 samples are tested for physico-chemical compliance annually, with at least 98.5% complying.

Nevertheless, monitoring acts as verification of the risk management framework, and by itself does not protect against contamination; meaning that from time to time there are incidents and alerts which highlight the need to improve preventive risk management.

Sources and volume of water drawn

Tracking the volumes of water from sources, such as reservoirs, in-stream, groundwater aquifers and recycled water schemes, underpins sustainable water management.

Surface water dominates water supply for NSW cities and large towns. In addition, across the western slopes and plains, and in the larger coastal catchments, groundwater is often a significant component of water supplies (Table 6.1). (Here, urban water use relates to areas where the utilities have more than 10,000 connected properties.)

Table 6.1: Urban water sources 2013–14, and annualised typical change (7 years)

Utility (more than 10,000 connected properties)*	Surface water**		Groundwater		Recycled water***	
	ML	%	ML	%	ML	%
Sydney Water	530,587	0.9%	–	–	41,543	++
Hunter Water	67,520	0.9%	4,230	–5.6%	2,505	–
Albury	7,599	4.8%	–	–	–	–
Ballina	3,840	1.2%	–	–	257	–
Bathurst Regional	6,354	–1.7%	9	–	638	–
Bega Valley	1,756	6.0%	1,489	–3.4%	623	–
Byron	2,837	1.1%	–	–	390	–
Clarence Valley	6,199	–3.5%	–	–	176	–
Coffs Harbour	5,957	1.7%	–	–	–	–
Dubbo	6,406	0.3%	1,934	0.8%	–	–
Essential Energy	5,700	1.8%	–	–	515	–
Eurobodalla	3,055	–5.2%	363	–	216	–
Gosford	16,110	5.1%	123	–3.2%	32	–
Goulburn Mulwaree	2,759	3.0%	–	–	–	–
Kempsey	–	–	3,627	12.0%	97	–
Lismore	3,426	–0.7%	–	–	–	–
MidCoast	8,124	–1.3%	542	–3.5%	372	–
Orange	4,557	0.4%	59	9.7%	2,903	–
Port Macquarie–Hastings	6,090	–0.9%	–	–	142	++
Queanbeyan	3,995	2.0%	–	–	–	–
Riverina	2,681	–9.3%	11,819	1.3%	–	–
Shoalhaven	14,049	–0.9%	–	–	194	–
Tamworth Regional	9,358	5.1%	579	–7.2%	–	–
Tweed	9,808	–0.4%	–	–	563	–
Wingecarribee	5,671	–0.2%	–	–	124	++
Wyong	15,914	–1.6%	6	–14.0%	962	–
Total (LWUs)	152,245	–0.1%	20,550	–1.5%	8,204	–
Total	750,352	0.7%	24,780	–1.8%	52,252	++
Overall total 827,384 ML in 2013–14, 1.35% annual average increase						

Source: DWE 2009a, Table 8; NOW 2010, Table 8; NOW 2011, Table 8; NOW 2012, Table 8; NOW 2013, Table 8; NOW 2014, Table 8; NOW 2015a, Table 8.

Notes: Does not include irrigation and other non-urban supply.

As local water utilities (LWUs) may draw on different sources depending on conditions (e.g. drought) the breakdown between sources can vary significantly year by year. The annualised typical change is the 7-year linear trend for each water source (LWUs with fewer than 5 years of data have been excluded).

* Data on the smaller LWUs can be found in the sources.

** Surface water includes bulk water purchased from non-retail suppliers such as WaterNSW (previously the Sydney Catchment Authority).

*** '++' typical annual average over 7 years exceeds 20%; '–' annual average change unclear or less than ±20%.

Recycled water is a small, but growing portion of the total water supply, for example, in 2013–14, 84% of non-metropolitan LWUs recycled effluent (NOW 2015a, Table 8).

Year by year, the proportion of each source drawn by the utilities will change, mostly due to weather conditions impacting on surface water availability and reservoir volumes. Over the past three years total water use has varied between 656.5 GL and 827.4 GL. Despite this 26% variation over a three year period, over the longer term (seven years), overall urban water use has an annual average growth rate of 1.35%, with recycled water growing at 0.71% per year.

Sydney (volumetrically the largest supply utility) dominates these trends – both for improvements in water recycling and total demand growth.

Pressures

Water pollution

The quality of water affects its suitability for human use and may affect the health of aquatic ecosystems. To a significant extent, water quality reflects the state of vegetation cover and land management practices in river catchments, and the land overlying aquifer recharge zones.

Water demand

Water efficiency efforts have seen per property water consumption reduce (see Responses, below), however there is constant pressure on water supplies from the demands of a growing population.

Sydney

Before 2004–05, the proportion of potable water consumed across Sydney Water's areas of operation – Sydney, the Illawarra, Blue Mountains and adjacent areas – compared to the long-term sustainable yield, had grown to exceed 100%. At its peak, 650 GL per year of potable water was being supplied to users, including residential, industrial, commercial and government. This proportion fell to 89% in 2013–14.

This translates to a daily potable water consumption pattern that has been steadily declining, down from 343 litres per person in 2004–05 to 307 litres in 2013–14 (Figure 6.1) (Sydney Water 2014). This figure is well below the water conservation target in Sydney Water's operating licence of 329 litres per person per day by 30 June 2011, and which was achieved five years early.

Despite a population increase across Sydney Water's area of operations of about 27% over the past two decades, total water use has declined by about 15%. This sustained decline is primarily due to changes in water use behaviour (influenced by voluntary and mandatory water restrictions) together with various demand management programs, such as water efficiency, leakage reduction programs and water recycling.

Lower Hunter

Over the past 12 years, Hunter Water has supplied between 63.2 and 77.6 GL of potable water per year across its area of operations, comprising the local government areas of Newcastle, Lake Macquarie, Maitland, Cessnock, Port Stephens, and (since 2008) Dungog.

As a result of a wet year and mild conditions experienced over the 2011–12 summer period, residential water use (both per person and per property) was at a 10-year low in 2011–12. The summers of 2012–13 and 2013–14 returned to typical hot dry weather, resulting in higher water use (Hunter Water 2014).

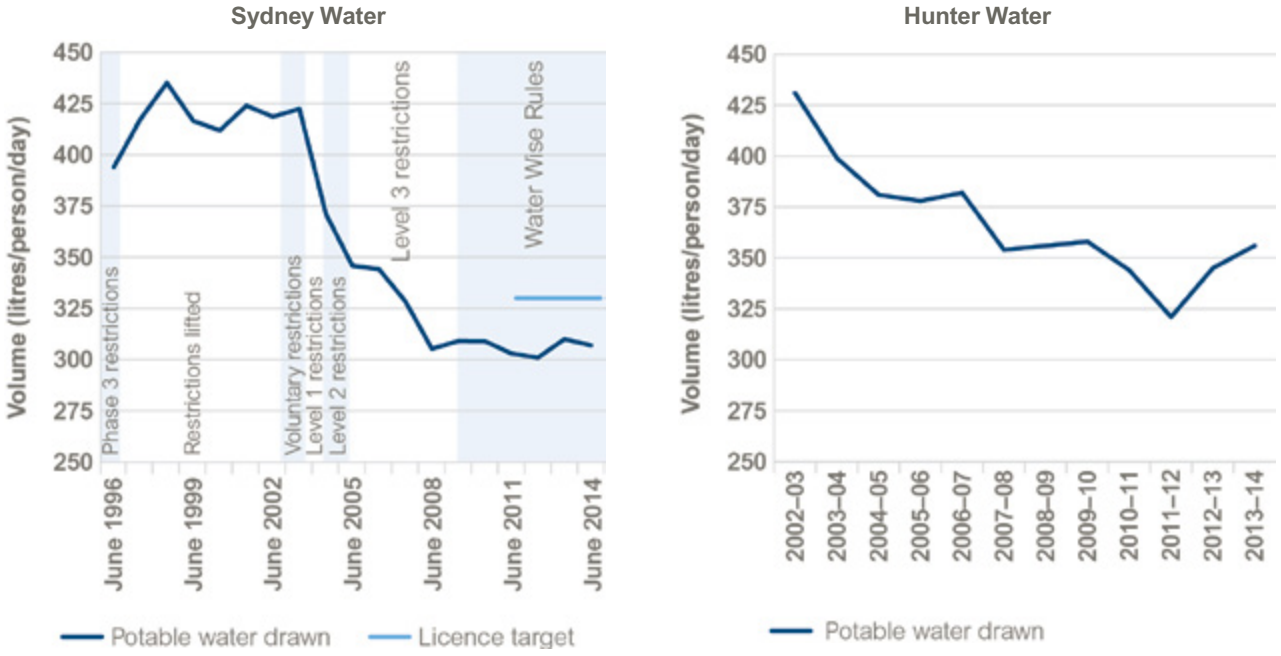
Over the past 12 years, daily potable water consumption has declined by about 12%, despite a population growth of over 10%. This means that annual per person potable water consumption has fallen by as much as 25% (in 2011–12) and has averaged 20% over the past five years (Figure 6.1).

Residential water use

In Sydney, the Illawarra and Lower Hunter, the residential sector is the largest water user, accounting for around 65 to 75% of total water consumed.

In regional NSW, the residential sector accounts for two-thirds of total urban water consumed (NOW 2012, Table 8). In regional NSW, over the past 23 years, the average annual volume of water supplied by LWUs to connected residential properties has fallen by 48% (a saving of about 90 GL per annum). From an annual median of 330 kilolitres per connected property in 1991–92, demand dropped to 173 kL in 2013–14. For five

Figure 6.1: Demand for potable water, Sydney Water (1996 to 2014) and Hunter Water (2002–03 to 2013–14)



Source: NWC 2009; Hunter Water 2011; NWC 2011; Sydney Water data 2015; Hunter Water 2014

Notes: This figure shows total residential and non-residential consumption relative to total population across the utilities' operational areas.

of the past seven years, the annual demand has been 172 kL, with a small decrease to 159 kL and 155 kL per connected property in 2010–11 and 2011–12 respectively (Figure 6.2, overleaf).

Drought and climate change impacts on water demand

As droughts occur naturally in Australia, aquatic ecosystems adapt to periods of dryness. However, severe, extensive or prolonged drought can have major repercussions – for the environment and water users, as well as socioeconomically.

The condition of riverine water quality, along with the effects of catchment disturbance, diffuse runoff from agricultural activities and urban expansion, are discussed in Theme 16: Water resources. The condition of groundwater is discussed in Theme 19: Groundwater.

Over the longer term, projected changes in rainfall due to climate change are expected to create risks for water availability (Vaze & Teng 2011). In addition, the frequency and intensity of heavy rainfall events leading to flooding are likely to be different from the impacts on seasonal or average rainfalls (DECCW 2010).

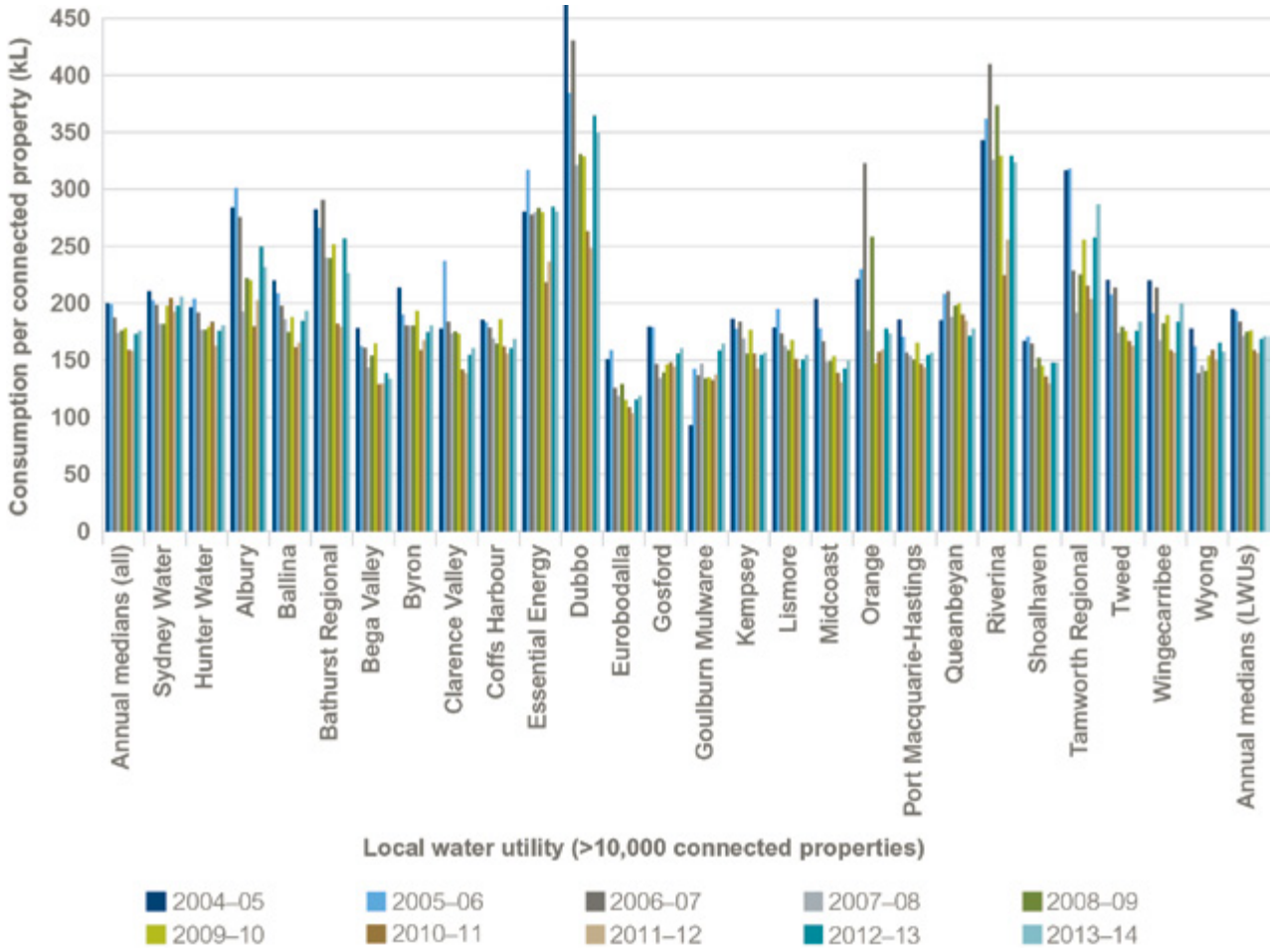
Moreover, the volume of water held in storages varies with climatic conditions, partly because of changes to rainfall, evapo-transpiration and runoff and also because hotter, drier conditions increase the watering of lands and use of evaporative coolers.

Responses

To help secure long-term potable water supplies for towns and cities statutory water sharing plans have been developed under the *Water Management Act 2000*. These plans provide better security of entitlement for all water users as well as the environment. About 95% of water use in NSW is now covered by a water sharing plan (for details, see Theme 16: Water resources).

Planning for water use to meet current and future socioeconomic demands and environmental needs must be balanced. It should also take into account the long-term variability in water availability due to the extremes of climate, such as droughts and floods. As such, there are three distinct components to water management in NSW:

Figure 6.2: Average annual per-property residential water consumption by local water utilities, 2004–05 to 2013–14



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

Notes: This figure shows total residential consumption relative to total residential connections across the utilities' operational areas.
Local water utilities (LWUs) included have more than 10,000 connected properties. Data for the smaller LWUs are available in the source tables.
The Hunter Water supply network interconnects with adjacent LWUs, enabling it to supply and receive bulk treated water from Wyong and Gosford councils and MidCoast Water.
The statewide median for regional NSW was 196, 188 and 166 litres per person /day in 2013–14, 2012–13 and 2011–12 respectively.

- 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 Theme 16: Water resources).

Management plans

Metropolitan water management

Metropolitan water plan: The 2010 Metropolitan Water Plan (NSW Government 2010) sets out how the NSW Government will provide a secure and sustainable supply of water to meet the needs of Sydney, the Blue Mountains and the Illawarra. The plan is currently being reviewed to take account of the latest data, research findings and technological advances.

There are four major parts of this plan to secure 'Water for Life':

- **Dams** – A network of dams supplies the majority of Sydney's drinking water. Continued investment in the network will help to ensure this key element of supply. The Water Wise Rules (see end of this section) help keep more water in dams during droughts, and the existing dams have been modified to allow for greater draw-down at such times of drought, and new infrastructure can allow storages to be replenished from groundwater reserves.
- **Recycling** – Recycled water schemes have been developed with the capacity to deliver 63 GL of recycled water in greater Sydney (see also Status and trends).
- **Desalination** – In case of severe drought Sydney's desalination plant can produce up to 90 billion litres of water a year, enough to supply up to 15% of greater Sydney's current water needs.
- **Water efficiency** – Improvements in water efficiency can be achieved by installing more efficient appliances, educating the community and modifying processes to help use water wisely (see also Demand management initiatives below).

Water conservation measures adopted during times of drought over the last decade have been replaced by a simpler set of common-sense, Water Wise Rules for Sydney, the Blue Mountains and the Illawarra (Figure 6.1). These permanent rules are designed to embed good practice amongst all water users; and water consumption remains well below levels seen prior to the previous drought. However, maintaining and improving the full range of savings previously achieved has yet to be accomplished.

Lower Hunter Region: The NSW Government's Metropolitan Water Directorate led the development of the Lower Hunter Water Plan (DFS 2014) in close consultation with Hunter Water, other government agencies and the Lower Hunter community. Released in April 2014, the plan is a package of water supply and demand measures that ensures a reliable water supply over the long term and sets out actions for responding to severe droughts. A key recommendation of the Lower Hunter Water Plan was the implementation of the Water Wise Rules (see Metropolitan Water Plan) which commenced on 1 July 2014.

The plan also sets out actions for responding to droughts, including:

- additional water efficiency initiatives for households and business
- increased water recycling where viable
- water restrictions
- water transfers to and from the Central Coast under an existing transfer agreement
- temporary, portable desalination units, as a contingency measure for responding to a very extreme drought.

The shift towards higher density living over the longer term, the use of water efficient appliances, the implementation of the Water Wise Rules, and NSW BASIX requirements are likely to be strong influencing factors that will help the Hunter region continue improving (downward) the average water consumption of its customers.

Urban water management

Country Towns Water Supply and Sewerage Program: More than one million people in NSW live in country towns. This key program assists regional LWUs to provide appropriate, affordable, cost-effective, and sustainable urban water supply and sewerage services. Along with the NSW Best-Practice Management of Water Supply and Sewerage Framework (NOW 2015b), the program mandates:

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

Financial grants help with infrastructure improvements needed to deliver improved public health, environmental outcomes, and security of supply. Over the program's life (from 1994–95 to 2016–17), over $1.2 billion is projected to have been invested via the program.

Drinking water quality management: NSW Health has oversight of drinking water quality in regional NSW. It administers the requirement (under the Public Health Act 2010 and Public Health Regulation 2012) that all water suppliers must establish and adhere to a Drinking Water Management System.

NSW Health and DPI Water have jointly developed the NSW Guidelines for Drinking Water Management Systems. Local Public Health Units and DPI Water officers meet with utilities to discuss progress on implementation, review and audit of management systems. This also involves identifying barriers to implementation and solutions (such as minor works, treatment optimization and improved monitoring).

These management systems provide water suppliers with a structured risk-based approach to managing drinking water quality. The process of developing management systems and improvement plans has highlighted the need to identify and reduce potential risks in catchments, treatment plants and distribution systems.

To date NSW Health has assisted 74 regional water utilities to develop their management systems. Other utilities have developed their management systems independently.

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

Pricing water better

Giving customers strong water pricing signals can reduce water consumption by more accurately reflecting the value of water resources and the true costs of supplying water. In NSW water prices are set or overseen by the NSW Independent Pricing and Regulatory Tribunal (IPART). Water pricing has undergone significant reform over the past 20 years, with tariffs shifting away from a reliance on fixed annual charges towards ‘pay-for-use’ pricing.

All water utilities in NSW now have domestic water metering. All free water allowances for potable water supply ceased by 2007. Up to 2011–12, the gradual increase in the median residential water usage charge for LWU customers was reflected in an ongoing reduction in average demand per connected property, producing a relatively stable typical water supply residential bill (i.e. steady in CPI-adjusted terms).

Over the past three years, increases in the median charge and the average demand per connected property has led to a statewide median typical residential bill for water supply of $582 (Jan 2015$). This represents only a 1% annual average increase over nearly two decades (NOW 2015a).

In addition to helping achieve a steady reduction in the residential water supplied per property, strong pricing signals over the last decade have also enabled regional NSW LWUs to avoid over $1 billion in capital expenditure for augmenting headworks and treatment capacity.

Rainwater tanks

Across NSW the use of rainwater tanks as an adjunct to reticulated supply is increasing. For example, on the Central Coast (Gosford and Wyong) there are over 18,500 tanks installed, representing 1-in-7 connected properties (NOW 2015a, Appendix J).

Demand management initiatives

In 2013–14 51.8 billion litres of water were recovered from recycled water schemes operated by Sydney Water, local councils and private schemes.

Metropolitan

Water efficiency and recycling assist in reducing the demands on drinking water supplies across Sydney Water’s areas of operation (Sydney Water 2014):

- Twenty-three recycled water schemes recycled 47 billion litres in 2013–14, saving 13 billion litres of drinking water. These schemes can also reduce nutrient discharge and free up water that can be released from the supply dams for environmental flows. Together, these help improve downstream river health.
- Water efficiency measures and residential and business demand management programs (such as WaterFix and the Every Drop Counts Business Program) saved over 45 billion litres of drinking water in 2013–14.

Sydney Water actively looks for and repairs leaks. In 1999–2000, leaks wasted over 180 ML of water a day. In 2013–14, leakage was estimated to account for 107 ML per day (39 GL per year), about 7.4% of potable water used. Since 2008, Sydney Water has been within its target band for water leakage (105±16 ML per day) (Sydney Water 2014).

Water Savings Action Plan requirements were established in 2005 under the *Energy and Utilities Administration Act 1987*.

In Sydney Water's area of operations, action plans were required of all local councils, businesses and government agencies that use more than 50 ML of water per year per site. The plans involved assessing current water use and identifying cost-effective measures to reduce water consumption. Full implementation will save an estimated 8272 ML of water each year.

Regional

Across the many LWUs in regional NSW there are a wide range of demand management and water conservation measures being implemented. These are reported via the NSW performance monitoring and benchmarking system (e.g. see NOW 2015a, Table 8C).

NSW Government responses

The Building Sustainability Index

The Building Sustainability Index (BASIX) for new homes was introduced in 2004 to ensure homes are designed to use up to 40% less urban water than the average dwelling built before its introduction. Based on the commitments made on BASIX certificates, the average BASIX-compliant home has water consumption of around 135 litres per person per day. These savings reduce statewide demand by 13 GL per year. By the end of the 2013–14 financial year, cumulative water savings amounted to more than 103 GL of potable water. Water efficiencies from BASIX-compliant alterations and additions will add further savings.

The NSW Climate Change Fund

Established in 2007, the Climate Change Fund supports a range of programs helping business, households, schools, communities and government to save water and energy. These programs include the Water Savings Fund, Central Coast Water Savings Fund, Rainwater Tanks in Schools, NSW Green Business and Public Facilities.

At 30 June 2014, supported projects are estimated to be saving more than 14 GL of water per year (OEH 2014) (see also Theme 3: Energy consumption):

- households – 5.6 GL/y
- businesses – 5.6 GL/y
- government – 1.7 GL/y
- community – 1.3 GL/y.

On average, every dollar the fund has invested in energy and water saving initiatives delivers more than $4.20 in utility bill savings.

Sustainability advantage

The Sustainability Advantage program works to improve organisations' competitiveness and financial performance by targeting the delivery of better environmental practices by the business. It focuses on industrial ecology projects among businesses keen to exploit opportunities for the exchange of materials, energy, water and by-products.

National responses

Initially a NSW program, the National Australian Built Environment Rating System (NABERS) developed into a national program that rates buildings on the basis of their measured environmental impacts. Management effectiveness measures have been developed for issues such as energy, water, stormwater runoff and pollution, sewage, landscape diversity, waste and toxic materials. These measures provide an indication of how well the issues are being managed.

NABERS Water ratings are available for commercial office buildings, hotels, shopping centres and homes. OEH is working with the NSW Department of Education and Communities to develop a rating for NSW schools and with NSW Health to rate public hospitals.

In 2010–11, 431 NABERS Water ratings were issued. Close to 600 businesses are engaging with NABERS to rate their premises. NABERS has driven substantial efficiency gains in the built environment. On average, office buildings using NABERS to measure and manage their water use have improved their water efficiency by 9%. Altogether, these buildings are saving 1100 ML of water each year.

Under the national Water Efficiency Labelling and Standards (WELS) scheme, registration and water efficiency labelling of washing machines, dishwashers, toilets, urinals, taps and showers is mandatory. The introduction of water efficiency labelling of combined clothes washer–dryers is also currently being considered (DEWHA 2008). At present, only toilets are subject to minimum water efficiency standards. Through its participation in the WELS scheme, the NSW Government proposes introducing minimum standards for washing machines and dishwashers.

The National Water Initiative (NWI) is a shared commitment by governments across Australia to increase the efficiency of water use and provide greater certainty for investment and productivity for communities and the environment. The urban water component of the NWI focuses on the need to secure urban water resources by improving the reliability of supply, water efficiency and integrated water planning. The NSW Implementation Plan for the National Water Initiative (NSW Government 2006) contains specific actions for implementing the NWI's eight key elements. All 32 eligible NSW urban water utilities have met the rigorous national auditing requirements. Information is published annually by the Australian Government through the National performance reports (e.g. National Performance Report 2013–14: Urban water utilities (BOM 2015)).

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7 WASTE AND RECYCLING

Total waste generation has continued to rise in NSW, however there was a decrease of 0.4 million tonnes from 2010–11 to 2012–13. The amount of waste recycled in NSW and thus diverted from landfill in 2012–13 was 62.5%, equating to about a 4% increase on 2008–09 levels. In the Metropolitan Levy Area waste generation per person decreased by 3% from 2010-11 to 2012-13.

Commercial and industrial waste is close to achieving the 2014 target recycling rate of 63%. Construction and demolition waste has increased with the uplift in the housing market and a large-scale infrastructure project, and the amount of this waste being recycled fell to 69%.

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

Post-campaign research on the *Hey Tosser!* anti-litter campaign has indicated that the program has helped change attitudes to litter and litterers, and litter in NSW is reducing faster than the national average.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Total waste generation	M	Increasing impact	✓✓
Per person waste generation	M	Stable	✓✓
Total and per person solid waste disposal	G	Decreasing impact	✓✓
Total and per person solid waste recycled	G	Decreasing impact	✓✓
Litter items per 1000 m^2	G	Decreasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Improper management of waste presents issues for the environment, the economy and the community. Impacts of waste include odour, noise, dust, greenhouse gas emissions and harm to flora and fauna. Hazardous wastes can cause serious health problems, significant pollution and the leaching of toxins or nutrients into groundwater and land. Litter and illegal dumping are anti-social behaviours that reduce the amenity of public spaces. Landfill facilities remove space from the community and may compromise the use of land in the future.

The economy depends on the environment and natural resources to provide raw materials and absorb the waste and emissions we produce. Recycling such raw materials, keeps them in the productive economy for longer. This has the dual benefit of lowering demand for new resources and reducing the need to dispose, treat or manage waste.

In 2012, the cost to Australian businesses (excluding mining and agriculture) of managing their generated waste was about $2.2 billion. In addition, businesses spent about $24.3 billion on materials that were discarded as part of the creation of a product. For NSW businesses, this equates to about $825 million for disposal and recycling services and about $7.8 billion in waste materials every year (EPA 2014b).

Status and trends

Waste data areas

Changes to waste regulation have influenced the way waste data has been collected since SoE 2012 (EPA 2012). Waste data is now reported based on the:

- Metropolitan Levy Area (MLA) – as an amalgamation of the former Sydney Metropolitan Area and the former Extended Regulated Area comprising the Hunter, Central Coast and Illawarra regions
- 'rest of NSW' (as an amalgamation of the former Regional Regulated Area and the former Non-Regulated Area), that is, the area outside of the MLA.

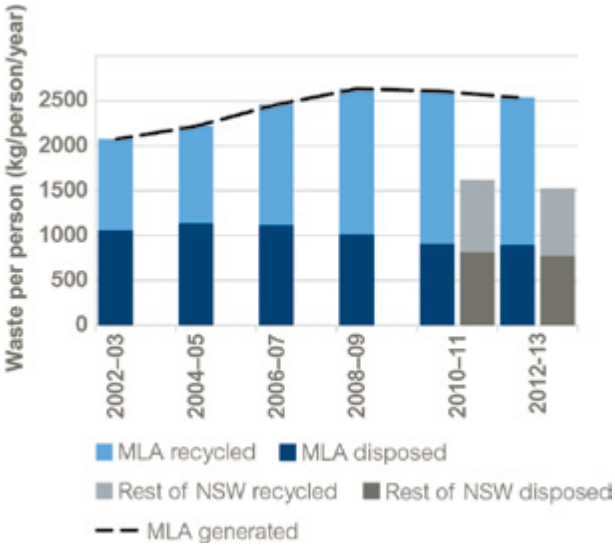
Waste data for the 'rest of NSW' is unavailable prior to 2010–11. The data from 2010–11 onwards is not as good as that for the MLA, as it does not comprehensively cover all issues and it is based on voluntary surveys. The data has been included as a starting point, with improved data collections expected in future SoE reports, following the implementation of mandatory reporting from resource recovery facilities from 2015 onwards.

Waste disposal rates and trends per person

In 2012–13, per person waste generated in the MLA was 22% higher than the base year of 2002–03, but 3% lower than in the previous reporting period of 2010–11 (see Figure 7.1).

The waste disposal per person in the MLA represented 51% of the waste generated in 2002–03, compared with 35% in both 2010–11 and 2012–13. This continues the trend reported in SoE 2012 where waste disposed per person was decreasing. Figure 7.1 also shows the flipside to this trend, with the amount of waste recycled per person becoming an increasing proportion of waste generated. These trends are due to the significant increase in recycling capacity which has been absorbing any additional waste generated and reducing the amount of waste sent to landfill (EPA 2014b). There has been a 73% increase since 2002-03 in people who have access to a council garden organic kerbside service and 17% increase in people who have access to a council dry recycling kerbside service.

Figure 7.1: Per person waste recycled, disposed and generated



Source: EPA data 2015

Note: MLA = Metropolitan Levy Area.

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 recycling target
Municipal	31%	33%	38%	44%	52%	55%	66%
C&I	34%	38%	44 %	52%	57%	61%	63%
C&D	64%	62%	67%	73%	75%	69%	76%

Source: EPA data 2015

Notes: *Waste Avoidance and Resource Recovery Strategy targets first established. C&D = construction and demolition. C&I = commercial and industrial.

Total waste disposal rates and trends per waste stream

NSW collects data and initiates programs to manage three distinct waste streams:

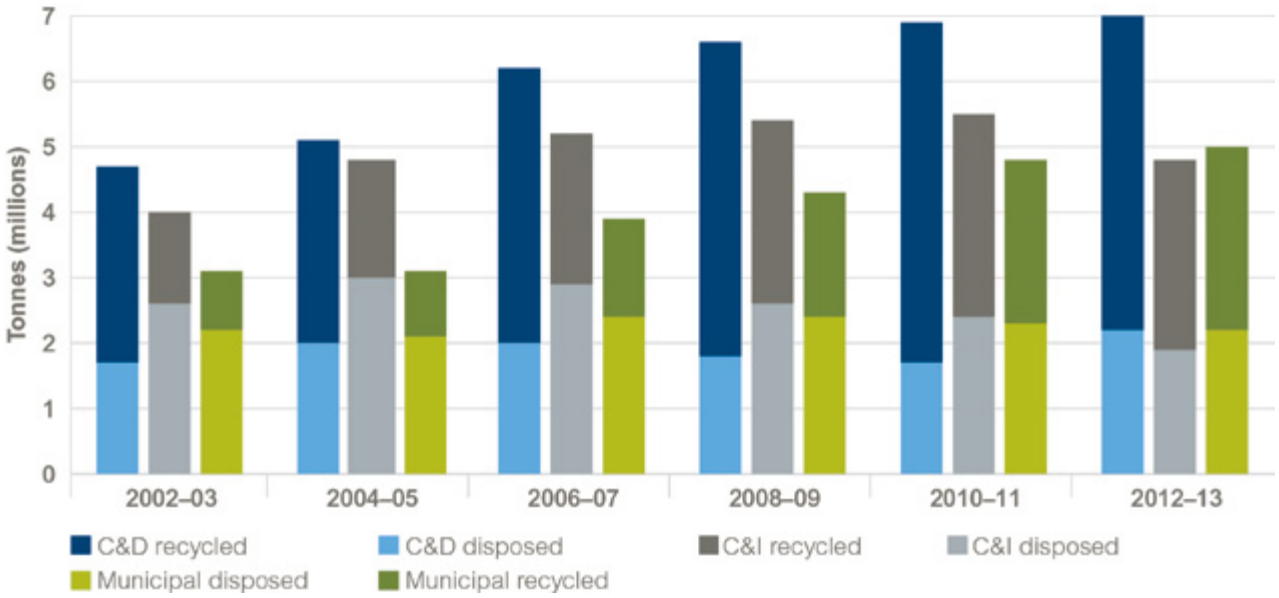
- municipal waste – includes household and other council waste and predominantly consists of materials such as paper, garden and kitchen waste
- construction and demolition (C&D) waste – is mostly inert materials such as timber, bricks, plaster, offcuts, concrete, rubber, steel and excavated earth
- commercial and industrial (C&I) waste – contains relatively higher proportions of metals, plastics and timber than other forms of waste.

The NSW Waste Avoidance and Resource Recovery Strategy 2007 (WARR Strategy) (DECC 2007) set targets for increasing recycling in the three regulated waste streams by 2014. The targets were: 66% for municipal waste, 63% for C&I waste, and 76% for C&D waste (Table 7.1).

The NSW recycling rates across all waste streams have grown steadily since 2002–03, when WARR Strategy targets were first established, but is holding steady since the last progress report.

NSW has implemented programs to reduce waste to landfill, and increase recycling. To reach the targets in 2014, NSW recycling needed to increase by approximately 19% in municipal, 4% in C&I and 11% in C&D, provided that generation and disposal remained constant.

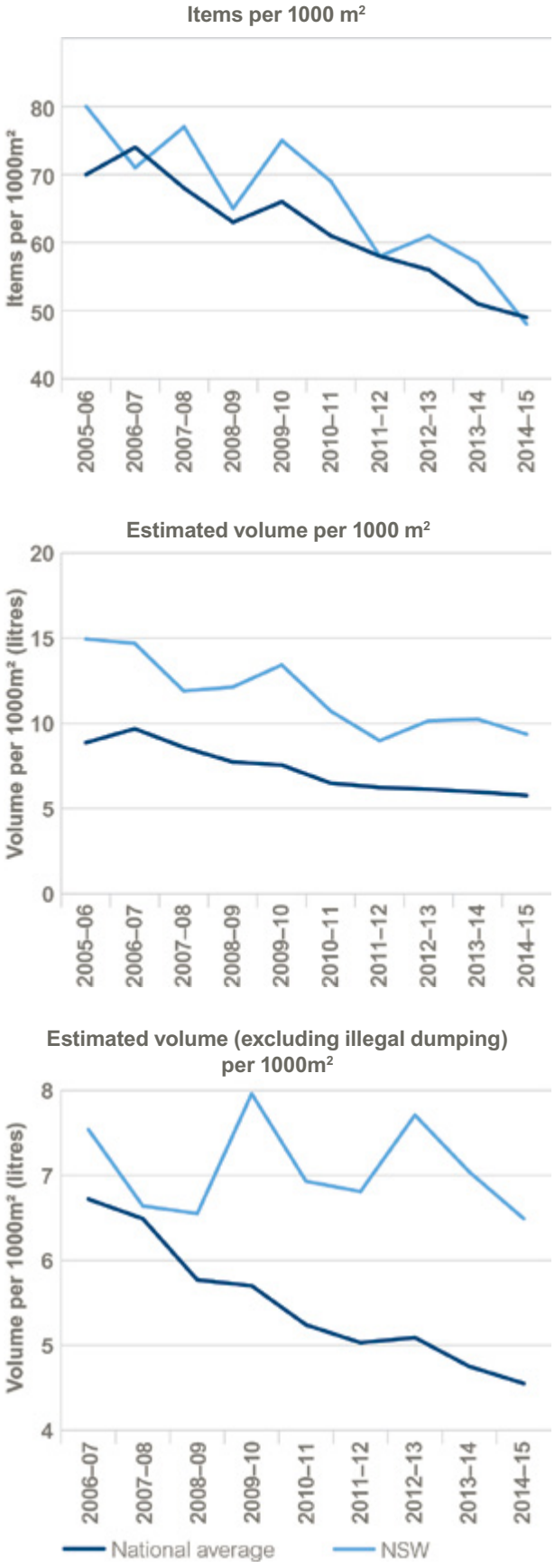
Figure 7.2: Waste disposed and recycled by waste stream for NSW, 2002–03 to 2012–13



Source: EPA data 2015

Notes: C&D = construction and demolition. C&I = commercial and industrial.

Figure 7.3: NSW versus national averages for litter items and volumes 2005–06 to 2014–15



Source: EPA data 2015

Waste stream data shows that between 2002–03 and 2012–13, the amount of C&D waste and municipal waste generated has increased at a substantially greater rate than C&I waste (Figure 7.2). This is likely due to the influence of the two main drivers for waste generation: population growth (see Theme 1: Population) which has historically heavily impacted municipal waste generation; and economic growth (see Theme 2: Economics and the environment), which has been closely correlated with activity in the building industry which is itself correlated with generation of C&D waste.

Total waste generated across NSW is 42% higher in 2012–13 as compared with the base year, but has seen a drop of 2.3% since 2010–11, which is consistent with the trend depicted in Figure 7.1.

In 2012–13, NSW recycled 10.5 million tonnes of all waste categories compared with 5.3 million tonnes in 2002–03 (Figure 7.2, overleaf). However, there are several factors that may affect this trend in the future, and which may account for the slight drop in total recycling rates between 2010 and 2012 (Figure 7.2). Recovered resources are often competing in global markets against virgin resources. Volatility in commodity prices for oil, iron ore, steel, etc. can have a flow on impact to the prices and demand for recycled materials such as plastics, scrap steel and paper. These global markets are also affected by increasing supply in other countries and fluctuations in the Australian dollar.

Litter trends

The 2014–15 National Litter Index (NLI) Annual Report indicates that the amount of litter in NSW is continuing its downward trend (Figure 7.3). In 2014–15 the amount of litter by item decreased at a much greater rate than the national average. The number of littered items decreased by 16% compared to 2013–14 data; the national decrease was 4%. Since 2005–06 NSW littered items have fallen by 40% to an average of 48 items, representing the first time since 2006–07 that NSW has fallen below the national average, which is 49 items for 2014–15.

The 2014–15 NLI reports that 'by volume' litter had an overall decrease of 9% in volume compared to 2013–14 and a 37% decline since 2005–06. Volume figures include estimated volume of illegal dumping (which are larger items) together with litter volumes. When illegal dumping volume estimates are removed there has been an average decrease of 8% in NSW from 2012–14, which is greater than the national average of 6.8%.

The most littered item in NSW and nationally continues to be cigarette butts, which account for around 31% of all littered items, however there was a decrease from 20 cigarette butts per 1000 m^2 in 2013–14 to 15 in 2014–15. While cigarette butts contribute significantly to the number of litter items they do not with respect to volume. Beverage containers constitute 45% of the volume of littered items in the NSW litter stream (excluding illegal dumping), with a steady rise from 35% in 2007–08.

Industrial sites still represent the most littered site type in NSW by both item number and volume, with highways, car parks and retail sites representing moderate amounts of litter items and volumes. Beaches, recreational parks and residential areas continue to be the state's least littered site types by both item numbers and volumes.

Pressures

Population growth and increasing economic activity

The link between economic growth, population demographics and the growth in per capita waste production was set out in SoE 2012.

Waste generation is one of the few socioeconomic and environmental indicators that is outpacing economic production. At the national level, per unit of economic production (GVA), waste intensity increased between 1996–97 and 2012–13 when measured for the agriculture, mining and manufacturing industries (ABS 2015). Economic growth in various sectors has historically led to increases in waste generated, for example, uplifts in the housing market or increased infrastructure development is strongly correlated with increases in the amount of C&D waste produced (see Theme 2: Economics and the environment).

Hazardous substances

The availability of infrastructure to collect and treat problem waste streams, including toxic and hazardous wastes, has an impact on the management of these wastes. The difficulties with managing the increasing amount and complexity of these wastes was set out in SoE 2012. A key challenge in this area has been establishing product stewardship programs, in which producers take responsibility for the products they make throughout their lifecycle, including end-of-life. Further, a lack of available community services for the collection and safe disposal of problem wastes has been identified as an issue preventing the community from separating these wastes from existing waste and recycling streams.

Changes in waste materials

There are also broad changes occurring to the composition of waste that may affect recycling rates into the future. These changes include a shift to more complex products and packaging that combine polymers, alloys or material types, which require new technologies in order to separate and recycle the end-of-life product. Increases in plastic packaging of food, for example, may affect the quality and recovery rates of organic waste (Wright et al. 2013).

An emerging pressure for waste policymakers is the presence of plastics in the environment. Of particular concern are the findings from recent scientific research in relation to the impact of microplastics in the marine environment. Microplastics are small plastic particles (less than 5 mm) manufactured in cosmetics and derived from clothing fibres, which enter the water system. Microplastics present environmental risks due to their bioavailability to marine species and their characteristic of adhering to waterborne organic pollutants, resulting in the introduction of toxins to the base of the food chain (Wright et al. 2013).

Human behaviour

Waste avoidance and recovery is strongly influenced by consumer and community behaviour. For example, many households still do not separate their waste correctly and waste which could be recycled is placed in the 'red lid' household garbage bin (EPA 2014b). Research

has shown that food wastage is caused by consumer behaviours such as poor food storage, lack of meal planning and over-catering thus leading to higher than necessary levels of food waste appearing within the municipal solid waste stream (EPA, 2014b). The incidence of littering and illegal dumping is also inherently driven by human behaviour. Attitudes towards littering vary across the types of litters, with some small items such as cigarette butts more likely to be littered. The availability of bins also affects people's litter behaviour.

Responses

NSW Waste Avoidance and Resource Recovery Strategy 2014–21

Under the *Waste Avoidance and Resource Recovery Act 2001*, the EPA is required to produce a new NSW waste strategy every five years. The latest waste strategy was adopted in December 2014. It sets a blueprint for the management of waste and resources over the next seven years through ambitious targets to:

- reduce the rate of waste generation per capita
- increase recycling rates across all waste streams
- 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
- reduce the incidence of large-scale illegal dumping statewide.

Progress against the waste strategy is to be reported every two years. Each progress report will provide an assessment of performance against the targets. The waste strategy sets the parameters for measuring progress against each of the targets.

Waste Less, Recycle More

Implementation of the waste strategy is underpinned by the $465.7 million *Waste Less, Recycle More* initiative, a five-year funding package that was introduced in February 2013. In its first two years, this initiative injected $171.5 million into recycling, litter and illegal dumping prevention in NSW, to divert an extra 870,000 tonnes of waste from landfill. The program has stimulated a further $145 million in public and private sector investment in waste and recycling in NSW and helped to create 340 jobs.

To February 2015, *Waste Less, Recycle More* supported new food and/or garden kerbside waste collections in 31 council areas, 76 new community recycling centres for problem wastes, and free bin trim waste audits for 6569 small to medium businesses. Five regional illegal dumping squads have been established and 77 litter prevention projects are underway. There has been $40 million investment in new recycling infrastructure and support of the well-established *Love Food, Hate Waste* program through the award of $356,800 in 2012–13.

Local councils have received $79.6 million in direct funding for their own waste and recycling initiatives and worked together through regional waste groups to develop and finalise 13 regional waste strategies.

Illegal Dumping Strategy 2014–16

The waste strategy and *Waste Less, Recycle More* are supported by a number of implementation strategies to meet NSW waste targets. The Illegal Dumping Strategy 2014–16 (EPA 2014a) is the first of these which was released in June 2014 to deliver an integrated, multifaceted approach to combating illegal dumping. The Illegal Dumping Strategy sets out 21 actions on education, enforcement and infrastructure to prevent people from dumping illegally, and to take strong action against those who persist in doing the wrong thing. As a part of this strategy:

- the incidence of illegal dumping in key metropolitan areas will be reduced
- baseline data to allow target-setting in other parts of the state will be established.

Litter prevention programs

A number of programs have been introduced to achieve the anti-litter objectives of the waste strategy:

- A Draft NSW Litter Strategy has been prepared that will provide key information on why people litter, a broad analysis of NSW's litter profile, elements for any successful litter program and set out an action table of priority actions for the EPA.
- The *Hey Tosser!* campaign funded for four years through *Waste Less, Recycle More*, aims to change the social norms associated with littering. Phase 1 of the campaign ran from April to June 2014 and began to drive the litter prevention message into homes and public spaces across NSW. Research indicates that there has been some shift in social attitudes to littering since the campaign launched, with significant increases in people stating that the issue of littering is very or extremely important (up to 88% from 77%). Phase 2 ran from April to June 2015.
- A Litter Prevention Kit has been published that provides a resource for government, business and the community that includes information on how to run an effective litter prevention project, documenting local litter and *Hey Tosser!* creative material.
- The Local Litter Check is an easy to use litter diagnostic published by the EPA in 2013. It helps councils and community groups to understand their litter problems, design a solution and measure their results.
- In 2014, $2.67 million was provided to Councils through the EPA's Litter Prevention Grants. Over $500, 000 has been made available to community groups between 2013 and 2015 to tackle local litter hotspots.
- The EPA introduced a new Report Littering System in February 2015 whereby members of the public could report incidents of litter being dropped from vehicles. In March 2015 as a result of the new system the EPA began to issue fines; prior to the system the EPA issued advisory letters based on public reports. At 30 June 2015, 7111 people registered to report litter, 5027 reports were received and 2605 fines were issued by the EPA for littering from vehicles. This indicates a significant increase on previous enforcement activity and a high involvement by the community.
- The Review of NSW Waste and Environment Levy: Final Report (KPMG 2012) and amendments to the Protection of the Environment Operations (Waste) Regulation 2014 (POEO Waste Regulation) (commencing 1 August 2015).

Reforms to the waste regulatory framework

Creating a stable and level playing field within the waste sector increases investor confidence and ensures legitimate businesses can compete in the market. A number of changes have been made to the waste regulatory framework to modernise the waste industry since SoE 2012, including:

- using GPS tracking devices on vehicles used to transport waste through amendments to the Protection of the *Environment Operations Act 1977* (POEO Act), commenced 1 January 2015
- introduction of the proximity principle, which addresses the environmental and human health impacts in NSW associated with the unnecessary transportation of waste over long distances and places responsibility on licensed facilities for the waste they generate (POEO Waste Regulation, commenced 1 November 2014)
- increased enforcement and sentencing options for repeat waste offenders through amendments to the POEO Act, commenced 1 October 2013
- implementing changes to the waste levy as recommended by the independent review of the NSW Waste and Environment Levy and amendments to the POEO Waste Regulation (commencing 1 August 2015).

Future opportunities

The past three years have seen significant developments in the allocation of resources to the waste strategy and waste program. It is likely that in the immediate future, the waste policy space will be impacted by the implementation of these developments, as initiatives aimed at achieving the waste targets have an impact and the success of the *Waste Less, Recycle More* program becomes more apparent through measured outcomes.

The NSW Government is committed (ME 2015) to implementing a container deposit scheme (CDS) for the recycling of drink containers by 1 July 2017. Objectives of the scheme will include reducing litter and increasing resource recovery.

The intention is for NSW to implement a modern, cost-efficient scheme, which utilises modern technologies, such as reverse vending machines, and which complements the existing kerbside recycling system. This reform is part of the broader action being undertaken by the NSW Government to reduce litter generally, with the objective of delivering the government's target of a 40% reduction in litter volume by 2020.

Opportunities for government to address emerging issues will continue to arise, including:

- adoption of issue-specific strategies under the umbrella of the waste strategy, such as the draft infrastructure strategy and draft litter prevention strategy
- options for minimising microplastics in the marine environment.

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8 AIR QUALITY

Air quality in NSW has improved significantly since the 1980s due to initiatives that have reduced urban air pollution from industry, businesses, homes and motor vehicles. The concentrations of a number of the most common air pollutants, including carbon monoxide, lead and sulfur dioxide, are now low, while emissions of oxides of nitrogen and volatile organic compounds, which contribute to ozone pollution, have reduced by 30–40% across the Sydney region, but as these contribute to the formation of ground-level ozone they remain of concern.

Ground-level ozone – a key component of photochemical smog – remains an issue for Sydney and concentrations have generally exceeded national air quality standards on up to six days a year between 2012 and 2014.

There is growing evidence about the adverse health impacts of airborne particles. Particle pollution generally meets standards in Sydney, except when bushfires or dust storms occur. Such events mean that concentrations have exceeded national air quality standards on up to 18 days a year from 2012 to 2014. Some areas in regional NSW exceeded the particle standards on as many as 15 days a year over the same period, with bushfires, stubble burning, dust storms, coal mine dust and wood heaters as the major causes.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Concentrations of ozone	M	Stable	✓✓✓
Concentrations of particles (PM_{10})	M	Stable	✓✓✓
Concentrations of particles ($PM_{2.5}$)	M	Stable	✓✓✓
Concentrations of carbon monoxide	G	Stable	✓✓✓
Concentrations of nitrogen dioxide	G	Stable	✓✓✓
Concentrations of sulfur dioxide	G	Stable	✓✓✓
Concentrations of lead	G	Stable	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of 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 existing respiratory and cardiovascular problems and increases the risk of acute symptoms, hospitalisation and death (EPHC 2014). Repeated, long-term exposure increases the risk of chronic respiratory and cardiovascular disease and mortality, can impact birth weight, and can permanently affect lung development in children (WHO 2013b).

Further to its classification of diesel exhaust as a human carcinogen (WHO 2012), the International Agency for Research on Cancer has also classified outdoor air pollution as a human carcinogen (WHO 2013a).

The health costs of air pollution at 2005 levels in the Greater Metropolitan Region (GMR_2) were estimated to be $4.7 billion or $893 per head of population (DEC 2005). Across Australia's capital cities motor vehicle pollution health costs have been estimated at $3.3 billion per year ($1.5 billion for Sydney) (BTRE 2005).

Australians spend an average 20 out of 24 hours a day indoors, largely in the home environment (enHealth 2012). As a result, health risks from personal exposure to airborne substances may be more closely related to the pollutants encountered indoors than those outdoors.

Status and trends

National standards and goals

In 1998, in order to help protect the health of Australians, the National Environment Protection Council (NEPC) set ambient air quality standards and goals for six key pollutants in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM):

- ground-level ozone (O_3)
- particles (as PM_{10})
- carbon monoxide (CO)
- nitrogen dioxide (NO_2)
- sulfur dioxide (SO_2)
- lead.

(The AAQ NEPM standards for particles SO_2, NO_2 and O_3 are currently under review – see below.)

The AAQ NEPM goal for each pollutant sets the maximum number of days in which the relevant standard (a specified concentration of the pollutant) may be exceeded. To measure compliance with national goals, the NSW Government operates an extensive air quality monitoring network across the state (see 'Responses' below). NSW consistently meets the goals for carbon monoxide, nitrogen dioxide and sulfur dioxide; ozone and particles continue to be problematic.

Through ongoing research it has become clear that the smaller the particles the greater their potential impact (WHO 2013b). Because of this more detailed monitoring of very fine particles has been developed, with the AAQ NEPM being amended in 2003 to include two advisory reporting standards for $PM_{2.5}$.

Lead monitoring was discontinued in 2004 following a decrease in ambient lead levels to well within the national standard, largely as a result of the introduction of unleaded petrol.

Ozone

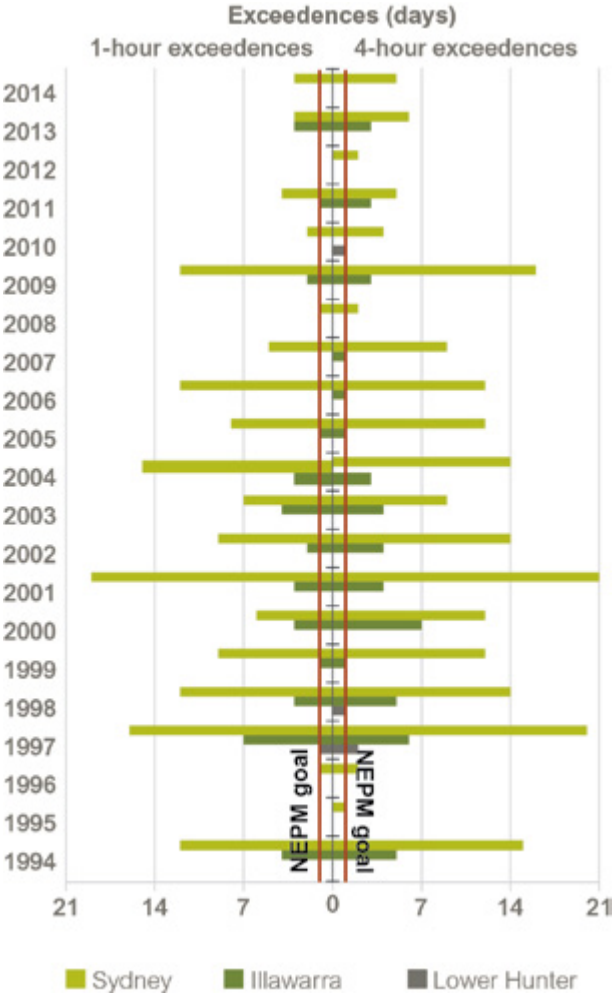
Ozone is present in both the upper atmosphere (stratosphere) and the lower atmosphere (troposphere). The 'ozone layer' in the stratosphere protects all life forms by reducing the levels of the Sun's damaging UV-B radiation reaching the Earth's surface.

Stratospheric ozone is not a pollutant. In contrast, tropospheric ('ground-level') ozone is an air pollutant that is harmful to human health and the environment (WHO 1998).

In the troposphere ozone is formed when 'precursor' compounds – especially oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) – react in warm, sunny conditions. These precursors can be natural or human in origin. Bushfires, for example, can generate ozone directly too.

As elevated ozone concentrations tend to occur during warmer months, the current problems are likely to be exacerbated by future climate change (DECCW 2010).

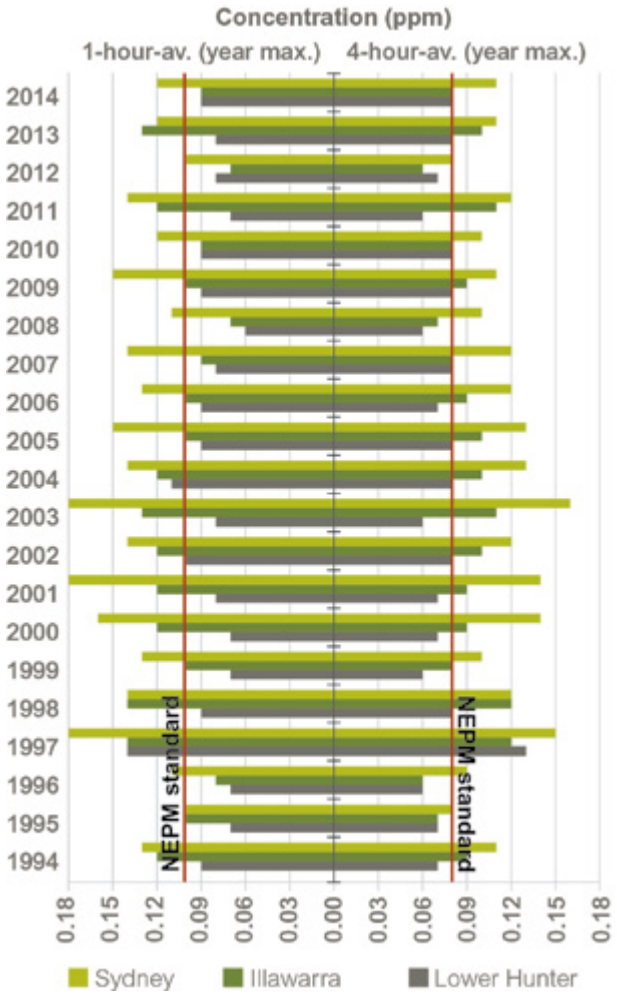
Figure 8.1: Exceedences of the AAQ NEPM standards for ozone in the GMR_2, 1994–2014



Source: OEH data 2015

Note: A day is counted only once per region, even if exceedences occur at multiple monitoring sites on that particular day. GMR_2 = Greater Metropolitan Region comprising Sydney, Illawarra and Lower Hunter Regions. AAQ NEPM = Ambient Air Quality National Environment Protection Measure.

Figure 8.2: Annual maximum one-hour-average and four-hour-average concentrations for ozone in the GMR_2, 1994–2014



Source: OEH data 2015

Note: GMR_2 = Greater Metropolitan Region comprising Sydney, Illawarra and Lower Hunter Regions. NEPM = National Environment Protection Measure.

While all parts of Sydney can experience ozone concentrations above the AAQ NEPM standards, the west and south-west of the city are the regions most often exposed as a result of summertime atmospheric circulation in the Sydney Basin (DECCW 2010).

The AAQ NEPM sets two standards for ozone: a one-hour standard of 0.10 parts per million (ppm) and a rolling four-hour standard of 0.08 ppm. The NEPM goal stipulates that by 2008 the maximum allowable number of exceedences for each standard is one day per year.

Between 2008 and 2014, the one-hour goals were met twice in Sydney: in 2008 and 2012 for the one-hour standard. Either or both of the standards have been exceeded in Sydney every year since 1996 (Figure 8.1). Between 1994 and 2014, ozone concentrations in Sydney exceeded the one-hour standard on up to 19 days per year. Over the same period, exceedences of the rolling four-hour standard occurred on up to 21 days.

The standards were exceeded less frequently in the Illawarra and during that period, occurring on up to seven days per year for both standards (Figure 8.1). Either or both of the AAQ NEPM ozone standards were exceeded in the Illawarra on more than one day in 1994, 1997, 1998, 2000–2004, 2009 and 2013. The Lower Hunter region recorded the fewest exceedences of the standards with neither standard being exceeded more than once a year (thus complying with the AAQ NEPM) since 1997.

Figure 8.2 shows the maximum recorded concentrations of ozone for each region from 1994 to 2014. These have been highest in Sydney and lowest in the Lower Hunter.

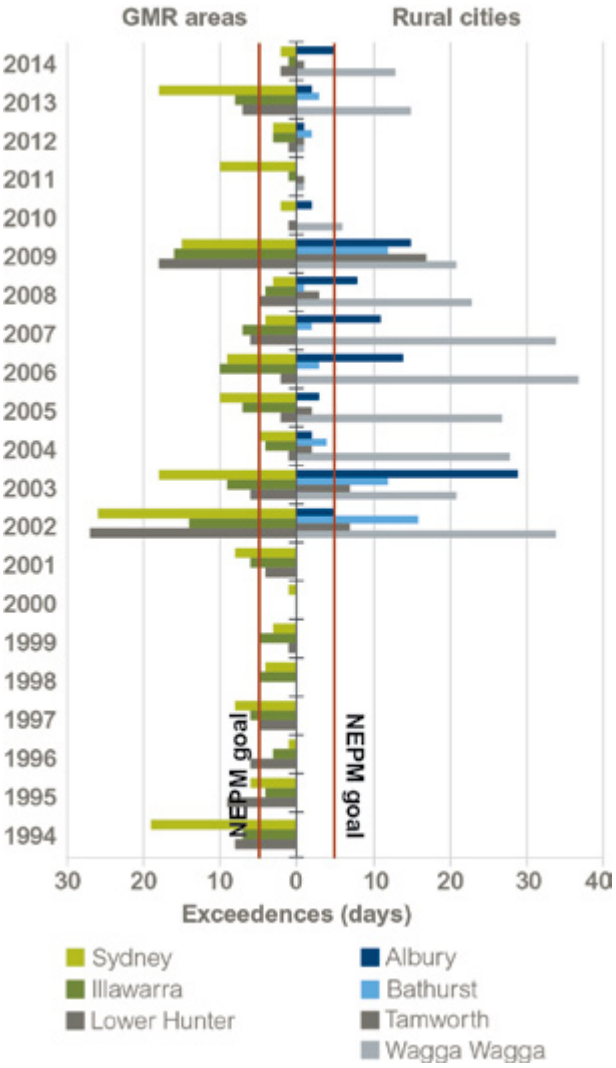
A statistical analysis to filter out most of the meteorological variability shows ozone concentrations in Sydney are not decreasing (see Figure 2.3 in SoE 2012 (EPA 2012a)).

Bushfire events and hazard reduction burns are potentially significant sources of ozone precursors and can have an impact on ozone pollution; plus many of the weather conditions that lead to high bushfire danger are also conducive to the formation of ozone. Importantly, burning causes at most 20–25% of exceedences; so even without bushfires, emissions from human activities are sufficient to cause infrequent exceedences of the AAQ NEPM standards at one or more monitoring stations in the region on a given day (DECCW 2010).

Particles

Particles smaller than 10 micrometres (µm) in diameter (PM_{10}) are associated with increased mortality and hospital admissions for people with both heart and lung disease. Health research identifies particles smaller than 2.5 µm ($PM_{2.5}$) as of particular concern. These 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 existing health conditions and impact more severely on children and the elderly (WHO 2013a).

Figure 8.3: Exceedences of the AAQ NEPM standard for particles (PM_{10}) in the GMR_2 (1994–2014) and NSW rural cities (2002–14)



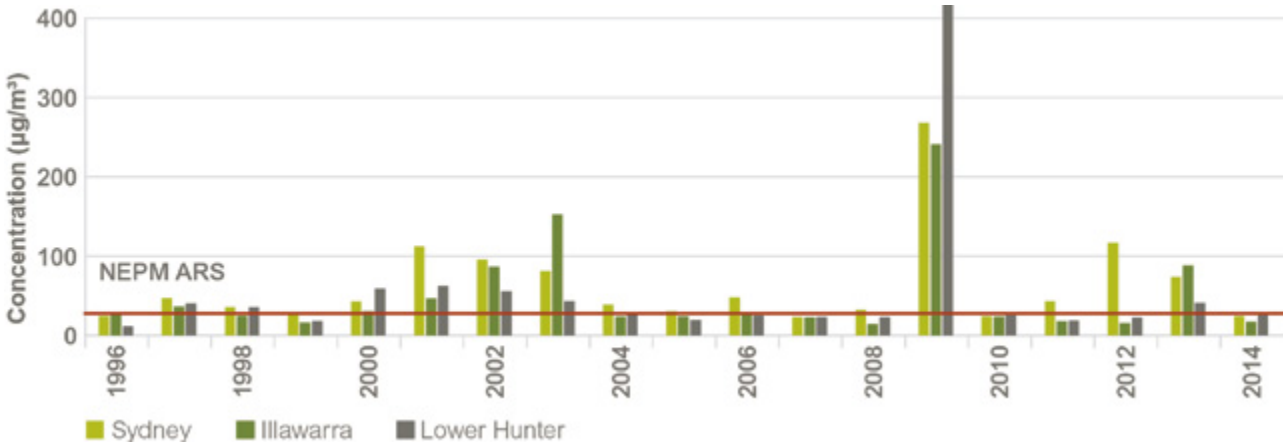
Source: OEH data 2015

Notes: GMR_2 = Greater Metropolitan Region comprising Sydney, Illawarra and Lower Hunter Regions. AAQ NEPM = Ambient Air Quality National Environment Protection Measure.

Particle concentrations are monitored across the GMR_2, as well as in Albury (NSW–Victoria border), Bathurst (Central Tablelands), Tamworth (North-West Slopes) and Wagga Wagga (South-West Slopes). Levels recorded in these centres are generally representative of the air quality in the surrounding regions.

The concentrations and sizes of airborne particles can vary greatly between sources, regions and seasons. In the GMR_2, as well as in Albury, Bathurst and Tamworth, the majority of exceedences occur in spring and summer, as bushfires and dust storms are more prevalent. In Wagga Wagga exceedences are most common in autumn.

Figure 8.4: Annual maximum 24-hour-average concentrations for particles ($PM_{2.5}$) in the Greater Metropolitan Region, 1996–2014



Source: OEH data 2015

Notes: NEPM ARS = National Environment Protection (Ambient Air Quality) Measure Advisory Reporting Standard.

Large-scale dust storms, whilst uncommon, can result in widespread and extreme levels of particles, for example in 2003 and 2009 (observable in Figure 8.4; see discussion in SoE 2012).

PM_{10}: Across the GMR_2 the national standard for PM_{10} is being met the majority of the time. Numbers of exceedences vary greatly from year to year (Figure 8.3), often in associated with bushfires or dust storms, for example:

- bushfires in 1994 and 2001–2003
- major statewide dust storms in September 2009
- hazard reduction burns in 2011
- NSW bushfire emergency in late 2013
- construction activity close to sampling stations.

The national goal of no more than five PM_{10} standards exceedences per year is regularly not being met.

The rural cities also have problems with particles. In 2003 and 2009, none of the four met the PM_{10} goal (Figure 8.3). Albury, Bathurst and Tamworth have achieved the goal in some of the years shown, while Wagga Wagga has met the goal in only two, particularly wet, years – 2011 and 2012. Dust storms, bush fires and drought-related factors have contributed to the general run of high exceedances in earlier years.

$PM_{2.5}$: The AAQ NEPM was amended in 2003, adding two advisory reporting standards for $PM_{2.5}$ – a 24-hour average of 25 µg/m³ and an annual average of 8 µg/m³.

In NSW measured $PM_{2.5}$ concentrations have generally been at or below the 24-hour-average standard but above the annual average standard. The $PM_{2.5}$ 24-hour maxima (Figure 8.4) show similar drought and bushfire influenced patterns to those of the PM_{10} levels.

Other AAQ NEPM pollutants

NSW consistently complies with the national air quality standards for the other AAQ NEPM air pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide and lead (these are detailed in SoE 2000 (EPA 2000).

As motor vehicles, fuels and industries have improved, nitrogen dioxide and sulfur dioxide levels less than 25–75% of their standards are usual (helping reduce acid precipitation). Leaded fuel, the primary source of lead in air at the regional scale has also been eliminated, and carbon monoxide levels are now generally only found to be elevated where traffic density is high and dispersion poor.

Air Toxics NEPM pollutants: The Air Toxics NEPM covers five air toxics: benzene, toluene, xylenes, formaldehyde and benzo(α)pyrene (BaP). The most recent monitoring (see Air Toxics NEPM pollutants in SoE 2012) shows that BaP levels were the most significant of all air toxics measured, but still only about 65% of the NEPM monitoring investigation level.

There can be occasions where incidents, such as equipment failure or fire, can result in harmful emissions of air toxics to the environment.

Indoor air quality

A range of building fixtures and fittings, indoor activities, and even the fabric of a building contribute emissions that can pollute indoor air. In addition, ambient air pollution – particularly fine particles and gases – infiltrates indoor spaces, affecting indoor exposure (see previous SoE reports for details, e.g. Indoor air quality in SoE 2012).

Monitoring in NSW homes has identified secondary tobacco smoke and emissions from solid-fuel heaters (e.g. wood heaters) and unflued gas heaters as key contributors to poor air quality – especially carbon monoxide, nitrogen dioxide and fine particles (Sheppeard et al. 2002; DEH 2004).

Unflued gas heaters remain the primary form of heating in about 18% of homes in NSW (CE&R 2008). In 2014, 10.2% of NSW homes used solid fuel heaters as their main source of heat (ABS 2014), compared to 13.7% in 2008.

Secondary tobacco smoke remains an important factor in indoor air quality.

Pressures

Variations in monitored pollutant levels

Ozone precursors and particles

The pollutants of ongoing concern for NSW air quality are fine particles, and the main precursors for ozone.

While the most important human-related causes of air pollution largely arise from businesses and industries licensed by the NSW Environment Protection Authority (EPA), as well as road and non-road transport and household activities, their significance varies between urban and rural/regional areas. On the other hand, natural causes of air pollution, such as bushfires and hazard reduction burns, windborne dust from exposed land, sea spray and vapours from grasses, plants and trees can also contribute to poor air quality. Once in the air, some pollutants undergo further chemical reactions and can be transported by air movement across regions.

Every five years, the EPA conducts an intensive investigation into air pollution emissions by source type across the GMR_3 (covering about 75% of the NSW population). The 2013 calendar year air emissions inventory is anticipated to be released in 2016.

According to the 2008 Air Emissions Inventory for the Greater Metropolitan Region of NSW (EPA 2012b) (see discussion in SoE 2012), from 1992 to 2008, air emissions steadily decreased in the Sydney region, with oxides of nitrogen decreasing by 27%, volatile organic compounds (VOCs) by 40% and PM_{10} by 20%. These declines occurred despite increases in key NSW statistics over the same period, such as:

- gross state product increased by 68%
- vehicle kilometres travelled increased by 26%
- population grew by 18%.

The decrease seen in oxides of nitrogen and VOCs in the Sydney region is largely due to mandated emission standards for road transport and improved identification and control of emissions from EPA-licensed industry.

In contrast, emissions of oxides of nitrogen steadily increased by 32% across the GMR_3. This reflects energy consumption (mostly supplied from coal-fired power stations in rural/regional areas) increasing by 28% between 1992 and 2008. Emissions of PM_{10} have risen by 48%, largely due to increased coal mining. VOC emissions in the GMR_3 decreased by 6%.

As well as being the largest source of particles in the Sydney region, wood smoke contains air pollutants such as carbon monoxide, oxides of nitrogen, and a range of organic compounds, some of which (e.g. benzo(α)pyrene and benzene) are toxic or carcinogenic.

Air toxics

A key source of air toxics included in the air emissions inventory includes EPA-licensed industry. The *Protection of the Environment Operations Act 1997* (POEO Act) and regulations include requirements for preventing and/or minimising air toxics from these premises.

Climate change pressures

Research into the relationship between global emissions of greenhouse gases (see Theme 5: Greenhouse gas emissions), climate change and air quality is ongoing (e.g. see Adapt NSW, also: Cope et al. 2008; DECCW 2010; Jacob & Winner 2008; Lacressonnière et al. 2014; Pfister et al. 2014; Walsh 2008). Whilst some forms of emission may decrease (e.g. from wood heaters), chemical and temperature changes in the atmosphere will most likely lead to key air pollutants increasing, influencing the formation of ozone and secondary particles ($PM_{2.5}$).

Population pressures

Increased development in urban centres can expose more people to elevated concentrations of air pollutants. In the Sydney basin, the growing populations in areas in the southwest, west and northwest may be especially affected by elevated ozone – due to both the atmospheric conditions in those areas being conducive to ozone formation, and due to increased population generating increased emissions of precursors. This increased exposure risk may also be compounded by the greater vulnerability of sensitive populations arising from an aging demographic.

Increased development at the interface with natural bushland also has the potential to increase population exposure to the effects of smoke from bushfires and hazard reduction burns. Similarly, increased development along urban transport corridors has the potential to increase population exposure to emissions.

There is also pressure on air quality for urban and regional centres associated with the expansion of mining activities and ports.

Responses

Continued improvement in managing air quality is a priority for the NSW Government, as is informing and engaging the public on air quality issues. This involves maintaining and expanding monitoring networks, maintaining and making accessible air emissions inventory information and conducting research and regional airshed modelling to provide a sound evidence base for implementing air quality policies and programs. The provision of current air quality monitoring information and air pollution forecasts and alerts to the public also allows communities to be aware of local air quality and engage in informed discussions on air quality issues. It also enables people to manage their exposures.

The monitoring network continues to provide up-to-date air quality information to the community through the Office of Environment and Heritage (OEH) website, which links through to a system of email and SMS health alerts for high pollution days. Air quality information is also routinely reported within NSW annual air quality statements and NSW annual NEPM compliance reports. These are available on the OEH website.

Controlling particle emissions

In December 2013, the EPA released Managing Particles and Improving Air Quality in NSW (EPA 2013). This publication details current management of particles pollution in NSW along with a set of principles and actions to reduce particle emissions.

Particle characterisation studies

The NSW Government has been investigating sources of particle emissions in Sydney and in the upper and lower Hunter.

The Sydney Particle Study (2010–13) found that organic matter (in both autumn and summer) and sea salt (in summer) were significant 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.

In September 2013, OEH and NSW Health reported the results of the Upper Hunter Fine Particle Characterisation Study (Hibberd et al. 2013), prepared by CSIRO and the Australian Nuclear Science and Technology Organisation (ANSTO). The study found that dominant sources contributing to $PM_{2.5}$ concentrations in Muswellbrook and Singleton include wood smoke, vehicle and industry emissions (such as emissions of sulfur dioxide, and nitrogen dioxide emissions from power stations). $PM_{2.5}$ levels were higher in winter, due to wood fires used for residential heating.

The Lower Hunter Particle Characterisation Study air sampling program was completed in February 2015. Four sites were investigated: Newcastle and Beresfield ($PM_{2.5}$); and Mayfield and Stockton ($PM_{2.5}$ and, in response to community input, PM_{10}). Results are expected to be published in 2016.

Controlling transport emissions

In the Sydney region, transport is a significant source of ozone precursor emissions (NO_x and VOCs), as well as particulates and particulate precursors.

Key initiatives by NSW are to make fuels and vehicles cleaner, and deliver cleaner freight and passenger transport options to reduce emissions, and improve health and liveability.

Vapour recovery (VR1 and VR2)

Emissions of VOCs from service station operations represent about 1–2% of total VOC emissions in the GMR_3.

- **VR Stage 1** (managing the filling of underground storage tanks from road tankers) has been completed for the majority of service stations in Sydney, Wollongong, Newcastle and the Central Coast
- **VR Stage 2** (capture of emissions from vehicle petrol tanks during refuelling) has commenced at large petrol stations. Most of the smaller stations in Sydney are required to be upgraded by 2017.

Summer petrol volatility

From 15 November to 15 March each year the volatility of petrol supplied in Sydney is limited to 62 kilopascals, with petrol importers and blenders required to test batch volatility and report to the EPA.

Controlling industrial emissions

The POEO Act, the POEO (Clean Air) Regulation and POEO (General) Regulation 2009 set the framework for managing air pollution from major industry in NSW. These controls will also help reduce localised emissions of air toxics.

Best practice measures for controlling emissions from coal mining

In recent years, mining and transport of coal have been a key focus of regulatory activities. Through the Dust Stop Pollution Reduction Program, all operating coal mines in NSW had pollution reduction programs attached to their environment protection licences.

From March 2013, licensees were required to undertake site-specific best management practice reviews and to implement the findings. Implementation has succeeded in mines achieving an estimated 80% control of wheel generated dust – reducing annual particulate emissions by about 20,000 tonnes. Mines have also investigated best practice measures designed to reduce emissions from overburden operations.

In 2014, the EPA introduced another pollution reduction program to require all open cut mines to report on the area of land exposed to wind erosion and is reviewing the mines' responses in terms of changing operations during adverse weather. The EPA is also investigating approaches to reduce diesel emissions from machines used at coal mines.

Compliance audit of coal train loading and unloading facilities

The EPA conducted a compliance audit program of licensed coal loading and unloading premises (EPA 2014) and is requiring the audited facilities to rectify identified non-compliances. Individual facility audit reports are available on the EPA public register.

Assessment and control of air quality impacts from licensed activities

When development applications are submitted to government, the EPA helps to assess, provide advice and place conditions on the development and operation of activities licensed under the POEO Act.

Reducing diesel and marine emissions

From 2011 to 2014, the EPA ran the Clean Machine Program, which supported diesel emission reductions from non-road diesel machines (e.g. plant and equipment such as cranes and gantries, bulldozers, loaders, graders, and tractors) by promoting procurement of lower emitting equipment and better worksite practices, and by subsidising retrofitting of heavily polluting machines with exhaust emissions after-treatment devices (diesel particle filters).

Whereas merchant shipping activities tend to take place in the industrial ports, which are often close to industrial areas, cruise ships mostly use facilities in closer proximity to urban areas. As bunker fuel used by such ships tends to have a high sulfur content, exhaust emissions have been impacting communities close to cruise ship terminals.

Recent amendments to the Clean Air Regulation will require:

- use of low sulfur fuel (0.1% or less) by cruise ships while berthed in Sydney Harbour from 1 October 2015
- use of low sulfur fuel (0.1% or less) by cruise ships while in Sydney Harbour from 1 July 2016.

The regulation amendment focuses on Sydney Harbour because cruise ship visits to Sydney Harbour constitute over 90% of all such visits to NSW ports. Further consultation will be undertaken with local communities in regional NSW ports before considering any broader application of these requirements.

Following the Clean Machine Program, the EPA released its Diesel and Marine Emissions Management Strategy (EPA 2015) in February 2015. It 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.

Controlling commercial and domestic emissions

The NSW Government has implemented a number of policies focused on the domestic-commercial sector as it is a significant contributor to air pollution in NSW. Many of these issues are managed by, or in conjunction with, local government.

Wood smoke management program

The EPA administers the wood smoke laws in NSW and works with industry, other Australian jurisdictions and the Commonwealth to improve standards for heating appliances. Wood heaters offered for sale must meet emission standards, enforced through periodic EPA audit programs.

The EPA also supports councils across NSW in managing wood smoke. The 2014 Wood Smoke Reduction Program provided councils with grants of over $1 million for community education programs, rebates for cleaner forms of heating and smoky chimney surveys.

To help reduce the release of air toxics, under the POEO (Clean Air) Regulation 2010, it is illegal in NSW to burn wood preservative-treated timber (such as copper chrome arsenate (CCA) and pentachlorophenol (PCP)).

The EPA continues to explore new regulatory and non-regulatory environmental measures to control wood smoke. In March 2015 the EPA released a proposed regulatory amendment to the 2010 Clean Air Regulation for consultation. The proposed amendment incorporates recent changes to national standards for wood heaters and a new schedule of wood heater installation approval controls that local councils can elect to adopt.

Air Emissions in My Community web tool

In 2013 the EPA released the Air Emissions in My Community web tool. The tool presents aggregated data and charts for different geographic areas down to council and postcode level, to provide community access to information and understanding of air pollution sources in local areas.

Managing indoor air quality

Tobacco smoke

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 bans in NSW now comprise all enclosed public areas and certain public outdoor areas, as well as in motor vehicles in the presence of under-16 year olds. From July 2015, smoking bans also cover commercial outdoor dining areas. In NSW nine out of 10 adults now live in a smoke free home.

Heating in homes and schools

By 2011, under the NSW Gas Heater Replacement Program, all 'hi-NO_x' unflued gas heaters in NSW schools had been replaced with 'low-NO_x' units (around 51,000 heaters). From 2012 onwards, all new NSW schools and school buildings built since 2012 are fitted with flued gas heaters. Maintenance of existing unflued heaters will continue, but once heaters reach the end of their serviceable life, and a school requires a heating upgrade, all unflued gas heaters in that school will be replaced with flued gas heaters.

Solid fuel heating

See 'Wood smoke management program'.

Legionnaires' disease

The Public Health Regulation 2012 (updating the regulation from 2000) is the current legislation regarding control for Legionnaires' and other diseases.

Home maintenance

Information about asbestos, lead paint, and accumulated contaminated dusts and other materials that can be disturbed during home maintenance is provided on the DIY Safe, Asbestos Awareness, and the Heads of Asbestos Coordination Authorities websites.

Supporting climate change strategies

Air pollution and climate change may affect each other, so policy responses can be interlinked. For example, weather conditions influence the formation of ozone and secondary particles, and changes to weather conditions due to climate change are likely to increase formation rates of these pollutants. Another example is the transport and energy sectors, which are both are key sources of greenhouse gases; policies to address greenhouse gas emissions (e.g. improving energy efficiency and increasing renewable energy usage) can also have significant benefits in reducing other emissions (see also responses in Theme 3: Energy consumption, and Theme 5: Greenhouse gas emissions).

Monitoring and reporting air quality

The air quality monitoring network comprises 43 multi-parameter monitoring sites across NSW. Twenty-two sites are located in Sydney, the Illawarra, the Central Coast and Lower Hunter regions. There are four sites in regional NSW that measure particles only. The Upper Hunter network (14 sites) and three supplementary sites in the Lower Hunter are industry-funded, but reported by OEH as part of the network. Industry has funded these 17 sites in addition to the monitoring required of individual operators under their environment protection licences.

Improving presentation and communication of air quality data

Monitoring stations are 'live-linked' to the NSW Government's air quality information system. This allows increased access to current and historical data, better online mapping, and hourly updates of the air quality index for each station and region. The index is now based on six pollutants and reports six categories – very good, good, fair, poor, very poor and hazardous. There is also a subscription service available to the public (via SMS and email) which allows users to receive air pollution forecasts and various alerts (e.g. health alerts due to high pollution).

National and interjurisdictional responses

In 2014, on the matter of $PM_{2.5}$, the NEPC released an impact statement and draft variation to the AAQ NEPM particle standards for public consultation (EPHC 2014). This review is being led by NSW, in consultation with other jurisdictions.

In April 2014 Australian environment ministers agreed to develop a national clean air agreement to address the challenges facing air quality. The agreement will focus actions

to reduce air pollution and improve air quality through cooperative action between industry and government at the national, state and local level. Under the agreement, governments will work to develop emission control measures for wood heaters and non-road spark ignition engines and equipment, and agree to strengthen reporting standards for particulate matter under the AAQ NEPM.

Possible new emission control measures to be considered under the agreement include measures to address mercury releases into the environment and jurisdictional initiatives to reduce localised non-road diesel engine emissions and shipping emissions.

Cleaner vehicles, fuels and engines

Following agreement with the states, the Australian Government has introduced Euro 5 and Euro 6 standards for limiting exhaust emissions from light vehicles (all new cars, four-wheel drives and commercial vehicles less than 3500 kg gross vehicle mass) (Regulation (EC) No. 715/2007 of the European Parliament). The Euro 5 emission standard (as Australian Design Rule ADR79/03 & 04) will be phased in from November 2013 for new model vehicles (excluding the particle number limit for diesel vehicles). Full compliance with Euro 5 for all new vehicles is required by November 2016. Compliance with Euro 6 (ADR 79/05) will be phased in from 1 July 2017; by 1 July 2018, all new light vehicles sold in Australia will need to meet the higher standard.

National Indoor Air Project

The former Australian Department of Sustainability, Environment, Water, Population and Communities, in conjunction with the CSIRO, published the findings of the Indoor Air Project in 2010 (CAWCR 2010).

As Australia doesn't have guidelines for indoor air quality, definitive rating of the study's results weren't produced. However, the concentrations of indoor air pollutants observed were similar to or lower than those observed in previous studies. Other findings included:

- on average, for every 31 days of observations there would be one day where indoor $PM_{2.5}$ exceeded the advisory reporting standard set for outdoor air
- patterns of elevated NO_2 concentrations were linked to the use of unflued combustion heaters as well as proximity to busy roads
- ozone concentrations were lower indoors than outdoors, in part due to Australian dwellings generally having limited indoors sources of ozone and the efficiency of furniture and the building fabric in removing ozone from the air.

Building rating schemes

The National Australian Built Environment Rating System (NABERS) provides tools to rate the environmental impact of commercial building operations using third party verified data, such as utility bills or on-site measurements. It is administered by OEH.

There are ratings to measure the energy and water efficiency, waste management and indoor environment quality of offices, energy and water tools for shopping centres and hotels, and an energy tool for data centres.

NABERS indoor environment ratings include a measurement of indoor air quality, thermal comfort, lighting, office layout and occupant satisfaction. As at 30 June 2015, there have been 38 NSW buildings certified with NABERS indoor environment ratings.

The Green Building Council of Australia introduced Green Star in 2003, providing design, as-built, and performance ratings for buildings.

Future opportunities

Building codes and standards

There is growing interest in controlling areas such as building construction materials and management of indoor air quality at the design stage, e.g. via new building code rules.

Emissions from domestic appliances and surfaces, furnishings and consumer products are also areas of potential investigation.

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9 CONTAMINATED SITES

Reports of potentially contaminated land have continued to rise, with 166 sites reported between January 2012 and June 2014. At present 332 contaminated sites are being regulated by the EPA and 130 sites have been remediated. There are approximately 860 sites awaiting assessment.

Between 2012 and 2014, 30 new sites were regulated under the *Contaminated Land Management Act 1997* and 27 sites were remediated. Service stations accounted for 60 per cent of the newly regulated sites.

The main drivers for the remediation of contaminated land in NSW are the pressures for development and real estate values. Sites in the major coastal cities, particularly Sydney, are readily remediated as land values are high, while rural sites present a greater challenge due to lower land values.

The amendment to the CLM Act in 2009 resulted in a significant increase in sites notified to the EPA. As a result the EPA commenced a backlog program in late 2014 to address the sites still awaiting assessment.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Number of regulated contaminated sites	M	Stable	✓✓
Number of regulated contaminated sites remediated	M	Decreasing Impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Contaminated land is largely a legacy of historically poor industrial and waste management. Contaminated land can have major economic, legal and planning implications for the community. It can limit land-use potential and increase costs for developers and councils. The investigation and clean-up of contaminated land is important to protect human health and the environment.

Although contaminated sites can occur anywhere, they are typically clustered in areas that have been used for heavy industry or chemically-intensive agriculture.

With the significant decline in manufacturing and heavy industry in NSW since the 1970s (Wilkinson 2007), there has been large-scale redevelopment of these 'brownfield' sites. Many of these former industrial areas have been subsequently redeveloped to high density residential areas close to infrastructure, transport and jobs, including the Green Square/Waterloo corridor, Pyrmont/Ultimo and Rhodes Peninsula. Much of this transition has been facilitated by the regulatory and policy framework for managing contaminated sites in NSW.

Status and trends

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

- the regulation of *significantly* contaminated land under the *Contaminated Land Management Act 1997* (CLM Act)
- 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 & EPA 1998).

Notified sites

As of December 2014, there were approximately 1531 sites notified to the EPA since 1997, of which 166 sites were notified between January 2012 and June 2014. Of the total number of sites notified, the NSW Government has assessed around 658 sites since 1997, with 171 sites assessed between January 2012 and December 2014.

The number of notified sites has increased since January 2012, reflecting the increase in the reporting (notification) of potentially contaminated sites to the EPA since December 2009. This increase is due to amendments to the CLM Act that improved the clarity of reporting requirements. These amendments include a more objective basis for the 'duty to notify' the EPA of contaminated land. This is based on standard criteria listed in revised guidelines and a more stringent obligation on land owners and polluters to notify the EPA of contamination when they become aware or ought reasonably to have become aware of the contamination. The increased reporting also reflects a greater understanding of the potential implications of land contamination in the real estate and finance industries.

Total regulated and remediated sites

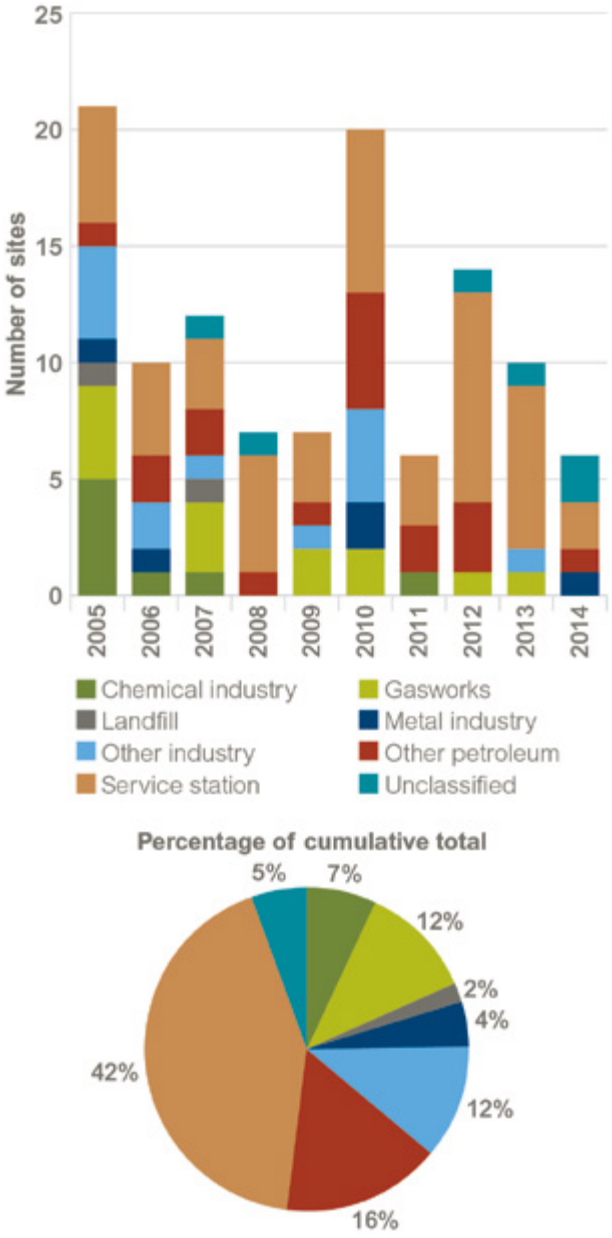
As of December 2014, there were approximately 330 significantly contaminated sites regulated under the CLM Act since 1997 (Figure 9.1). In the same time period approximately 130 sites have been remediated. As shown in Figure 9.1 the total number of remediated and regulated sites rose at a steady rate between 2005 and 2014. Between 2012 and 2014, there were 30 newly regulated sites under the CLM Act and an additional 27 sites remediated.

Figure 9.1: Total sites regulated under the CLM Act and remediated, 2005–14

Source: EPA data 2015

* Figure published initially was 1531, which was from May 2014

Figure 9.2: CLM Act newly regulated sites by contamination type 2005–14



Source: EPA data 2015

Regulated sites by contamination type

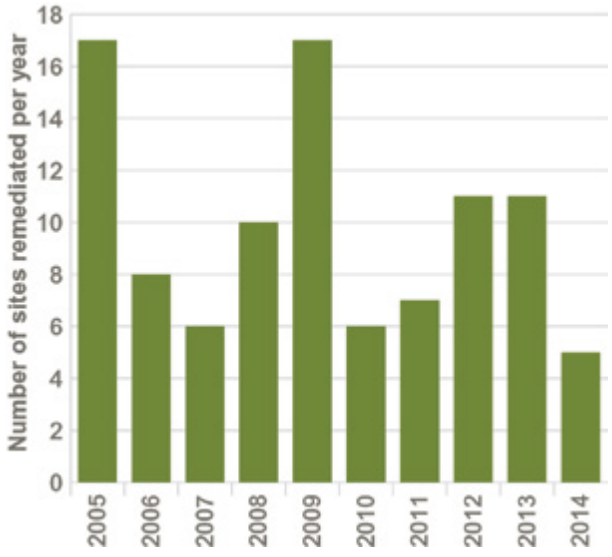
Figure 9.2 shows fluctuations in the number of new sites regulated every year, and between 2012 and 2014 there was a decrease in the number of newly regulated sites. Service stations are the most common type of seriously contaminated site to be regulated. Between 2005 and 2014 they accounted for 42% of newly regulated sites under the CLM Act, however between 2012 and 2014 service stations represented 60% of newly regulated sites.

The Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008 (UPSS Regulation) was introduced in 2008 to address the historical practices that resulted in this industry being the largest single source of contaminated land (Figure 9.2). Results of the EPA's underground petroleum storage system audit program indicate that across the industry there are varying levels of compliance with the UPSS Regulation. Audits in the Sydney metropolitan area found 48% of sites with UPSS were totally compliant. Of those non-compliant sites, follow-up audits show 26% of sites are moving towards compliance. The major fuel chains are generally compliant while the independent fuel owners and operators are slowly moving towards compliance under the guidance and assistance of the EPA (EPA 2014).

Remediation of contaminated sites

Figure 9.3 shows fluctuations in the number of sites remediated over the last 10 years. The regulation of large complex sites is resource-intensive. Such sites include the remediation of the BHP Billiton (BHPB) Hunter River sediments and residential precincts, such as the Rhodes Peninsula and Breakfast Point. For example, the remediation and dredging for the BHPB Hunter River sediments project cost approximately $400 to $500 million and took more than two years after extensive preparation. It involved the removal of approximately 600,000 cubic metres of contaminated sediments from the riverbed for treatment and storage in a specially constructed cell on Kooragang Island.

Figure 9.3: Remediation of contaminated sites 2005–14



Source: EPA data 2015

Pressures

Land redevelopment

The main driver for the remediation of contaminated land in NSW is development pressure and real estate values. Sites in the major coastal cities, particularly Sydney, are readily remediated as land values are high, while rural sites face a greater challenge due to lower land values.

Information needs

The extent of contamination below the ground is often difficult to identify and manage. As such, obtaining sufficient information to characterise the risks and costs can be challenging.

Community perceptions

Significantly contaminated sites can pose a risk to human health and the environment in NSW. Media reporting of high profile contaminated sites, such as Orica Botany and Kooragang Island, has led to increased community awareness of the risks and an expectation that the responsible parties will be held accountable. This has led to the EPA being more transparent in its regulation of contaminated sites in order to proactively manage community perceptions of the risks.

Sustainable remediation

Large land remediation projects can consume significant amounts of energy 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 (ESD) is an object of the CLM Act.

Responses

Legislative reforms

In April 2013, the then national Standing Council on Environment and Water agreed to amend the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (the ASC NEPM), which came into effect in May 2013. The NEPM provides a nationally consistent policy framework for the assessment of site contamination, including a recommended general process for the assessment of site contamination and supporting technical guidelines.

Key changes include the approach to site characterisation, investigation levels for evaluating potential human health risks associated with soil and groundwater impacts, ecological investigation levels, and the frameworks for the assessment of potential human health and ecological risks.

In order to facilitate the implementation of the ASC NEPM in NSW, it was formally approved under the CLM Act. Other guidelines made under this Act are currently being updated to reflect the changes to the ASC NEPM.

Underground petroleum storage systems regulation change

The NSW Government is continuing to implement the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008 (UPSS Regulation) a key element of the EPA's strategy to prevent contamination. However, implementation has been challenging for small operators and those in regional areas. Associated financial constraints have impeded the ability of some operators to comply.

The implementation of the UPSS Regulation has provided an opportunity to educate and train councils on the requirements of the Regulation, assist owners and operators of UPSS throughout NSW with compliance and assess the degree of compliance in a structured audit program. Furthermore, it allows an increased awareness of the UPSS Regulation through advertising and media.

The UPSS Regulation was revised in September 2014 to clarify the statutory requirements for the management and operation of underground petroleum storage system infrastructure in NSW. The amendments removed inconsistencies in definitions that limited the scope of the UPSS Regulation, prescriptions that caused confusion and limited the application of alternative management options, and unnecessary reporting timeframes. The remade UPSS Regulation also aims to encourage innovative solutions and cost effective technologies for leak detection and monitoring systems.

Cost recovery

The CLM Act provides for the recovery of costs associated with the administration of statutory instruments to manage significantly contaminated sites in line with the polluter pays principle. A 2014 NSW Auditor-General's report to Parliament – Performance Audit: Managing Contaminated Sites (Audit Office 2014) – recommended that the EPA should begin recovering costs for sites which require additional administrative work because of their complexity or the non-cooperation of owners and polluters. The EPA is now implementing the cost recovery provisions of the Act. These sites generally involve large polluters that have the capacity to pay the necessary costs to manage the contamination.

Preventative approaches program

High-risk industries targeted under the EPA's preventative approaches program include car wrecking yards, drycleaners and marinas. The preventative approaches program seeks to reduce the number of contaminated sites in the long term by providing information to these industries about best environmental management practices. The EPA has worked cooperatively with stakeholders, such as industry representative bodies and local councils, to ensure guidance materials are appropriate for these industries. Measures implemented as part of the program include site audits, identification of best practice measures, development and dissemination of educational materials and liaison with industry associations. Future programs will target battery recyclers.

Backlog program

The amendment in 2009 of the notification requirements under the CLM Act resulted in a significant increase in sites notified to the EPA. While an initial screening process is used to prioritise sites that require more timely action, there is a significant backlog of sites awaiting further assessment. The EPA commenced the backlog program in late 2014 to address these sites. There are approximately 860 sites awaiting assessment of which 840 fall within the backlog program (i.e. sites notified prior to July 2013). The program involves the allocation of additional staff to obtain information relating to notified sites and to conduct detailed reviews of this information to determine whether regulation of those sites under the CLM Act is required. The backlog program will significantly reduce the number of sites awaiting assessment.

Capacity building

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

Between January 2012 and December 2014, the Contaminated Land Management Program, funded by the Environmental Trust and administered by the EPA, provided almost $1.2 million in assistance to local governments via six grants for the investigation, remediation and management of former gasworks sites under the Council Gasworks Program. Almost $1.7 million was provided to 10 local governments under the Derelict Underground Petroleum Storage System Program. Notable projects include support for the remediation of the Wagga Wagga Gasworks creek line and the remediation of five contaminated sites for Gunnedah Shire Council in decommissioning petroleum infrastructure and preliminary investigations under the Underground Petroleum Storage System Pilot Program.

In April 2014, the Environmental Trust endorsed a further $6 million funding to the EPA over three years (2014–2017). In addition to the areas of funding above, this funding will provide more direct assistance to regional local government areas through a Regional Capacity Building Program to place contaminated site specialists in regional local councils, as well as the Regional Acceleration Program to provide specialists to assist regional notifiers of contaminated land to coordinate the necessary information required to manage the sites appropriately.

The NSW Government has an ongoing relationship with University of Technology Sydney to deliver a set of professional short courses on contaminated site assessment, remediation and management. The short courses aim to build the capacity of environmental consultants, local government officers and members of industry. The courses commenced in 2009 and continues into a seventh year in 2015. Attendance has increased from 44 participants in 2009 to 112 in 2014, with a significant number of participants from local councils in 2014. Participants have reported high levels of satisfaction with the courses and the development of new skills and knowledge.

A series of workshops on contaminated land, the UPSS Regulation and the amendments to the ASC NEPM have been presented across NSW since 2012. These workshops aim to develop a cooperative approach between local government, state government and industry and to foster better regulation of contaminated land in NSW. Feedback from the workshops has been positive and there has been considerable stakeholder demand for further workshops.

Strategic projects

The EPA initiated a number of strategic projects in late 2014 in response to the NSW Auditor-General's performance audit on managing contaminated sites. Notable projects include the development of model procedures for key landholding agencies in NSW for the identification and management of contaminated sites, and a review of the adequacy of the management of historic contamination at cattle dip sites and derelict mines.

Future opportunities

Regional capacity building

The lack of specialist technical skills has been identified as a significant obstacle to preventing and managing contaminated land in rural and regional areas. There are also misconceptions around regulatory liability and a lack of financial and human resource capacity to effectively manage or apply appropriate planning considerations to contaminated lands.

The further rollout of the Contaminated Land Management Program and specifically the Regional Capacity Building Program is critical to increase the capacity of regional councils to manage contaminated land. Direct assistance to regional local councils by employing specialist technical staff to provide regional-specific assistance and capacity building in contaminated land management should result in improved environmental outcomes in rural and regional areas.

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10 SOIL CONDITION

Soil resources in NSW are generally in a moderate condition, despite a broad decline in the condition of most soils since the arrival of European settlers. Some parts of the state are in poorer condition and display a significant loss of soil function.

Significant land degradation concerns are apparent across many areas of the state, with 74% of the 124 priority soil monitoring units selected for assessment being rated as poor or very poor for at least one soil degradation hazard.

On a statewide level, the loss of organic carbon and topsoil loss due to sheet erosion are responsible for the greatest loss of soil health and productivity. Topsoil loss due to wind erosion and salinity are also issues of concern.

Much of the change in soil health has occurred over longer timeframes, largely reflecting historic loss due to the lack of knowledge about managing soils sustainably in Australian conditions. More currently, the increasing intensity of land use, climate variability and extreme weather events represent greater risks to managing soil decline.

New conservation farming practices, such as reduced tillage, have helped to maintain soil condition generally, soil structure in particular, and to control erosion. The extent to which they improve the management of organic carbon levels and prevent acidification is less clear.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Topsoil loss (due to erosion)	M	Increasing impact	✓✓
Loss of organic carbon	M	Increasing impact	✓✓
Increase in salinity	M	Stable	✓✓
Change in soil pH (acidity)	M	Increasing impact	✓✓
Decline in soil structure	M	Stable	✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

The assessments of environmental trends in this theme are informed, in part, using information drawn from the related Theme 11: Sustainable land management, which describes ongoing pressures and short-term change.

Context

Soils make a significant contribution to the economic and ecological prosperity of NSW. Healthy soils deliver essential ecosystem services, including: decomposition of organic matter, nutrient transformation, exchange and cycling, water infiltration, redistribution and filtering, along with climate regulation through carbon storage and cycling. They provide habitat for biota and support ecosystems and the primary production of 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; CofA 2014; Stockmann et al. 2014). Therefore, in order to maintain productivity and ecosystem services, soils must be managed sustainably. This theme describes the changes in soil condition relative to pre-European conditions that have occurred over the longer term (since European settlement) and as a result the soil degradation currently found in NSW.

The consequences of most types of soil degradation – such as soil loss from accelerated erosion, dryland and irrigation salinity, and subsoil acidity – are long-term and often either irreversible or difficult 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). In production landscapes, the application of best management practices can prevent or even reverse some lower levels of soil degradation.

Status and trends

Assessing the health of soil

Soil health is characterised by five key attributes or indicators of soil function: soil pH, soil carbon, soil structure, soil salinity and depth of topsoil.

In practice, soil health is often assessed by describing the extent of change or soil degradation that has occurred. In this analysis, seven change processes that relate to soil characteristics are recorded:

- change in soil pH (acidification)
- loss of soil carbon
- change in soil structure (compaction)
- increase in soil salinity (salinisation)
- loss of top soil through:
  - sheet erosion
  - gully erosion
  - wind erosion.

It should be noted that acid sulfate soils have been excluded from this description as they are not specifically a soil health issue.

There is a close relationship between the indicators of soil health and the soil change or degradation processes that result in loss of health, as described in Table 10.1.

The most recent systematic statewide assessment of NSW soil health commenced in 2008 under the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (MER Strategy) (DECCW 2010). The monitoring program aimed to establish a baseline for soil condition in NSW and set up a permanent network of condition monitoring sites (Chapman et al. 2011).

As it was not feasible to monitor all soil types across the whole state, priority soil monitoring units (SMUs) were selected on the basis that they were broadly representative of regional conditions, but weighted towards areas considered to be of higher agricultural or ecological importance. Ten priority SMUs were identified in each of the 12 rural catchment management authority regions and four SMUs in the Sydney metropolitan area, for a total of 124 SMUs. The priority SMUs cover 280,000 square kilometres or 35% of NSW.

Up to 10 monitoring sites were established in each SMU. A program of soil data collection, with laboratory analysis, was undertaken at each site, together with the collection of land management data (see the related Theme 11: Sustainable land management). As the attributes of soil health and soil change processes can be quite variable in different naturally occurring soils, the health of each soil type was assessed as change relative to benchmark levels for the soil type, where it is still found substantially in its natural state.

A reanalysis of the original MER data was conducted in 2012 based on local land services (LLS) boundaries rather than catchment management authority (CMA) regions, using more complete and updated data (OEH 2014a). A total of 866 sites were surveyed, with full laboratory data available for 777 sites, with the

Table 10.1: Relationship between soil health and soil degradation processes

Soil health indicator	Soil degradation process	Characteristics of soil condition and soil degradation processes
Soil pH	Acidification	Soil pH is an important chemical determinant of soil health. Most plants and crops grow best in soils that are slightly acidic to slightly alkaline, with many specific plants and crops being most productive in either slightly acidic or slightly alkaline soils. While both strongly acidic and strongly alkaline conditions are detrimental to plant growth, the main process of soil degradation is acidification. This is generally caused by intensification of land management with associated leaching processes, removal of soil nutrients and acidifying nitrogenous fertilisers. Acidification reduces soil health and productivity and affects ecosystem function.
Soil carbon	Loss of organic carbon	Organic carbon is the main biological determinant of soil health by promoting soil nutrient recycling and improving soil structure. Organic carbon decline is generally a result of vegetation clearing and changes in land management leading to reduced replenishment of organic matter and greater losses to the atmosphere.
Soil structure	Soil structure decline	Soil structure refers to the arrangement of soil particles and voids. It governs soil water storage and movement and gas exchange and is the main physical determinant of soil condition. Soil structural condition is sensitive to land management practices. Soil compaction is caused by overworking wet or water-logged soils, use of heavy machinery, or excessive trampling by large animals.
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 changes that alter the hydrological balance in the landscape, such as clearing of vegetation, poor drainage and/or excessive levels of irrigation of crops or pastures with poor quality irrigation water, or in urban areas. An excessive level of salt is detrimental to plant growth and ecosystem processes.
Depth of topsoil	Topsoil loss due to erosion: • sheet erosion • gully erosion • wind erosion	The topsoil layer is the soil stratum that supports most plant growth. It contains the majority of nutrients and organic matter available for plant growth. Its structure supports root development, along with the uptake of nutrients and water. Removal of the topsoil stratum reduces productivity and impacts on ecosystem functions. Topsoil loss is caused by erosion processes – sheet, wind and gully erosion. Sheet erosion is caused by rain splash and diffuse water flows during heavy or intense rainfall and flooding. Gully erosion is the erosion of topsoil and subsoil by concentrated overland water flow in small localised areas of the landscape. Wind erosion is caused by strong winds in dry conditions, where soils are bare or the ground layer of vegetation cover has been removed or thinned due to poor growing conditions, clearing or overgrazing. Many soils have eroded severely in the past to the extent that the topsoil has been completely removed. Off-site sediment and nutrient export affects water quality, aquatic ecosystem function and productivity.

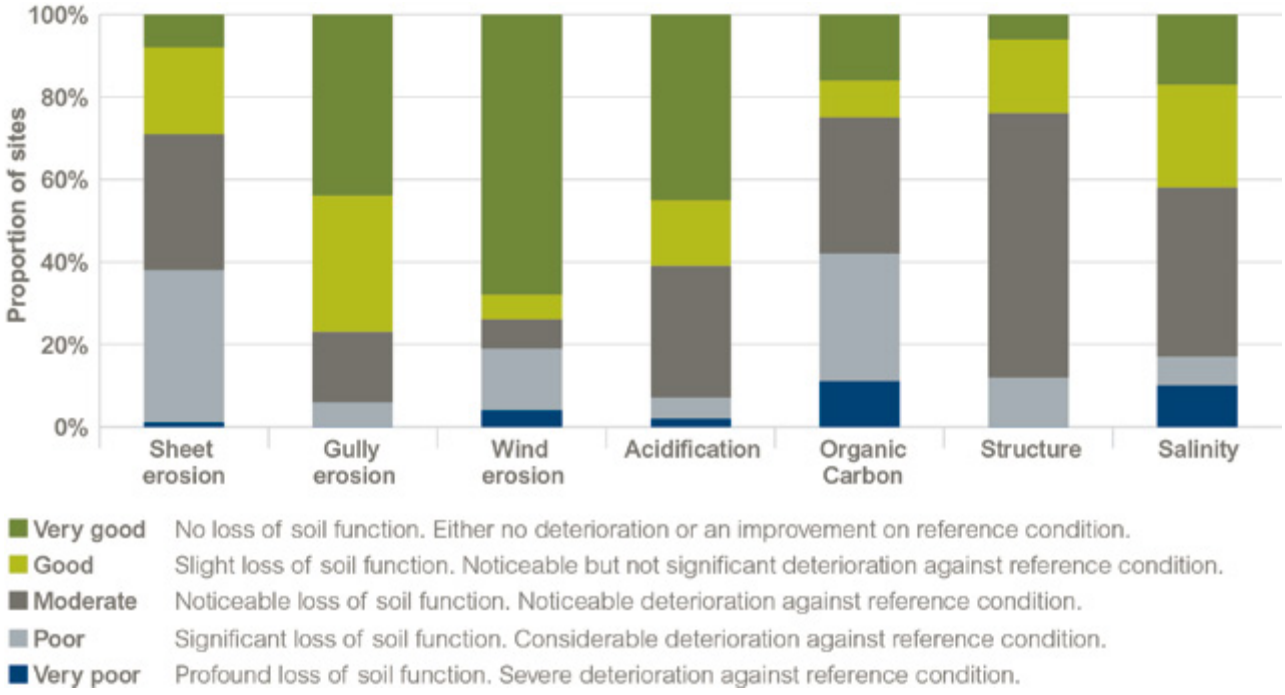
condition rating class determined for each of the seven soil degradation processes. A summary of the main findings is provided below.

The distribution of the condition classes for each soil degradation process for each SMU is depicted in Figure 10.1 (overleaf).

Figure 10.1 shows that, on a statewide basis, soils in NSW are assessed as being in moderate condition overall, but quite variable for different soil types. There has been a noticeable decline in the condition of most soils in NSW relative to their reference condition since the arrival of European settlers. As a result there has been a corresponding loss of soil function for ecosystem services and agricultural productivity.

However, it is evident that some parts of the state are in poorer condition overall, or display a significant loss of soil function due to some specific soil degradation processes. The percentages of SMUs in each LLS region that have poor or very poor ratings (i.e. where there

Figure 10.1: Proportion of soil monitoring units in each soil condition rating class by soil degradation process



Source: OEH 2014a

is significant or profound loss of soil function and where there is considerable or severe deterioration against reference condition) for each soil degradation process are shown in Table 10.2.

Of the 124 SMUs examined, 74% had poor or very poor ratings for at least one soil change process. It should be noted that the SMUs only cover 35% of the state but they are considered to be broadly representative of their respective regions and the state as a whole. A brief summary of the main issues resulting in loss of soil condition in NSW is given below, based on Table 10.2 and Figure 10.1.

Organic carbon loss

Forty-one per cent of SMUs have ratings in the poor or very poor range. It is an issue broadly across the state and a significant concern (poor in 25% or more of SMUs) in seven of the 11 LLS regions.

Topsoil loss through sheet erosion

Thirty-eight per cent of SMUs have ratings in the poor or worse range. It mainly affects central and coastal regions of NSW but is a significant concern (poor in 25% or more of SMUs) in 10 of the 11 LLS regions.

Topsoil loss through wind erosion

Nineteen per cent of SMUs have ratings in the poor or worse range. It is a significant issue of concern in three of the western-most LLS regions.

Increase in salinity

Seventeen per cent of SMUs and 15% of sites have ratings in the poor or worse range and it is a significant concern in four LLS regions.

Acidification, soil structure decline and topsoil loss due to gully erosion are issues affecting localised areas, with the results suggesting they are of significant concern in two or fewer LLS regions respectively.

The results suggest that, on a statewide basis, loss of organic carbon (41%) and topsoil loss due to sheet erosion (38%) are the two processes responsible for the greatest deterioration in soil condition over the longer term. Topsoil loss due to wind erosion (19%) and increased soil salinity (17%) are also issues of some concern. Acidification may however be more widespread than these results suggest, as it is believed to affect over half of Australia's agricultural soils (Wilson et al. 2009; ASoEC 2011).

Table 10.2: Percentage of soil monitoring units in each local land service region where soil degradation processes are rated as poor or very poor

Local Land Service (LLS) region	Sheet erosion*	Gully erosion	Wind erosion	Acidity	Organic carbon	Structure	Salinity	SMUs with at least one process rated poor or very poor**
Central Tablelands	47	13	0	0	40	0	47	**73**
Central West	26	4	4	0	19	13	22	**61**
Greater Sydney	50	0	0	43	57	0	30	**90**
Hunter	53	0	0	25	50	0	33	**80**
Murray	31	0	31	0	0	8	8	**62**
North Coast	80	20	0	22	56	0	0	**100**
North West	38	0	38	0	18	24	8	**88**
Northern Tablelands	67	8	17	11	33	11	0	**83**
Riverina	32	5	16	0	0	5	32	**63**
South East	76	9	0	18	59	0	24	**88**
Western	0	7	52	0	74	39	8	**76**
NSW (percentage of SMUs surveyed)	**38**	**6**	**19**	**7**	**41**	**10**	**17**	**74**
Ranking by severity of issue	**2**	**7**	**3**	**6**	**1**	**5**	**4**	

Source: OEH 2014a

Notes: *Indicates, for example, in Central Tablelands Local Land Service (LLS), 47% of soil monitoring units (SMUs) have sheet erosion rated as poor or very poor.

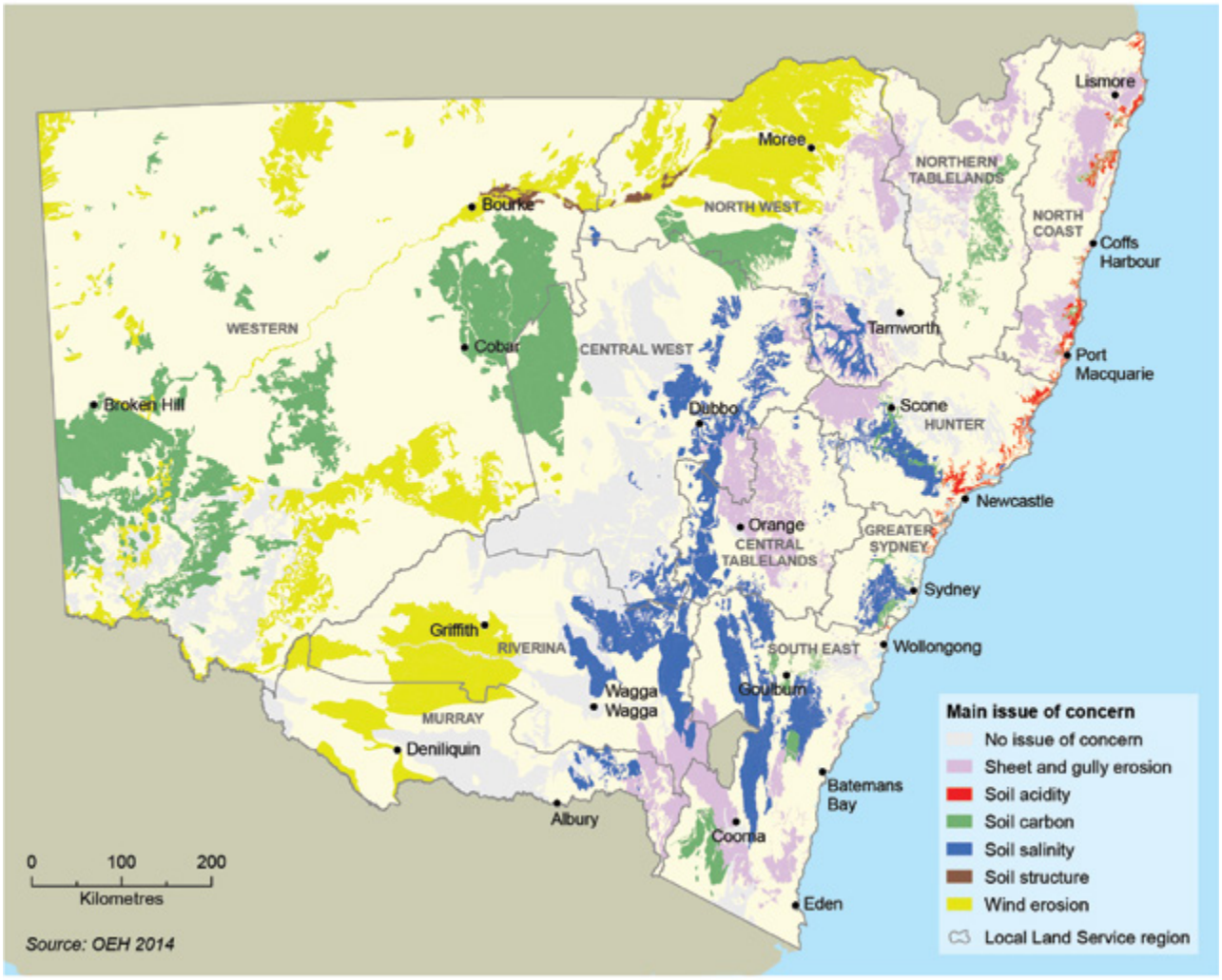
**Indicates, for example, in Central Tablelands LLS, 73% of SMUs are rated poor or very poor for one or more soil change processes.

Determining the levels of organic carbon in soil and the amount that has been lost is important, not only to assess and monitor soil health, but also to evaluate the potential for carbon sequestration in soil. Recent modelling (Gray et al. 2015) has estimated the amount of organic carbon in the top 30 centimetres of soil in NSW at 4.21 gigatonnes (Gt) prior to European settlement. Current stocks are lower suggesting that 530 million tonnes of soil organic carbon, or 12.6%, has been lost across the whole state. However, the study also found that the extent of soil organic carbon decline is highly dependent on the environmental land-use regime, with the greatest decline of 44.3 tonnes per hectare, constituting a 50% loss, occurring under a regime of regular cropping of soils with less siliceous (more mafic) parent materials in cooler (moist) conditions. Less intensive land uses, more siliceous parent materials and drier conditions were all factors contributing to a lesser decline in soil organic carbon.

The main soil health issues affecting SMUs where significant loss of soil function has occurred (identified by ratings of poor or very poor) are presented in Map 10.1 (overleaf). This map displays the main issues of concern for SMUs, and more than one issue may be significant. The map clearly shows that different soil decline processes are the dominant issues of concern in different parts of the state (further details based on the former CMA regions are presented in OEH 2014a).

The map does not necessarily indicate that the whole SMU is affected by the issue. The history of land use and land management will vary across any SMU, resulting in differing levels of change or deterioration in soil health. Much of the observed decline in the condition of NSW soils can be attributed to historic management approaches. Since the 1990s, there have been improvements in soil and land management, such as conservation farming and cell grazing, which have helped to minimise further loss of soil condition.

Map 10.1: Main soil health issues within soil monitoring units



Pressures

Unsustainable land management and land use

When European settlers first arrived in Australia they adopted traditional farming practices that had been developed to suit different soil profiles and different climate regimes in a different part of the world. Much of the soil degradation described in this theme is historic in nature and occurred before an understanding developed of how to manage soil sustainably in Australian conditions.

The development of modern land management systems such as pasture rotation, conservation farming and no-till farming has halted the decline and in some instances reversed the loss in soil condition due to the impact of purely European land management practices. The extent to which soils are now being managed within their inherent capability given the current land use and the land management practices being conducted on them is described in the related Theme 11: Sustainable land management.

Climate variability

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 exceeded, leading to loss of soil condition and degradation. Climate change is expected to lead to more extreme weather events, increasing the challenge to manage for the

variability in weather and possible drying conditions across much of NSW (Baldock et al. 2012; OEH 2014b), increasing the risk of some soil degradation hazards, particularly wind erosion and loss of soil carbon (Rengel 2011).

Changed population and settlement patterns

Rising population in urban areas leads to more intensified land use. Increased demand for food at local, regional, national and international levels also leads to intensification in the use of productive land, increasing the risk of soil degradation. At the urban fringe highly productive land is coming under growing pressure to be converted to urban settlements, while population loss from rural areas reduces the capacity of managers to manage land effectively (see Appendix 2: Private landholder capacity to manage natural resources of SoE 2009 (DECCW 2009)).

Economic factors

Declining farm profitability and poor international trading conditions, in particular a high exchange rate on the Australian dollar as experienced in the recent past, are also factors that may lead to an intensification of production activities, which may not be sustainable over the longer term.

Responses

These responses are the same as those described for the related Theme 11: Sustainable land management.

Legislation and policy framework

Important legislation providing for the protection and management of soil and lands in NSW includes the following.

The *Soil Conservation Act 1938* provides for the conservation of soil and farm water resources and the mitigation of erosion. It establishes the Soil Conservation Service, a state-owned soil conservation and environmental consulting business.

The *Native Vegetation Act 2003* regulates the clearing of native vegetation in NSW by outlining requirements for landowners when they clear native vegetation. Proposals for broadscale clearing of native vegetation must be assessed to determine whether this will improve or maintain environmental outcomes using the Environmental Outcomes Assessment Methodology (EOAM). This methodology establishes specific criteria for the assessment of impacts on land and soils when clearing is being considered.

Policy instruments supporting soil management include:

- the State Environmental Planning Policy (Rural Lands) 2008
- the Policy for Sustainable Agriculture in NSW (NSW Agriculture 1998).

Programs

The performance monitoring system of the Soil Health Evidence Based Assessment (SHEBA) program (formerly SoilWatch) is used in many regions of NSW. It complements and supplements surveillance monitoring throughout the state.

Locally, the Landcare network contributes to integrated natural resource management at a grass-roots level. Nationally there are over 4000 Landcare groups and almost 2000 of these are registered in NSW. Groups are involved with a wide variety of land and water management issues, which can include soil erosion, streambank erosion, weed control, revegetation, degradation of the riparian zone, and farmland improvements. The projects and issues addressed by Landcare groups often assist in effective soil conservation by promoting the sustainable use of soils through education and community awareness programs.

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soil carbon have been developed and published (Grealish et al. 2011).

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11 SUSTAINABLE LAND MANAGEMENT

Land and soil resources in NSW are generally being managed sustainably at both statewide and regional scales at the current time. However, some parts of the state are not being managed sustainably for individual soil hazards.

Whether land is managed within its capability is a short-term assessment, based on the impact of present land management practices and the resultant risk of soil degradation occurring. Sixty-nine per cent of soil monitoring units surveyed were rated as poor or very poor for the management of one or more of the seven land degradation hazards.

The main hazards of concern, identified at various locations across the state, are soil acidification and wind erosion. Salinity and decline in organic carbon are also issues for particular soil types and specific regional areas.

Land and soils subject to more intensive land uses are at greater risk of not being managed within their capability.

The unpredictability of severe climate or weather events, and of economic conditions, interacts with management decisions to increase the risk of degradation where land use is marginal for a district.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Land management within capability	M	Unknown	✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Appropriate land management is vital for the sustainable use of soil and land resources to meet the demands placed on it by current and future generations and to maintain soil productivity and ecosystem services. Managing land within its capability is essential to ensure that soil condition, productivity and valuable ecosystem services are maintained.

The land's capacity to support a range of uses is constrained by intrinsic factors such as soil properties, terrain features, water availability and climatic variability, as well as extrinsic social and cultural factors such as market conditions and government policy. The greater the land's inherent physical capability, the more intensive the land management practices it can support. The key to sustainable land management is to understand the processes that lead to land degradation at any particular place and then manage the land within its inherent capability.

The related Theme 10: Soil condition, describes current soil condition at a particular point in time, which results from the cumulative changes that have occurred over the longer term, since European settlement. It describes the processes that have led to changes in soil condition and accounts for any soil degradation that has occurred.

This Theme 11: Sustainable land management, is an assessment of current land management practices and whether these practices are being conducted within the inherent physical capability of monitored sites to support these practices. It describes the risk or potential change in soil condition over the short term (5–10 years) due to the specific effects of the present land management regime. This is important to inform sustainable management, given the lag between changes in land use or management practices and the subsequent appearance of land degradation or recovery.

The establishment of soil monitoring units (SMUs) across NSW and the land management within capability (LMwC) framework provides baseline data on soil condition and land management. Ongoing monitoring of these sites will enable future SoE reports to report on changes or trends in soil condition and land management over time.

Status and trends

'Land use' is the purpose to which land is put (such as forestry or cropping) whereas 'land management' practices are the detailed activities involved in undertaking the land use (such as tree thinning or stubble burning).

Land and soil capability (LSC) is a classification system to describe the capacity or resilience of land and soil to withstand the known impacts of various land uses. The LMwC framework describes the capacity of the land and soil, for any given LSC rating, to sustain the actual suite of land management practices to which it is subject without causing degradation to soil, land and water resources (OEH 2012).

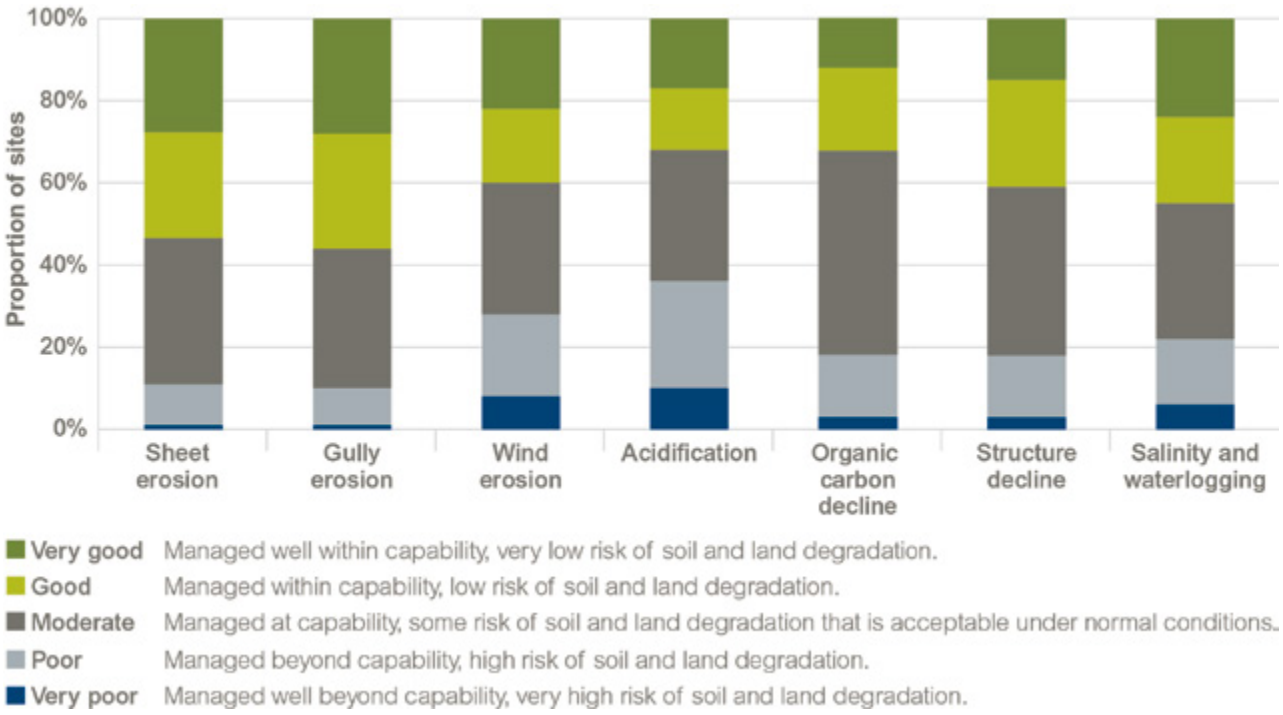
The intensity of the disturbance created by human uses of land, coupled with the characteristics of the land and seasonal conditions, defines the risk of a decline in soil health or the occurrence of land degradation.

Soil health is maintained and does not lead to soil degradation over the longer term where land is managed within its capability, but prolonged exposure to risk increases the probability of a loss in soil condition.

While the processes resulting in land degradation are well understood, the complex relationships between land management, LSC and climate variability, and the cumulative impacts on soil condition that result, are more difficult to assess or readily quantify (Bennett et al. 2010). The LMwC framework was developed to assess these complex relationships. The LSC for each SMU was determined at 662 sites across NSW, to describe their capability to support a range of current land uses. These sites were drawn from the network of soil condition monitoring sites, updated in 2012.

The LMwC of the sites was assessed by comparing current land management practices, based on landholders' records, against the assessed LSC at each site and rating these practices for whether they were within, or beyond, the capability of the land. This assessment was conducted following the methodology and rules specified in the LMwC framework (Gray et al. 2011; Gray et al. 2015).

Figure 11.1: Proportion of soil monitoring units in each land management within capability rating class by soil degradation process



Source: OEH 2014a

The final ratings indicate the extent of present impact or likely risk of each of the seven soil degradation processes or hazards occurring, that describe soil condition outcomes. The same soil degradation processes or hazards (but with waterlogging combined with salinity) were used to assess the overall sustainability of current land use and land management practices, as were used to assess the overall condition of soil in NSW – see the related Theme 10: Soil condition. While Theme 10 describes the cumulative impacts on soil health over the longer term, land management within capability describes the present and ongoing sustainability of current management activities over a shorter term (around 5–10 years).

On a statewide basis, the results presented in Figure 11.1 suggest that land in NSW is generally being managed at a level or intensity that is in accordance with its inherent physical capability; however, there are some parts of the state where individual land degradation hazards are not being managed sustainably. Soils subject to more intensive land uses tend to be at greater risk of being used beyond their natural capability.

The distribution of outcome ratings for each SMU is displayed in Figure 11.1 for each soil degradation process (or hazard).

The percentages of SMUs in each local land services (LLS) region with poor or very poor ratings, that is, those being managed slightly or well beyond capability, so that the risk of land degradation is high or very high, are shown in Table 11.1 (overleaf) for each land degradation hazard.

Of the surveyed SMUs, 69% had a poor or very poor rating for at least one hazard. In these areas, there is a risk of ongoing or future land degradation occurring, due to specific hazards that are not being adequately managed at present.

A brief summary is given below of the main land degradation issues (hazards or risks) that occur where the intensity of management practices exceeds LSC, as revealed by the LMwC assessment process.

Acidification

Thirty-five per cent of all sites have ratings in the poor or very poor range. In many parts of NSW, management of this issue is poor relative to soil capability, with the majority of LLS regions being affected. It is a significant issue of concern (≥25% of sites) in eight of the 11 LLS regions.

Table 11.1: Percentage of soil monitoring units in each local land services region where land management within capability is rated as poor or very poor for any land degradation hazard

Local land services region	Sheet erosion*	Gully erosion	Wind erosion	Acidification	Organic carbon decline	Structure decline	Salinity and waterlogging	SMUs with at least one process rated poor or very poor**
Central Tablelands	20	20	10	40	10	10	20	**60**
Central West	6	6	25	25	19	13	25	**56**
Greater Sydney	14	14	29	71	43	43	29	**71**
Hunter	15	15	8	23	15	15	8	**54**
Murray	17	17	0	50	33	33	50	**100**
North Coast	40	40	10	30	10	10	20	**60**
North West	5	0	19	24	14	5	19	**48**
Northern Tablelands	27	27	18	45	0	0	9	**73**
Riverina	17	17	17	33	50	50	33	**92**
South East	6	6	41	53	0	0	12	**76**
Western	0	0	50	6	6	6	19	**63**
NSW (percentage of all SMUs surveyed)	**11**	**10**	**28**	**35**	**20**	**16**	**21**	**69**
Ranking by severity of issue	**6**	**7**	**2**	**1**	**4**	**5**	**3**	

Source: OEH 2014a
Notes: * Indicates, for example, in Central Tablelands Local Land Service (LLS), 20% of soil monitoring units (SMUs) have sheet erosion rated as poor or very poor.
** Indicates, for example, in Central Tablelands LLS, 60% of SMUs have one or more hazards rated poor or very poor.

Wind erosion

Twenty-eight per cent of all sites have ratings in the poor or very poor range. Locations where this issue is managed poorly are found across much of the state. It is a significant issue of concern (≥25% of sites) in four LLS regions.

Salinity and waterlogging

Twenty-one per cent of all sites have ratings in the poor or very poor range. Locations where this issue is managed poorly are found in many parts of NSW. It is a significant issue of concern (≥25% of sites) in four LLS regions.

Organic carbon decline

Twenty per cent of all sites have ratings in the poor or very poor range. Locations where this issue is managed poorly are found in many parts of the state. It is a significant issue of concern (≥25% of sites) in three LLS regions.

Soil structure decline

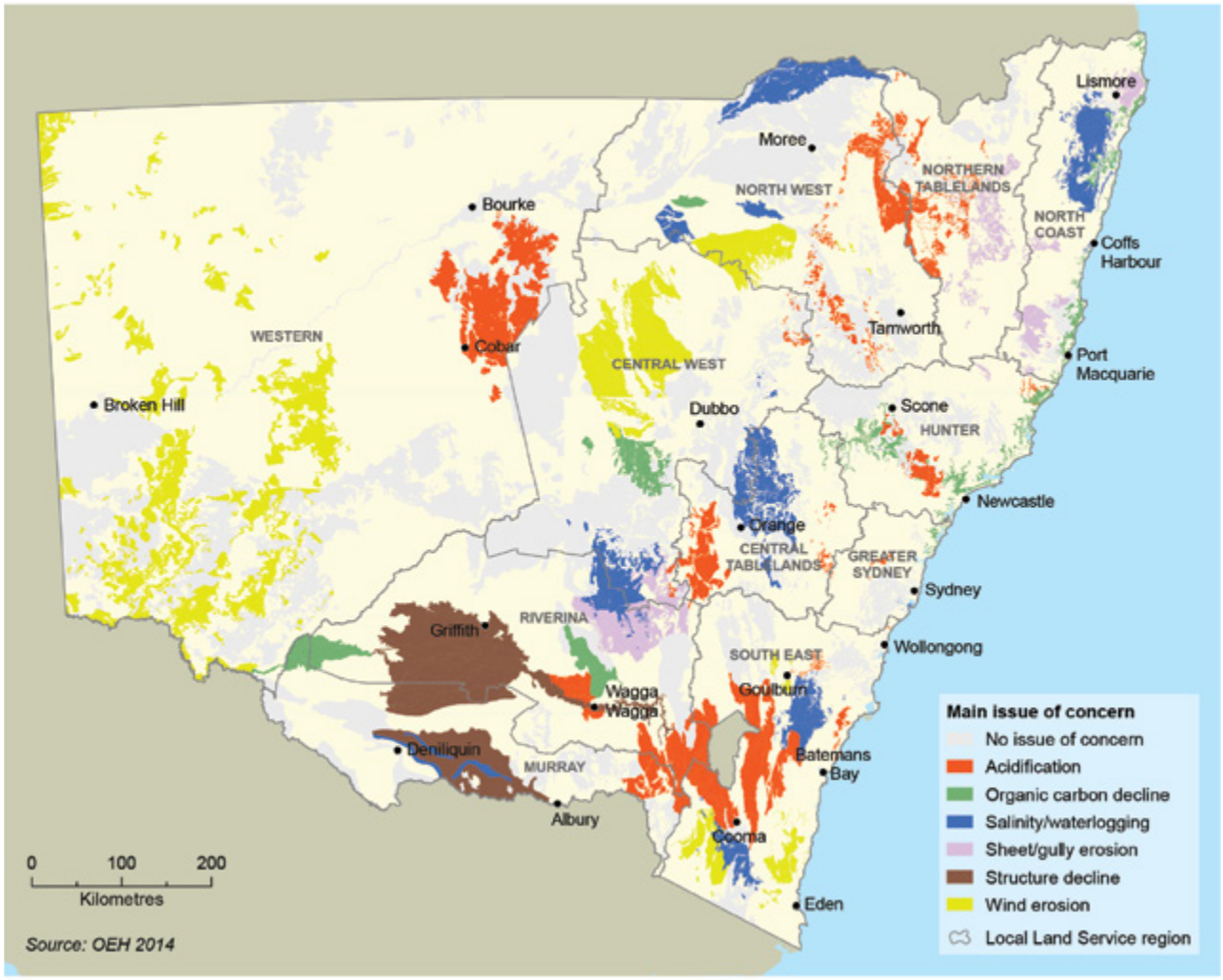
Sixteen per cent of all sites have ratings in the poor or very poor range. The locations where this issue is managed poorly are relatively regionalised within the state. It is a significant issue of concern (≥25% of sites) in three LLS regions.

Management of sheet erosion and of gully erosion are issues confined to localised areas of NSW, and are significant matters of concern in two LLS regions.

The results suggest that on a statewide basis, acidification and wind erosion are the two land degradation issues that are being managed least sustainably. Salinity and waterlogging, organic carbon decline and loss of soil structure are also issues of some concern.

The areas assessed as being at significant risk of ongoing or future degradation as a result of present land management practices are not large. Generally, they tend to occur in clusters of locations where a particular land use is marginal for the district. Map 11.1 shows the main issues of concern for individual SMUs at the present

Map 11.1: Main issue of concern by soil monitoring unit for land management within capability



time, in regard to managing land within its capability across NSW; however, this does not mean that the whole of the SMU is affected by the issue (further details based on the former CMAs are available in OEH 2014a).

Pressures

The pressures that influence land use and land management are numerous. They involve a complex interplay of economic, social and environmental factors.

Intensifying land use

To manage soil sustainably, changes to land use and land management that involve greater levels of soil disturbance demand a higher level of soil capability. As land management practices intensify there is a higher risk of reducing soil condition.

In many parts of NSW, land use is changing to more intense types as the population increases, particularly along the coast and near major urban settlements. These areas have growing populations, which lead to intensification of soil disturbance on all types of land.

Climate variability

Decisions about land use or land management practices can be affected by seasonal weather conditions, increasing the risk of land degradation or a decline in soil condition.

While a soil type may be capable of supporting certain uses or management practices during normal weather patterns, major climatic patterns or events, such as prolonged droughts, severe storms or high intensity rainfall events, can exacerbate land degradation processes and cause extensive damage.

These pressures will be coupled with the expected effects of climate change which are likely to include drying and more extreme weather events for much of NSW (DECCW 2010; Baldock et al. 2012; OEH 2014b). Changes in climate are expected to lead to changes in land use and land management over the longer term.

Economic factors

Land management decisions are often made with imperfect knowledge of future weather patterns and market fluctuations. Declining farm profitability or poor terms of trade can lead to intensified production activities (see 'Appendix 2: Private landholder capacity to manage natural resources' of SoE 2009 (DECCW 2009)).

As fuel becomes more expensive and competition for essential resources like water and fertilisers increases, significant challenges for managing the land sustainably will arise (Cribb 2010). These will be exacerbated in the future by increased population pressures and greater demand for food resources.

Responses

These responses are the same as those described for the related Theme 10: Soil condition.

Legislation and policy framework

Important legislation providing for the protection and management of soil and lands in NSW includes the following.

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The ERF provides funding through a reverse auction mechanism that allows land managers proposing to sequester carbon to be financially rewarded for doing so. The first round of auctions in early 2015 resulted in 47 million tonnes of CO_2-e abatement (28 million tonnes of CO_2-e being contracted for sequestration and 19 million by other means).

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12 THREATENED SPECIES

The number of species considered at risk of extinction continues to rise but at a slowing rate. There are currently 999 species listed as threatened under NSW threatened species legislation.

Species diversity is at threat from a number of human-induced pressures, in particular habitat loss, including clearing of native vegetation, and the impacts and spread of invasive species, most notably predation by foxes and cats. Species' ability to adapt to these pressures is further exacerbated by climate change.

A sustained pattern of decline in species diversity has prompted the setting up of the *Saving our Species* program, which is based on prioritising actions to maximise the number of terrestrial threatened species secured in the wild in NSW in the most cost effective manner. A process of legislative reform to streamline biodiversity legislation and improve outcomes for species is now under way.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Number of threatened species, communities and populations	P	Increasing impact	✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

The NSW landscape is not in pristine condition. Biodiversity has been modified and is constantly changing in response to mainly human-induced pressures (Byron et al. 2014). In particular, species diversity has been in a general pattern of decline since European settlement (DECCW 2009; EPA 2012). Conservation of threatened species has a key role in stabilising this loss of biodiversity.

The NSW approach to conserving threatened species now places a greater emphasis upon protecting specific species identified as being at risk of extinction. Tracking the progress of threatened species in NSW is indicative of the status of overall species diversity and may be used to understand the effectiveness of biodiversity conservation programs.

Status and trends

Threatened species listings

SoE 2012 (EPA 2012) noted the paucity of data available to monitor and evaluate biodiversity. Figure 7.2 in SoE 2009 (DECCW 2009) contained data describing the historical decline in distribution of native terrestrial vertebrate species while Figure 7.3 in SoE 2009 described the sustainability of native terrestrial vertebrate species. However, there have been no updates to these analyses since then, and there is little new information to evaluate the status and trends of native fauna populations or species distributions generally. As a result, this report is restricted to describing the status of native plant and animal species listed as threatened under the *Threatened Species Conservation Act 1995* (TSC Act) and the *Fisheries Management Act 1994* (FM Act).

Table 12.1: Number of listed threatened species and populations in NSW (at 31 December 2014)

Taxa	Number of NSW native species	Presumed extinct	Critically endangered	Endangered	Vulnerable	Number of threatened species listed	% of species listed	Endangered populations
Mammals	138	25	2	16	39	82	59%	10
Marine mammals	40	0	0	3	4	7	17%	0
Birds	452	12	11	23	91	137	30%	7
Amphibians	83	0	5	12	11	28	34%	1
Reptiles	230	1	0	18	23	42	18%	1
Plants	4677	33	51*	336	227	647	14%	29
Aquatic plants and algae	?	1	1	1	0	3	?	1
Freshwater fish	60	0	2	6	1	9	15%	4
Marine fish, sharks and rays	?	1	1	2	3	7	?	0
Terrestrial invertebrates	?	1	2	14	0	17	?	1
Aquatic invertebrates	?	2	2	3	4	11	?	0
Fungi	?	0	0	5	4	9	?	0
Total	**?**	**76**	**77**	**439**	**407**	**999**	**?**	**54**

Source: Office of Environment and Heritage (OEH) and Department of Primary Industries (DPI) data 2015

Notes: *Numbers include provisionally listed species

At 31 December 2014, 999 species in NSW were listed as threatened under the TSC and FM Acts. Over the past three years, listings have increased by 10, with both aquatic and terrestrial species listings increasing by five each – an increase of 1%.

This represents a decrease in the rate of species listings since SoE 2012. It should be noted that this slowing rate may reflect limited information availability rather than actual outcomes for species (see below). There are currently 77 species presumed extinct with no additional listings in that category since SoE 2012. However, further species losses may be expected due to the time lag between pressures being experienced and the remaining population dying out (referred to as the 'extinction debt') (Tilman et al. 1994).

Table 12.1 displays numbers of listings for various plant and animal groups.

According to the listings, the taxa most at threat from extinction are:

- terrestrial mammals – 59% listed
- amphibians – 34% listed
- birds – 30% listed.

The number of endangered populations is now 54, an increase of five (10%) since SoE 2012.

Figure 12.1 shows the increase in numbers of listed species and ecological communities, in each category, since the threatened species legislation was enacted in 1995. As noted above, growth in the overall number of species listings has slowed down in the last three years. There are 108 threatened ecological communities – an increase of just less than one per cent over the past three years.

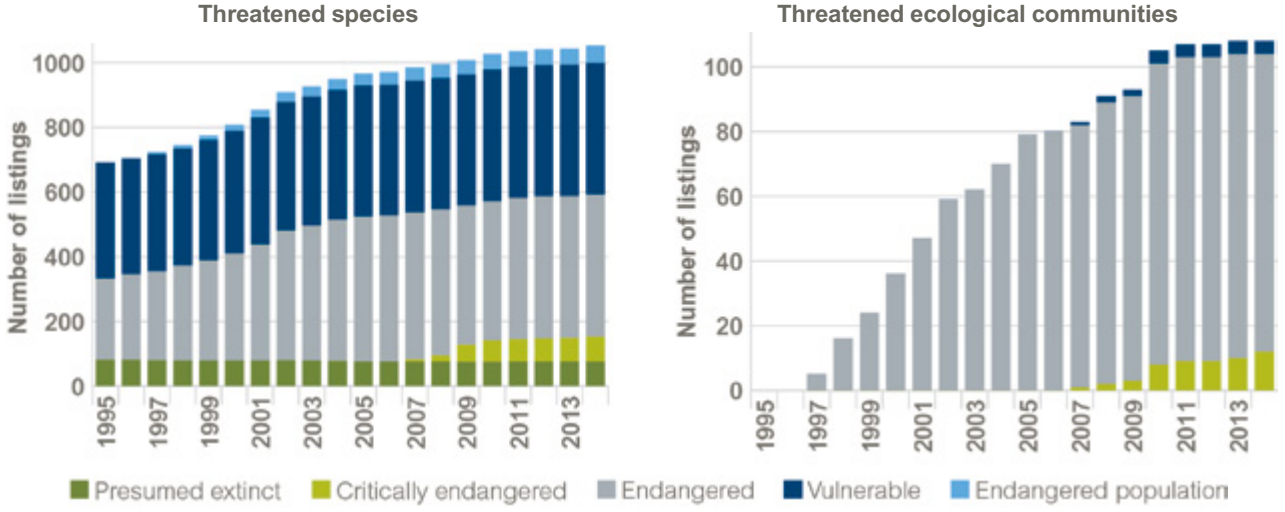
In addition, the trend of threatened species moving into categories closer to risk of extinction has slowed, with 51% of all currently listed threatened species categorised as endangered or critically endangered, the same proportion as in SoE 2012.

Are threatened species listings a reliable indicator?

Issues with relying on threatened species listings to indicate the status of threatened species in NSW have been well documented in previous SoE reports. Recent criticisms of the data are:

- bias towards iconic species, such as vertebrates and flowering plants. Invertebrate animals, fungi and non-vascular plants are poorly represented (EDO 2014; OEH 2014)
- overreliance on public nominations (which have decreased in recent years) where species tend to be nominated in a piecemeal fashion with no clear overarching strategic direction (OEH 2014)
- resourcing constraints affecting both the Threatened Species Scientific Committee under the TSC Act and the Fisheries Scientific Committee under the FM Act preclude strategic reviews of the listings to ensure the lists accurately reflect the current extinction risks for species (OEH 2014)

Figure 12.1: Changes in total listings of threatened species and ecological communities 1995–2014



Source: OEH and DPI data 2015

- resources may also be provided to the scientific committees for a specific purpose, resulting in skewed listings
- nominating species for listing can be time consuming and often requires specialist skills and knowledge
- listings only commenced in 1995 and this skews the trend data, as the number of listings rose quite rapidly initially and the point at which they reflect the actual situation is unclear.

It is possible that many species actually at risk of extinction are not included on the threatened species lists (EDO 2014).

Limited information availability

There is no broad strategy or framework to monitor the conservation status of species in NSW. This is despite various requirements for monitoring and assessment in the current regulatory framework (Byron et al. 2014). As a result, there is limited information readily accessible to understand the overall status and trends for threatened species in NSW.

In 2014, the Independent Biodiversity Legislation Review panel recommended the development and use of a comprehensive system for monitoring and reporting the condition (extent and quality) of biodiversity in NSW (Byron et al. 2014). The NSW Government's adoption of this recommendation may assist with availability of data for future SoE reports. Further information on the biodiversity legislation reforms is provided below.

Pressures

The major threats to biodiversity include habitat loss, including the clearing and the disturbance of native vegetation, the impacts of invasive pest and weed species, altered fire regimes, and climate change (Byron et al. 2014). The pressure affecting the largest number of terrestrial threatened species in NSW (87%) is the clearing and disturbance of native vegetation, followed by invasive pest and weed species (Coutts-Smith & Downey 2006). Introduced pests are likely to have had the greatest impact on native fauna. In particular foxes and cats are considered to be responsible for the majority of fauna extinctions in NSW (Morton 1990; Dickman 1996a; Dickman 1996b).

The current status of a number of key pressures on threatened species are described in other sections of this report including:

- Theme 13: Native vegetation – The clearing of native vegetation and the associated destruction of habitat has been identified as one of the greatest threats to biodiversity in NSW.
- Theme 15: Invasive species – Invasive species have been implicated in the decline of many native species, and are thought to impact over 70% of listed threatened species.
- Theme 17: River health – Water extraction, altered river flow regimes and degraded water quality impact on the critical ecological processes that trigger breeding events for various aquatic and bird species.
- Theme 1: Population – Expanding human settlements demand space and can increase the fragmentation of ecosystems, making biodiversity an important environmental consideration in land-use planning.
- Climate change (see Theme 5: Greenhouse gas emissions) – Rapid changes in climate can challenge the ability of species to adapt through methods such as dispersal and resettlement, and can exacerbate the effects of other pressures (such as the expansion of invasive species) (DECCW 2010).

Pressures not dealt with specifically in other sections of this report include altered fire regimes due to European settlement and the indirect impacts of development. These include road mortality and disturbance to behaviour and breeding cycles from infrastructure, noise and lighting (Byron et al. 2014).

Most of the pressures above were described in greater detail in SoE 2012 and that information continues to be relevant.

It should also be noted that many of the pressures discussed operate together to have a cumulative or synergistic impact on species' decline. A synergistic impact occurs where the interaction between multiple disturbances results in an impact that is greater than the sum of the individual pressures (see Raffaele et al. 2011; Goldman Martone & Wasson 2008; Simberloff & Von Holle 1999).

Listing of key threatening processes

The threatened species legislation provides for a key threatening process to be listed if it either adversely affects a listed species or could cause a species that is not threatened to become threatened.

There are currently 46 key threatening processes listed in the threatened species legislation. Since SoE 2012, one key threatening process has been listed relating to a native species – the noisy miner.

Noisy miners physically attack and actively drive away birds of similar or smaller size from areas they occupy. This aggressive behaviour often results in the noisy miners being the only small–medium-sized bird species present in an occupied habitat (NSW SC 2013).

Responses

Although many of the established responses set out in SoE 2012 are still in force and relevant, the last three years have seen a number of reviews of the existing response mechanisms that may result in substantial changes to the way threatened species conservation is approached in NSW in the future.

Biodiversity legislation reforms

In 2014 the Minister for the Environment established an independent panel to review the *Native Vegetation Act 2003*, *Threatened Species Conservation Act 1995*, *Nature Conservation Trust Act 2001* and parts of the *National Parks and Wildlife Act 1974*. The aims of the review were to recommend simpler, more streamlined and effective legislation to conserve biodiversity (including threatened species), support sustainable development and reduce red tape.

Published in December 2014, the panel's final report, Review of Biodiversity Legislation in NSW (Byron et al. 2014), made 43 recommendations, including that the TSC Act be repealed and reconstituted into a new Biodiversity Conservation Act. In March 2015 the NSW Government endorsed all 43 recommendations.

Saving our Species program

Under both the TSC and FM acts, a priority action statement is required to provide a strategic framework for coordinating conservation and management actions across listed threatened species.

In 2013, the performance of the NSW Threatened Species Priorities Action Statement under the TSC Act was reviewed following its first three years of operation (2007–10). This review found that while significant worthwhile conservation work was being undertaken, it was unclear to what extent this work benefited threatened species. The review has led to an innovative method of developing projects to meet the needs of threatened species in NSW, namely the *Saving our Species* program. The program aims to maximise the number of terrestrial threatened species that can be secured in the wild in NSW for 100 years.

Through *Saving our Species*, terrestrial 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 (such as the smoky mouse, eastern bristlebird and granite rose) that can be successfully secured by carrying out targeted conservation projects (such as weeding or revegetation) on a specific site
- **iconic species:** five species that are especially valued by the community – the koala, brush-tailed rock-wallaby, mallee fowl, southern corroboree frog, and Wollemi pine
- **data-deficient species:** species where there is insufficient information to allocate them to another management stream (includes 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 will have conservation projects developed for them
- **keep watch species:** these species, for example Hall's babbler and the spiny mintbush, require no immediate investment because they are either naturally rare, have few critical threats, or are more abundant than previously assumed.

Priorities for action under *Saving our Species* are species in the site-managed, iconic, data-deficient and landscape-managed species management streams.

The Independent Biodiversity Legislation Review Panel recommended designing a legislative framework for action on threatened species and ecological communities that formalises the programmatic approach taken by *Saving our Species*. This recommendation has been adopted by the government.

NSW public reserves system

The NSW public reserves system covers around 7.1 million hectares or about 8.9% of the state (see also Theme 14: Protected areas and conservation). It conserves representative areas of the full range of habitats and ecosystems, and the majority of plant and animal species found in NSW. Over the past three years there have been significant additions to under-represented areas of the 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.

Policy and guidelines for fish habitat conservation and management

In 2013, an updated policy and guidelines were published aimed at maintaining and enhancing fish habitat in NSW for the benefit of native fish species (including threatened species) in marine, estuarine and freshwater environments (DPI 2013).

NSW biodiversity offsets policy for major projects

In October 2014, the NSW biodiversity offsets policy for major projects was released, which clarifies, standardises and improves biodiversity offsetting for major project approvals. The policy aims to strike an effective balance between the needs of proponents, communities and the environment by:

- providing clear, efficient and certain guidance for stakeholders
- improving outcomes for the environment and communities
- providing a practical and achievable offset scheme for proponents.

The Independent Biodiversity Legislation Review Panel recommended expanding the offsets policy for major projects to create a consistent approach to avoiding, minimising and offsetting biodiversity impacts for all types of development, and to drive a positive market for landholders to opt in to long-term stewardship contracts to supply environmental services. This recommendation has been adopted by the government.

Future opportunities

The NSW Government has announced an additional $100 million over five years from 2016–17 to *Saving our Species*. These funds will allow the program to expand to cover more species and also ecological communities and threatening processes that impact many species across the landscape.

The NSW Government is looking at increasing landscape-scale conservation to complement threatened species protection and recovery. This would involve a greater uptake of what is currently known as BioBanking and biodiversity certification schemes, along with developing a comprehensive network of biodiversity corridors (Byron et al. 2014) (see also Theme 14: Protected areas and conservation).

The review of biodiversity legislation in NSW (Byron et al. 2014) has emphasised the need for monitoring and evaluation of the condition of biodiversity in NSW. Under the *Saving our Species* program, monitoring and reporting is also mandatory for funded projects, and this may lead to more comprehensive datasets to enable reporting on changes in the distribution and abundance of threatened species in future State of the Environment reports.

There is also scope to incorporate the traditional knowledge of Aboriginal people, which historically has been underutilised, to better conserve and manage native species and ecosystems (Byron et al. 2014).

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13 NATIVE VEGETATION

Clearing rates for native vegetation in NSW have generally been relatively stable over the past 10 years. Sixty-one per cent of NSW remains covered by native vegetation. Only 9% of NSW has vegetation considered to be in close to natural condition. Condition is variable in the remaining 52% but has deteriorated, largely due to the effects of different land-use and land management regimes.

Land clearing has been recognised as the main threat to the extent and condition of native vegetation in NSW. With improved technology for the monitoring of clearing it is now recognised that the level of clearing is relatively low, at around 11,000 hectares per year.

While some vegetation classes, particularly woodlands and grasslands, have been substantially depleted since European settlement, others remain largely intact.

Vegetation condition largely reflects the primary land use and 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 pressures from invasive species and climate change.

Substantial programs of restoration and revegetation that are occurring at local and regional levels are expected to lead to improvements in the condition of vegetation over the longer term.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Clearing rate for woody native vegetation	M	Stable	✓✓✓
Extent of native vegetation	M	Stable	✓✓
Condition of native vegetation	M	Increasing impact	✓
Levels of pressures on native vegetation condition	M	Stable	✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

NSW contains a great variety of native vegetation, with outstanding examples 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.

Native vegetation extent and condition are indicators of ecosystem health and diversity (Saunders et al. 1998). Generalised mapping based only on vegetation structure and growth form provides a useful overview for reporting on the statewide status and extent of native vegetation, but is less descriptive of ecosystems and habitats than more detailed mapping of vegetation that is based on information about species composition. The description in this section is largely based on generalised mapping as more detailed mapping is not yet available on a consistent basis across the state.

This theme is only concerned with the state of terrestrial vegetation. Freshwater aquatic vegetation is considered in Theme 18: Wetlands, and coastal aquatic vegetation is considered in Theme 20: Coastal, estuarine and marine ecosystems.

Status and trends

Vegetation extent

Information on the extent of NSW native vegetation 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 'vegetation extent categories', which represented various levels or degrees of modification, and was presented as Map 7.1 under Vegetation extent in SoE 2009 (DECCW 2009). A summary of the outcomes is displayed below in Table 13.1.

In 2012, the data from 2009 was combined with the most current map of change in woody vegetation to determine how much of each extent category is comprised of woody vegetation (SoE 2012). Map 5.1 under Vegetation extent in SoE 2012 depicts the location and extent of native vegetation that is woody or non-woody in each of the extent modification categories.

Monitoring of woody vegetation and definitions of what is regarded as woody vegetation are described below under 'Clearing of woody vegetation'.

Extent of intact native vegetation

'Native – intact' vegetation covers 61% of NSW. Vegetation communities that occur naturally can still be identified in this category as the vegetation retains its structural integrity (Keith & Simpson 2006; Keith & Simpson 2008), but

Table 13.1: Extent of native vegetation in NSW

Vegetation extent category	Description	Area (% of state)	Proportion woody (%)*
Native – intact	Native vegetation in which the structure has not been substantially altered	61%	55%
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%	50%
Native/non-native mosaic	Vegetation that cannot be classified as native or non-native using current remote sensing technologies	20%	15%
Non-native/other	Non-native vegetation (crops, plantations, pasture) or other non-vegetative land cover	11%	–

Source: EPA 2012

Notes: *This describes the percentage of each category that is woody and figures do not sum to 100%. Overall, 45% of all native vegetation was categorised as woody.

these communities are not necessarily in good condition. Only 9% of native vegetation in NSW is regarded as being in close to natural condition as it is managed with conservation as the primary objective. The remaining vegetation in this category faces impacts from a variety of land uses, leading to changes in species composition and ecological function, reduced vigour or regeneration, and diminished habitat values.

The current extent of intact native vegetation in NSW reflects differing rates of clearing 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 and so have experienced little change in extent. The status of intact native vegetation formations in NSW was summarised in Table 5.5 under Vegetation extent in SoE 2012.

Vegetation condition

Where native vegetation still exists, it ranges in condition from a close to natural state if undisturbed, to heavily degraded. Between these two extremes, native vegetation has been modified to varying degrees by land management practices and unplanned threats such as weed invasion, drought and fire. The negative 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 diminishes habitat values and impairs ecosystem processes. Decline in vegetation condition is generally less immediately visible than clearing and occurs over a longer time frame, making it more difficult to monitor and assess.

A broad assessment of vegetation condition – largely based on generalised land-use mapping – where vegetation condition declines with an increase in land-use intensity, was presented in Map 7.2 under Vegetation extent in SoE 2009. The results of this mapping are summarised in Table 13.2. Both the condition categories and the area estimates are strongly aligned with the vegetation extent categories described in Table 13.1, as the extent categories in that table incorporate an inherent description of vegetation condition.

The map described the broad transformation that occurred to the structure of vegetation across the landscape when it was modified to make land suitable for a range of human uses, but it is static in nature and can only be updated if further major land-use changes have occurred since the map was prepared.

Table 13.2: Native vegetation condition classification

Category	Description	Area (% of state)
Residual	Native vegetation structure, composition and regenerative capacity remain intact, with no significant land-use disturbance	9%
Modified	The structure, composition and regenerative capacity are intact, with some land-use disturbance	52%
Transformed	The structure, composition and regenerative capacity are significantly altered by land use	7%
Indeterminate	Vegetation cannot easily be classified as either transformed or replaced	19%
Replaced or managed	Native vegetation has been replaced by non-native vegetation	12%
Removed	Native vegetation has been removed to leave non-vegetated land cover	1%

Source: DECCW 2009

Pressures

Vegetation extent

Land clearing

Native vegetation has been extensively cleared in NSW for settlement, industry and agriculture. Clearing facilitates land-use change and due to the ongoing nature of the subsequent uses of cleared land it is generally irreversible. The clearing process actively displaces many native animals and plants and has a negative impact on biodiversity. Over time, the effects of fragmentation and disturbance lead to weed invasion and further deterioration in the condition and habitat values of remnant vegetation.

Clearing is therefore accepted as being the main cause of vegetation change and decline. Clearing of native vegetation, and the associated destruction of habitat has been identified as the process representing the greatest single threat to biodiversity in NSW (Coutts-Smith & Downey 2006). Land clearing is also listed as a key threatening process under the *Threatened Species Conservation Act 1995*.

Clearing of woody vegetation

In the past, monitoring of the extent of clearing of woody vegetation in NSW has been conducted by analysing Landsat remote sensing data using the statewide landcover and trees study (SLATS) methodology (DNRW 2007). However, the Landsat 5 satellite failed in November 2011. Landsat 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 was available for both platforms.

Woody vegetation change based on Landsat imagery had a 30-metre resolution, with an operational definition of woody vegetation being woody communities with 20% or more canopy cover, which are taller than about two metres (e.g. woodlands open forest and closed forest). SPOT 5 imagery has a five-metre resolution and provides more detailed mapping, detecting woody vegetation down to 5% crown cover, enabling the detection of change in open woodlands, grasslands with scattered trees and highly modified areas.

Comparison of the two platforms indicates differences in the estimates of change in woody vegetation derived from both platforms. SPOT 5 imagery detects more and smaller changes than Landsat, while the change estimates from Landsat tend to overestimate change due to the coarser resolution. The difference is dependent on the spatial pattern of change and is greater where clearing is discontinuous. Due to this variability, clearing rates derived from the two platforms are not directly comparable.

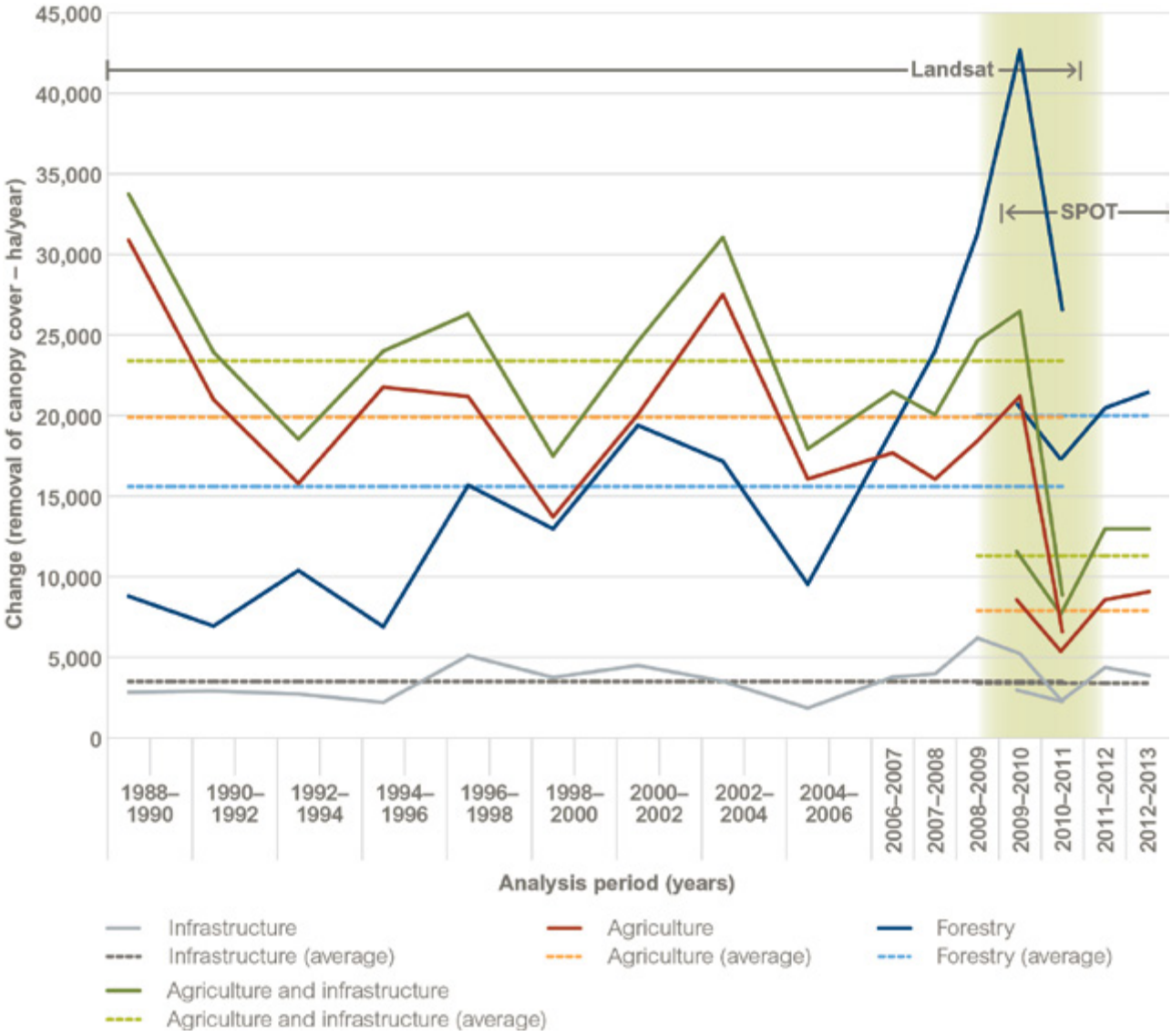
Figure 13.1 presents both Landsat and SPOT 5 data on the changes in woody vegetation due to clearing for agriculture, infrastructure development and forestry over the past 24 years of monitoring.

The estimate of clearing discussed in this report relates only to activities that lead to permanent changes in land use and landscape function, that is, changes due to agriculture and infrastructure development. The four years of SPOT 5 data from 2009–10 display a relatively stable pattern of clearing at about 11,000 hectares per year, apart from the unusually low result in 2010–11, attributed to a particularly wet year affecting the ability to conduct clearing operations. This pattern is also consistent with the last seven years of Landsat data, which have also displayed a relatively stable pattern from about 2004 compared to prior variations.

Forestry operations are not described as clearing because they do not lead to land-use change. Most areas where change is detected due to harvesting are expected to be regenerated as regrowth forest.

Monitoring of change due to increases in woody vegetation resulting from revegetation is inherently more complex than monitoring of clearing. A methodology is being developed to measure this and estimates of revegetation should be available in future reports. While no data is available as yet, it is expected that this will show that levels of clearing are being balanced by levels of revegetation.

Figure 13.1: Woody vegetation change in NSW, 1988–90 to 2012–13



Source: OEH data 2015

Notes: Until 2006–07, the annual rate of clearing was derived from change detected over a two-year period (for example, 1988–90 represents two years from around the end of 1988 to around the end of 1990) with the value averaged over the two years. From 2006–07 onwards, assessments have been conducted yearly.

There is some variability in the actual length of the two-yearly or yearly intervals, depending on the availability of remote sensing data suitable for analysis due to seasonal factors.

The green shaded area represents the overlap when data was available from both the Landsat and SPOT platforms.

Clearing of non-woody vegetation

However, not all clearing occurs through the direct removal of trees in areas covered by woody vegetation. Non-woody vegetation is taken to be vegetation that does not meet the criteria to be classified as woody vegetation. It refers to all grasslands and large areas of open woodlands and arid shrublands characteristic of western NSW.

Much of the native grassland in NSW has been cleared or modified by pasture improvement, through the application of fertilisers, and by the ploughing and sowing of introduced grasses and clovers. Some freshwater wetlands and arid shrublands have, in effect, also been cleared, by prolonged overgrazing.

Vegetation condition

Land use

Map 5.2 under Vegetation extent in SoE 2012 shows the levels of pressure from a variety of land uses on vegetation extent and condition. The land uses themselves are described in Guidelines for Land Use Mapping in Australia: Principles, procedures and definitions (ABARES 2011). These have been reclassified into five categories of inferred pressure that describe the generally increasing levels of disturbance to native vegetation as the intensity of the operations or processes associated with different land use increases. The extent of vegetation in the individual pressure categories is summarised in Table 13.3. However, the intensity of land use is also affected or modified by the specific land management practices adopted in carrying out any specific land use (see Theme 11: Sustainable land management).

General pressures

Not all the pressures on vegetation condition are due to land use. 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 and the emerging effects of climate change are all pressures that affect the condition of native vegetation.

The impacts of land clearing on habitat have been discussed under 'Vegetation extent' above. However, habitat fragmentation caused by clearing continues to have long-term impacts on native vegetation well after the initial clearing occurs, primarily through dieback, invasions of weeds and feral animals, and loss of native species.

While most arid shrublands and grasslands are not subject to extensive clearing, they are affected by overgrazing, which represents the cumulative impact of native species, farm stock and feral pest 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.

Changes to water regimes and the effects of drought have resulted in extensive dieback in floodplain forests and wetlands (see Theme 17: River health and Theme 18: Wetlands).

Climate change is pervasive and 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 in snow cover in alpine habitats (Nicholls 2009) is decreasing the area and suitability of habitat for a range of specialised alpine species (Green & Pickering 2009).

Other significant and pervasive pressures affecting vegetation condition are discussed as separate issues in this report. These include soil degradation (see Theme 10: Soil condition) and invasive species (see Theme 15: Invasive species).

Table 13.3: 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

Responses

Native Vegetation Act 2003

The *Native Vegetation Act 2003* (NV Act) has been the key legislation regulating the clearing of native vegetation in NSW. The Act came into effect in December 2005 and aims to prevent broadscale land clearing unless it maintains or improves environmental values. The Act regulates the clearing of native vegetation in most of NSW, except on land in urban areas and land excluded for major development, and in national parks, conservation areas, state forests and reserves (see Theme 14: Protected areas and conservation).

Native vegetation regulation

In September 2013 the regulation for the NV Act was revised and the Native Vegetation Regulation 2013 came into effect, to cut red tape for farmers while maintaining environmental protection. The new regulation clarifies the definitions for a range of routine agricultural management activities (RAMAs) where clearing does not require approval. It also introduced a new class of RAMAs – Ministerial Orders, which provides for self-assessable codes of practice that apply to the clearing of invasive native species, thinning and the clearing of paddock trees.

Property vegetation plans

The provisions of the NV Act are largely implemented through a framework of voluntary agreements called property vegetation plans (PVPs), which only permit clearing on properties if environmental values are maintained or improved. PVPs are based on maintaining or improving outcomes under four criteria in the Environmental Outcomes Assessment Methodology (EOAM): biodiversity, soil health, water quality and soil salinity. Local land services play a pivotal role in establishing PVPs with private landholders.

A range of other measures to improve landscape management, enhance the condition of native vegetation and maintain biodiversity are also implemented through PVPs. For example, special protection is provided for landscape and vegetation types that have been cleared to below 30% of their original extent, and measures are in place to reward landowners for voluntary conservation activities. Other activities are described under ‘New restoration or revegetation of native vegetation’ and ‘New management of native vegetation’ in Table 13.4.

Table 13.4: Summary of native vegetation management activities undertaken in NSW from 2005–06 to 2013–14

Category	Description	Total area (last 3 years: 2011–12 to 2013–14)	Total area (2005–06 to 2013–14)
New conservation areas	New public reserves or additions as well as private conservation areas (see Theme 14: Protected areas and conservation)	71,360	1,296,270
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 PVPs	711,850	2,588,220
New management of native vegetation	Management through Invasive Native Scrub, Thinning and Private Native Forestry PVPs, new areas of public forest, weed removal programs, and management to reduce grazing pressure	2,475,120	7,450,090
New clearing of native vegetation	Approved clearing under NSW legislation including *Native Vegetation Act 2003*, former *Native Vegetation Conservation Act 1997*, *Plantations and Reafforestation Act 1999*	4,410	25,590

Source: OEH data 2015

Biodiversity legislation reforms

In 2014 the Minister for the Environment established an independent panel to review the *Threatened Species Conservation Act 1995, Native Vegetation Act 2003, Nature Conservation Trust Act 2001* and parts of the *National Parks and Wildlife Act 1974*. The aims of the review were to recommend simpler, more streamlined and effective legislation to conserve biodiversity (including threatened species), support sustainable development and reduce red tape. The new legislative framework will repeal the *Native Vegetation Act 2003* and associated regulations while seeking to continue to balance production imperatives with best available measures to minimise any adverse environmental impacts, particularly for threatened species or communities.

Management of native vegetation

Since 2006, the NSW Government has collected data on native vegetation programs from various agencies to produce the NSW Report on Native Vegetation (OEH 2011), including the native vegetation report card, which shows the extent of a range of activities conducted to manage native vegetation in NSW since 2005–06. These are summarised in Table 13.4, overleaf.

The first three categories describe positive changes in the extent or condition, or both, of native vegetation, while 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, while the areas to improve the condition or management of native vegetation are quite substantial, it is still too early for many of the measures listed in Table 13.4 to be detectable as changes in the extent or condition of native vegetation described above.

Future opportunities

More regional programs involving local communities should provide greater opportunities to improve vegetation condition, enhance habitat connectivity and reduce fragmentation which will, over time, increase the resilience, health and productivity of native vegetation on public and private land.

Although clearing may be slowing and fragmentation reduced, 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.

Work has commenced on developing a single Biodiversity Assessment Methodology (BAM) as part of the biodiversity reforms that will replace the EOAM and all other currently used methods. The BAM will streamline assessments by using a modular approach to assessing biodiversity and other environmental impacts (such as land degradation and salinity, currently assessed by the EOAM).

OEH has commenced a Native Vegetation Information Strategy 2014–18 to improve the quality, detail and utility of vegetation information to better inform the status of native vegetation in NSW. This includes more detailed mapping of vegetation and more robust descriptions of vegetation types and conditions.

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14 PROTECTED AREAS AND CONSERVATION

As at January 2015, the area of the NSW public reserve system was 7,107,533 hectares, or about 8.9% of NSW. Since 2012 the area of the reserve system has grown by 26,599 hectares.

The representativeness of the protected area system is improving with some significant additions to underrepresented areas, but some bioregions and vegetation classes are still underrepresented, particularly in the central and western regions.

There has been little change to the system of marine protected areas over the past three years.

Conservation on both private and public land provides greater connectivity across landscapes and is becoming increasingly important. A range of measures has been developed under the Conservation Partners Program to encourage and support conservation on private land.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Area of terrestrial reserve system	M	Decreasing Impact	✓✓✓
Area of the marine protected areas system	M	Stable	✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of 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.

For the terrestrial environment, nearly all of such land is in the state's public reserve system. This is a substantial network of protected areas that:

- conserves representative areas of the full range of habitats and ecosystems, plant and animal species, and significant geological features and landforms in NSW
- protects areas of significant cultural heritage
- provides opportunities for recreation and education.

As well as the protected area system, NSW also conserves the environment through other measures. Conservation of natural values across the whole is increasingly being focused on public and privately owned areas outside the reserve system (for details on the status of wetlands conservation, see Theme 18: Wetlands).

In the NSW marine environment, six marine parks with multiple-use zoning plans conserve marine and coastal ecosystems and habitats, while permitting a wide range of compatible uses. Twelve aquatic reserves are in place along the NSW coast to conserve biological diversity, or particular components of biological diversity as per the new *Marine Estate Management Act 2014*.

The National Parks and Wildlife Service (NPWS) in the Office of Environment and Heritage (OEH) is the agency responsible under the *National Parks and Wildlife Act 1974* (NPW Act) for managing and protecting more than seven million hectares of conservation reserves in NSW. These are mostly land-based, but sometimes include estuarine and oceanic areas. OEH also administers several schemes that encourage and support landholders to protect biodiversity on private land.

The recently created Marine Estate Management Authority is responsible under the Marine Estate Management Act for overseeing and coordinating the management of the entire NSW marine estate (all tidal rivers, estuaries, shoreline, and waters out to three nautical miles) as a single continuous system, and is developing a marine estate management strategy to coordinate implementation by all the other agencies involved.

The Department of Primary Industries (DPI Fisheries) undertakes the day-to-day management of NSW marine parks and aquatic reserves, and is responsible under the *Fisheries Management Act 1994* for the protection of key fish habitat, both inland and marine.

The Forestry Corporation manages flora reserves under s.16 of the *Forestry Act 2012* and Schedule 3 s.6.

Fourteen state parks cover significant natural areas of bush and wetlands, although they are often reserved primarily for nature-based recreation. They are managed by various trusts under the *Crown Lands Act 1989*.

Other important natural areas are also administered by trusts under the Crown Lands Act, often with day-to-day management by local councils (e.g. Warringah Council manages Manly Warringah War Memorial Park, which comprises several Crown reserves around Manly Dam).

Local land services manages travelling stock routes (TSRs) as a trust under the Crown Lands Act in the central and eastern divisions of NSW, and TSRs in the western division of the state are held by private landholders as leaseholders under the Act.

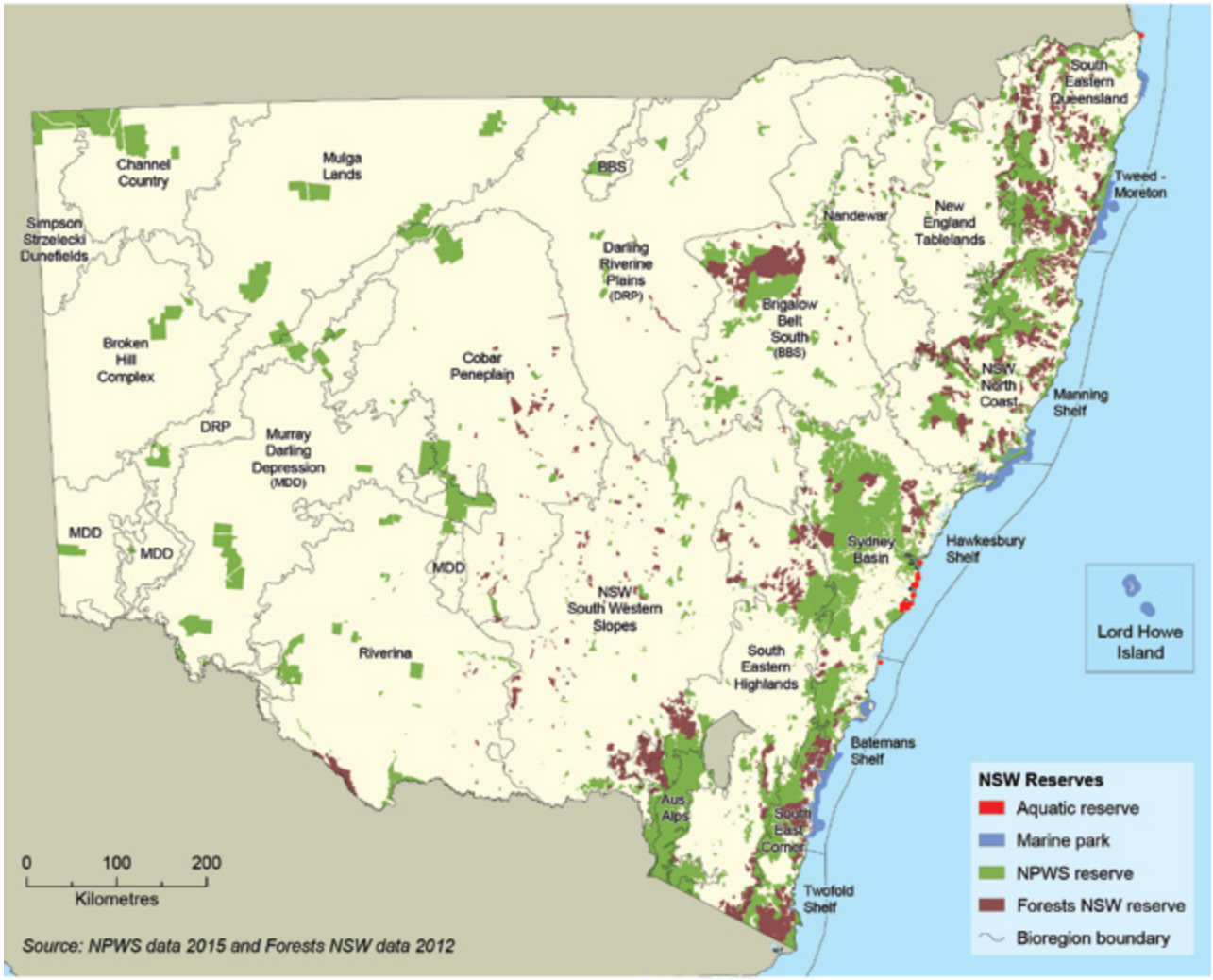
Status and trends

Land-based formal reserve system

This section focuses on protected areas that meet certain formal reserve levels under the International Union for Conservation of Nature (IUCN) Protected Areas Categories System. These are depicted in Map 14.1. Other types of less formally managed areas that have value for nature conservation are considered in later sections.

At 1 January 2015, the area of the NSW public reserve system reserved under the NPW Act, across 886 parks, was a total of 7,107,533 hectares, or approximately 8.9% of NSW.

Map 14.1: NSW national parks and forest reserves, marine parks and aquatic reserves



An additional 481,417 hectares are reserved for conservation as Crown reserve and flora reserve that covers approximately 0.6% of NSW.

State conservation areas (SCAs) form part of the areas reserved under the NPW Act and provide for dual uses, allowing resource exploration and mining as well as protecting natural and cultural values. A review of SCAs conducted in May 2013 concluded that the dual purpose SCA category was no longer needed for seven SCAs and parts of two SCAs. As a result, 29,424 hectares were reclassified and incorporated into Lachlan Valley National Park.

Further, the former Dharawal SCA was gazetted on 26 March 2013 as Dharawal National Park.

Since 2012, large areas of new parks and reserves have been created. There were 62 additions to parks and reserves ranging up to 29,424 hectares. Table 14.1 (overleaf) summarises the changes in types of terrestrial protected areas in NSW.

The largest areas of parks and reserves created or increased include:

- South Coast (Dharawal National Park)
- Sydney region (Berowra Valley National Park)
- Darling Riverine Plains (Warrambool)
- North Coast (Everlasting Swamp National Park)
- Yathong Nature Reserve (4151 hectares of additional areas added on 1 January 2015).

Table 14.1: Extent and types of terrestrial protected areas in NSW and changes since 2012

Type of protected area	Total number	Area (ha)	Change since January 2012
NSW national parks and reserves			
National parks	203	5,233,999	Four new national parks – an increase of 0.9% due to the re-categorisation of state conservation areas and regional parks
Nature reserves	423	951,904	Six new nature reserves – an increase of 1%
Aboriginal areas	19	14,198	No new areas, but a small increase to one existing area
Historic sites	16	3,023	No new sites or increase
State conservation areas	119	528,280	Decrease of 4.7% (five state conservation areas were re-categorised as national parks)
Regional parks	20	19,946	Decrease of 11% (due to re-categorisation of part of regional park to national park)
Karst conservation reserves	4	5,228	No new reserves, but a small increase to one existing area
Community conservation areas: Zone 1	34	132,760	No new areas, but a small increase to one existing area
Community conservation areas: Zone 2	5	21,661	No new areas or increase
Community conservation areas: Zone 3	23	196,533	No new areas, but a small increase to one existing area
Total	**866**	**7,107,533**	
Wilderness declarations			
Wilderness areas	51	2,099,278	An increase of 0.4%
Wild rivers	7 rivers and associated tributaries		No new rivers and associated tributaries
Reserved areas in state forests			
State forest dedicated reserve: special protection	Not reported	29,123	No change
State forest informal reserve: special management	Not reported	175,431	No change
State forest informal reserve: harvest exclusion	Not reported	240,349	No change
Total state forests reserves		**444,903**	

Source: NPWS data 2015 and Forests NSW data 2015 (up to and including 1 January 2015)

Progress on long-term reservation objectives in NSW bioregions

Many regional ecosystems remain poorly reserved. In general, the best-protected ecosystems are those on the steep ranges of eastern NSW, much of the coast, and the Australian Alps. Poorly protected ecosystems include most in far western NSW; the northern, central and southern highlands and western slopes; and those on the richer soils of the coastal lowlands.

There is an ongoing targeted program for new additions in underrepresented areas. SoE 2012 (EPA 2012) reported that less than 2% of the Broken Hill complex was formally reserved. This is no longer the case as all bioregions now have 2% or more area in the reserve system.

Of the 18 bioregions in NSW, four still have fewer than 50% of their regional ecosystems included in the reserve system. At a finer scale, 30 of the 131 subregions in NSW still have fewer than half of their regional ecosystems represented in the reserve system.

Table 14.2 describes progress in meeting the objective of a comprehensive, adequate and representative reserve system across the state.

Table 14.2: Progress towards meeting long-term reservation objectives in NSW bioregions

NSW section of the bioregion	Area (hectares)	Area in formal reserves managed by NPWS (hectares)	Reserves (% of bioregion)	Remaining native vegetation cover (% of bioregion)	Progress towards compre-hensiveness (%)*	Progress towards repre-sentativeness (%)*
Mulga Lands	6,591,283	287,702	4.4	99	59	56
Channel Country	2,340,662	218,779	9.4	100	41	44
Simpson–Strzelecki Dunefields	1,095,796	119,146	10.9	100	43	35
Broken Hill Complex	3,763,317	75,616	2.0	100	38	27
Australian Alps	464,297	377,381	81.3	97	100	100
Murray–Darling Depression (MDD)	7,935,880	462,295	5.8	89	70	38**
South East Corner	1,153,600	496,561	43.0	85	97	97
Riverina	7,022,691	237,014	3.4	50	78	48
Cobar Peneplain	7,377,221	194,083	2.6	67	50	52
NSW North Coast	3,962,537	980,148	24.7	69	92	88
Sydney Basin	3,573,565	1,439,968	40.3	68	98	91
Darling Riverine Plains	9,419,258	249,877	2.7	51	48	45
South Eastern Queensland	1,647,040	227,633	13.8	53	95	86
South Eastern Highlands	4,989,020	729,281	14.6	38	85	73
New England Tableland	2,860,297	274,325	9.6	43	86	72
Brigalow Belt South	5,624,738	487109	8.7	37	65	48
Nandewar	2,074,881	85,949	4.1	39	70	72
NSW South Western Slopes	8,103,373	183,590	2.3	13	54	49

Notes: * The national reserve system (NRS) target for comprehensiveness is for at least 80% of extant regional ecosystems in each bioregion defined in the Interim Bioregionalisation of Australia (IBRA) to be protected in public reserves by 2015. Ecosystems in a bioregion are excluded from the calculation where they lie along the margins of the region and their occurrence is relatively insignificant.
The NRS target for representativeness is for at least 80% of extant regional ecosystems in each IBRA subregion to be protected in public reserves by 2025. Ecosystems in a subregion are excluded from the calculation where they lie along the margins of the region and their occurrence is relatively insignificant.

** Some of the more substantial changes have occurred due to the revised boundaries of IBRA v7. This change in MDD is largely due to the recognition of a third MDD subregion within NSW, extending across the border from SA.

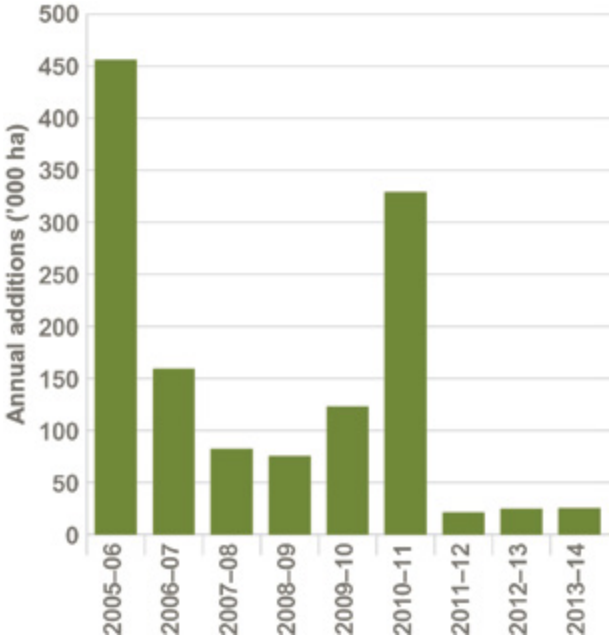
The NSW National Parks Establishment Plan 2008 (DECC 2008) is currently in the process of being reviewed. Further details are available at OEH priorities in acquiring land.

Private land conservation

Private land conservation provides a crucial supplementary role to the public reserve system 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 is an essential element in conserving the biodiversity of NSW. Around 3.9% of land in NSW currently has some form of private land conservation management (see Table 14.3).

Since SoE 2012, relatively fewer additions have been made to the public reserve system (Figure 14.1) and private conservation initiatives have become increasingly important in a relative sense compared to formal reservation.

Figure 14.1: New formal conservation areas added each financial year beginning from 2005–06



Source: NPWS 2015

Conservation on other tenures

Forests NSW conservation zones

Forestry Corporation uses a land classification system in state forests that sets out management intent and identifies areas set aside for conservation.

Through this zoning system, about 486,000 hectares of state forest (22%) are excluded from harvesting for conservation reasons. A further 544,964 hectares are excluded from harvesting for silvicultural reasons. These areas, 47% of the total area of state forests, make a significant contribution to the protected area network in NSW.

Travelling stock routes

Travelling stock routes (TSRs) are authorised thoroughfares 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.

Table 14.3: Private land conservation mechanisms and area protected in NSW

Conservation mechanisms	Number	Area protected (hectares)
Conservation agreements	396	146,000
Wildlife refuges	678	1,936,358
Nature Conservation Trust agreements	91	24,886
Incentive property vegetation plans	1885	860,258
Registered property agreements	336	52,606
BioBanking agreements	32	4,845
Land for wildlife	1125	87,242
Indigenous protected areas	9	16,000
Total		**3,128,195**

Source: OEH 2014

TSRs are located on Crown land, and are often found in environments that are poorly represented in the public reserve system, heavily disturbed and in poor condition. The natural values of approximately 700,000 hectares of TSRs in the eastern and central divisions of NSW are currently being assessed.

Marine protected areas

The *Marine Estate Management Act 2014* commenced on 19 December 2014 and now provides for the declaration and management of marine parks and aquatic reserves. The *Marine Parks Act 1997* and aquatic reserves division of the *Fisheries Management Act 1994* have been repealed.

Management rules for marine parks are contained in the Marine Estate Management (Management Rules) Regulation 1999. The Aquatic Reserve Notification 2015 (NSW Government 2015) sets out the activities prohibited within each aquatic reserve.

A new project announced in December 2014, the Hawkesbury Shelf marine bioregion project, will assess marine biodiversity within the Newcastle–Sydney–Shellharbour region. The assessment will include a review of the current management arrangements for the 10 aquatic reserves in this region.

Types of marine protected areas

As reported in SoE 2012, there are three types of marine-protected areas in NSW: marine parks, aquatic reserves and the marine components of national parks and nature reserves.

Extent of marine protected areas

Day-to-day management of marine parks in NSW is the responsibility of the Department of Primary Industries. A slight decrease in sanctuary zones is expected in mid to late 2015 from the NSW Government's decision to rezone 10 sites from 'sanctuary zone' to 'habitat protection zone' to make shore-based recreational line fishing lawful.

Pressures

Threats to values in terrestrial reserves

The values of the NSW reserve system are impacted by both current and emerging threats. Every three years, OEH reports on the state of the parks of NSW. In 2013, the major reported threats to terrestrial reserves were weeds, pest animals, fire, and habitat and species isolation (Table 14.4). Climate change and illegal activities are identified by a large number of park managers as ongoing or emerging threats and these are also profiled in this section.

The State of the Parks program is based around a triennial online survey that asks park managers to provide current information about each of their parks. The program collects a wide variety of information about all parks in the NSW reserve system.

Table 14.4: Major threats to park values reported in 2013

Type of threat	Number of parks identifying this threat	Total area of all parks affected
Weeds	654	28%
Pest animals	567	40%
Fire	360	29%
Habitat / species isolation	196	4%

Source: NPWS State of the Parks data 2013

Weeds

More than 1750 introduced plant species have established self-sustaining populations across NSW, with over 340 recognised as significant environmental weeds. Across the reserve system, some of the most invasive weeds are bitou bush, lantana, blackberry, scotch broom, privet, introduced perennial grasses, and exotic vines, all of which occur to varying degrees of severity. Just under three-quarters of reserves across NSW have identified weeds as a current threat, with 28% of the total area of these reserves affected by this threat. The severity of this impact is considered to be moderate to high across these reserves. This means that the threat will lead to a moderate to major reduction in extent and/or condition of reserve values within three to five years, if it continues to operate at current levels. Reserve values that

are most frequently reported as being affected include threatened flora and fauna, endangered ecological communities and Aboriginal sites including rock engravings and grinding grooves.

Pest animals

A number of pest animals, including foxes, wild dogs, pigs, rabbits, goats and feral cats are also widespread across the reserve system and the landscape generally. Feral horses, deer, rats and cane toads present localised issues in some reserves and emerging pest threats include pest birds, such as common mynas, exotic turtles and invertebrate pests like the pandanus planthopper. Pest animals have been identified as a current threat in over half of the reserves, with the total area potentially affected high. This reflects that many pest animals can travel over large distances and accordingly affect a greater proportion of the reserve system. Pest animals pose a significant threat to native wildlife, including threatened species, through competition and predation.

Fire

This is an ongoing threat to the reserve system, though active planning and threat mitigation reduces the severity of impacts and protects life and property.

During 2012–13, there were 351 wildfire incidents, compared to a five-year average of 200 per annum. The total area burnt was approximately 132,500 hectares, compared to the five-year average of 58,403 per annum.

During the last 10 years, 33% of fires in the reserve system 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, with this accounting for 9% of the area burnt by wildfires.

Habitat and species isolation

Reserves where habitat and species isolation has been identified as a current threat typically lack connectivity between the reserve system and key habitats and corridors. High levels of urban interface or agricultural lands bounding the perimeter of the reserve represent ongoing challenges in managing this threat.

Illegal activities

Illegal activities are of increasing concern across the reserve system. Activities leading to impacts on values include antisocial behaviour, arson, collection of plants or other materials, collection or release of animals, harming of animals, plants or habitats or approaching marine animals at close distance, illegal commercial operations, vandalism and related offences, vehicle-related offences and other wildlife crimes.

Overall, vehicle-related offences and vandalism affect the largest area of parks. These activities have a negative effect on visitors' experiences. They also affect biodiversity, particularly threatened fauna, flora and endangered ecological communities.

Climate change

This will have an impact on the reserve system due to the increased severity and occurrence of bushfires, increased impacts on coastal reserves from storms and sea level rise, along with increased weed invasion and loss of specialised habitats, for example, in sub-alpine areas. Some of the reserve values affected or potentially lost include threatened seabird habitat, freshwater lagoons, saltmarsh areas, frontal dune systems, and rainforest species, resulting in changes to species distribution and abundance.

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, and the impacts of stock encroachment, and neighbouring land uses.

Where the primary land use is a form of agricultural production, some activities may not be completely compatible with specific conservation objectives. Land managers may need to address potential threats from land uses that are not compatible with conservation values. Unpredictable events, such as bushfires or sustained drought, may exacerbate these impacts.

Monitoring and support services can assist private landholders to manage their land for long-term conservation and sustainable production. NSW Government support includes providing extension and information services, incentive programs and facilitating state or federal tax concessions.

Threats to marine protected areas

The key threats to marine protected areas include overuse of resources, invasive species, marine pollution, land-based impacts and climate change (MBDWG 2008).

Community opinion on threats to marine protection

In 2014, the NSW Government surveyed the community to determine their views on the values, benefits, threats and potential opportunities that they derive from the marine estate.

Results revealed that the community identified pollution in its different forms as the greatest threat to environmental values and benefits, such as littering, sediment and runoff, and oil and chemical spills.

The community perceived the top economic threats to the marine estate as water pollution affecting tourism, loss of natural areas and habitats affecting tourism, and increasing costs to access the marine estate.

The top social threats to negatively impact the marine estate are antisocial behaviour, loss of appeal due to water pollution, littering and overcrowding.

Responses

Additions to the land-based formal reserve system

Since January 2012, 66 additions were made to the reserve system across 13 NSW bioregions, including Brigalow Belt South, Cobar Peneplain, Darling Riverine Plains, Murray–Darling Depression, Nandewar, New England Tablelands, NSW North Coast, NSW South Western Slopes, Riverina, South East Corner, South Eastern Highlands, South Eastern Queensland and Sydney Basin.

These additions provide improvements to the connectivity of existing reserves, as well as improvements to biodiversity protection.

There were 29 additions to parks in the Great Eastern Ranges, which provide significant habitat corridors across NSW. There were significant wetland additions on the Clarence River Floodplain (Everlasting Swamp, a large coastal floodplain wetland of national and international significance) and in the Gwydir wetlands.

Private land conservation

In 2014 the Minister for the Environment established an independent review panel to review the *Native Vegetation Act 2003*, *Threatened Species Conservation Act 1995*, *Nature Conservation Trust Act 2001* and parts of the *National Parks and Wildlife Act 1974*. The aims of the review were to recommend simpler, more streamlined and effective legislation. The panel provided 43 recommendations in its report (Byron et al. 2014) including a number of recommendations concerning private land conservation.

The panel recommended the consolidation of private land conservation into a three tiered system including a biodiversity offsetting mechanism, voluntary conservation agreements, and wildlife refuges. It also recommended the government consider additional investment in positive conservation action.

Plans of management for the formal land-based reserve system

At 1 January 2015, a total of 368 plans of management (PoMs) have been adopted, covering 547 parks and reserves. In total, more than 5.9 million hectares are now covered by a plan of management, representing around 80% of the reserve system. Those parks which do not yet have a PoM have a statement of management intent (SMI). An SMI is an interim document outlining the management principles and priorities for an individual park with reference to its key values and major threats.

Management directions are included in each SMI with reference to the diversity of existing thematic plans that may already be in place for that park, for example, a fire management strategy. Publication of a draft plan of management will replace these statements of management intent.

Managing threats in the land-based reserve system

Weed and pest management

The NSW Government works across agencies to ensure successful weed and pest management on public tenures.

Priorities include managing key threatening processes, including those caused by weeds. NPWS is making significant progress in the control of major environmental weeds. For example, through its Bitou Bush Threat Abatement Plan (DEC 2006), the NSW Government has reduced the spread of bitou bush and greatly reduced its density in national parks. Survey results at over 30 sites show that where control and adequate monitoring has occurred there has been recovery of native biodiversity.

In NSW, pest management priorities for the conservation of biodiversity are focused on threatened species, and are identified in the Threatened Species Priorities Action Statement (PAS) and in individual threat abatement plans (TAPs). These documents set priorities for pest management on parks with a focus on protecting threatened species. (See also Theme 15: Invasive species.)

The PAS and TAPs inform the regional pest management strategies which detail priorities across the state. These were developed with extensive stakeholder consultation, to help coordinate on-park pest management programs with pest management on surrounding lands.

The NSW Government works closely with stakeholders including the local land services and private land managers to tackle wild dog problems across the state under a national wild dog action plan.

Fire management

Managing fire is a core function of NPWS, with the overriding objective being to safeguard human life and property. NPWS undertakes the majority of all hazard reduction across the state. Consultation is undertaken with local communities, bushfire management committees, rural fire brigades and other interested parties in the preparation of fire management plans and strategies. One hundred per cent of the NSW reserve system is covered by a reserve fire management strategy (RFMS) except newly gazetted areas. Draft RFMS are developed for new reserves within three months of being gazetted.

Under the Enhanced Bushfire Management Program, the NSW Government has committed to nearly double hazard reduction and improvement of bushfire response capabilities on parks and reserves by 2016. An additional $62.5 million over five years from 2011 has been allocated to NPWS for hazard reduction and an additional 94 trained fire fighters have been employed full time. In the three years to June 2014, NPWS worked with the Rural Fire Service to carry out hazard reduction burn operations covering over 360,000 hectares. The average annual area treated, approximately 120,000 hectares, was nearly double the average for the previous three-year period.

In 2013, NPWS released Living with Fire in NSW National Parks – a strategy for managing bushfires in national parks and reserves 2012–21 (OEH 2012).

Climate change

NPWS contributes to research to better understand the impacts of projected climate changes on sensitive ecosystems. The Climate Change Impacts & Adaptation Knowledge Strategy 2013–17 (OEH 2013) is addressing information about the impacts and adaptation of climate change. It is one of six themes under the OEH Knowledge Strategy 2013–17.

Marine parks

The NSW Government announced its response to the Report of the Independent Scientific Audit of Marine Parks in NSW (Beeton et al. 2012) in March 2013.

The new approach to the management of the marine estate including marine parks and aquatic reserves is underpinned by the *Marine Estate Management Act 2014* that commenced in December 2014 and repealed the former *Marine Parks Act 1997*.

The new Act provides for the integrated declaration and management of a comprehensive system of marine parks and aquatic reserves in the context of the whole marine estate. It also establishes the Marine Estate Management Authority and an independent marine estate expert knowledge panel.

The Authority has been tasked with implementing a schedule of works during 2015–16 with several tasks of relevance to marine protected areas, including:

- the NSW Marine Estate Management Strategy
- progressing regulations to complement the Marine Estate Management Act, including provisions related to the management of marine parks and aquatic reserves
- a review of marine park zone types, objectives and guidelines for use
- piloting the new approach to marine park management and zoning at Batemans and Solitary Islands marine parks
- overseeing an assessment of the Hawkesbury Shelf marine bioregion to provide advice on options to enhance the conservation of marine biodiversity
- developing a threat and risk assessment framework to identify and assess the key threats and associated risks to the values of the NSW marine estate to inform management of marine parks and aquatic reserves.

Future opportunities

The NSW Government has identified five reserve system planning regions across NSW that group together bioregions at similar stages of reserve building (OEH 2014). The regions will help focus attention on the work required across the state to direct conservation efforts and to develop comprehensive, adequate and representative systems of reserves.

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15 INVASIVE SPECIES

Invasive species, including pest plants and animals, fungi and a range of pathogenic microorganisms, are widespread across NSW. Once established, invasive species are difficult to manage effectively and remain a significant threat to biodiversity. Many invasive species are listed as key threatening processes in NSW legislation, with pest animals and weeds identified as a threat to over 70% of all threatened species.

Most pest animals have been established in NSW for many years. Predation by introduced carnivores, particularly foxes and cats, has led to the significant decline or extinction of a range of native fauna species. Grazing and browsing by introduced herbivores or omnivores, such as rabbits, goats and pigs, leads to habitat degradation and a decline in native flora species. Pest fish have significant impacts on key species and aquatic ecosystem processes, with carp constituting 83% of total fish biomass across much of the Murray–Darling Basin. Most parts of NSW are affected by weeds that have an impact on native species, ecosystems and agriculture.

Pathogens and diseases are an emerging threat to both biodiversity and agriculture and they are becoming increasingly prevalent in Australia.

Invasive species place a substantial burden on the Australian economy. In NSW, weeds account for $1.8 billion per annum in lost production and control costs while the cost to the Australian economy of dealing with the impacts of pest animals is over $1 billion annually.

The proposed *NSW Invasive Species Plan 2015–2022* sets out goals and provides strategic direction and guidelines to exclude, eradicate or manage invasive species as appropriate to their situation.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Number of new invasive species detected	M	Stable	✓
Spread of emerging invasive species	M	Increasing impact	✓
Impact of widespread invasive species	P	Stable	✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Invasive species are animals, plants or other organisms introduced into places out of their natural range, where they become established and disperse, generating a negative impact on the local ecosystem and species (IUCN 2014). The current report considers predominantly the effects of invasive species on native fauna and flora. The report does not review in detail additional impacts on industry (such as agriculture, forestry, and fisheries) and human health and wellbeing (such as diseases or parasites).

In NSW, many established invasive species were introduced for specific purposes before their invasive potential was realised. Common examples include species introduced for:

- agricultural production (domesticated animals and crops)
- aesthetic purposes (pets and garden plants)
- sport (foxes for hunting)
- land management initiatives (bitou bush used for sand dune stabilisation).

The introduction of new invasive species in NSW is usually inadvertent, with unintended transport throughout NSW and Australia, or into Australia via natural or human-mediated means such as in vehicles, equipment, packing material, soil or garden refuse, or through ocean shipping. It is also important to effectively manage the import and the keeping of exotic plants and animals in NSW to prevent the establishment of new pest species in the open environment.

Invasive species affect the environment through a range of mechanisms: from predation and consumption, to competition, habitat modification and degradation, and even disease transmission. Invasive species have been implicated in the decline of many native species, and are thought to affect over 70% of entities listed under the *NSW Threatened Species Conservation Act 1995* (TSC Act)
(Coutts-Smith et al. 2007).

Invasive aquatic species have been recognised as having an impact upon native fish species including threatened species. Several key threatening processes have been listed under the *Fisheries Management Act 1994* (FM Act). These include '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'.

Status and trends

Extent of invasive species

Since 1788, around 3000 introduced plant species have established self-sustaining populations in Australia. More than 1750 of these have been recorded in NSW, with over 340 weeds recognised as posing significant threats to biodiversity (Downey et al. 2010).

More than 650 species of land-based animals have also been introduced to Australia. Of these, 73 have established wild populations (NLWRA 2008), but not all are regarded as a threat to native fauna and flora. Introduced fish species make up around a quarter of all freshwater fish species in the Murray Darling Basin (Lintermans 2009).

Australian waters host over 200 species of introduced marine organisms (DPI 2008); however not all of these are considered invasive. It is not known how many insects and other invertebrates have been introduced into Australia (Coutts-Smith et al. 2007).

Impacts of invasive plant and animal species

The native plants and animals in Australia's ecosystems have co-evolved over millions of years. When invasive species are introduced to these systems, they can have significant negative impacts because native species have not evolved mechanisms to deal with the specific threats they represent. Although these invasive species have similarly not evolved with native conditions, other disturbance events of the native systems often allow for their initial establishment and subsequent significant environmental impact.

Hence, predation by introduced carnivores, such as foxes and cats, has led to significant decline and extinction of a range of native fauna species. Grazing and browsing by introduced herbivores, such as rabbits and goats, have also led to habitat degradation and a decline in native flora species. Competition and habitat structural change by weeds has similarly affected native plants and animals.

Since 1788, the influence of invasive species on the NSW environment has been significant, with pest animals and weeds thought to impact over 70% of entities listed under the TSC Act (Coutts-Smith et al. 2007). Addressing the impacts of pest animals and weeds is a significant component of the NSW Government's new *Saving our Species* program, which sets priorities for ensuring threatened species are secured and remain viable into the future.

Invasive species also place a substantial burden on the Australian economy. In NSW, weeds account for $1.8 billion per annum in lost production and control costs (NRC 2014). The cost to the Australian economy of dealing with the impacts of pest animals is over $1 billion annually (DPI 2008). These costs comprise cost of labour, chemical and machinery on agricultural lands, the lost production on agricultural lands, lost value due to price responses in agricultural markets, and expenditure by public agencies. They do not include environmental and social impacts.

Categories of invasive species

Invasive species are generally categorised as widespread or emerging or new species, depending on their current extent and ability to persist and spread, as described below:

- **new species:** any species that has not been recorded previously in NSW or has not established self-sustaining populations, but has the potential to invade and spread across broad areas
- **emerging species:** a subset of invasive species that has established a self-sustaining population and is actively expanding its range or has the potential to spread further
- **widespread species:** a smaller subset of invasive species that has been present for some time and has now established a broad range across a region or the whole state.

New and emerging pest animals

In late 2014, two new invasive species with the potential to have significant impacts on the environment of NSW were identified and management programs were put in place. These were the red imported fire ants, for which an eradication program was established and the fish species known as tilapia, for which an extensive advisory and education program was established.

Red imported fire ants: On 28 November 2014, a suspected incursion of fire ants was detected in Port Botany. This incursion was confirmed as red imported fire ants (RIFA), with DNA testing showing the infestation may have come directly from Argentina. RIFA have previously been detected in areas around Brisbane in Queensland, where control efforts are ongoing. Although listed as a key threatening process, this was the first record of the ants in NSW.

RIFA are aggressive with a painful bite and are highly invasive. Fire ants can significantly affect public health and lifestyle, the environment and agriculture. The one nest at Port Botany was located and destroyed. Assessment of the nest suggested it had been there for at least six months. A two-kilometre radius around the infected site was inspected for any other evidence of RIFA. Beyond this, key habitat areas were inspected, including the third runway at Sydney Airport and Kamay Botany Bay National Park (at La Perouse and Kurnell). No other nests were found. A second round of surveillance was completed in August 2015 as part of a national eradication plan. Luring and baiting programs will continue as prescribed by the plan. A complementary passive surveillance program is also in place to ensure the Botany Bay community and surrounding communities have the capacity to quickly identify and report red imported fire ant if it is found.

Tilapia: Tilapia is an internationally recognised pest fish that originates from the warm waters of 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 wild pest populations that dominate native fish in parts of Queensland, including catchments that lie directly adjacent to the Murray–Darling Basin (MDB). So far, the species has not been detected in the MDB; however, a coastal population was detected in northern NSW in November 2014. Research has suggested tilapia could become widespread if introduced into the MDB.

NSW and Queensland governments and the Murray–Darling Basin Authority have recognised the critical importance of stakeholder education to exclude tilapia from reaching the MDB. The agencies have identified areas of high incursion risk and have developed a community

education package for landholders living in the high risk areas. This cooperative work is helping to improve knowledge of pest fish issues and reducing the risk of tilapia being intentionally translocated into the MDB. The project has demonstrated the value of governments working with communities to help rapidly detect and respond to new tilapia incursions.

Emerging pest animal species that are already having severe impacts on biodiversity include deer and cane toads, both of which are listed as key threatening processes under the TSC Act.

The increase in distribution of deer species was described in SoE 2012 (EPA 2012) and demonstrated their expansion.

Cane toads in Taren Point: Cane toads were reported as an emerging species of concern in 2012 with viable populations established on the far north coast and at Taren Point in southern Sydney.

A cane toad containment line has been successfully established, with only one breeding population of cane toads known south of the Clarence River. This isolated southernmost population was discovered in Taren Point in Sydney in 2010. A successful cane toad management program has been led by Sutherland Council. As part of this program, 1680 cane toads were caught and euthanised between 2010 and 2013. Extensive monitoring surveys conducted in 2014 resulted in the capture of only 11 cane toads. This program should result in a cane toad-free Taren Point in the near future.

New and emerging weeds

A total of 243 plant taxa have naturalised or were in the process of naturalising in NSW from 2000–12 – a rate of 18–19 per year (Hosking et al. 2003; Hosking et al. 2007; Hosking et al. 2011; Johnson et al. in prep.). It is likely that new naturalisations will continue in NSW. Ongoing research is helping to identify the main causes and risk factors, but the rate of naturalisations has been less comprehensively studied since the last reporting period. It is essential that new naturalisations are reported (refer to the mouse-ear hawkweed example below) to enable evaluation of weed risk and the deployment of rapid responses (including eradication where possible) for the high risk species. Below are two examples of how this work is being undertaken to control mouse-ear hawkweed and orange hawkweed in our sensitive and unique alpine environments.

New weed – mouse-ear hawkweed: On 12 January 2015, a bushwalker and camper reported a possible location of mouse-ear hawkweed (MEHW) in a remote part of Kosciuszko National Park (the park). National Parks and Wildlife Service (NPWS) staff inspected the location and confirmed the find. This was the first record for NSW; there is another infestation under active management in the Victorian Alps. In New Zealand, this is a major widespread weed impacting conservation and grazing areas.

The MEHW infestation in the park was estimated to cover 150 square metres. It is estimated that the infestation has probably been on site for around seven to 10 years and was probably transported on hiker boots, clothing or camping equipment from New Zealand.

The infestation was treated in January 2015 and the site quarantined. Joint surveys across the Main Range of the park were carried out under the direction of NPWS.

To date, 25 locations have been searched over 112 hectares of park around the only known infestation. No additional sites of MEHW have been reported. Further surveys are planned as well as follow-up treatment. Tools developed as part of the orange hawkweed program (see below) have been key to the rapid response to this species.

Emerging weed – orange hawkweed: Originating from Europe, orange hawkweed (OHW) has become a major weed in the United States, Canada, Japan and New Zealand. This weed is at the early stages of invasion in Australia (present in Tasmania, Victoria and NSW), but has the potential to occupy large areas of south-east Australia. Economic modelling figures on the potential production losses in grazing areas in 2002 were conservatively estimated at $48 million (DPI 2012) or about $66 million today (CPI-adjusted to 2015). Based on the New Zealand experience, if OHW is left unchecked, the growth across south-east Australia could have disastrous economic and ecological ramifications, which would be impossible to reverse.

The only records of OHW in NSW are in Kosciuszko National Park. This weed was located after 2003 fires and is found in a

separate location to mouse-ear hawkweed and thought to be introduced during the construction of the Snowy Mountains Hydro-electric Scheme in the second half of last century. The cumulative area OHW had occupied was estimated at 8.2 hectares. A measure of the program's current success is the reduction of infestations to less than 4% of this original size.

Detection of every last plant is needed to ensure eradication, but the search area is remote, rugged and large, covering 8591 hectares. This area requires constant surveillance in order to find and treat plants before they set seed. Tools developed or being developed to assist eradication include development of effective control techniques, a volunteer program to hunt for OHW, the use of helicopters for remote aerial insertions, and novel techniques, such as the use of unmanned aerial vehicles to search new potential areas, and detector dogs being trained to find outlier populations. It is estimated that seeds can remain viable for five years; therefore, with these new tools, eradication could be achieved in five to 10 years.

Emerging weed – sea spurge: Sea spurge (*Euphorbia paralias*) is an invasive beach weed that originated from Europe. Sea spurge was probably introduced to Australia in ships' ballast water about 70 years ago. The plant first appeared in Western Australia and is now found throughout south-eastern Australia, including Tasmania and the islands of Bass Strait. In the past 20 years, it has colonised beaches along the NSW South Coast and is progressively working its way north.

Widespread pest animals and weeds

Widespread pest animal species have had significant impacts on native species throughout NSW.

Rather than attempting to eradicate widespread invasive species over the entire extent of their distribution, priorities for control of these species are determined and resources focused in areas where the benefits of control will be greatest. This asset-based approach ensures invasive species management is focused on protecting priority assets at affordable cost. The highest priority environmental assets for protection from invasive species are threatened species and other entities listed under the TSC Act.

Table 15.1 lists the top five widespread terrestrial pest animals that threaten native fauna and flora (Coutts-Smith et al. 2007) and shows that they are listed as key threatening processes (KTPs) under the TSC Act and whether there is a pest control order under the *Local Land Services Act 2013*.

Table 15.1: Top five terrestrial pest animals posing a threat to native fauna and flora in NSW

Common name	Scientific name	KTP listing	Pest control order
Feral cat	*Felis catus*	Yes	No
Red fox	*Vulpes vulpes*	Yes	Yes*
Feral goat	*Capra hircus*	Yes	No
Rabbit	*Oryctolagus cuniculus*	Yes	Yes
Feral pig	*Sus scrofa*	Yes	Yes

Source: Coutts-Smith et al. 2007

Notes: *Unlike the other pest control orders, this does not include a general destruction obligation as defined under the Act.

All parts of NSW are affected by weeds that threaten native fauna and flora. Weeds now make up 21% of the total flora of NSW. The numbers of weed species are highest near the coast, particularly around major towns and cities, and in regions with high rainfall. They tend to decline from east to west (Coutts-Smith & Downey 2006). Those with the greatest impact on NSW native fauna and flora and the biodiversity values most at risk have been determined and documented in the Biodiversity Priorities for Widespread Weeds (DPI & OEH 2011). Biological control agents have been successfully reared and released leading to a broadscale reduction in the threat to biodiversity from some of the most significant widespread weeds including bridal creeper, Madeira vine, bitou bush and mistflower.

Table 15.2 (overleaf) lists the top 20 widespread weeds based on their potential impact on biodiversity in NSW as a whole (Downey et al. 2010), and shows whether they are listed as a Weed of National Significance (WoNS), a key threatening process under the NSW TSC Act, or listed under the NSW *Noxious Weeds Act 1993*. Thirty-two WoNS have been identified by Australian governments based on their invasiveness, potential for spread, and environmental, social and economic impacts.

Table 15.2: Top 20 widespread weeds posing a threat to native fauna and flora in NSW

Common name	Scientific name	Weed of national significance (WoNS)	Key threatening process (KTP) listing	NSW noxious weed*
Madeira vine	*Anredera cordifolia*	Yes	Yes	Yes
Lantana	*Lantana camara*	Yes	Yes	Yes
Bitou bush	*Chrysanthemoides monilifera* subsp. *rotundata*	Yes	Yes	Yes
Ground asparagus	*Asparagus aethiopicus*	Yes	Yes	Yes
Blackberry	*Rubus fruticosus* species aggregate	Yes	Yes**	Yes
Scotch broom	*Cytisus scoparius* subsp. *scoparius*	Yes	Yes	Yes
Japanese honeysuckle	*Lonicera japonica*	No	Yes**	Yes
Broad-leaf privet	*Ligustrum lucidum*	No	Yes**	Yes
Narrow leaf privet	*Ligustrum sinense*	No	Yes**	Yes
Cat's claw creeper	*Dolichandra unguis-cati*	Yes	Yes	Yes
Salvinia	*Salvinia molesta*	Yes	Yes**	Yes
Serrated tussock	*Nassella trichotoma*	Yes	Yes	Yes
Cape ivy	*Delairea odorata*	No	Yes	No***
Blue morning glory	*Ipomoea indica*	No	Yes	Yes
Balloon vine	*Cardiospermum grandiflorum*	No	Yes	Yes
Lippia	*Phyla canescens*	No	Yes**	Yes
Bridal creeper*	*Asparagus asparagoides*	Yes	Yes	Yes
Mickey Mouse plant	*Ochna serrulata*	No	Yes**	Yes
Turkey rhubarb	*Acetosa saittata*	No	Yes**	Yes
Sweet vernal grass	*Anthoxanthum odoratum*	No	Yes	No

Source: Updated list from Downey et al. 2010

Notes: * Noxious weed declaration may be at different control classes or only in certain parts of NSW. The Weeds Australia website contains a summary of the state and territory noxious weed legislation and associated lists.

** Relates to 'Garden escapes' KTP

*** Cape ivy is declared on Lord Howe Island only

Invasive aquatic species

Invasive aquatic species pose environmental, social and economic threats by damaging the natural balance of aquatic flora and fauna. Invasive species can threaten indigenous aquatic and terrestrial life directly as predators or competitors for food or indirectly by altering their natural habitat. It is believed invasive species can contribute to the decline of some threatened native species. Therefore the introduction of non-indigenous fish and marine vegetation to NSW waters is listed as a key threatening process under the FM Act. Table 15.3 lists common invasive aquatic species in NSW.

Table 15.3: Common invasive aquatic species in NSW

Common name	Scientific name	KTP listing
Carp	*Cyprinus carpio*	Yes
Redfin	*Perca fluviatilis*	Yes
Eastern gambusia	*Gambusia holbrooki*	Yes
Pacific oyster	*Crassostrea gigas*	Yes
Caulerpa	*Caulerpa taxifolia*	Yes
Tilapia	*Oreochromis mossambicus*	Yes

Source: Department of Primary Industries data 2015

Some invasive aquatic species have been introduced accidentally into NSW waters, while others were deliberately introduced, including eastern gambusia which was introduced in the early 20th century in an attempt to control mosquitoes.

Pathogens

Pathogens can emerge as threats to biodiversity, with some becoming more prevalent, both internationally and in Australia. Pathogens can also effect animal and plant production systems and human health, and biosecurity risk management as implemented by DPI (Biosecurity and Food Safety) contributes to sustainable economic growth, protection of the environment and improving community wellbeing.

Some of the impacts of exotic and translocated native pathogenic microorganisms on native fauna and flora are well understood. The impacts of some emerging pathogens may not be well understood. Four pathogens are listed as key threatening processes (KTPs) under the TSC Act, with all four having potentially serious consequences for the health of the environment.

The four KTPs are:

- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species (endangered parrot)
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
- Infection of amphibians (frogs) with chytrid fungus resulting in chytridiomycosis (disease)
- Introduction and establishment of exotic rust fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae.

A variant (strain) of the rust fungus *Puccinia psidii* sensu lato (commonly referred to as myrtle rust) was first detected in Australia in April 2010 at a site 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* are at risk of becoming threatened by this pathogen (Carnegie et al. 2015).

Pressures

SoE 2012 (EPA 2012) outlined key pressures in relation to invasive species as habitat disturbance, greater mobility and trade, expansion of range, climate change and lack of information on the distribution and abundance of invasive species.

Updates are provided below on pressure due to climate change and the consequences of the lack of information about invasive species.

Climate change and weed spread

The impact of climate change upon weeds is becoming clearer in Australia. As climate regimes continue to change it is likely that potential new weeds will emerge from the established pool of naturalised plants (Duursma et al. 2013). Consideration of climate change scenarios and species distribution models can be useful for predicting future breakouts of invasive plants. This allows land managers to pre-emptively manage and effectively control them.

The extent of suitable habitat of invasive and naturalised non-native species has been assessed and predicted under current and future climate conditions. The alpine ecoregion, including that within NSW, may be particularly vulnerable to future incursions by naturalised plants (Duursma et al. 2013). Although not all naturalised plants would be predicted to increase under future climate scenarios, changing climate regimes would have the potential to create more favourable conditions for naturalised plants in a southerly direction. For example, results suggest that the areal extent of hotspots in two ecoregions, Tasmanian temperate forests and Australian Alps montane grasslands, may increase.

Potential delays in management due to lack of biological data

The Office of Environment and Heritage (OEH) has attempted to undertake assessments using the NSW Weed Risk Management system for new and emerging weeds which impact environmental assets. Of the 218 species assessed, 72 lacked sufficient data to complete an assessment. Therefore, where a species is at

the early stages of invasion, but the information required to complete an assessment is unavailable, the risk that such a species will not be managed in a timely manner is high (Hamilton et al. 2014).

Responses

Determining priorities for managing widespread invasive species

The NSW Government determines priorities for control of invasive species and focuses resources in areas where the benefits of control will be greatest. The highest priority environmental assets for protection from invasive species are threatened species and other entities listed under the TSC Act. This prioritised approach to invasive species management ensures maximum benefit from finite resources.

Farmers contribute to protecting the environment from invasive species by playing an important role in soil, water and air quality, vegetation management and management of invasive species (including coordinated regional approaches that involve public and private landholders).

Containment of new and emerging invasive species

For the management of new and emerging invasive species, the focus is to eradicate or contain the spread of the invasive species before it can cause significant environmental impacts.

Some emerging species are already having severe impacts on native fauna and flora or the environment within their current distribution. For example, the establishment of strategic containment lines for cane toads serves to delineate different approaches to management. Containment lines are mapped lines, often delineated along natural landforms, such as a river or along local government boundaries or other management boundaries.

Containment lines are detailed in WoNS strategic plans. For example, under this approach, asset protection is undertaken within the core distribution, while populations just outside this distribution are locally eradicated (i.e. all individuals are removed). Any isolated populations well away from the core distribution are eradicated.

Establishment of regional weeds committees

The NSW Government is responding to a Natural Resources Commission review of weed management in NSW by establishing regional weeds committees in each of the local land services regions. The role of the committees will be to provide 'tenure neutral' strategic planning and coordination of weed management activities at the regional level – consistent with the goals of the NSW Invasive Species Plan – to minimise the impacts of invasive species in NSW.

Saving our Species program

Invasive species management is an important component of the NSW Government's *Saving our Species* program, which sets priorities for ensuring threatened species are secured and remain viable into the future. With invasive species thought to impact over 70% of entities listed under the TSC Act, actions to ameliorate the fate of threatened specifies will continue to be identified, acted upon and reported against as the program progresses.

NSW Invasive Species Plan

The proposed NSW Invasive Species Plan 2015–2022 (a consultation document released in August 2015) (DPI 2008) focuses on the four goals of:

- 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 NSW has the ability and commitment to manage invasive species.

NSW Biosecurity Strategy 2013–2021 and new Biosecurity Act

The NSW Government launched the NSW Biosecurity Strategy 2013–2021 in May 2013. The NSW Biosecurity Strategy is based on the principle of shared responsibility for effective biosecurity management and increases awareness about biosecurity issues in NSW. The Strategy aims to expand on the former

2007 NSW Department of Primary Industries' Biosecurity Strategy to address not only primary industries, but the broader biosecurity spectrum in terms of biodiversity and the natural environment, infrastructure and service industries as well as lifestyle, recreation, sport and social amenity. It also outlines how the NSW government will partner with other levels of government, industry and the community to identify and manage biosecurity risks.

The strategy identifies four key goals focusing on biosecurity:

- shared responsibility
- contribution to sustainable economic growth
- protects the environment and community
- underpinned by a responsive and consistent legislative framework.

A key component of the Strategy will be the *Biosecurity Act 2015*, which has been passed by the NSW Parliament and is awaiting assent and commencement. The Act will provide for the prevention, elimination, minimisation and management of biosecurity risks; and for other purposes.

Future opportunities

Continual improvements to surveillance and biosecurity measures may be needed to prevent new and potentially invasive species from threatening natural ecosystems and the productivity of farming systems.

Development of biological controls and other new techniques will continue to provide opportunities for effective and affordable management of widespread invasive species and further opportunities should continue to be explored.

Pathogens and diseases 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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16 WATER RESOURCES

After two wetter than average years in 2010–11 and 2011–12, the last two years of records show much of NSW has been experiencing drier climatic conditions and consequently lower surface water availability. Under the drier conditions river flow variability has been reduced and the proportion of water being extracted has risen.

The ongoing impacts of water extraction and flow regulation remain significant pressures on the health of river systems but greater amounts of water are now being made available for the environment.

Demand for the state's water resources is high but is being managed through water sharing plans that balance equity of access for users, while maintaining ecosystem health.

Water sharing plans are being developed for all water sources in NSW. Since 2004, a total of 70 water sharing plans have been implemented, covering about 95% of water use, including all plans for the Murray–Darling Basin. The remaining coastal plans will be completed in 2015.

Cumulative holdings of environmental water by the NSW Government stand at around 397,418 megalitres (ML). Substantial volumes of water have also been recovered for the environment in the Murray–Darling Basin by the Australian Government, with current holdings for NSW of about 1,341,518 ML.

Over the past three years, around 600,000 ML (on average) of environmental water per year have been delivered to environmental assets in inland NSW and substantial releases made to the Snowy River with 190,000 ML released in 2013–14.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Proportion of water extraction covered by water sharing plans	G	Decreasing Impact	✓✓✓
Environmental share of available water	M	Decreasing Impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Water resources are critical for many human needs, including town water supplies, domestic and stock water, the irrigation of crops, and for mining and industry. Most of these needs are satisfied by water held in storage or extracted from rivers and groundwater.

The need to maintain a healthy environment as well as securing water resources for human use and to enable economic growth depends on an adequate supply of good quality water. Water resources are needed to preserve the health of riverine, estuarine and wetland ecosystems and to maintain the food chains that support fish and other aquatic species. The health of riverine ecosystems and floodplain wetlands is discussed in Theme 17: River health and Theme 18: Wetlands, and estuaries and coastal lakes in Theme 20: Coastal, estuarine and marine ecosystems.

Water use planning must be balanced in order to meet socioeconomic demands and environmental needs, while taking into account the long-term variability in water availability due to climate extremes, such as droughts and floods. To address these needs, NSW is developing statutory water sharing plans to provide greater certainty for all water users as well as the environment. These plans, which are discussed later in this theme, aim to protect water for the environment and provide better security of entitlement for all water users.

Status and trends

Water use and sources of water

Long-term average water use in NSW is about 7000 gigalitres (GL) per year, but use is quite variable and depends on rainfall and flow conditions. Around 80% of this water is extracted from regulated rivers, where flows are controlled by large rural water storages operated by WaterNSW. The remainder comes mainly from groundwater, around 11% (see Theme 19: Groundwater), with the balance drawn from unregulated rivers.

Agriculture is the largest user of bulk water and the most variable, with overall use ranging from just under 80% when water levels are high to around 45% when they are low (ABS 2006; ABS 2010; ABS 2012; ABS 2013; ABS 2014). Water supply, which includes sewerage and drainage services, as well as water lost to evaporation and leakage during water delivery, is the second largest ‘user’, accounting for around 10% of total water use, followed by household use.

Water extraction

The major regulated river valleys in NSW are the Murray, Murrumbidgee, Lachlan, Macquarie, Gwydir, Namoi, Border and Hunter and they account for the bulk of water extraction in the state. Significant extraction also occurs in the Barwon–Darling River system, which is unregulated. Water from the Snowy River is stored and diverted to the Murray and Murrumbidgee rivers through the Snowy-Mountains Hydro-electric Scheme to generate electricity and supplement water extraction in those inland valleys. Water is also extracted from the Hawkesbury–Nepean for urban use in Sydney.

The relative amount of water diverted by users from regulated rivers and the water available to the environment varies from year to year, depending on the prevailing weather conditions, water availability and the flow rules in water sharing plans (see Responses section). At the beginning of each water accounting year – and periodically throughout the year – water is allocated for consumption in the regulated river valleys, according to the security of entitlement and the water resources available. Water for town supply, major utilities, and domestic and stock use has the highest level of security. Other high security licences receive a high proportion of their water allocations in all but the driest years and are typically used for irrigation of permanent plantings, such as horticulture and vines, and for industries that require an assured supply of water.

Allocations to general security licences are more variable from year to year and are mostly used for irrigating annual crops, such as cereals, rice, cotton and pastures. Depending on water sharing plan rules, general security water can be carried over from year to year, if annual allocations are not fully used. Water that is not allocated for extraction each year is considered environmental water, along with that 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 based on climate and flow data for the last 120 years is used to simulate flow behaviour in regulated rivers and the impact of water resource development on the natural flows of rivers. This modelling provides a basis for setting long-term diversion limits in water sharing plans.

The models describe the variation that can be expected in river flows and the levels of water extraction over the longer term, which provides a context against which actual flows can be described and interpreted. As a general rule, the models show that the proportion of water remaining for the environment is higher during wetter periods than during drier periods. By contrast, when flows are low, there is less water available in total and a greater proportion of it is generally allocated for consumption.

Current river flows and extractions

In the decade up until 2010–11, water extractions had been gradually falling due to the severity of drought conditions. Figure 16.1 shows that the quantity of water extracted from regulated rivers rose sharply in 2010–11 as surface water availability increased following widespread heavy rains, but is now tapering off as conditions dry out across much of NSW.

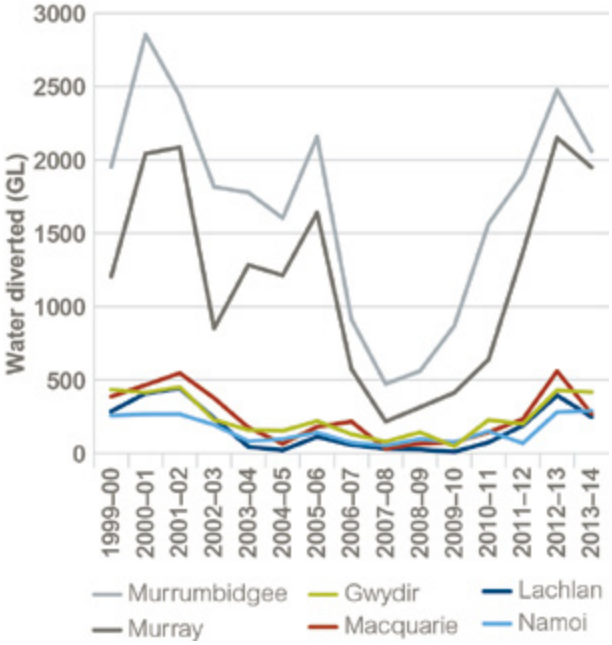
The proportion of water extracted and that remaining for the environment in the major regulated river valleys of NSW is shown in Figure 16.2, overleaf.

Following a wet period in 2010–11 and/or 2011–12, depending on the individual catchment, conditions are now becoming drier in most river valleys across NSW. While the proportion of water retained in river systems was relatively high during the two wet years, in the two years since, extraction levels have generally exceeded 50% of the total water available in most inland regulated river valleys.

Environmental water

To offset the impact of water extraction and flow regulation, and to maintain the health of natural systems and water resources, a share of the water resource is set aside for environmental purposes. Two types of environmental water are

Figure 16.1: Water diverted by licensed users in major NSW regulated valleys, 1999–2000 to 2013–14



Source: DPI Water data 2015

Notes: Observed diversions are metered general security, high security and supplementary diversions.

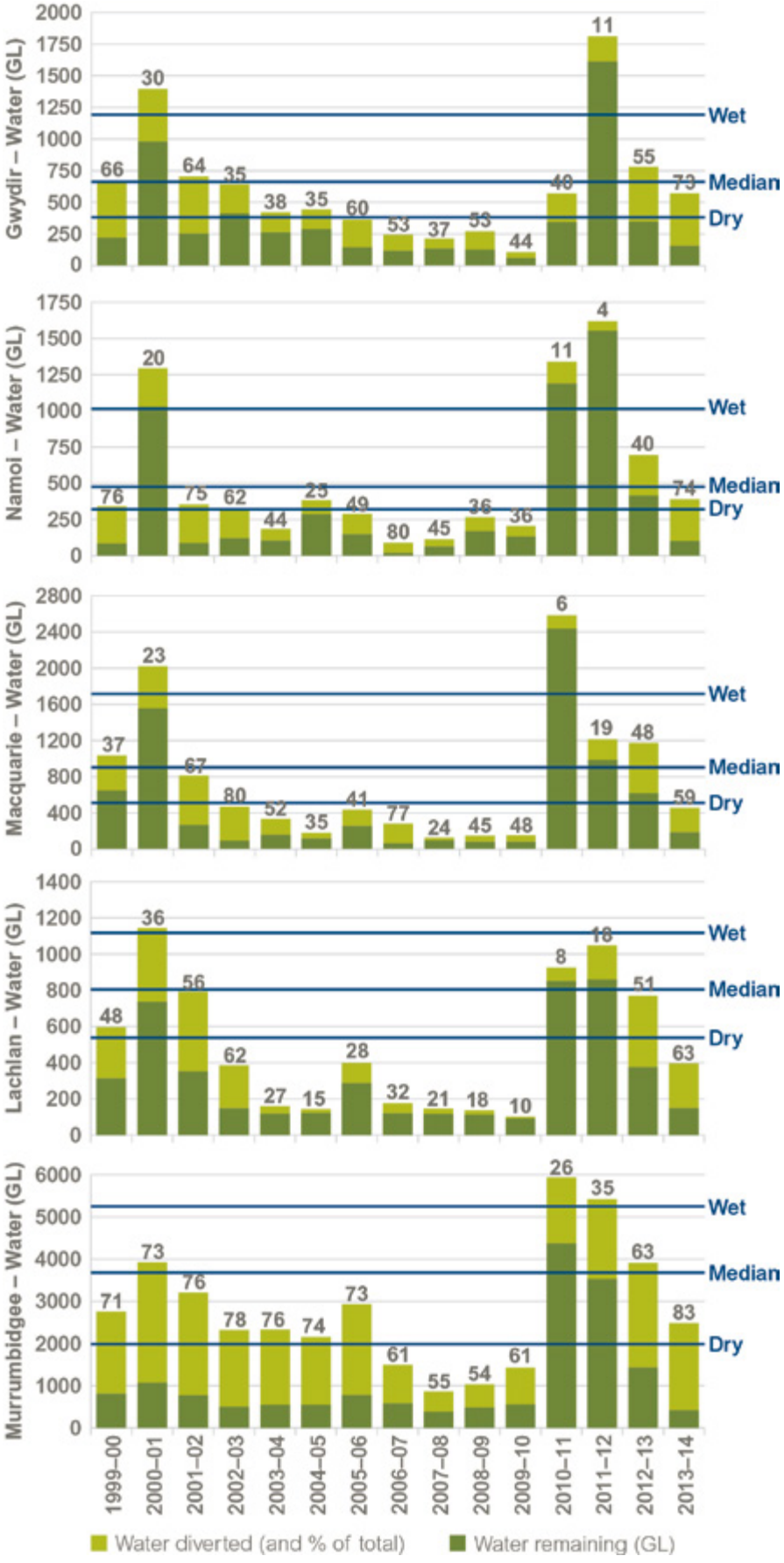
recognised under the *Water Management Act 2000* and provided for in water sharing plans for regulated rivers in NSW: planned environmental water and adaptive environmental water.

Planned environmental water: is committed to the environment by environmental water rules in water sharing plans. This is done by limiting overall water extraction to ensure that an agreed amount of water remains in the river and applying specific environmental flow allocations or 'rules'.

Adaptive environmental water: is water that is committed to the environment through water access licences. This is equivalent to 'held water' under Australian legislation. It is generally purchased in water markets from willing sellers or created through investment in water savings measures that convert previous water losses into an equivalent licensed entitlement. Adaptive environmental water is actively managed for specific environmental outcomes and can be used to supplement planned environmental water.

Unregulated water sharing plans generally rely on rules that limit extraction of river flows to

Figure 16.2: Diversions (GL and percentage of total) and water remaining (GL) after extraction in the major NSW regulated valleys, 1999–2000 to 2013–14



Notes: Some of the 'water remaining' is lost to evaporation, seepage and other transmission losses. While it is in the system, it provides some benefit to the environment, depending on how long it remains and the volume and timing of the flow. Observed diversions are metered general security, high security and supplementary diversions. Floodplain harvesting is not included and further reduces the volume of water remaining in the charts.

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 Hydro-electric 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 (110-year) hydrological modelling of conditions for water sharing plans.

The typical dry year is the 80th percentile of total water available, the typical median year the 50th percentile and the typical wet year the 20th percentile. Percentile is the proportion of time the flow volume is equalled or exceeded.

Source: DPI Water data 2015

Table 16.1: Cumulative holdings of adaptive environmental water recovered by the NSW Government to June 2015 by valley or program (ML entitlement)

Valley/Program	NSW environmental water holdings				Total
	High security	General security	Supplementary allocation	LTCE*	
The Living Murray				221,487	**221,487**
Gwydir	1,249	17,092	3,141		**21,482**
Macquarie	–	48,419	1,451		**49,870**
Lachlan	1,795	36,569	–		**38,364**
Murrumbidgee	–	28,508	5,680		**34,188**
NSW southern Murray–Darling Basin	2,027	30,000	–		**32,027**
Subtotal	**5,071**	**160,588**	**10,272**	**221,487**	**397,418**

Source: OEH data 2015

Notes: *The Living Murray holdings are expressed as long-term cap equivalent (LTCE), which equates to the long-term water availability associated with these licences. This water is held in the Murray, Murrumbidgee and Lower Darling rivers across a range of entitlement types.

These figures do not included unregulated water holdings which are not actively managed.

protect a share of water for the environment. In most cases, rules set out an annual extraction limit and a low flow 'cease-to-pump' level. This threshold is intended to minimise impacts on low flows and protect water for basic ecosystem health and riparian water users.

Environmental water recovery

Water has been purchased or recovered for the environment in NSW through a number of water recovery programs by the NSW Government. This water contributes to the total NSW Environmental Water Holdings. The cumulative total for all NSW adaptive environmental water at June 2015 was 397,418 ML.

Table 16.1 summarises the collective amount of water holdings acquired by NSW from water recovery programs, by river valley. Table 16.2 describes water holdings acquired by the Australian Government.

Environmental water delivery

How much water is available to be released for the environment depends on the annual allocations available to the different entitlement types.

Table 16.3 presents the volumes of water that were released from storages in different river valleys through specific environmental allowances between 2012–13 and 2014–15, or as a result of adaptive environmental licences. It does not include water made available to the environment through fixed rules in water sharing plans, such as prescribed end-of-system flows or dam transparency releases.

Around 689,000 ML of environmental water were delivered to environmental assets in inland NSW valleys during 2012–13, 635,000 ML in 2013–14, and 452,000 ML in 2014–15.

Significant environmental water deliveries occurred in the Lachlan River basin where the Australian and NSW Governments coordinated the largest ever release of held environmental water in the Lachlan system. A total of 89,779 ML of environmental water was released over autumn to spring of 2013. The Murrumbidgee River also saw the largest release of environmental water to date, which delivered a total of 223,957 ML over 62 days, including significant contributions from the Australian Environmental Water Holder, the Living Murray Initiative, and NSW environmental water accounts. This release was targeted specifically to support the Murray cod breeding season and created suitable conditions for successful breeding. These water deliveries continued to build on the significant ecological responses that occurred during the two above average wet years from 2010 through to 2012.

An evaluation of the environmental water management program from 2006–13

Table 16.2: Cumulative holdings of environmental water recovered by the Australian Government by valley (ML entitlement)

Valley	Australian Government environmental water holdings for NSW			Entitlement (Total)
	High security entitlement	General security entitlement	Supplementary entitlement	
Border Rivers	–	420	–	**420**
Gwydir	4,508	89,525	20,451	**114,484**
Lachlan	933	86,923	–	**87,856**
Lower Darling	397	795	–	**1,192**
Macquarie/Cudgegong	–	126,224	8,292	**134,516**
Murray	15,677	335,035	211	**350,923**
Murrumbidgee	7,629	233,994	20,820	**262,443**
Murrumbidgee (Lowbidgee)	–	–	381,000	**381,000**
Namoi (Upper)	–	105	–	**105**
Namoi (Lower)	–	7,322	–	**7,322**
Peel	–	1,257	–	**1,257**
Total	**29,144**	**881,600**	**430,774**	**1,341,518**

Source: Environmental water holdings, Australian Government Department of the Environment (as at 10/8/2015)

(OEH 2015) found that the condition of wetland communities targeted for environmental watering had improved since the program commenced, due to the increased frequency or extended duration of watering events (see also Theme 18: Wetlands). While the contribution of water held under licences was modest (around 10% of all environmental water delivered) it was important in providing the flexibility to target specific priority sites or resources that cannot be met through the fixed rules in water sharing plans.

Table 16.3: Environmental water delivered in inland rivers of NSW, 2012–13 to 2014–15 (ML)

Water source	2012–13		2013–14		2014–15	
	EWA	AEW	EWA	AEW	EWA	AEW
Gwydir	3,074	48,074	1,000	31,915	29,880	50,894
Macquarie	128,063	137,718	43,675	20,985	19,117	16,037
Lachlan	–	66,656	–	23,123	–	6,433
Murrumbidgee	26,787	219,204	106,398	144,424	55,089	196,523
Murray and Lower Darling	–	59,563	–	263,550	5,751	72,731
Total	**157,924**	**531,215**	**151,073**	**483,997**	**109,837**	**342,618**
Total environmental water	**689,139**		**635,070**		**452,455**	

Source: OEH data 2015

Notes: EWA refers to environmental water allowance, which is water held in storage to be released for an environmental purpose.
AEW refers to adaptive environmental water, which is water allocated to the environment under the conditions of water access licences and includes licences held by the Australian Government Environmental Water Holder and water sourced through the Living Murray Initiative coordinated by the Murray–Darling Basin Authority.

Pressures

Drought

Droughts are a naturally occurring phenomenon in Australia and its aquatic ecosystems are adapted to periods of dryness. However, extensive or prolonged drought can have major repercussions for all water users and the environment, and the recovery or resilience of natural systems may be compromised.

Water extraction

Maintaining high levels of water extraction relative to total river flows over an extended period places stress on river health. Scientific evidence now shows that the total volume of water extracted from rivers in NSW has affected the health of aquatic ecosystems. For example, the Macquarie Marshes Adaptive Environmental Management Plan (DECCW 2010) describes the decline and/or loss of wetland communities that has resulted from water extraction, combined with the effects of river regulation and drought.

The Sustainable Yields Assessment Project for the Murray–Darling Basin (CSIRO 2008) modelled rainfall runoff and inflows to river systems for a range of scenarios and levels of water resource development. These analyses found that water resource development has caused major changes in the flooding regimes that support important floodplain wetlands in the basin.

River regulation

Water storages and regulating structures have been built to provide greater security of supply, moderating the effects of variability in stream flows and enabling storage of water for release during dry periods, including the severe drought recently experienced. However, a consequence of river regulation is the modification of natural flow regimes, including reduced flow variability, altered seasonality of flows, and changes to river morphology.

Aquatic ecosystems, particularly inland rivers, are adapted to highly variable flow levels. To a significant extent, aquatic species are dependent on this variability to maintain or complete their life cycles. Over the longer term, modification of natural flow patterns has contributed to a loss of biodiversity and declining health in aquatic ecosystems.

The Sustainable Yields Assessment Project assessed the degree of regulation of river flows due to water resource development in each valley of the Murray–Darling Basin, and the ratio of water releases to total water availability (CSIRO 2008). The Murray, Murrumbidgee and Macquarie were found to be highly regulated; the Lachlan, Gwydir and Namoi moderately regulated; and the Border Rivers subject to low levels of flow regulation. The Paroo is the only entirely unregulated river valley in the Murray–Darling Basin and has no significant water extraction. These results show a strong pattern of conformity with the overall river ecosystem health outcomes described in Map 4.2 in SoE 2012 (EPA 2012).

Climate change

Over the longer term, projected changes in rainfall due to climate change are expected to create risks for water availability (CC 2011; Vaze & Teng 2011). Analyses of modelled runoff projections indicate that a shift in the seasonality of patterns is virtually certain, with significantly more summer runoff (up to a 20% increase) and significantly less winter rain (up to a 25% decrease). In northern NSW, which is dominated by summer rainfall and runoff, projections indicate a slight increase in mean annual runoff (DECCW 2010; Vaze & Teng 2011). However, in the southern regions of the state, which currently experience winter-dominated rainfall and runoff, the projections indicate moderate to significant decreases in mean annual runoff (DECCW 2010; Vaze & Teng 2011).

A pattern of more severe droughts and intense rainfall events is likely to increase the risk of severe flooding when rain does occur, particularly in low-lying areas, such as the Illawarra region (CC 2011).

Water pollution

The quality of water affects its suitability for human use and may affect the health of aquatic ecosystems. To a significant extent, water quality reflects the state of vegetation cover and land management practices in river catchments. The condition of riverine water quality and the effects

of catchment disturbance and diffuse runoff from agricultural activities and urban expansion are discussed in the related Theme 17: River health.

Responses

Water reforms

Significant progress has been made in water reform in NSW including:

- introducing and implementing the *Water Management Act 2000*, which recognises the importance of transparent and controlled allocation of water to the environment and extractive uses
- implementing the Murray–Darling Basin Cap on water extractions in the basin
- establishing environmental and water sharing rules in water sharing plans and tradeable water property rights
- developing 70 water sharing plans (including for groundwater)
- implementing the National Water Initiative
- acquisition of additional water for the environment through programs such as The Living Murray, Snowy Initiative, Riverbank and wetland recovery programs
- agreement to implement the Australian Government's Basin Plan 2012 which commenced in 2012, and the securing of substantial investment in water saving projects to contribute to the achievement of the plan's Sustainable Diversion Limits.

Water Management Act 2000

The *Water Management Act 2000* provides for the sustainable and integrated management of the state's water through water sharing plans and rules for the trading of water in a particular water source. Since 2009, some amendments have been made to strengthen the Act's compliance and enforcement powers and comply with obligations imposed by market rules under the Australian Government *Water Act 2007*.

Murray–Darling Basin cap

An audit of water use in the Murray–Darling Basin in 1995 concluded that the high level of use was a major factor in the decline in river health and as a result, a limit ('cap') on surface water extractions in the basin was introduced to prevent further growth in extractions. This cap will now be replaced by the Sustainable Diversion Limits (SDLs) in the Basin Plan, which for surface water sources in NSW are lower than the extraction limits in the NSW water sharing plans. The SDLs will be implemented from 2019 through water resource plans.

Water sharing plans

Water sharing plans have been a significant development in improving the management of water resources in NSW. They can apply to rivers, groundwater (see Theme 19: Groundwater), or a combination of water sources. These statutory plans provide a legislative basis for the sharing of water between the environment and extractive users. They bring certainty for both the environment and water users over their 10-year duration and provide the basis for the trading of water licences and water allocations.

Water sharing plans aim to:

- protect the fundamental health of the water source
- ensure that the water source is sustainable in the longer term
- provide water users with long-term certainty about access rules.

In addition to the extraction limits in the water sharing plans that ensure a proportion of the water available is protected for the environment, environmental flow rules ensure that water is provided for the environment through mechanisms such as specific releases from dams or end of system flow targets.

Since 2004, a total of 70 water sharing plans have been implemented across NSW, covering about 95% of water used, including all plans for the Murray–Darling Basin. Plans for the remaining coastal water sources are being developed progressively and will be completed in 2015.

Water resource plans

In the Murray–Darling Basin (which covers almost all of inland NSW) water sharing plans will be replaced by water resource plans under the Basin Plan. These will be progressively developed to be completed by 2019 when the revised SDLs under the Basin Plan come into effect. NSW has 22 water resource plans to develop – covering surface water and groundwater.

Murray–Darling Basin Plan

A key role for the Murray–Darling Basin Authority (MDBA) is to oversee the implementation of the Basin Plan, an Australian Government legislative instrument that sets Sustainable Diversion Limits (SDLs) on the use of both surface and groundwater in the basin. These SDLs must be met by 2019 and the Australian Government has committed to bridge the gap to the lower SDLs through investment in water recovery.

The Basin Plan 2012 was passed by the Australian Government Parliament in November 2012. In February 2014 NSW agreed to implement the Basin Plan, when the Australian Government acknowledged that the priority for meeting the remaining water recovery targets would be through infrastructure and environmental works and measures, rather than the previous focus on buybacks of irrigation licences, and that additional assistance would be provided for communities impacted by reduced water availability under the Basin Plan.

National Water Initiative

The National Water Initiative (NWI) commits NSW to achieving sustainability in the use of its water resources. It facilitates the expansion of trade in water resources to promote the highest value uses of water and most cost-effective and flexible mechanisms of water recovery to achieve environmental outcomes. To track progress towards the NWI objectives, the National Water Commission produces report cards, assessing individual water sharing plans within each jurisdiction, the 2013 National Water Planning Report Card (NWC 2013) being the most recent.

Environmental water recovery

Water recovery programs by the NSW and Australian Governments have recovered substantial volumes of water. The Australian Government will continue to recover water for the environment to achieve the Basin Plan Sustainable Diversion Limits. The initial water recovery target under the Basin Plan is a long-term average figure of 2750 GL. As at May 2015 the Commonwealth Environmental Water Office held 1575 GL across the basin (expressed as a long-term average, amounting to 2289 GL of actual water entitlement). This is around 60% of the target.

Floodplain Harvesting Policy

Floodplain harvesting is the collection or diversion of water flowing across floodplains. Floodplain harvesting works and water extractions fall under the scope of the *Water Management Act 2000*, but these diversions have not been considered as extractions as they have not yet been licensed.

Following community consultation the NSW Office of Water published the NSW Floodplain Harvesting Policy in 2013 (NOW 2013). The policy requires all floodplain harvesting activities to have a water supply work approval and a water access licence to harvest water. Licensing of floodplain harvesting is now under way in the northern valleys of the Murray–Darling Basin, where it is considered most significant. Floodplain harvesting extractions will be managed within the long-term average annual extraction limits under water sharing plans.

Rural floodplain management plans

Rural floodplain management plans have been developed for 17 floodplains covering approximately 20,800 square kilometres. Completion of another four plans will bring the total coverage to more than 24,300 square kilometres. Plans have been developed for the floodplains of the Namoi, Gwydir, Macquarie, Lachlan, Murrumbidgee and Murray rivers and the Liverpool Plains. The objective of the plans is to enhance the health of flood-dependent ecosystems by increasing floodplain connectivity while also managing the risk from flooding by controlling floodplain development likely to block or redistribute flows during floods.

Future opportunities

Over the next few years, the remaining coastal water sharing plans will be completed for all river valleys and work will commence on the water resource plans required under the Basin Plan. More floodplain management plans will be produced, and licensing of floodplain water harvesting will continue to be rolled out, all with the aim of enhancing the sustainable and equitable management of water resources in NSW.

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17 RIVER HEALTH

The overall condition of rivers across NSW is moderate. Riverine 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 and altered river flows, and catchment changes such as vegetation clearing. Generally the greatest signs of ecosystem stress occur where flow regimes have changed most.

Coastal rivers are less affected by flow regulation so with the exception of fish communities, are in better ecological health.

Fish communities are generally in poor condition across the state and continue to decline 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 have improved, largely due to revised standards, which take better account of the variability that occurs naturally at the regional level.

The NSW Government is finalising water sharing plans for all major rivers in NSW to ensure a balance between human uses of water and the environment. Seventy plans have been implemented across NSW including all for the Murray–Darling Basin, with the remaining coastal plans to be completed in 2015.

Environmental water management plans enable water to be directed to protect important environmental assets on a priority needs basis.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
SRA ecosystem health index for Murray–Darling Basin rivers	P	Stable	✓
River condition index for NSW rivers	M	Unknown	✓
Health of fish assemblages	P	Increasing impact	✓✓
Nitrogen and phosphorus levels	M	Decreasing impact	✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Healthy riverine ecosystems, comprising rivers and their riparian zones, floodplains and wetlands, are vital for the maintenance of aquatic and terrestrial biodiversity. Healthy rivers are also critical to provide the ecosystem services necessary to maintain good water quality and supply, and enable opportunities for future economic growth. Rivers support a variety of human uses, including activities such as agriculture, aquaculture, fishing, recreation and tourism. A primary objective of river management is to achieve a long-term balance, whereby the integrity of natural systems is preserved while providing for a range of beneficial human uses.

Status and trends

NSW has approximately 58,000 kilometres of rivers and major streams, which can generally be categorised as either short, high-gradient coastal streams or long, low-gradient inland rivers. About 97% of river length in NSW has been substantially modified (NLWRA 2002). Typical changes include the regulation of river flows and extraction of water, removal of riverine vegetation, sedimentation from erosion of land and river banks, and the introduction of exotic species.

River health

Ecosystem health

The Sustainable Rivers Audit (SRA) developed a rigorous method to assess the ecosystem health of rivers in the Murray–Darling Basin based on indexes for hydrology, fish, macroinvertebrates, riparian vegetation and physical form (Davies et al. 2012).

While further data has been collected up till 2014, a full assessment of river health under the SRA has not been completed since 2010, using the data collected during the previous three years of sampling. Map 4.2 in SoE 2012 (EPA 2012) still displays the most current SRA ratings of ecosystem health available, by river valley for the inland rivers of the Murray–Darling Basin. Overall, the Paroo was the only river found to be in good ecosystem health, with the Condamine-Culgoa and Warrego rivers being in moderate health. Most other rivers received ecosystem health ratings of poor or very poor.

Since SoE 2012 the River Condition Index (RCI) methodology has been developed which provides an alternative assessment of river condition to the SRA and one that is applicable to all rivers in NSW. It is based on five component indexes: riparian vegetation cover, hydrological stress, biodiversity condition, geomorphic condition and catchment disturbance (Healey et al. 2012). This method provides spatial coverage across all of NSW, but data for all the indexes may not be available for all river systems.

Using data that is largely the same as that used for the last SRA analysis and covering a similar time span, an initial RCI map was compiled for all of NSW. This is displayed in Map 17.1.

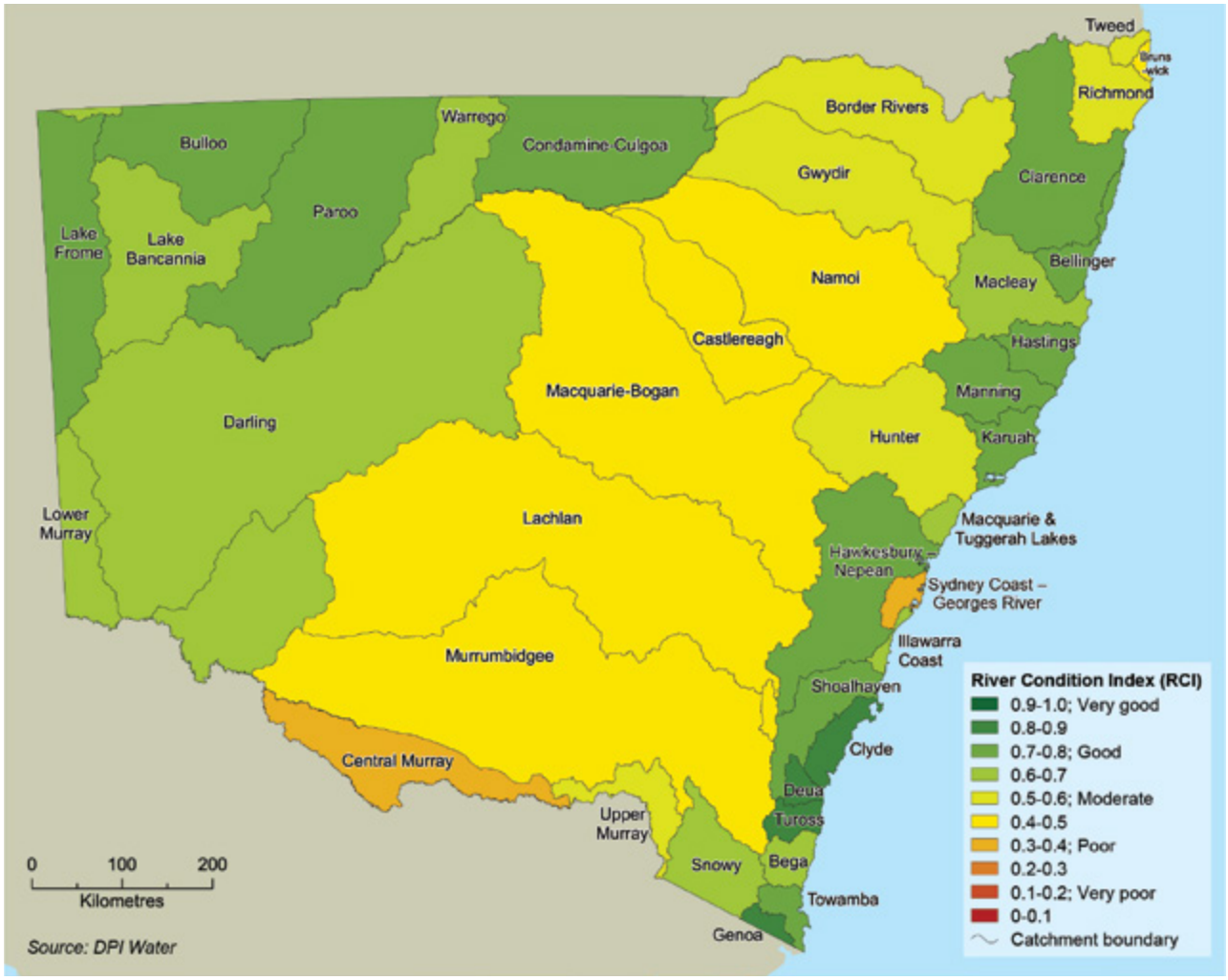
Fish

While little new data has become available for the macroinvertebrate, riparian vegetation or physical form components of the SRA index or the RCI, data from 2012–14 is available on fish communities for significant parts of NSW, including much of the Murray–Darling Basin and some northern coastal rivers.

The data that has been collected (Table 17.1) shows little change in the composition of freshwater fish assemblages since SoE 2012. For those catchments where a full condition assessment is available, condition has improved slightly in the Bogan and Namoi valleys, declined slightly in the Castlereagh and Macquarie valleys, and declined markedly, from ‘poor’ to ‘extremely poor’ condition in the NSW portion of the Condamine-Culgoa catchment.

Of the 10 catchments where overall fish condition index scores could be produced for the whole catchment, none were rated as being in ‘good’ condition. One catchment was in ‘moderate’ condition, three were ‘poor’, and one was ‘very poor’. Five river valleys were rated as being in ‘extremely poor’ condition, (in descending order), the Castlereagh, Condamine-Culgoa, Macquarie, Murrumbidgee and Lachlan.

Map 17.1: River condition index



Notes: The map shows that, across NSW, river condition is moderate. Rivers in the Murray–Darling Basin are generally in poorer condition than those in the Eyre Basin or on the coast of NSW, while the rivers in the best condition are found on the far south coast.

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 a site or zone prior to 1788 (Muschal et al. 2010; Davies et al. 2012). It has declined slightly across all valleys since SoE 2012, from an average of 37 to 33. This is largely due to decreases in the Castlereagh, Macquarie and Condamine-Culgoa valleys.
- **Recruitment** of native fish has declined slightly since SoE 2012, from an average of 49 to 42. However, the patterns of change for fish recruitment differed markedly between valleys, increasing substantially in the Bogan and Warrego valleys while declining in the Condamine-Culgoa, Macquarie, Castlereagh and Gwydir valleys.
- **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 declined substantially across most of the analysed valleys from an average of 52 to 40 and is largely due to the widespread recruitment of carp immediately prior to and during the current reporting period.

Table 17.1: Changes in fish condition index for NSW Murray–Darling Basin rivers, 2009–11 to 2012–14

Valley	2009–11	2012–14
Border Rivers	Moderate	n/a
Condamine-Culgoa	Poor	Extremely poor
Warrego River	Very poor	Very poor
Paroo River	Moderate	Moderate
Gwydir River	Poor	Poor
Namoi River	Very poor	Poor
Castlereagh River	Very poor	Extremely poor
Bogan River	Very poor	Poor
Macquarie River	Very poor	Extremely poor
Darling River	Poor	n/a
Lachlan River	Extremely poor	Extremely poor
Murrumbidgee River	Extremely poor	Extremely poor
Upper Murray River	Extremely poor	n/a
Central Murray River	Very poor	n/a
Lower Murray River	Poor	n/a

Source: Department of Primary Industries data 2015

Threatened species

The decline in biodiversity and the number of species listed as threatened is a serious environmental concern (see Theme 12: Threatened species). While it may be more widely recognised that many terrestrial mammals, birds and other species are threatened, a number of aquatic species are also under threat. In NSW, nine of the 28 native freshwater fish species found in the NSW portion of the Murray–Darling Basin are listed as threatened with extinction under the *Fisheries Management Act 1994*, and an additional four species of fish have populations listed as endangered. Seven freshwater invertebrates are also listed as threatened species under the Act.

Water quality

Water quality targets

SoE 2012 demonstrated that there was little relationship between standard water quality targets and aquatic ecosystem health, due to the highly variable nature of natural water quality regionally (see the discussion under 'Water quality by river valley' in the Water quality section of SoE 2012). New catchment zone water quality targets developed under the Murray–Darling Basin Plan 2012 (Schedule 11) are now being used to assess water quality at inland monitoring stations, replacing the previous default trigger values for slightly disturbed ecosystems listed in the National Water Quality Management Strategy (NWQMS), (ANZECC & ARMCANZ 2000). The NWQMS guidelines are still being used to assess coastal sites, but are currently being reviewed.

Nutrients

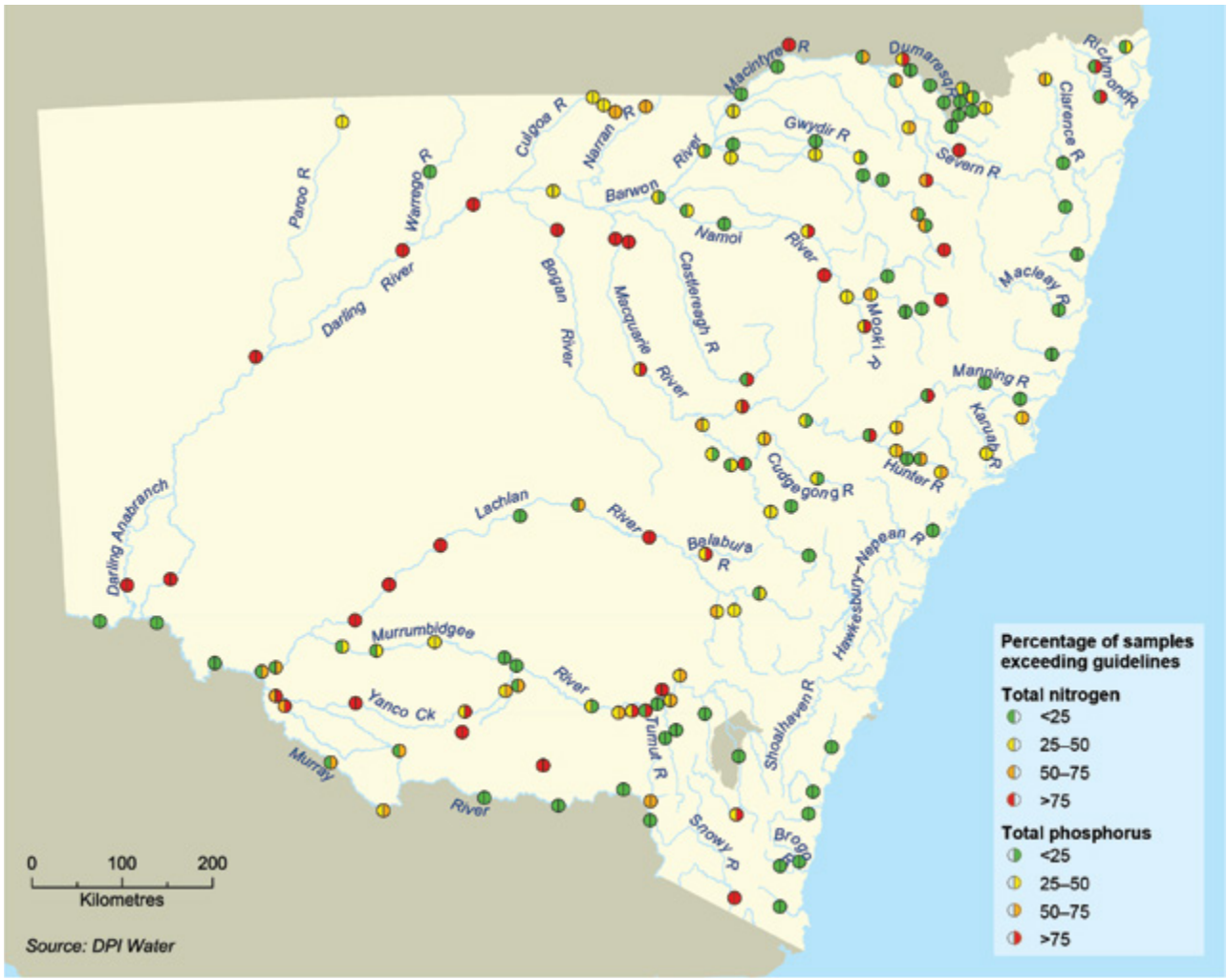
Nutrients, especially nitrogen and phosphorus, can have a significant effect on water quality when present in excess of ecosystem needs. Map 17.2 shows the percentage of water samples from streams across NSW that had nitrogen and phosphorus concentrations above water quality targets.

There are fewer inland sites with greater than 75% exceedence for both total nitrogen and total phosphorus than in SoE 2012. This is largely attributable to the use of the revised targets discussed above.

Inland sites that rate poorly for both total nitrogen and total phosphorus are located in the Border Rivers region, Gwydir and Namoi (montane zone C2 of the Basin Plan) where they are related to the basalt derived soils in those areas, and in the Lower Lachlan River (zone A3 of the Basin Plan). Poor ratings were also found in the middle and lower Darling zone and the upper and middle central Murray zone due to anomalies in the setting of the new targets. In the former, due to data deficiencies, default NWQMS targets were still applied, while in the latter several tributaries should more appropriately be allocated to the Murrumbidgee, not the Murray River.

Only one coastal site, Little Plains River at Wellesley in the Snowy River catchment, had greater than 75% exceedence for both total nitrogen and total phosphorus.

Map 17.2: Exceedences of water quality targets for total nitrogen and total phosphorus, 2012–14



Pressures

Water extraction and altered flow regimes

Natural river flows have been modified by the effects of water extraction and particularly in inland NSW, the regulation and control of flows through the installation of dams and other structures (see Theme 16: Water resources). Modified flow regimes, including dampening of both the peaks and troughs, impacts the critical ecological processes that trigger breeding events for bird and fish species, and these have been a significant factor in the decline of aquatic ecosystems over the longer term. Flow regimes are also important for creating and maintaining physical habitat within the channels of NSW rivers.

Blockages to fish passage

Many of Australia's native fish species rely on the ability to access suitable habitat to complete different stages of their lifecycles.

The 'installation and operation of instream structures and other mechanisms that alter natural flow regimes and streams' has been listed as a key threatening process under the *Fisheries Management Act 1994*. This disruption to migration by native fish populations leads to exclusion from large areas of vital breeding and spawning habitat, restricts access to food sources, limits the availability of shelter leading to an increase in predation, and reduces genetic variability within populations. A database has been compiled by Fisheries NSW of all known fish barriers across NSW. Currently, over

10,000 structures have been identified with over 4000 of them listed as barriers to fish. Dams, weirs and regulators are the most common type of major barrier with over 1800 identified across the state. In addition over 1775 road crossings also block fish passage.

Infrastructure hazards

Each year a large portion of water is diverted for irrigation purposes by means of diversion channels and pumps. In the process many adult fish are caught up in pumps or entrained in irrigation canals. If pumping is occurring during spawning season, eggs and larvae are also destroyed. On the Namoi River, some pumping stations have been recorded removing over 200 fish per day (Baumgartner et al. 2009). There are over 4546 pumps greater than 200 millimetres in size within the western flowing rivers in NSW.

Fluid shear stress is a common issue associated with undershot (gated) weirs. Within the Murray–Darling Basin, more than 80% of main channel weirs employ an undershot design (Boys et al. 2014).

High levels of mortality can be sustained in eggs and larvae as they pass through an undershot weir due to the distortion encountered. Small scale experiments have indicated that golden perch display a high susceptibility to fluid shear stress with mortality rates in eggs exceeding 90% (Boys et al. 2014; Baumgartner et al. 2006).

Cold water pollution

Discharging water from the bottom of dams results in colder water being injected into sensitive downstream ecosystems. The cold water released alters the thermal regime of rivers, sometimes for hundreds of kilometres downstream. The effects of cold water pollution (CWP) are known to impact a range of physiological and biological processes in native fish species including feeding, spawning, hatching and larval development (Lugg & Copeland 2014).

Within NSW, nine dams are believed to cause ‘relatively large and pervasive’ CWP (Blowering, Burrendong, Burrinjuck, Copeton, Hume, Keepit, Khancoban, Pindari and Wyangala) with some downstream temperatures dropping more than 10°C below natural summer conditions.

Catchment disturbance

The extent of vegetation cover within a catchment and local land use and land management practices such as agriculture and urban development affect the extent of water pollution, particularly increased nutrient and sediment levels in the river or stream, and modify the geomorphology of the river channel. Examples of these impacts include the widening of channels, head cut incisions in headwater streams and increased sediment loads that smother aquatic habitats (Brierley & Fryirs 2005). Generally, the more intensive the development the greater the impact on riverine ecosystems.

Invasive species

Alien fish compete with native species and prey on fish and frog eggs, tadpoles and juvenile fish, fundamentally altering food webs. Freshwater fish surveys over the past three years found:

- 8% of all sites sampled were free from introduced fish, mainly in coastal rivers
- 12.7% of sites contained only introduced fish
- introduced taxa accounted for 50% of the fish species collected at each site, 52% of total fish abundance and 72% of total fish biomass, averaged across all sites.

These numbers are higher than those reported in SoE 2012, even allowing for the greater proportion of sampling that occurred in the Murray–Darling Basin during the latest surveys.

In late 2014, DPI confirmed the first record of the pest fish tilapia (Mozambique mouthbreeder) in a northern NSW coastal catchment near Cabarita Beach (see Theme 15: Invasive species).

Drought

Although the Australian landscape is adapted to natural drought conditions and many species’ lifecycles rely on the natural variability in river flows that results, prolonged drought is a major disturbance to riverine systems and can place severe stress on aquatic ecosystems.

Climate change

Climate change is likely to have an incremental impact on existing pressures, particularly water availability and altered river flows. Cumulatively the consequences of these pressures could be substantial as important ecological thresholds may be crossed (CSIRO 2008).

The pressures described above have not changed greatly since SoE 2012 and many were described in greater detail there.

Responses

Water and flow management

Water sharing plans

Water sharing plans are a significant water management tool for addressing river health in NSW. They improve the management of river flows and water extraction practices and protect a proportion of all flows for the environment. Seventy water sharing plans have now been implemented across NSW, including all of those for the Murray–Darling Basin. The remaining coastal plans will be completed in 2015.

Under the Basin Plan, the water sharing plans in the Murray–Darling Basin will be replaced by 22 water resource plans by 2019. Water sharing plans and water resource plans are described in greater detail in Theme 16: Water resources.

Environmental water recovery

The NSW Government has purchased or recovered water for the environment through a number of water recovery programs. The cumulative total for all adaptive environmental water at June 2014 was 397,418 ML (see also Theme 16: Water resources).

In addition the Australian Government is recovering significant volumes of water across the Murray–Darling Basin to meet the recovery targets under the Basin Plan. As at May 2015, the Australian Government's NSW environmental water holdings for surface water amounted to 1,341,518 ML.

NSW and Australian Government agencies work together on the release and management of environmental water holdings. This environmental water is managed through:

- annual environmental watering plans that outline the priorities for how environmental water is to be used in the coming year, depending on climatic factors and water availability
- environmental water management plans that are strategic plans for wetlands, which provide a link between environmental water management and the activities undertaken by other government agencies. These plans identify environmental assets and values, assess water-use priorities, and outline the water and land management issues that need to be addressed to support environmental values.

Rural floodplain management plans

Rural floodplain management plans have been or are being implemented for 21 floodplains.

The objective of the plans is to enhance the health of flood-dependent ecosystems by increasing floodplain connectivity while also managing the risk from flooding through control of development that is likely to block or redistribute flows during floods. Floodplain management plans are statutory plans under the *Water Act 1912* and *Water Management Act 2000* and form the basis for assessing floodplain work approvals (see Theme 16: Water resources for more details).

Pollution

NSW diffuse source water pollution strategy

Pollution from diffuse sources accounts for the majority of pollutant loads in the state's waterways. The objective of this strategy (DECC 2009) is to reduce diffuse source water pollution in all NSW surface and ground waters. To do so, it focuses on sources of priority pollutants that are not currently regulated. The three main pollutants to be addressed are sediments, nutrients and pathogens, which can arise from a multitude of sources, including agricultural land uses, sealed and unsealed roads, and urban stormwater.

Cold water pollution

A floating curtain system at the Burrendong dam intake tower was completed in 2014 to reduce the impact of cold water pollution on the Macquarie River. The newly installed system is designed to allow warmer surface water to be released in order to restore more natural temperatures downstream. Initial testing has indicated that a positive effect is being reflected downstream since the installation of the system. While an overall mean recovery of 2.5°C has been recorded, further improvements are being investigated.

Fish habitat

Fish habitat policy and guidelines

In 2013, an updated policy and guidelines were published aimed at maintaining and enhancing fish habitat in NSW for the benefit of native fish species (including threatened species) in marine, estuarine and freshwater environments (DPI 2013).

Fishways

Since 2013, 34 structures have been remediated, opening approximately 5500 kilometres of river habitat. This remediation included several removal projects, the construction of 13 fishways as well as the replacement of low level road crossings and causeways with larger fish friendly box culverts, allowing fish passage and better flood access for landholders.

Future opportunities

The monitoring of habitat and ecosystem responses to environmental flows will allow knowledge to be refined so that through adaptive management better targeting of high-value ecosystems can occur, enhancing the benefits of such flows.

While point sources of water pollution are generally well-managed, there is still scope to improve the management of diffuse-source pollution, primarily 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.

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18 WETLANDS

Increased rain and flooding in 2010 to 2012 inundated many wetlands, increasing waterbird abundance and breeding activity. In 2013 to 2014 the return to a drying climatic phase has seen a reduction in the extent of wetland inundated and a decrease in waterbird abundance and breeding activities.

Inland wetland vegetation communities that have received environmental watering have improved in condition since 2012. On ground surveys at sites that received environmental water revealed vegetation condition and waterbird diversity were maintained, with many of these wetlands acting as refuges for dependent species during the drying period.

Wetland condition is affected by dry climatic conditions, decreased water availability and changed patterns of water flows as well as catchment land practices. This is being addressed through the management of allocated environmental water (allowances in water sharing plans and adaptive environmental water licences through the purchase of water entitlements from willing sellers and water savings through infrastructure projects), and the implementation of the 2012 Murray–Darling Basin Plan.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Wetland extent	M	Stable	✓
Wetland condition	M	Stable	✓
Waterbird abundance and diversity	P	Increasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Wetlands are important ecosystems because they support high biodiversity. A diverse array of wetland types (lakes, lagoons, estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs and seagrass beds) form habitat for a wide range of animals including waterbirds, fish, frogs, invertebrates, and water-dependent plant species (DECCW 2010a).

They are inundated by water on a cyclical, intermittent or permanent basis with generally slow moving fresh, brackish or salt water (DECCW 2010a). Wetlands play a key role in the biogeochemical cycling of trace gases (e.g. methane and carbon dioxide) and nutrients, and they regulate regional hydrological cycles and climate. Important wetland ecosystem services can contribute to regional economies through the provision of estuarine commercial fisheries, grazing and tourism.

Wetlands provide a vital habitat for migratory bird species protected under bilateral international agreements, including the Ramsar Convention. Ramsar wetlands are recognised for their biodiversity and ecosystems. 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.

Additional significant wetlands in NSW include those mapped under State Environmental Planning Policy no. 14 – Coastal Wetlands (SEPP 14) and others listed as endangered ecological communities under the *Threatened Species Conservation Act 1995.*

Status and trends

Wetland extent and condition

The annual eastern Australia aerial survey of wetlands and waterbirds (Porter et al. 2014) covers wetlands across the eastern third of the continent. It includes estuaries, coastal lakes, rivers, swamps, floodplains, saline lakes, as well as dams, reservoirs and impoundments.

This survey shows (Figure 18.1) that floodplain wetland area across eastern Australia declined in 2014 to below the long-term average (1983 to 2014), and that this decline over time was statistically significant.

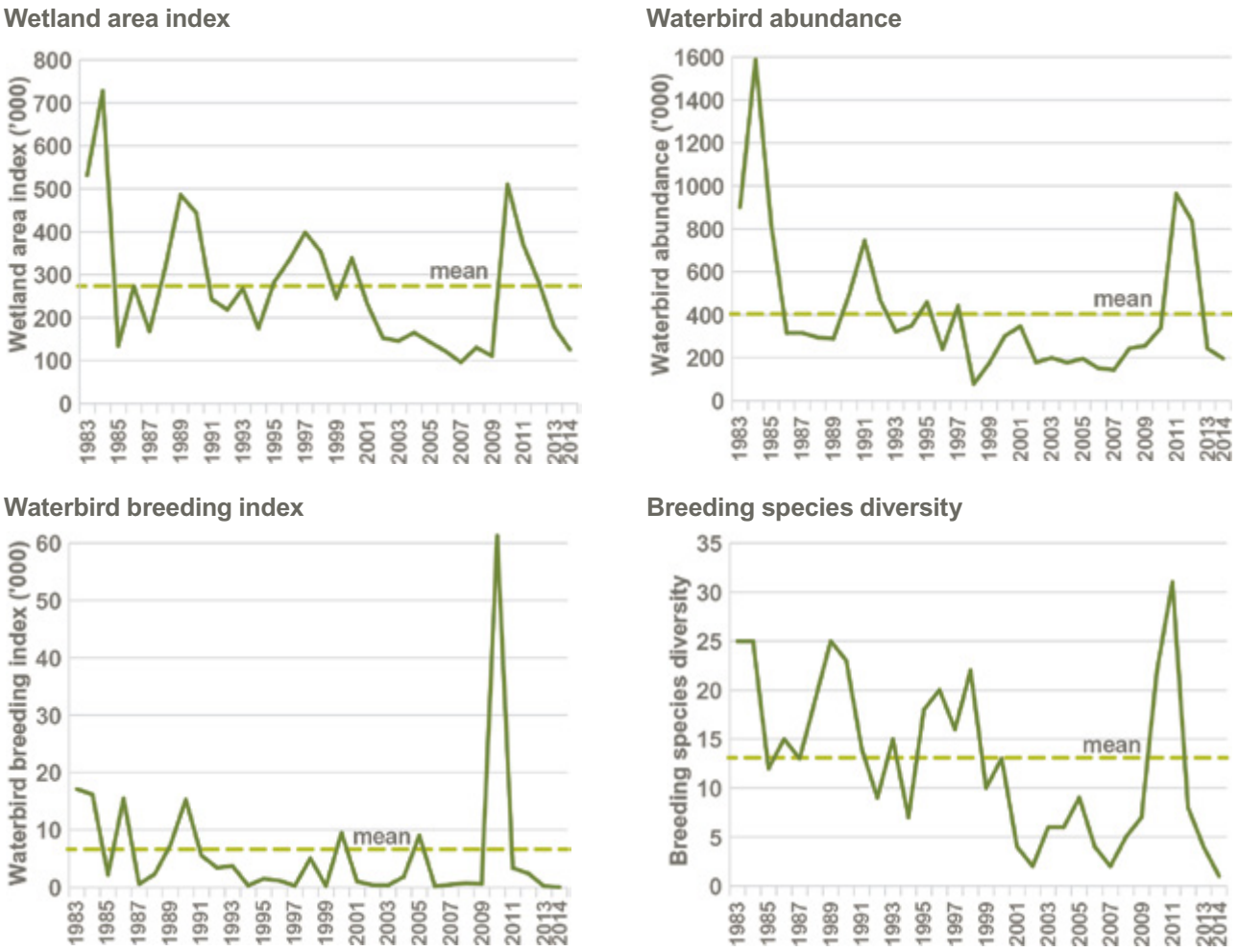
The 2014 aerial surveys showed that the Macquarie Marshes and Lowbidgee wetlands were partially filled by environmental flows, but these were relatively small areas compared to the large flooding years. Most rivers in the Murray–Darling Basin had reduced flows with mostly dry wetland habitat on their floodplains, including the large lakes of the Menindee Lakes (Porter et al. 2014).

During this dry phase, many NSW inland wetland areas, including several not covered by the annual aerial survey, were beneficiaries of environmental water and provided refuges for water-dependent plants and animals.

The NSW Office of Environment and Heritage (OEH) manages environmental water in five valleys in the Murray–Darling Basin (Lower Lachlan, Macquarie Marshes, Gwydir Wetlands, Lower Murrumbidgee and Murray) (see Theme 16: Water resources). Monitoring of wetland vegetation across these valleys indicated an improvement in the condition of wetland vegetation communities compared to that measured at the conclusion of the Millennium drought in 2008 (DECCW 2010b; DECCW 2010c; DECCW 2011a; DECCW 2011b; Wen & Saintilan 2015), in most valleys (OEH 2014). Examples in the largest and most important wetland complexes of NSW where flood-dependent vegetation has responded well to natural flooding and delivered environmental water since 2011–12 include:

- Lowbidgee river – red gum forests and woodlands in Yanga National Park
- Gwydir wetlands – vegetation including semi-permanent wetland vegetation, water couch, spikerush meadows, and the marsh club-rush, very tall sedgeland and coolibah –black box endangered ecological communities
- Macquarie marshes – river red gum forests and woodlands, lignum shrublands and reedbeds, large areas of semi-permanent wetland vegetation, water couch, and reed beds (OEH 2014).

Figure 18.1: Estimated wetland area, and waterbird abundance and breeding in eastern Australia, 1983–2014



Source: Porter et al. 2014

Notes: Aerial survey along 10 aerial survey bands, 1983–2014.

However, some areas that have not received adequate water have not recovered to pre-drought conditions (OEH 2014).

It is recognised that a NSW wetland inventory to assess condition and extent of all wetland types in NSW would be beneficial in informing the next SoE report.

Waterbirds

Wetlands provide important waterbird habitat, supporting breeding and foraging activities. For all waterbird species combined across eastern Australia, the total breeding index from the annual waterbird survey (Porter et al. 2014) was the lowest on record (with a result of 12) and well below the long-term average (6901).

Waterbird breeding species richness was also the lowest on record, comprising one non-game species. Game species abundances were all well below long-term averages, in many cases by an order of magnitude (Porter et al. 2014).

This decline reflects the general lack of suitable inundated habitat and breeding conditions across eastern Australia during this period. Recent research also indicates that migratory waterbird habitat is declining across East Asia (a major stopover point for many migratory waterbird species) and this is likely to be impacting on shorebird populations (Murray & Fuller 2015).

While the aerial survey reported the lowest breeding index on record, waterbird breeding events occurred at a number of inland NSW wetlands that received environmental water in 2013–14. These breeding events resulted in the successful recruitment of a variety of

Table 18.1: Extent of wetland types and their inclusion in NSW reserves, 2014

Wetland type	Total area in NSW (ha)	Total area in NSW public reserve system (ha) (% of total)	Additions of wetland to NSW public reserve system in 2012–14 (ha)	Examples of new areas of wetland declared or added to NSW public reserve system in 2012–14
Coastal wetlands				
Floodplain wetlands	11,890	2,476 (21%)	1,264.5	Everlasting Swamp National Park (1,262 ha, new reserve gazetted Nov. 2014) Everlasting Swamp State Conservation Area (addition to existing reserve 2.5 ha)
Freshwater wetlands	1,926	221 (11%)	–	
Estuarine wetlands	110,791	14,735 (13%)	20.5	Clybucca Aboriginal Area (addition to existing reserve 1.5 ha) Minimbah Nature Reserve (addition to existing reserve 19 ha)
Coastal lakes and lagoons	66,103	18,480 (28%)	–	
Total	**190,710**	**35,912 (19%)**	**1,285**	
Inland wetlands				
Floodplain wetlands	4,008,834	267,505 (7%)	6,866	Gwydir Wetlands State Conservation Area (addition to existing reserve 2,220 ha) Lachlan Valley National Park (addition to existing reserve 714 ha) Paroo-Darling National Park (addition to existing reserve 518 ha) Warrambool State Conservation Area (3,313 ha, new reserve gazetted Aug. 2013) Doodle Comer Swamp Nature Reserve (addition to existing reserve 101 ha)
Freshwater lakes	296,071	21,034 (7%)	0.3	Murrumbidgee Valley National Park (addition to existing reserve 0.3 ha)
Saline lakes	18,542	–	–	
Total	**4,323,447**	**288,539 (7%)**	**6,866.3**	

Source: OEH data 2015

waterbird species including cormorants, egrets and darters. On-ground surveys also indicated waterbird diversity was maintained at these sites (Wassens et al. 2014; Spencer et al. 2014).

Monitoring results also indicate that populations of wetland-dependent fauna, other than waterbirds, are increasing across the state's inland wetlands. An example of this is the vulnerable southern bell frog. With populations expanding into new wetland sites, all indications point to this species making a concerted recovery from the impacts of the Millennium drought. This recovery has been well supported through environmental water delivery to key wetlands (Wassens et al. 2014).

Reservation of wetlands

Table 18.1 summarises the 8151.3 hectares of wetlands that were added to the NSW public reserve system in 2012 to 2014.

Coastal wetlands

Coastal wetlands included within the NSW public reserve system increased by 1285 hectares in 2012 to 2014. Additions to the reserve system included Everlasting Swamp and the adjacent Imersons Swamp located on the NSW North Coast, 15 kilometres west of Maclean, within the Clarence River floodplain. These sites form one of the largest coastal floodplain wetlands remaining in NSW and are a high conservation priority.

The reservation of these wetlands as Everlasting Swamp National Park also complements the small proportion of the wetland (460 hectares) currently protected as Everlasting Swamp State Conservation Area (SCA) and is a significant environmental achievement.

Inland wetlands

In 2012 to 2014, 6866.3 hectares of inland wetlands were added to the NSW public reserve system. In November 2014, a few thousand hectares of the Gwydir wetlands, 60 kilometres north-west of Moree, were reserved as part of the existing Gwydir Wetlands SCA. The Gwydir wetlands play an important role in the biological and ecological functioning of the Murray–Darling Basin. The Gwydir wetlands also provide habitat for migratory waterbirds, with parcels of the wetlands listed under international treaties including Ramsar, and recognised for their unique assemblages of wetland and floodplain plant communities.

The Gwydir wetlands system exists as a remnant within a highly modified agricultural landscape where remaining vegetation communities are highly fragmented and poorly conserved in NSW. It makes this particular addition to the reserve system valuable for its conservation of biodiversity and landscape connectivity, as well as for the maintenance and restoration of ecological health in this unique inland floodplain wetland complex.

Pressures

Water availability

Water availability is the most significant pressure on the health of wetland ecosystems. Altered flows from water extraction and the building of dams, levees and diversion structures has had long-term and ongoing effects upon water availability, especially for important breeding locations such as the Macquarie Marshes and the Lowbidgee wetlands. Wetlands have experienced additional pressures due to prolonged periods of reduced water availability. The strong La Niña events in 2010 and 2011 that produced flooding rains, inundated many wetlands across NSW, and initiated the recovery of wetland vegetation condition and extent from the drying effects of the Millennium drought. The improvement in wetland vegetation condition and extent is continuing to be supported where environmental water can be delivered (OEH 2015).

Water resource extraction and diversion is further described in Theme 16: Water resources.

Climate change is likely to further affect water availability, with higher temperatures, increased rates of evaporation, altered tidal ranges and flooding duration (DECCW 2010a).

Water quality

Development, clearing, cropping, grazing, mining, point-source discharges (such as sewage) and other land uses affect water quality. Increasing levels of nutrients (called eutrophication) and sediments from these activities can result in depletion of dissolved oxygen levels (called hypoxia or black water), fish kills, excessive plant growth, increased turbidity and siltation. Sediments can form muddy deposits, reduce light penetration and smother plants and animals.

In NSW, human disturbance of catchments (primarily the clearing of vegetation) has resulted in large increases in the loads of sediments entering wetlands (see the State of the catchments reports for detailed reporting).

Physical disturbance

Physical disturbances such as mining activity and land clearing within the floodplains of inland NSW have a major impact on habitat quality and extent.

Site-specific studies have identified impacts from longwall mining to upland swamps in the Upper Nepean, Woronora and Warragamba catchments, including changes to site geology, surface and groundwater quality, and changes to ecological features (GHD 2013). Water quality is affected by erosion, flushing of sediment and

other products from mining activities. In addition, subsidence can fracture the base of swamps and drain groundwater-dependent ecosystems (GHD 2013).

Invasive species

The introduction and 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 also the State of the catchments reports).

Introduced plants can change wetland structure and function resulting in poorer habitat value for native fauna, increases in sedimentation, and creation of monocultures, which reduce the overall biodiversity of a wetland. Introduced plants can reflect the degree of degradation or restorability of a wetland.

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 also caused extensive damage to the condition of wetland vegetation, soils, channels and bank structures of watercourses. Many feral animals, such as cats and foxes also prey on small native animals and birds. (See Theme 15: Invasive species for more detail on the spread and impact of weeds and pest animals.)

Responses

NSW policy and legislation

The NSW Wetlands Policy (DECCW 2010a) promotes the sustainable conservation, management and wise use of wetlands in NSW and the need for all stakeholders to work together to protect wetland ecosystems and their catchments. There are a number of regulations under the *Threatened Species Conservation Act 1995* and State Environmental Planning Policy no. 14 – Coastal Wetlands (SEPP14) which have been put in place to help protect wetlands and wetland species.

Water to restore and maintain wetlands

The environmental water management program (EWMP) aims to improve the ecosystem function of wetlands and rivers by rehabilitating wetland habitat for significant water-dependent biota, 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.

Environmental water was purchased by NSW from willing sellers under three major programs: NSW RiverBank, the Rivers Environmental Restoration Program, and the NSW Wetland Recovery Program.

The Australian Government is continuing to recover water for the environment across the Murray–Darling Basin to ensure sustainable diversion limits set by the 2012 Basin Plan are met by 2019.

Future opportunities

NSW wetlands inventory

An inventory and enhanced mapping of wetlands across NSW will provide better information on the location and types of wetlands at a statewide level and a more reliable mapping layer for reporting. Many wetlands do not fall into the currently mapped layers. This affects the ability to report on their condition and extent. A wetlands inventory pilot project is being proposed for 2015–16. It will provide greater understanding of the extent and condition of wetlands in selected areas in NSW.

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19 GROUNDWATER

Demand for groundwater in NSW has increased over recent years as conditions dry out in many parts of the state.

Overall, groundwater use has been rising since the low levels recorded in 2010–11 but extraction from most groundwater sources is below the long-term sustainable extraction limit.

During 2013–14, the Lower Gwydir, Lower Namoi and some Upper Namoi groundwater sources experienced the highest levels of groundwater demand, temporarily exceeding their plan's extraction limit for the year. Extraction from these systems will be managed in coming years to ensure that sustainable limits are not exceeded over the longer term.

Extraction from some groundwater sources was above the long-term sustainable yield when water sharing plans commenced but allocations have been progressively reduced to align with diversion limits over the life of the plans.

Water sharing plans continue to be implemented for groundwater sources, with 41 now completed, including all sources in the NSW Murray–Darling Basin. A further 12 groundwater sharing plans for coastal sources are to be completed by 2016.

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Long-term extraction limit: use	G	Decreasing impact	✓✓
Long-term extraction limit: entitlement	G	Decreasing impact	✓✓✓
Aquifer integrity	G	Stable	✓✓
Groundwater quality	M	Stable	✓✓
Extent and condition of groundwater-dependent ecosystems	U	Uncertain	✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

Where surface water is available, groundwater is generally seen only as a supplementary water resource. However, for many communities in regional NSW, groundwater is the primary source of water for drinking, domestic and stock use, and it is also widely used in agriculture and industry.

A range of ecosystems also depend on groundwater for their continued survival, including some highly specialised and endemic subterranean systems, as well as surface water systems (wetlands, rivers and lakes) that are connected to groundwater, and some terrestrial ecosystems.

Significant changes to the quantity and quality of groundwater available have the potential to degrade ecosystems and affect human uses of this water. Many groundwater-dependent ecosystems (GDEs) are hidden underground and therefore the impacts on these systems are likely to be less obvious and understood.

Status and trends

Extent and major uses of groundwater

Approximately 11% of all water used in NSW is from groundwater sources. Around 13% of the estimated use of groundwater in NSW is for domestic and stock purposes, used for drinking water and watering stock. For more than 200 towns in NSW, groundwater is the principal source of water supply.

Agriculture is the greatest user of groundwater in NSW with most of this being for irrigation in the inland floodplains of NSW that are underlain by alluvial aquifers. Groundwater is a source of water for some mining operations, but it can also be an obstruction or hazard that must be extracted for mining to proceed.

Groundwater resources in NSW

Groundwater is found throughout the NSW landscape and may be available to the environment and extractive users at a range of depths and salinities, in any locality.

The upper phreatic aquifer is typically the most important groundwater system with respect to GDEs and for groundwater connection with surface water. It is strongly influenced by climate and topography as well as the permeability of the host geology. In general, depth to groundwater tends to be shallower and salinity lower in the higher rainfall areas in the east of the state, increasing westward where evaporation rates are higher and the topography more subdued.

The unconsolidated sediments of floodplain alluvium and coastal sand beds yield the greatest supplies of groundwater due to their more permeable nature. The yield and salinity of groundwater in the consolidated porous rocks of the sedimentary basins ranges from the freshwater supplies of the Great Artesian Basin to the higher salinity groundwater associated with some coal deposits. The third aquifer type, the fractured groundwater systems, are typically low yielding although there are notable exceptions such as the basalt aquifers on the north coast.

About 98% of all metered groundwater extraction in NSW is from inland alluvial groundwater sources, which include the highest yielding aquifers and provide good quality water used extensively for irrigation.

The alluvial systems of the Lower Gwydir, Upper and Lower Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and Lower Murray Rivers account for the majority (about 80%) of metered groundwater use.

While extractions from these six major inland alluvial aquifers fluctuate around levels close to the limits for sustainability, the overall level of groundwater extracted from all metered sources in NSW is much lower than the cumulative sustainable extraction limit.

In large areas of NSW, the potential to extract groundwater is low because of hydro-geological factors, or the quality of the water is not suitable for use. Extraction is not metered in many areas of NSW where demand is low, particularly on the coastal side of the Great Dividing Range.

Levels of extraction and recharge

Variability in climatic conditions affects the amount of groundwater used. Groundwater is managed on a long-term average basis, allowing the large storage capacity of groundwater systems to provide a buffer in times of drought. Extraction may increase substantially during drought conditions to offset the lack of surface water, causing groundwater levels to decline.

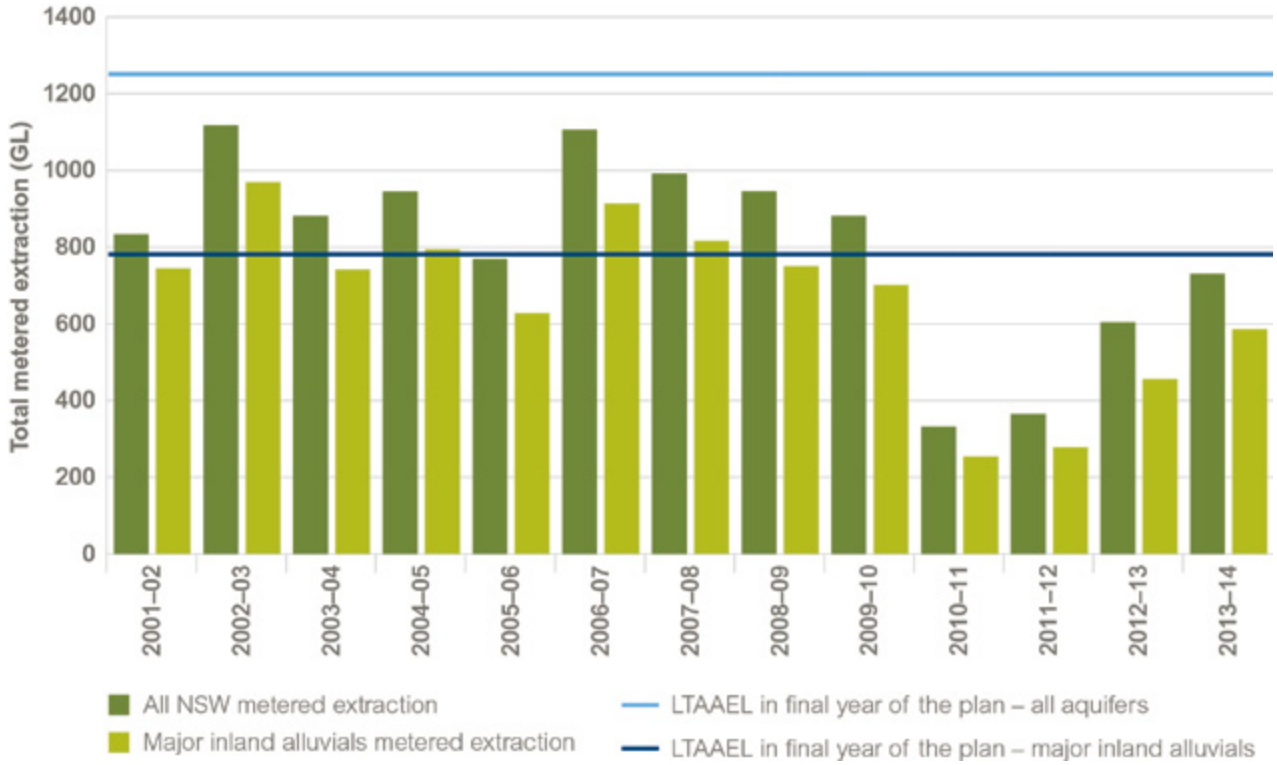
In periods of high rainfall there is less demand for groundwater, allowing groundwater levels to recover, thus providing a reliable and secure water resource.

Figure 19.1 shows groundwater extraction from all metered aquifers in NSW and the major inland alluvial aquifers over the 13 years to 2013–14. Two peaks in extraction occurred in 2002–03 and 2006–07 when drought conditions were particularly acute and surface water was low. A gradual decline in extraction has occurred since 2006–07 as the effects of the drought eased, but largely due to the introduction of water sharing plans in the major inland alluvium groundwater sources. The lowest extraction for the decade occurred in 2010–11, when around a third of the volume was used compared to when demand was at its peak.

Since 2011–12, groundwater extractions from all NSW water sources, including the major inland alluvium water sources, have been gradually increasing from the low point of the previous year. This is due to increased demand as low rainfall and surface water availability affects valleys, particularly in northern NSW. However, overall extractions from all NSW metered water sources still remain well within the long-term average annual extraction limits.

The overall volume of groundwater extracted in NSW is somewhat higher than the metered extraction recorded. This is because extraction is not metered in many areas of NSW where groundwater demand is low, particularly on the coastal side of the Great Dividing Range.

Figure 19.1: Annual levels of groundwater extraction from metered aquifers in NSW and the major inland alluvial aquifers, 2001–02 to 2013–14



Source: DPI Water data 2015

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 dark blue line is the long-term average annual extraction limit (LTAAEL) for these major groundwater sources only, which is the level of water that can be extracted annually on a sustainable basis over a longer time frame.
The light blue line is the LTAAEL for all metered extraction in NSW.
Extraction limits are being reduced gradually to align with the LTAAEL by the final year of relevant water sharing plans in 2016–17.

Long-term average annual extraction limits

The long-term average annual extraction limit (LTAAEL) is the volume of groundwater that can be extracted sustainably, on an annual average basis over a longer term, from the groundwater sources defined in water sharing plans. It is effectively the plan 'limit'.

Where data is available, the extraction limit is based on numeric models that simulate rainfall and river leakage over a period of 20 to 30 years. In other areas it is based on either the previous history of groundwater extraction or the estimated rainfall recharge expressed as a percentage of annual average rainfall. The portion of recharge not available for extraction is allocated to the environment, as is the average volume of groundwater held in storage to protect significant environmental assets and ensure long-term viability of the groundwater source.

Water sharing plans and extraction levels

To address historical over-allocation, the water sharing plans for the large inland alluvial systems of the Lower Gwydir, Upper and Lower Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and the Lower Murray provide for progressive reductions in water allocations over their 10-year terms, down to the predicted sustainable limits of these systems. The implementation of such plans has expanded beyond these six major inland alluvial aquifers, with all inland (Murray–Darling Basin) groundwater sources in NSW now covered by water sharing plans (see Responses section).

The water sharing plans for groundwater ensure that the resource is managed sustainably, so that extraction remains in balance with recharge and groundwater levels do not become depleted, causing unacceptable impacts to the aquifer or GDEs.

Extraction compared to extraction limits

Groundwater use for the period 2013–14 as a percentage of the LTAAEL is shown in Map 19.1. This provides an indication of sustainable use in areas where groundwater use is metered and monitored. With dry conditions and low surface water availability prevailing in most areas, particularly in northern NSW, demand for groundwater was higher, leading to higher extraction levels. The highest percentages of extractions against LTAAEL were from the Lower Gwydir, Lower Namoi and Upper Namoi water sources (between 112% and 127%).

If this trend continues in coming years lower annual allocations or 'available water determinations' (AWDs) may be announced.

Extractions above 75% of LTAAEL were also recorded in the Wagga Wagga Alluvium, Peel Alluvium, Upper and Lower Macquarie Alluvium, Lower Murrumbidgee Alluvium (around Hay) and Upper Murray Alluvium (around Howlong).

Groundwater-dependent ecosystems

Groundwater-dependent ecosystems (GDEs) are described in water sharing plans for groundwater as 'ecosystems where the species composition or natural functions depend on the availability of groundwater'. The dependence on groundwater may be complete or partial, such as during periods of drought. The degree and nature of the dependency influences the extent to which ecosystems are affected by changes to water quality or quantity in groundwater aquifers.

GDEs occur across a broad range of environments, from highly specialised subterranean ecosystems to more generally occurring terrestrial, aquatic and marine ecosystems. There are two main groupings of GDEs – subsurface ecosystems and surface ecosystems – and seven broad types overall, based on ecological, geomorphic and water chemistry criteria. These are listed below and were described in greater detail under 'Groundwater-dependant ecosystems' in SoE 2012 (EPA 2012).

Subsurface ecosystems

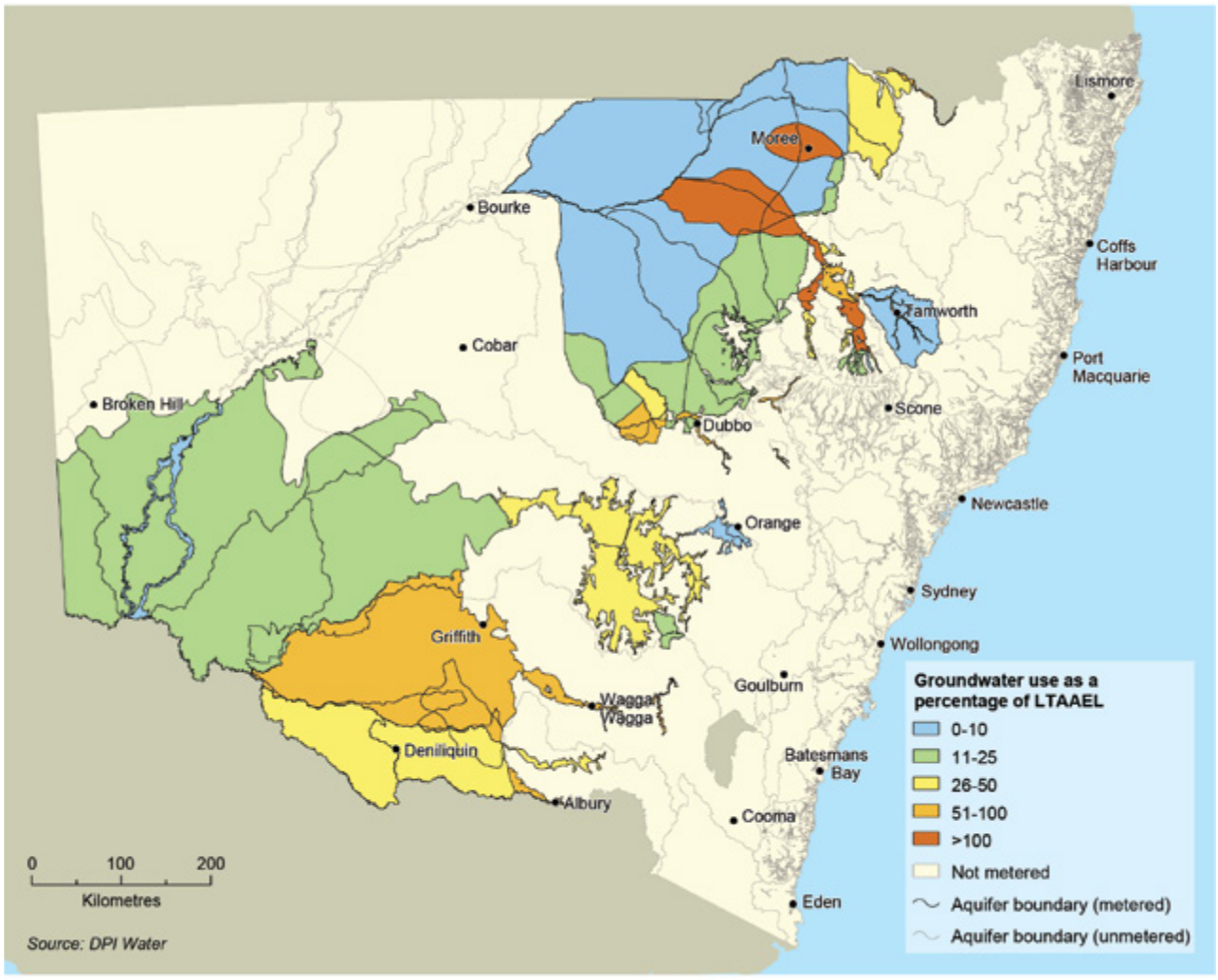
- subsurface phreatic aquifer ecosystem
- karsts and caves
- subsurface baseflow streams.

Surface ecosystems

- surface baseflow streams
- wetlands
- estuarine and near-shore marine ecosystems
- groundwater-dependent or phreatophytic vegetation.

The most significant, diverse and potentially sensitive groundwater-dependent ecosystems and organisms are found in underground springs and cave systems.

Map 19.1: Extraction from NSW groundwater aquifers as a percentage of the long-term average annual extraction limit, 2013–14



Notes: Only those areas of NSW where groundwater use is metered are shown on the map.

LTAAELs for the Lower Gwydir, Lower and Upper Namoi, Lower Macquarie, Lower Lachlan, Lower Murrumbidgee and the Lower Murray alluvial water sources are being reduced during the life of their respective water sharing plans. Usage is compared with the LTAAEL applicable for the 2013–14 water year, not the LTAAEL specified for the end of the plan (at year 10).

Identification of groundwater-dependent ecosystems

Interest in GDEs and their sustainability is relatively recent and little is known about their location or condition (Eamus & Froend 2006). However, since the release of the NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002), the NSW Government has been actively engaged in identifying GDEs across the state, and the number of GDE types has grown as knowledge has improved. Current mapping is still limited and is not yet available statewide, but mapping of GDE extent is complete for coastal NSW except the Greater Sydney area, as well as the Namoi valley. GDEs in the other inland valleys will be mapped over the next three years.

Pressures

Excessive demand and extraction

Reducing the storage levels of an aquifer or the permanent mining of the resource will affect its stability and integrity over the longer term, as well as having permanent consequences for all dependent ecosystems and beneficial uses. There is a risk that competition for groundwater resources can impair the long-term security of these resources.

NSW groundwater sources have been assessed for risk due to groundwater demand using a standard developed under the National Framework for Compliance and Enforcement Systems for Water Resource Management.

The outcome of this risk assessment is shown in Map 4.6 in SoE 2012.

The areas at highest risk were characterised by high consumption with entitlements close to or above extraction limits.

Saline intrusion

Where the level of extraction of groundwater is high and the aquifer is overlain by saline aquifers or is located near the coast, there is a risk of saline water intrusion into the depleted aquifer. This will have a detrimental effect on water quality and related uses. The intrusion of sea water is relevant particularly to the coastal sand beds north of Newcastle, which are an important source of water for the Greater Newcastle area.

Studies have recently been completed to assess the risks caused by high volume groundwater extraction on groundwater quality in the six major inland alluvial aquifers. Localised areas of water quality decline have been discovered and strategies are being developed to address those areas of risk.

Coal seam gas

Great care needs to be taken to ensure that mining and coal seam gas developments do not result in permanent damage to aquifers; therefore, the coal seam gas (CSG) industry in NSW is strictly regulated. All CSG operations require approval from a consent authority and an environment protection licence from the EPA. Both the consent and the licence include legally enforceable conditions intended to protect the environment, including surface and groundwater resources. There is a low risk of enhanced inter-aquifer connectivity, aquifer destruction or surface pollution if a CSG project is operated and managed in accordance with its conditions of approval, its environment protection licence and the codes of practice and guidelines that apply in NSW.

At present the Camden site operated by AGL is the only CSG site in NSW in production. Other projects at Gloucester (AGL) and Narrabri (Santos) are currently in the exploration phase.

Groundwater level and quality are regularly monitored across the state with a network of 4700 state-owned monitoring bores at 2800 sites, with real-time data made available for 390 of these bores on the internet. DPI Water is also enhancing its deep monitoring sites and constructing new bores in groundwater sources that are being actively explored for CSG and mining opportunities in NSW.

Chemical contamination

Groundwater contamination by chemical pollutants can significantly reduce the value of water to users or the environment and increase the cost of water treatment. It may prevent some types of water use altogether. Once an aquifer is polluted, it is extremely difficult and expensive to restore.

Groundwater contamination is largely associated with long-standing existing or former industrial areas and tends to be in urbanised areas concentrated around Sydney, Newcastle and Wollongong.

Climate change

The Sustainable Yields Assessment Project for the Murray–Darling Basin (CSIRO 2008) identified that current and probable future levels of groundwater extraction will have a greater impact on inland aquifer systems than any likely reduction in recharge from rainfall and river systems due to climate change. Along the coast, the potential impacts of sea level rise and climate change on coastal aquifers will be more significant, with saline intrusion on freshwater coastal aquifers affecting associated groundwater-dependent ecosystems.

Responses

Water Management Act 2000

The *Water Management Act 2000* requires all groundwater aquifers to be managed sustainably and this is occurring through the implementation of statutory water sharing plans for groundwater.

NSW State Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (DLWC 2002) provides guidelines on how to protect and manage groundwater-dependent ecosystems. Work is ongoing to establish the location of these ecosystems and how heavily they rely on groundwater.

NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (DPI 2012) has been developed as a component of the NSW Government's Strategic Regional Land Use Policy. The new policy details how potential impacts to aquifers, such as those posed by mining and CSG activities, should be assessed and licensed to strike a balance between the water requirements of towns, farmers, industry and the environment. This plays an important role in the assessment of proposed mining and CSG developments.

Interim aquifer interference regulation

An interim aquifer interference regulation took effect on 30 June 2011, which requires new mining and petroleum exploration activities that extract more than three megalitres (ML) per year from groundwater sources to hold a water access licence.

Water sharing plans for groundwater

As of July 2015 there are 41 gazetted water sharing plans which cover groundwater sources, including all of inland NSW, with another 12 plans for coastal aquifers expected to be completed by 2016.

The intent of water sharing plans for groundwater is to manage the resource so that extraction remains in balance with the capacity to replenish it over the longer term.

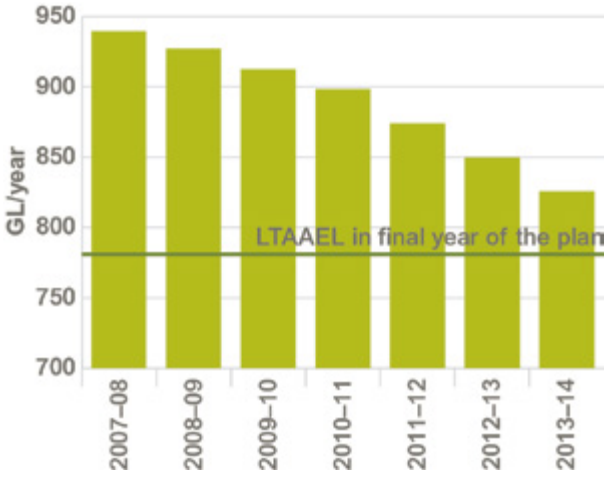
The environmental provisions in the groundwater sharing plans are centred on:

- protecting the long-term storage component of the aquifer
- reserving a proportion of the average annual recharge for the environment.

In some NSW groundwater systems, the level of entitlement was greater than the sustainable yield of the aquifer at the commencement of the water sharing plan. The implementation of water sharing plans for all groundwater sources includes a process to manage groundwater use to align with the sustainable yield of aquifers.

This is being achieved by reducing allocations in the major inland alluvial groundwater sources over the 10-year-period of the water sharing plans. Figure 19.2 shows the effect of these reductions in the early years of the plans. Usage in other over-committed groundwater systems is being similarly managed.

Figure 19.2: Entitlements to groundwater under water sharing plans in the major inland alluvial aquifers



Source: Office of Water data 2011

Cap and Pipe the Bores program

Since the 1990s, various programs have been in place to cap and pipe bores across the Great Artesian Basin, which underlies parts of NSW, Queensland, the Northern Territory and South Australia, to reduce water wastage and improve groundwater pressure.

The Cap and Pipe the Bores program provides financial incentives to landholders to offset the cost of rehabilitating bores and installing efficient piped systems to replace open bores. The pipeline systems provide water to properties,

prevent large quantities of salt from entering drainage systems, and help drought-proof properties. These measures have produced savings of 78,500 ML per year in the NSW part of the Great Artesian Basin and there has now been an increase in water pressure across the basin. A further joint Australian–NSW Government phase of the program was announced in July 2015.

Aquifer protection and research

Significant effort in groundwater research has occurred over the past three years. With the assistance of industry and government partners, NSW has undertaken studies to better understand the dynamics and chemistry of NSW aquifer systems, and their hydraulic interaction with rivers, and to learn more about groundwater-dependent ecosystems. Some of these studies have been completed and are already influencing decision-making for groundwater management.

Future opportunities

In many groundwater management areas, meter readings are not reported. Current knowledge of groundwater recharge and availability is based on estimates using the limited data available and conceptual models of groundwater recharge. Better monitoring of extraction will improve these models and enable greater accuracy when setting extraction limits.

The connections between groundwater and surface water systems should also be better understood. The potential for holistic management of closely linked systems as a single integrated resource needs further development.

As part of the water sharing plans, the sustainable extraction limit for each water source is set and in the major freshwater aquifers entitlements and extractions are at this level. However, many water sources that are deep or contain brackish groundwater have water that is not yet allocated. A process has been formulated for the controlled allocation of a proportion of this water where its use will not adversely affect surface water flows, other groundwater users or the environment, with three such controlled allocations undertaken so far.

Knowledge of groundwater-dependent ecosystems is still at an early stage and better understanding is needed of their location, characteristics and levels of dependency. Little is also known about the fauna and flora that live within, or are dependent on, groundwater aquifers and this makes it difficult to manage groundwater systems to protect them.

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20 COASTAL, ESTUARINE AND MARINE ECOSYSTEMS

Overall, the water quality of the NSW marine environment and ecosystem health is considered to be good, though a wide range of threats and risks are acknowledged. Most coastal environments are in good condition as well, whilst the condition of NSW estuaries is typically not as good and is more variable.

Recreational water quality – beach suitability grades, based on levels of stormwater and sewage contamination being low – is rated as good or very good at 83% of all beaches in NSW and at 97% of ocean beaches. It is lower at around 60% of beaches in the more enclosed waters of coastal lakes and estuaries.

The overall condition of individual waterways is highly variable and generally reflects their level of resilience to change and the level of disturbance locally and across their catchments.

Most coastal, estuarine, and marine systems in NSW have been modified to some extent, and they continue to come under increasing pressure from coastal development. Extensive catchment clearing of more than 80% is evident in around 18% of estuaries. Only about one in five estuaries and coastal lakes retain more than 90% of their natural, uncleared vegetation in those catchment areas that drain directly to the estuary or lake (such waterways are mostly found along the south coast).

NSW indicators

G Good M Moderate P Poor U Unknown

Indicator and status		Environmental trend	Information availability
Percentage of ocean and estuarine beaches with beach suitability grades for swimming of good or better	G	Stable	✓✓✓
Frequency of algal blooms	G	Stable	✓✓
Distribution of rocky reef-covering biota	G	Unknown	✓
Chlorophyll *a* levels in estuaries	M	Stable	✓
Turbidity levels in estuaries	M	Stable	✓
Distribution of estuarine macrophytes	M	Unknown	✓
Levels of estuarine catchment disturbance	M	Increasing impact	✓
Rate of sea level rise	P	Increasing impact	✓✓✓

Notes: Terms and symbols used above are defined in About SoE 2015 at the front of the report.

Context

The coastline of NSW is about 1900 km long and the state's marine jurisdiction extends 5.6 km (three nautical miles) out to sea. As well as the mouths and lower reaches of coastal rivers, intermittently closed and open lakes and lagoons are a relatively common estuary type in NSW.

The north coast is generally characterised by broad coastal floodplains that have been extensively cleared and settled. The Sydney Basin is highly urbanised with drowned river valleys cutting through sandstone plateaus. Much of the south coast is less developed and characterised by many coastal lakes and lagoons with relatively small catchments. The coastal, estuarine and marine waters of NSW contain high levels of biodiversity because of their wide range of oceanic, shoreline and estuarine habitats, combined with the strong influence of both subtropical and temperate currents.

These varied environments provide many important ecosystem services, such as preventing coastal and seabed erosion, maintaining coastal water quality, and acting as critical habitats for fish and other marine life. The community values and uses provided by the NSW marine environment include healthy aquatic ecosystems, recreation, visual amenity and aquatic food production.

The desirability of coastal lifestyles and increasing settlement along the coast are placing estuaries and coastal lakes under ever greater levels of stress. The waters and ecosystems adjacent to urban and industrial areas are particularly exposed to the effects of pollution from urban runoff, stormwater and sewage discharge. The attendant pressures of development and urbanisation, and disturbance of the natural values of surrounding catchments need to be carefully managed to protect the health and preserve the condition of estuarine environments.

Systematic data has generally been lacking on the overall condition and long-term health of the coastal, estuarine and marine areas of NSW, along with the important ecosystems they support. However, considerable data has been collected over several decades on estuarine physical characteristics, which are essential for interpretation of estuary condition.

Status and trends

Water quality

The health of coastal, estuarine and marine ecosystems and the food webs they support is heavily influenced by water quality. While water quality is naturally variable across different estuaries, pressures on it over time can lead to a reduction in ecosystem health, including changes in the distribution and abundance of species, loss of biodiversity, and 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 transport pollution (depending on the relative volume of the receiving water body). This makes marine systems less vulnerable to degradation, compared with estuaries and coastal lakes (especially those that are only intermittently open to the sea), where lower levels of dilution and tidal flushing have a reduced capacity to ameliorate pollution inflows.

Even in well-flushed systems, sedimentation and local pollution from stormwater runoff associated with urban and industrial development and sewage system overflows can have an impact on water quality. Pollutants can accumulate in sediments, and bioaccumulation in the food web can then lead to adverse effects on ecosystems and human health.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) specify a wide range of criteria for physical, chemical and biological factors for water quality. Of these, bacteriological contamination is used as a broad, general indicator of the impacts of human activities on the health of coastal, estuarine and marine waters.

Recreational water quality

High rainfall causing stormwater discharges and sewage overflows is recognised as the principal factor in the contamination of water at NSW beaches. The Beachwatch programs monitor recreational water quality at swimming beaches in NSW. While not an assessment of overall water quality and waterway health, the results from both programs provide information on the risks of sewage and stormwater pollution at beaches. This indicates the fitness of water bodies for human

recreational use, as well as the effectiveness of stormwater management.

Beachwatch & Harbourwatch – conducted by OEH – monitors 129 swimming sites in the Sydney, Hunter and Illawarra regions (72 ocean beaches and 55 estuarine beaches and two lagoon/lake sites). Under the Beachwatch Partnership Program, regional coastal councils also monitor beaches in their areas. In the 2013–14 swimming season, 11 local councils participated in this program, which monitored 120 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), determined in accordance with the Guidelines for Managing Risks in Recreational Water (NHMRC 2008) (a new standard adopted by the Beachwatch programs in 2009). In 2013–14, 83% of the 249 swimming locations monitored were graded as 'very good' or 'good'. Reflecting the lower capability of these systems to dilute and flush pollution, only 41% of lake/lagoon swimming sites and one of the two ocean baths were graded as 'very good' or 'good'. However, 71% of estuarine beaches achieved these ratings, as did nearly all ocean beaches (97%) (Map 20.1).

Figure 20.1 (overleaf) shows the proportion of sites with only low levels of faecal contamination over the past 19 years at ocean and estuarine beaches in the greater Sydney area. Before about 2002, wet weather had a much greater impact on swimming locations in Sydney. As a comparison, during 1998–99, almost as much rain fell as in 2007–08 and 2010–11; however, in 2010–11, 85% of estuarine swimming sites recorded low levels of enterococci (MAC A or B) while reprocessing the 1998–99 data for this new assessment system gives a result of only 2%.

Map 20.1: Beach suitability grades at coastal and estuarine swimming sites in NSW, 2013–14

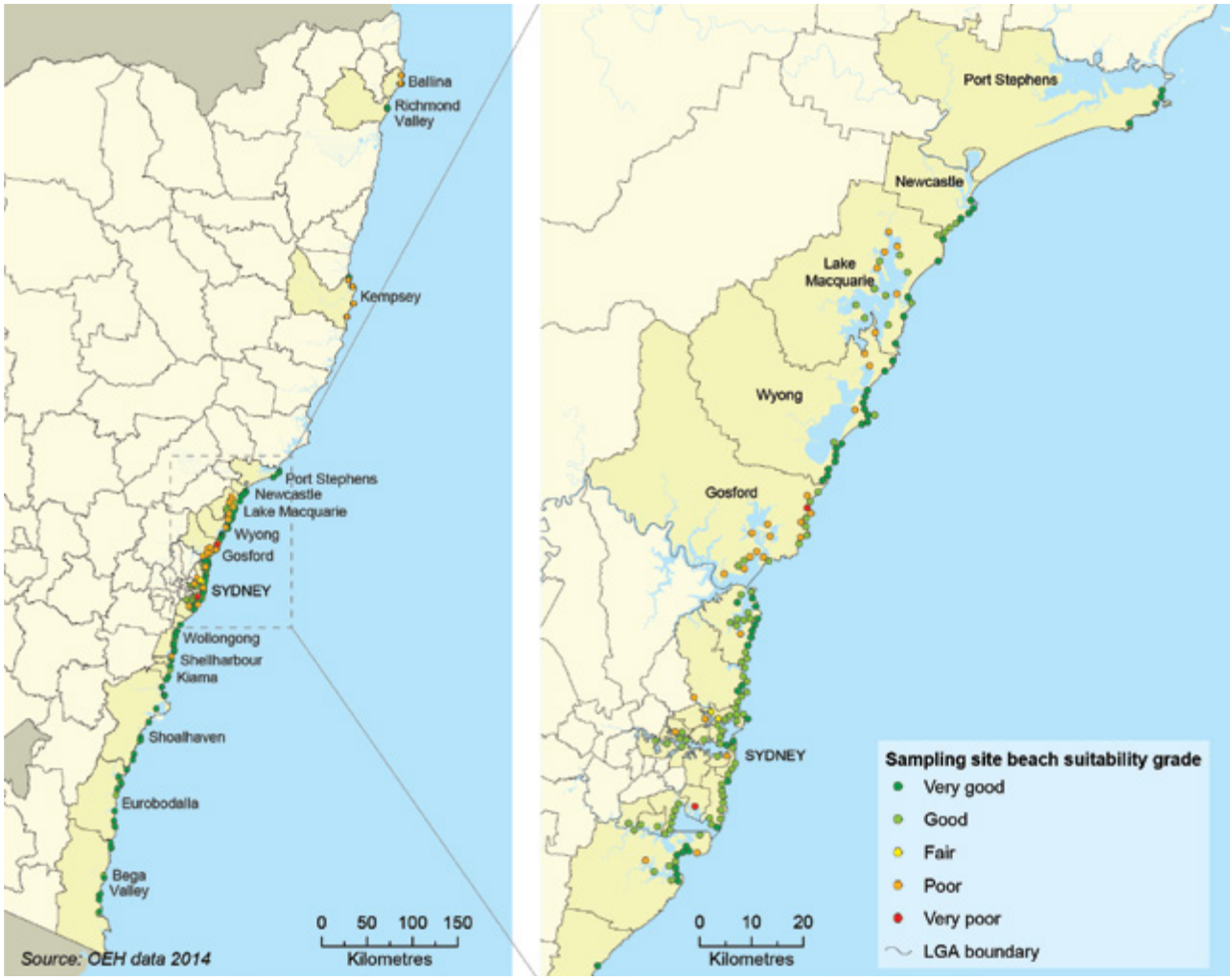
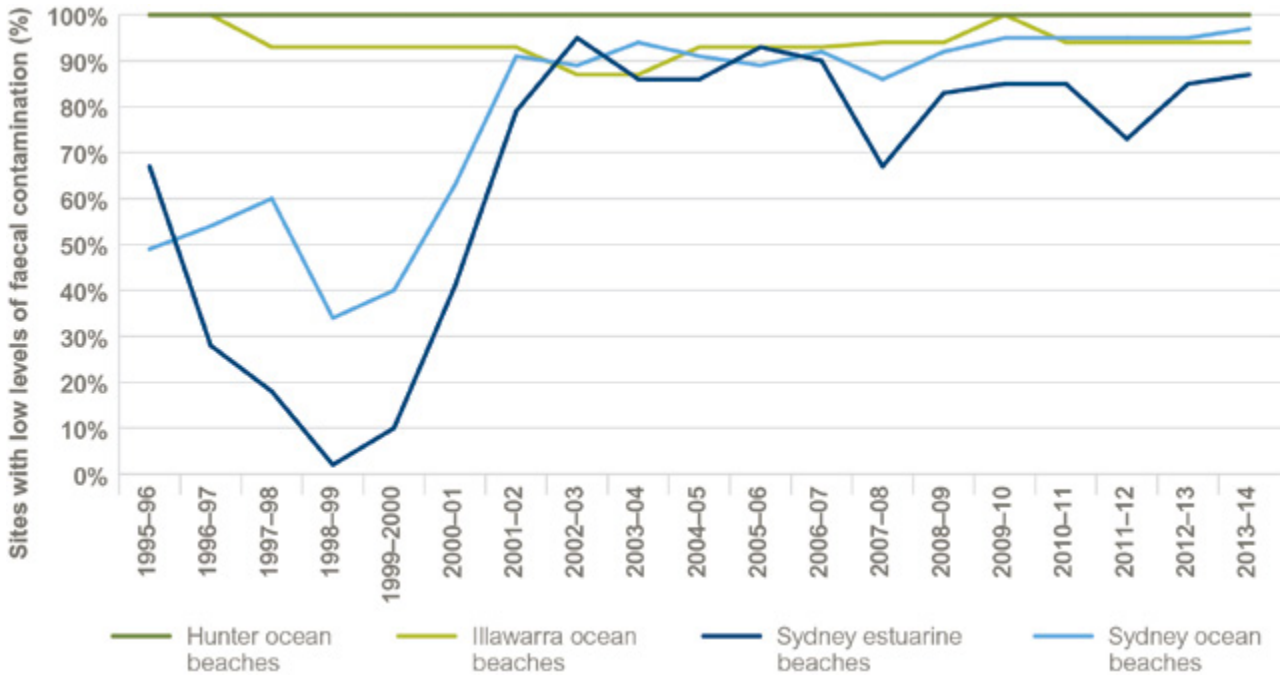


Figure 20.1: Percentage of Sydney, Hunter and Illawarra beach and estuary monitoring sites graded as having low levels of faecal contamination, 1995–96 to 2013–14



Source: OEH data 2014

Notes: Beach suitability grades are only available from 2009–10 onwards. To report on trends through time, Microbial Assessment Categories have been back-calculated using historical enterococci data. Microbial Assessment Categories A and B indicate generally low levels of faecal contamination and are required for a swimming site to achieve a 'very good' or 'good' beach suitability grade.

Data from the Beachwatch Partnership Program is not included.

Overall, these are strong results, with significant reductions in bacterial levels at swimming locations in the Sydney region arising from improvements in stormwater and wastewater management over the past decade. Nevertheless, the results for recent years continue to indicate the need to improve the management of stormwater inflows to estuaries in urban catchments.

Detailed results for all swimming sites monitored in NSW can be found in the State of the Beaches reports (OEH 2014).

Eutrophication

Catchment disturbance (e.g. soil erosion) together with urban, industrial, and effluent discharges, can add nutrients and particles to waterways. These are conditions that can skew aquatic biodiversity towards algae and other simple aquatic organisms. Eutrophication occurs as water clarity drops and nutrients and organic matter accumulate. This results in aquatic plants and animals struggling to get the light and oxygen they need to grow. Some algal species may produce toxins that have serious implications for fish, shellfish and humans coming into contact with the water.

Abnormally high turbidity (low water clarity) or high levels of chlorophyll *a* (indicative of high phytoplankton levels or algal blooms) can signal that a water body is experiencing eutrophication. Sometimes this can be attributed to natural causes, but often it is human-induced. Ocean upwellings, which have a close association with El Niño cycles, can lead to natural blooms.

As part of the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (MER Strategy) (DECCW 2010b), trigger values and compliance intervals for turbidity and chlorophyll *a* were derived (see Roper et al. 2011) using an approach consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000). Exceeding the guidelines' trigger levels does not automatically indicate that estuarine conditions are poor, but any pattern

of exceedances is regarded as a cue for further investigation to determine whether water quality issues exist.

Turbidity and chlorophyll *a*: Data on estuarine turbidity and chlorophyll *a* are available from July 2008 to March 2014. These data were categorised into six estuary types (Roper et al. 2011) and report card grades, which incorporate both magnitude and frequency of non-compliance with the NSW estuary specific trigger values (OEH 2013a). Report card scores are A (very good), B, C, D, F (very poor).

The results (Tables 20.1 and 20.2) indicate that in general the majority of all estuary types are in at least good condition, but that back dune lagoons and creeks are most likely to suffer from high turbidity when disturbed and drowned river valleys and barrier rivers and to some extent. Creeks are most likely to have poor scores for chlorophyll.

Algal blooms (offshore): Satellite data has been used for the broad and systematic assessment of the frequency and type of blooms in coastal and marine waters. This has shown that overall, the frequency of algal blooms appears to be relatively stable (see Algal blooms in SoE 2012 (EPA 2012)). ANZECC trigger values for offshore waters are currently being reviewed to account for smaller scale variations along the shelf of NSW.

Ecosystem health

Aquatic vegetation along the NSW coast falls into two broad categories: biota attached to rocky features (reefs, headlands, etc.) and plants rooted in sediments (mostly the estuarine macrophytes: seagrass, mangroves and saltmarsh). Coastal vegetation, such as dune, coastal heath and woodland, and back-beach swamp ecosystems, are important for the overall health of coastal environments.

Systematic, ongoing monitoring of these communities has not occurred, with the most recent major studies reported in SoE 2012 (summarised in Table 20.3, overleaf).

Threatened species

Information on the status of marine species is generally not as good as that for terrestrial species. However, 41 marine species and one marine population are currently listed as threatened, including some presumed extinct, in the *Fisheries Management Act 1994* (FM Act) and *Threatened Species Conservation Act 1995* (TSC Act):

- marine seabirds (19 species)
- marine mammals (7 species)
- fish (6 species)
- reptiles (3 species)
- marine invertebrates (4 species)
- macroalgae (2 species)
- marine vegetation (1 species, 6 populations).

These listings can be expected to change over time, with the number of species listed potentially growing as pressures on the marine environment increase. Higher order species, such as sharks, tuna and whales, remain the most vulnerable to external pressures (see 'Pressures' section).

Table 20.1: Turbidity – Percentage of estuaries that attained each grade

	Water quality grade				
	A	B	C	D	F
Barrier river	10	49	31	8	2
Back dune lagoon	19	31	31	6	12
Lagoon type B (creek)	5	23	31	31	0
Drowned river valley	14	42	42	0	0
Lagoon type A (lagoon)	35	30	22	9	4
Lake	37	21	26	15	0

Source: Roper et al. 2011; OEH 2013a

Table 20.2: Chlorophyll *a* – Percentage of estuaries that attained each grade

	Water quality grade				
	A	B	C	D	F
Barrier river	15	36	31	15	3
Back dune lagoon	38	44	19	0	6
Lagoon type B (creek)	19	23	42	8	8
Drowned river valley	14	28	14	28	14
Lagoon type A (lagoon)	30	30	34	4	0
Lake	15	37	42	5	0

Source: Roper et al. 2011; OEH 2013a

Table 20.3: Changes in rocky reef biota and macrophyte distribution

Rocky reef biota	Seagrass	Mangroves	Saltmarsh
	These macrophyte communities have an important role in maintaining sediment stability and water quality, and they provide shelter and food to a wide variety of aquatic biota.		
Whilst selected biota (such as specific species of seaweed) have been found to have increased or reduced abundance relative to the size of local human populations, overall there appears to be no significant association between human population level and either condition or patterns of change in condition.	Four estuaries account for more than 60% of the total area of seagrass in NSW. Causes of seagrass decline include: • eutrophication and pollution • physical disturbance, such as dredging and reclamation • changes to hydrologic flows • natural episodes (e.g. storms). The overall decline in the extent of seagrasses for the whole coast since European settlement has been estimated at less than 30%, but with many major estuaries, the loss is as much as 85%. Recent surveys indicate ongoing losses tend to be small and may relate to localised climatic events, such as high rainfall and flooding rather than direct human impacts.	Three major estuaries – Port Stephens and the Hunter and Hawkesbury rivers – account for approximately 50% of the total distribution of mangroves in NSW. Similar to seagrasses, the loss of mangroves has been estimated at between 30% and 70%. Mangroves are, however, quite resilient and are able to rapidly colonise favourable areas. In more than two dozen estuaries, mangrove forests have been found to be expanding. This may be due to the recolonisation of previously cleared areas, expansion into areas of saltmarsh, or colonisation of sediment banks and locations with altered hydrologic regimes.	There has been a substantial decline in the extent of saltmarsh since European settlement, estimated to be 30% to 70%. Recent surveys indicate ongoing losses tend to be small. Causes of saltmarsh decline include: • infilling • modified tidal flows • weed invasion • human disturbance • climate change. Losses of saltmarsh have been particularly severe in the Sydney region and on the central coast. Saltmarsh has been listed as an endangered ecological community in NSW due to the nature of ongoing losses.

Source: EPA 2012

Pressures

Population and demographic change

The majority of the NSW population lives close to the coast; in 2014, two thirds of the estimated resident population of NSW resided in the coastal councils. This proportion is rising due to the stronger population growth in the Greater Metropolitan Region (GMR_2), and because internal population migration is dominated by migration to coastal areas rather than inland areas (see Theme 1: Population for more details).

The average population density is greater than 40 people per km^2 in coastal catchments, greater than 200 people per km^2 in estuarine catchments, and more than 5000 people per km^2 in Port Jackson and Dee Why catchments. These population patterns place considerable pressure on coastal and estuarine ecosystems through increased development and disturbance of the catchments.

Catchment disturbance

Disturbances across catchments can include:

- changes to estuarine habitats, water quality and estuarine processes due to the removal of aquatic vegetation, introduction of new biota, waterway engineering (e.g. land reclamation, hard erosion control structures, weirs, training walls and artificial entrance openings), building works (e.g. marinas and boat ramps), fishing/trawling, and aquaculture developments
- disruption or modification of the riparian and foreshore zones, which are particularly important as barriers and filters protecting the water body and minimising erosion (pressures originating in this area are likely to have a more direct impact on estuary condition than the same pressure acting further away)

- further away from the water, changes in land use and the removal of vegetation, leading to increased loads of diffuse source nutrients and sediments, and pollutants (this can be a less immediate impact on estuary condition, but the cumulative impact from the large areas involved can be significant).

Systematic, ongoing monitoring of the condition of and disturbances to waterway riparian and catchment areas has not occurred. Recent major studies were reported in SoE 2012. Surveys tend to be conducted once, for example, land use, but need to be repeated at regular intervals to monitor change and any associated increase in pressure.

A key finding was that 71 (or more than a third) of NSW estuaries have catchment clearing rates of less than 20%. Of those 71, about half have less than 7.5% clearing. At the other end of the spectrum, 19 or about 10% of estuaries have clearing rates of more than 80% (Roper et al. 2011). These results indicate the relatively undeveloped nature of large parts of the NSW coast and the concentration of population within a discrete number of major urban centres. This variability is seen as a key strength in population patterns that should be protected.

A second observation is that the degree of clearing tends to increase further down a catchment. This is generally the part of the catchment that drains directly to the estuary (with nearly one in five estuaries having clearing rates greater than 80% in the direct drainage zone). Many of these estuaries are considered to be in a fair to poor state, particularly the smaller systems with intermittent connections to the ocean. Larger, or better-flushed, estuaries that have been extensively cleared were generally assessed to be in better condition.

Similar patterns of disturbance were found in riparian areas in that it is focused more on urban areas, but with some distinct differences. The extent of riparian disturbance generally reflects that part of the catchment draining directly into the estuary; however, the correlation is not as good with the fluvial catchment that drains areas above the tidal limit. For some catchments, the overall catchment clearing can be relatively low but the riparian clearance is high, reflecting development concentrated around an estuary. In non-urban areas, waterway disturbance had a tendency to relate to aquaculture (especially along the south coast).

Nutrient and sediment loads

Sediment and nutrient loads from land-use changes and land management practices were modelled (see Roper et al. 2011) and combined with data from the NSW Environment Protection Authority (EPA) licensing system (primarily point source discharges from sewage treatment plants) to give estimated annual loads for total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP).

This analysis reveals that, compared to natural levels, more than half of NSW estuaries are estimated to have experienced a doubling (or greater) of loads of TSS. For nutrients, nearly half of NSW estuaries have experienced a doubling (or greater) of TN levels, and nearly three in four estuaries have experience doubling (or greater) of TP levels (see SoE 2012 for details). As licensed discharges have been relatively stable, these variations have been driven more by broadscale catchment changes.

Part of these material inputs to estuaries are carried out to sea. This is estimated to be an average of around 23,000 tonnes of nitrogen, 2500 tonnes of phosphorus and 835,000 tonnes of sediment per year from 184 estuaries (Roper et al. 2011).

Direct 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 runoff in developed areas, as well as licensed discharges from industry, e.g. minerals production and refining, and sewage treatment plants.

Figure 20.2 shows licensed discharges of total nitrogen, total phosphorus and TSS to open marine waters and estuaries. Discharges to estuarine environments have been decreasing over the period shown. Licensed discharges of nitrogen to the marine environment have increased by about 1% per year, whereas phosphorus has been decreasing by about 1% per year. Discharges of suspended solids tend to reflect wet and dry periods (such as El Niño cycles), but have been relatively stable overall.

Licensed discharges of suspended solids to the marine environment represent less than 7% of the total received by the coastal, estuarine and marine environment. Also, except for Sydney and Wollongong coastal waters (and a few of the smaller north coast estuaries), diffuse source discharges to the marine environment are more significant contributors of nutrients to marine waters than are point source discharges.

Other pollution and refuse

Additional sources of coastal and marine pollutants include:

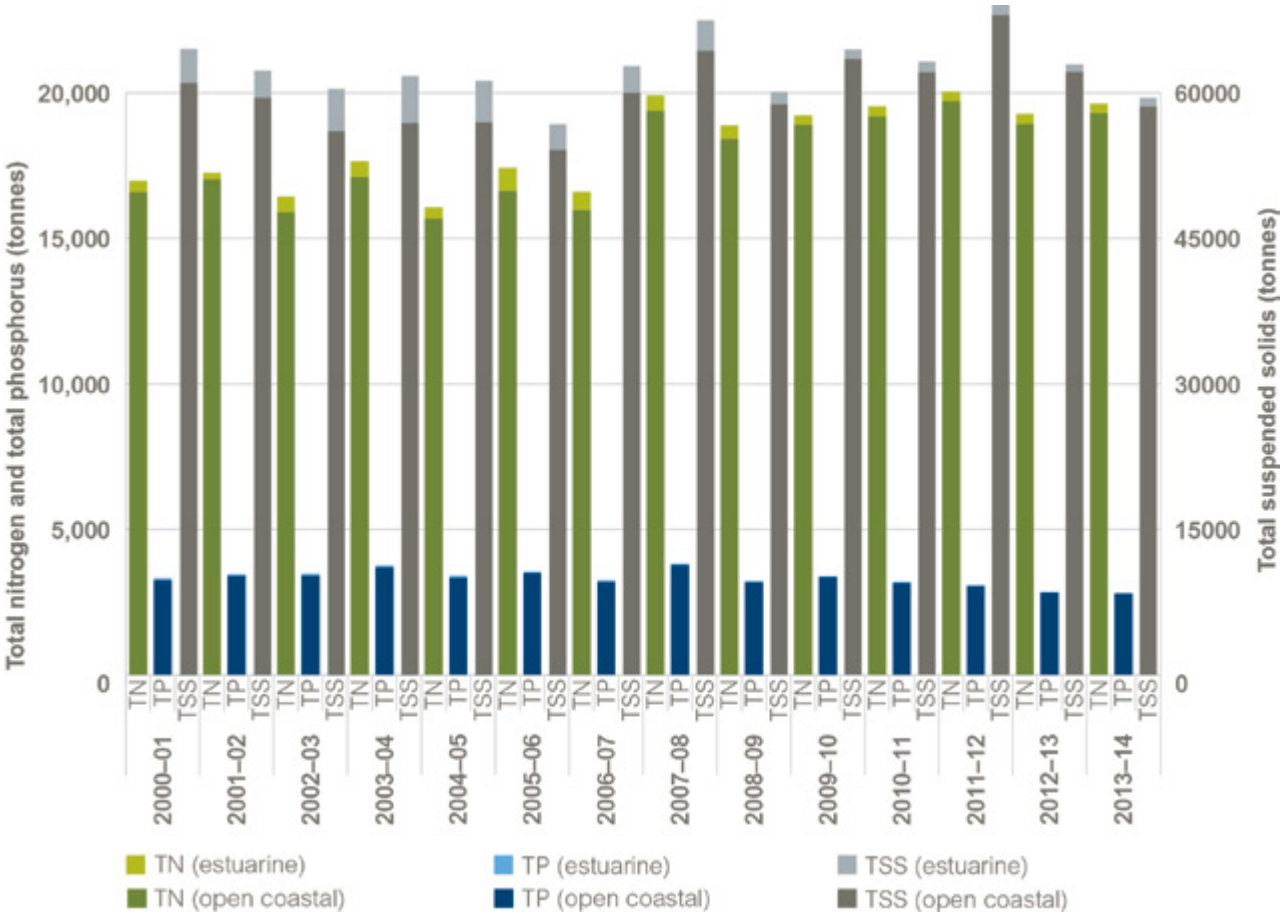
- garbage washed or blown from land
- discarded fishing gear (both commercial and recreational)
- material from shipping operations and incidents, such as ballast water discharges and sewage released from vessels, and oil or chemical spills.

No major shipping-related pollution incidents have been recorded in NSW marine waters over the last three years.

Entanglement and ingestion of such debris can be fatal to marine species, particularly threatened species, such as seabirds, turtles and whales. The Australian Government *Environment Protection and Biodiversity Conservation Act 1999* lists 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' as a key threatening process. Recovery in the populations of threatened species, such as humpback whales, is likely to result in a greater number of accidental entanglements.

As much debris is plastic, which both floats and is slow to degrade, the impacts can be multiple and long-lasting. This issue was a specific focus of World Oceans Day 2015 in Australia.

Figure 20.2: Licensed discharges to NSW open marine waters and estuaries, 2000–01 to 2012–13



Source: EPA data 2015

Notes: Data covers all licensees discharging into the marine environment under the load-based licensing scheme.

Fishing

Commercial and recreational fishing occurs in the coastal, estuarine and marine waters of NSW. Commercial fish catch data available for estuaries indicates fishing is conducted in a total of 57 estuaries with over half the total fish catch of 4800 tonnes coming from five estuaries. In decreasing order of catch size, these are Clarence River, Wallis Lake, Hawkesbury River, Port Stephens and the Myall River system.

Commercial and recreational fishing place pressures on the fisheries they target as well as other biodiversity and the broader environment. Impacts from fishing and trawling can include damage to habitat (by gear catching on the submerged reefs, dragging of nets across seagrass beds, etc.), bycatch, waste (see above), and demand on infrastructure.

Under the FM Act, hook and line fishing in areas important for the survival of threatened fish species is listed as a key threatening process. The current shark meshing program in NSW waters is also listed as a key threatening process under both the FM Act and the TSC Act.

Invasive species

The introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW is listed as a key threatening process under the FM Act. Marine invasive species are plants or animals – often introduced from overseas – that can have a significant impact on marine industries and the environment, by taking over habitats and directly competing with native species for food. Marine pests include mussels, crabs, seaweeds, sea stars and other marine species. Some marine pests are native to other regions of Australia but have been transported into NSW through shipping or the aquarium trade (see also Theme 15: Invasive species).

Climate change

Both the FM Act and TSC Act list human-induced climate change as a key threatening process.

The potential impacts of climate change on coastal, estuarine and marine environments are not well understood. Predicted increases in sea surface temperature and ocean acidification, however, are likely to have significant impacts, as is increased flooding from more frequent and more intense east coast lows, along with increased coastal inundation from sea level rise.

Sea surface temperature and salinity

Over the past 40 years, average sea surface temperatures in NSW coastal waters have increased by 0.5°C in the north of the state and up to 0.8°C in the south (OEH 2011). Temperatures in the Tasman Sea off the east coast of NSW have risen markedly. Climate change predictions for NSW include higher sea surface temperatures (potentially by up to 4°C), more frequent storms and stronger currents (Hobday & Lough 2011). Changes to currents, regional wind patterns and mixed layer depths are also likely to affect upwellings, with an associated impact on primary productivity (Hobday et al. 2006).

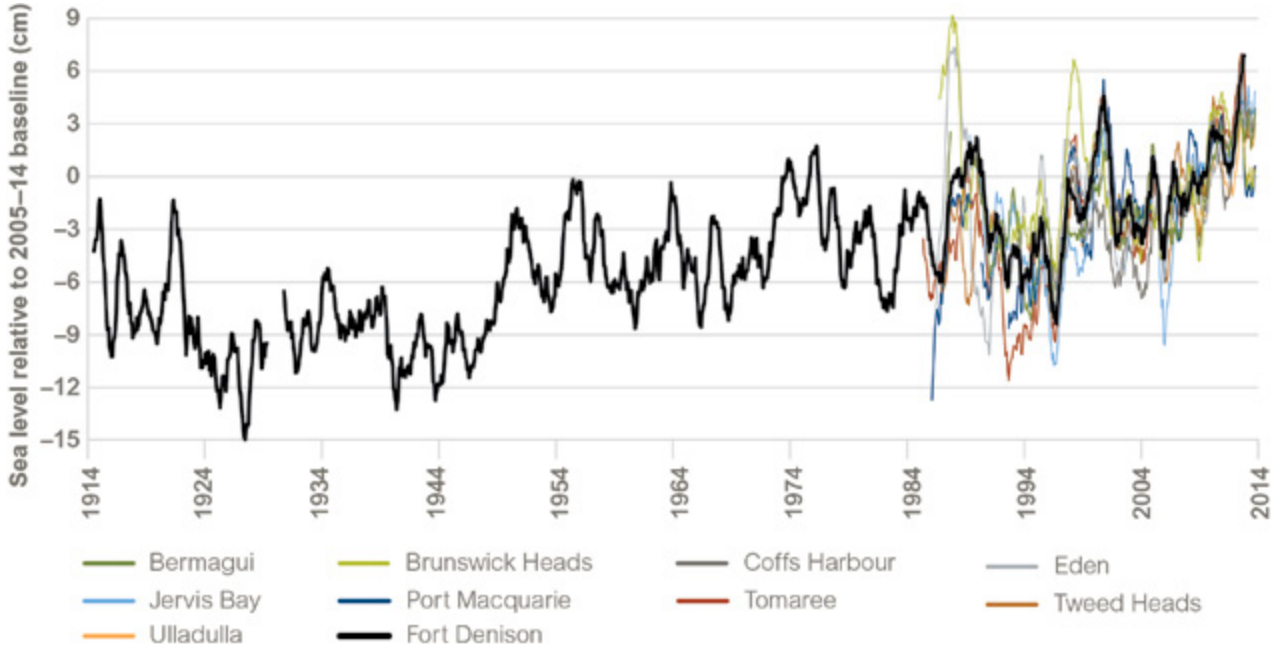
To illustrate this, the east Australian current now extends 350 km further south, making southern waters warmer and saltier than previously (Ridgway 2007). An observed impact of this change has been the spread of the black spiny sea urchin from NSW into Tasmania, where it was not previously found. The urchin is a voracious predator of important algal species and threatens fisheries (Ling et al. 2009). In addition, it has been found that 45 species of fish have changed their distribution in south-eastern Australia over recent years, with the change corresponding to warming observed in the marine environment (Last et al. 2010).

Marine acidification

The world's oceans currently absorb about 25% of the carbon dioxide (CO_2) generated by humans, with about 40% of this absorbed in the Southern Ocean (CSIRO & BoM 2010). The CO_2 absorbed by the ocean increases its acidity, which is registered as a decrease in pH. Since 1870 the marine waters of the Australian region have experienced a pH decrease of 0.09 (Lenton et al. 2015).

Any measurable change in pH is significant and has a potential impact on the marine environment. Ocean acidification will decrease the ability of calcitic organisms such as molluscs to form shells and corals (Fabry et al. 2008; CSIRO & BoM 2010). Organisms that secrete calcite in its more soluble form of aragonite are particularly susceptible.

Figure 20.3: Monthly average sea levels along the NSW coast, 1914 to 2014



Source: Couriel et al. 2014; Manly Hydraulics Laboratory data as at July 2015

Notes: These monthly water level trends for NSW tide gauges are based on rolling 12-month averages. Levels for all stations are normalised so the average water level for 2005–2014 is zero. In addition, tide-gauge data has been indexed relative to Fort Denison (Sydney Harbour).

Graph (from Couriel et al. 2014) has been updated with more recent, quality-controlled, data from the Manly Hydraulics Laboratory. Rolling 12-month averages with fewer than nine months of data have been excluded.

Since these organisms play an important role in food webs and the natural cycling of carbon, this will have far-reaching implications for the future health of ocean ecosystems. These effects are now being observed in the Southern Ocean, and a measureable decrease in the aragonite saturation state has been observed in the Australian region (Lenton et al. 2015).

Sea level rise and coastal inundation

Variations in climate and sea level are inextricably linked (BoM 2011). Warming temperatures lead to sea level rise for two main reasons: water expands as it warms and, as average temperatures rise, land-based ice sheets begin to melt (IPCC 2007). Whilst sea level rise is not uniform across the world or around Australia (due to regional climatic cycles such as El Niño – Southern Oscillation and the Indian Ocean Dipole and movements in the land from uplift or subsidence), Australian mean sea level trends are broadly consistent with average global trends from 1966 to 2010. This includes an increase in the rate of rise in the early 1990s (White et al. 2014). Allowing for differences characteristic of physical movement of ocean currents and weather systems, sea level rise at monitoring stations along the NSW coast shows common trends (Figure 20.3), and has generally increased by about 1 mm per year (at Fort Denison, the average rate has been 0.9 mm per year from 1914 to 2006) (Couriel et al. 2014).

Sea level rise is virtually certain to increase the extent or height of tidal levels, enlarging the areas of low-lying land near coastal waterways that are exposed to tidal inundation (DECCW 2010a). Due to the combined influence of sea level rise and higher rainfall events, the frequency, height and extent of floods are expected to increase in the lower parts of coastal floodplains (DECCW 2010a). With over 80% of the NSW population living in the coastal strip (see Theme 1: Population for more details), rising sea levels are likely to have a significant effect on human settlements in coastal NSW.

Most coastal dunes and some beach-barrier systems and estuaries are expected to be affected by an increased threat of erosion from a combination of sea level rise, changes in wave direction, and greater storm intensity. A number of sites along the NSW coast have already experienced additional coastal erosion (DECCW 2010a).

The effect of rising sea levels on natural systems is demonstrated by mangrove swamps encroaching on areas previously occupied by saltmarsh. In 70% of estuaries surveyed in Queensland, NSW, Victoria and South Australia, the area of saltmarsh taken over by mangroves has been greater than 30% and in some cases mangroves have completely replaced saltmarsh. This change has largely been attributed to a combination of localised land subsidence and sea level rise (Saintilan & Williams 1999; Saintilan & Williams 2000; Rogers et al. 2006). As water levels rise, the ability of some communities, such as saltmarsh, to colonise new areas at more suitable elevations may be impeded by the presence of coastal development (Goudkamp & Chin 2006). This phenomenon has been called 'coastal squeeze'.

Other pressures

A range of other pressures also affect waterway health, but their cumulative impact is more difficult to measure or assess. Tidal flows within estuaries may be directly affected by rock training walls designed to keep estuary entrances open, the artificial opening of lagoon entrances to alleviate flooding and water quality concerns, and other flood mitigation structures.

Changes to catchment hydrology can occur with land developments which increase the volume and frequency of freshwater flows entering estuaries. Conversely, inputs can decrease with upstream water storages, extraction of water for agriculture, and barriers such as weirs. Cumulatively, hydrology changes can have a significant impact on water levels, tidal and mangrove limits, salinity and nutrient concentrations, along with the distribution and composition of estuarine ecosystems.

Responses

Legislation

The NSW Coastal Policy 1997 (NSW Government 1997) and *Coastal Protection Act 1979* provide the strategic direction and legislative framework for managing the NSW coastal zone, including the requirement for coastal zone management plans (see below).

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 address planning issues relevant to the coastal zone:

- SEPP No 71 – Coastal Protection, which ensures that: development in the NSW coastal zone is appropriate and suitably located; there is a consistent and strategic approach to coastal planning and management; there is a clear framework for assessing development in the coastal zone.
- SEPP No 14 – Coastal Wetlands ensures that coastal wetlands are preserved and protected for environmental and economic reasons.
- Other SEPPs relevant to coastal development include: SEPP No 26 – Littoral Rainforests; SEPP No 50 – Canal Estate Development; SEPP No 62 – Sustainable Aquaculture.

The *Protection of the Environment Operations Act 1997* regulates point source discharges into coastal, estuarine and marine environments, and regulates discharges of oil and other noxious substances from ships.

The *Marine Estate Management Act 2014* (MEM Act) provides for the strategic and integrated management of the whole marine estate – our marine waters, coasts and estuaries (see also Theme 14: Protected areas and conservation). The new Act, which repeals the *Marine Parks Act 1997* and the aquatic reserves division of the *Fisheries Management Act 1994* (FM Act), provides for a comprehensive system of marine parks and reserves. It also provides a statutory base for the Marine Estate Management Authority and the Marine Estate Expert Knowledge Panel.

The MEM Act also 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 outcomes of the TARA will directly inform the development of a marine estate management strategy that will identify priority management actions and set cross-agency policy direction for managing the marine estate as a single continuous system. Both the TARA and the marine estate management strategy are currently under development and will be completed in 2015–16.

To this end, a Threat and Risk Assessment Framework (MEMA 2015) was published in April 2015. This key policy document sets out

how threats and risks to the environmental, economic and social benefits derived from the NSW marine environment will be assessed and prioritised. This assessment will support the development of management responses to the most important threats.

The FM Act and supporting regulations provide for conservation of fish stocks, key fish habitats, threatened species, populations and ecological communities of fish and marine vegetation.

Policies and programs

Complementing the regulatory regime, NSW is developing and implementing a range of polices, programs, and other activities.

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.

Management of water quality: The main responses aimed specifically at improving estuarine water quality by reducing pollution include:

- setting Marine Water Quality Objectives for NSW Ocean Waters (DEC 2005) – these describe the water quality needed to protect the community's values for, and uses of, the marine environment. They simplify and streamline the consideration of water quality in coastal planning and management planning strategies covering land use and catchment management, which set water quality objectives
- developing the NSW Diffuse Source Water Pollution Strategy (DECC 2009) – this recognises that diffuse source pollution accounts for the majority of the pollution load in NSW waterways, and it aims to coordinate the NSW Government's approach to manage these issues.

Coastal zone and estuary management plans: These plans are being prepared and implemented by local councils for about half of the state's 184 estuaries in order to achieve integrated, balanced and ecologically sustainable management. The Guidelines for Preparing Coastal Zone Management Plans (OEH 2013b) provide advice to local councils, their consultants and coastal communities on the preparation of coastal zone management plans.

The primary purpose of these plans is to address priority management issues in the coastal zone including:

- managing risks to public safety and built assets
- pressures on coastal ecosystems
- community uses of the coastal zone.

Plans for estuaries should include:

- a description of the condition of estuaries within the plan's area
- details of the pressures affecting estuary condition and their relative magnitude
- proposed actions to respond to pressures on estuary condition
- an entrance management strategy for intermittently closed and open lakes and lagoons
- an estuarine monitoring program.

Coastal reforms: The NSW Government has committed to continuing its coastal reform agenda. Three new elements of the reforms are being planned, which include:

- replacing the current legislation with new coastal management legislation – a proposed new coastal management Act
- new arrangements to better support council decision-making, including a decision support framework, a new coastal management manual, and improved technical advice
- more sustainable arrangements for funding and financing coastal management activities.

Public exhibition of a draft exposure Bill of the proposed new coastal management Act is scheduled for late-2015.

Regional plans: These set a strategic direction for selected, rapidly growing, coastal regions (see Theme 1: Population for more details).

Catchment action plans: These are being implemented by local land services and represent the key process that coordinates and drives natural resource management at the regional level.

Australian Government activities

Under the National Water Quality Management Strategy (NWQMS), management plans are being developed and implemented for estuaries, coastal waters, and other water bodies. These plans use the NWQMS to protect agreed

environmental values. A particular focus is on coastal pollution hotspots 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.

Future opportunities

NSW 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 all future settlements in catering for an expanding population and development needs.

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 resources
- strengthening comprehensive ecosystem health monitoring programs to provide sound scientific input to decision-making
- further development and expansion of risk assessment methods to help protect and rehabilitate the environment in the most resource efficient manner.

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ABBREVIATIONS AND ACRONYMS

AAQ NEPM	National Environment Protection Measure for Ambient Air Quality
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AEEA	Australian Environmental-Economic Accounts
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ANSTO	Australian Nuclear Science and Technology Organisation
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure 1999
AWD	available water determination
BAM	biodiversity assessment method
BASIX	Building Sustainability Index
BFCC	NSW Bush Fire Coordinating Committee
BioBanking	Biodiversity Banking and Offsets Scheme
BTRE	Bureau of Transport and Regional Economics
BoM	Bureau of Meteorology
BREE	Bureau of Resources and Energy Economics
C&D	construction and demolition (waste)
C&I	commercial and industrial (waste)
CAHC	Clean Air, Healthy Communities program
CBD	Commercial Building Disclosure
CCA	copper chrome arsenate
CCF	Climate Change Fund
CDS	container deposit scheme
CFI	Carbon Farming Initiative
CINSW	Coal Innovation NSW (Fund)
CLM Act	*Contaminated Land Management Act 1997*
CMA	catchment management authority
CO	carbon monoxide
CO_2	carbon dioxide
COAG	Council of Australian Governments
CSG	coal seam gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWP	cold water pollution
DCCEE	Department of Climate Change and Energy Efficiency (Australian Government)
DEC	Department of Environment and Conservation NSW
DECC	Department of Environment and Climate Change NSW (formerly DEC)
DECCW	Department of Environment, Climate Change and Water (formerly DECC)
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth)
DFS	Department of Finance and Services (NSW)
DLWC	Department of Land and Water Conservation (NSW)
DP&E	Department of Planning and Environment (NSW)
DPI	Department of Primary Industries (NSW)
DUAP	Department of Urban Affairs and Planning (NSW)

DWE	Department of Water and Energy (NSW)
EDO	Environmental Defenders Office (NSW)
EEGP	Energy Efficient Government Program (NSW)
EEAP	NSW Energy Efficiency Action Plan
ENSO	El Niño – Southern Oscillation (Index)
EOAM	Environmental Outcomes Assessment Methodology
EPA	Environment Protection Authority (NSW)
EPHC	Environment Protection and Heritage Council
ERF	Emissions Reduction Fund
ESCo	energy service company
ESD	ecologically sustainable development
ESS	Energy Savings Scheme
EWMP	environmental water management program
FM Act	*Fisheries Management Act 1994*
FMS	fire management strategy
GCCSA	(Sydney) Greater Capital City Statistical Area
GDE	groundwater-dependant ecosystem
GEMS	Greenhouse and Energy Minimum Standards
GMR	Greater Metropolitan Region (see Glossary)
GREP	Government Resource Efficiency Policy (NSW)
GSP	gross state product
GVA	gross value added
GWP	global warming potential
IBRA	Interim Biogeographic Regionalisation for Australia
IEA	International Energy Agency
IOD	Indian Ocean dipole
IPART	Independent Pricing and Regulatory Tribunal
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
KTP	key threatening process (see Glossary)
Landsat	*Land* and Earth Observation *Sat*ellite
LGA	local government area
LLS	local land services
LMwC	land management within capability
LSC	land and soil capability
LTAAEL	long-term average annual extraction limits (see Glossary)
LULUCF	land use, land use change and forestry
LWU	local water utility
MAC	microbial assessment category
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
MEHW	mouse-ear hawkweed
MEMA	Marine Estate Management Authority (NSW)
MER	monitoring, evaluation and reporting
MIL	monitoring investigation level
MLA	Metropolitan Levy Area
NABERS	National Australian Built Environment Rating System
NEM	National Electricity Market
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NGPSG	National GreenPower Steering Group
NHMRC	National Health and Medical Research Council
NLI	National Litter Index
NLWRA	National Land and Water Resources Audit
N	nitrogen

NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NOW	NSW Office of Water
NPW Act	*National Parks and Wildlife Act 1974*
NPWS	National Parks and Wildlife Service (NSW)
NRC	Natural Resources Commission
NRM	natural resource management
NRMMC	Natural Resource Management Ministerial Council
NRS	national reserve system
NV Act	*Native Vegetation Act 2003*
NWI	National Water Initiative
NWQMS	National Water Quality Management Strategy
O_3	ozone
OA	Office for Ageing (NSW)
OECD	Organisation for Economic Cooperation and Development
OEH	Office of Environment and Heritage (formerly DECCW)
OHW	orange hawkweed
P	phosphorus
PAS	priorities action statement
PCP	pentachlorophenol
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometres (10^{-6} metres)
$PM_{2.5}$	particulate matter less than 2.5 micrometres (10^{-6} metres)
POEO Act	*Protection of the Environment Operations Act 1997*
PoM	plan of management
PV	photovoltaic (solar energy)
PVP	property vegetation plan
RAMA	routine agricultural management activity (by local government)
RCEP	Regional Clean Energy Program
RD&E	research, development and extension
REAP	Renewable Energy Action Plan
RET	Renewable Energy Target
RFMS	reserve fire management strategy
RIFA	red imported fire ant
RIS	regulatory impact statement
SCA	state conservation area
SDL	Sustainable Diversion Limit (Murray–Darling Basin Plan)
SEEA	System of Environmental-Economic Accounts
SEPP	state environmental planning policy
SHEBA	Soil Health Evidence Based Assessment
SLATS	statewide landcover and tree survey
SMI	statement of management intent
SMU	soil monitoring unit
SNA	System of National Accounts
SO_2	sulfur dioxide
SRA	Sustainable Rivers Audit
T&I	Department of Trade and Investment (NSW)
TAP	threat abatement plan
TfNSW	Transport for NSW
TN	total nitrogen
TP	total phosphorous
TSC Act	*Threatened Species Conservation Act 1995*
TSR	travelling stock route
TSS	total suspended solids
UNFCCC	United Nations Framework Convention on Climate Change
UPSS Regulation	Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008
UV-B	ultraviolet radiation in the 280–320 nm wavelength band
VKT	vehicle kilometres travelled
VOC	volatile organic compound

VR1	Stage 1 vapour recovery (motor vehicle emissions)
VR2	Stage 2 vapour recovery (motor vehicle emissions)
WARR	Waste Avoidance and Resource Recovery
WELS	Water Efficiency Labelling and Standards
WHO	World Health Organization
WoNS	Weed of National Significance

UNITS

µ	micro (10^{-6})
µg	microgram (10^{-6} grams)
µg/m^3	micrograms per cubic metre
µm	micrometre (10^{-6} metres)
µS/cm	microSiemens per centimetre
cm	centimetre
CO_2-e	carbon dioxide equivalent units (see Glossary)
GL	gigalitres (10^9 litres)
GL/y	gigalitres per year
Gt	gigatonne
GWh	gigawatt-hour
ha	hectare
kg	kilogram
kL	kilolitre (10^3 litres)
km	kilometre
km^2	square kilometres
kWh	kilowatt-hour
L	litre
m	metre
m^3	cubic metre
ML	megalitre (10^6 litres)
mm	millimetre
Mt	megatonne (10^6 tonnes)
MW	megawatt (10^6 watts)
pH	measure of acidity or alkalinity
PJ	petajoule (10^{15} joules)
ppm	parts per million
t	tonne
y	year

GLOSSARY

acid sulfate soils: low-lying coastal clays and sands that contain sulfur-bearing compounds at concentrations above 0.05% in clays and 0.01% in sands

adaptive environmental water: water that is committed to the environment through water access licences; equivalent to 'held water' under Australian Government legislation

air toxics: gaseous, aerosol or particulate contaminants present in ambient air in trace amounts with characteristics (toxicity, persistence) which make them a hazard to human health, and plant and animal life

algal bloom: extensive growth of algae in a body of water, which occurs due to climatic conditions or as a result of excess nutrients in the water

alluvium: clay, silt, sand, gravel or similar material deposited by running water, especially during recent geological time

anthropogenic: produced or caused by human activity

aquaculture: cultivation for commercial purposes of aquatic organisms including fish, molluscs and plants in fresh or salt water

aquifer: rocks and porous sediments which hold and yield groundwater

ballast water: water carried in tanks to maintain stability when a ship is lightly loaded and normally discharged to the sea when the ship is loaded with cargo

benthic: bottom-dwelling; usually refers to organisms living on the substrate at the bottom of a water body

bioaccumulation: the accumulation in an organism of substances such as pesticides or other chemicals, which occurs when the organism absorbs a toxic substance at a faster rate than the substance is lost

biodiversity: the variety of all life forms; the different plants, animals and microorganisms, the genes they contain and the ecosystems they form

biological control: use of organisms (predators, herbivores, parasites and disease-producing organisms) to control pests and weeds

biomass: the total mass of living material occupying a specific part, or the whole of, an ecosystem at a given time

bioregion: relatively large areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of ecosystems – these landscape patterns are linked to fauna and flora assemblages and processes at the ecosystem scale, providing a useful means for simplifying and reporting on more complex patterns of biodiversity

biota: collectively, the plants, microorganisms and animals of a region

black water: occurs naturally due to the breakdown of leaf litter, inundated crops and other vegetation which results in the release of tannins and lignin causing water discolouration and is associated with low dissolved oxygen levels.

bloom: dense and visible growth of organisms (algae or other phytoplankton) in water, resulting from proliferation caused by increased nutrients (such as phosphorus), possibly toxic and generally resulting in reduced oxygen in the water

blue-green algae: members of the cyanobacteria (or Cyanophyta), characterised by blue-green pigmentation and a lack of cellular organisation

brownfield site: a site which needs to be cleared of existing industrial and commercial facilities with the accompanying risk of contamination

bycatch: species taken incidentally in a fishery along with the target species; often discarded

calcitic: in marine organisms, skeletons, shells, etc. can be based on calcium carbonate (calcite)

chain volume measures: volumes of economic activity or production that are weighted annually to remove the effect of changing prices and linked (or chained), to describe changes in levels of production or activity, particularly relevant where the prices of resources (like oil) or commodities (like computers) are subject to rapid change

climate variation/climate variability: long-term changes in the patterns of average weather of a region or the Earth as a whole

CO_2-equivalent (CO_2-e): a metric measure used to compare the global warming potential (GWP) of various greenhouse gases relative to the concentration of CO_2 (which is defined as having a GWP of 1). For example, methane is 21 times more effective than CO_2 at heating the atmosphere and therefore has a GWP of 21; thus five tonnes of methane is equivalent to 5 × 21 = 105 tonnes of CO_2

connectivity: the degree to which the landscape facilitates animal or plant movement or spread, and ecological flows

Country: (Aboriginal) the term used to describe both the land and waters, including the sea, to which Aboriginal people have a cultural connection

critically endangered species: species (or population or ecological community) facing an extremely high risk of extinction in NSW in the immediate future

cyanobacteria: see blue-green algae

disturbance: (ecology) any process or event which disrupts ecosystem structure and processes

diversion: volume of water taken from a stream or aquifer on a sustained basis to supply water for rural, urban and industrial use; includes diversions undertaken by a water authority, private company or a group of individuals authorised to act as a water supply authority

domestic household use: when referring to water use, this is residential water use, excluding use for stock in rural areas

ecological community: an aggregation of organisms characterised by a distinctive combination of two or more species

ecosystem processes: the numerous interactions between different components (living and non-living) of an ecosystem that support the biological elements of the system including the storage and cycling of energy, nutrients and minerals, predation and competition, disturbance, weathering, and succession

ecosystem services: any functions provided by an ecosystem, such as the provision of clean air and water, the maintenance of soil fertility and the removal of wastes, that benefit humankind

El Niño – Southern Oscillation (ENSO): a natural oscillation in the state of the ocean–atmosphere system that leads to substantial changes in atmospheric circulation throughout the Asia–Pacific region and generally drier conditions in eastern Australia

electrical conductivity: a measure of charged particles in water used to estimate salinity, measured in microSiemens per centimetre (µS/cm)

emissions trading: a scheme to provide for market-based allocation of discharge opportunities; the environmental regulator first determines total acceptable emissions and then divides this total into tradeable units (often called credits or permits); these units are then allocated to scheme participants

endangered species: a species (or population or ecological community) facing a very high risk of extinction in NSW in the near future, but not considered to be critically endangered

environmental flows: flows of water (by volume and season) necessary to maintain aquatic biota and ecosystem processes

ephemeral plants: plants with a short life cycle – either perennial plants that produce new growth in a short seasonal cycle or plants that emerge and grow in response to short wet periods in arid climates

estuary: the part of the mouth or lower course of a river in which its current meets the sea's tides, and is subject to their effects

euthanisation: the deliberate killing of a pest animal using humane means

eutrophication: the over-enrichment of a body of water with nutrients, primarily nitrogen and phosphorus, resulting in excessive growth of some plants and algae and the subsequent depletion of dissolved oxygen

e-waste: used ('end-of-life') electrical and electronic equipment, commonly composed of many component materials that are difficult and expensive to separate before they can be reused. Many of these materials, such as copper and gold, are valuable non-renewable resources; others, such as heavy metals, carbon black and brominated-flame retardants, are hazardous

extinct species: species that has not been recorded in its known or expected habitat in NSW over a time-frame appropriate to its life cycle and form

extraction: taking water from a waterbody or aquifer for use (also called abstraction)

faecal coliforms: a group of bacteria found in animal (including human) intestines and used as an indicator of the sanitary quality of water

faecal enterococci: a group of bacteria found in animal (including human) intestines and used as an indicator of the sanitary quality of water

fish kill: any sudden and unexpected mass mortality of wild or cultured fish

fishing effort: the amount of fishing gear used in a fishery over a unit of time, essentially fishing capacity times fishing activity

fishway: a structure placed on or around a constructed barrier (such as a dam or weir) to give fish the opportunity to migrate, also known as a fish ladder or fish pass

food web: a network describing the feeding interactions of the species in an area

fragmentation: the division of continuous habitat by vegetation clearance for human land-use activities, which isolates the remnant patches of vegetation and the species within them, and limits genetic flow between populations

fugitive emissions: releases of gases or vapours from mines or industrial equipment due to unintended or irregular occurrences (e.g. leaks)

full fuel cycle: emissions resulting from end use plus those resulting from feed stock extraction and refining, power generation and energy distribution

Greater Metropolitan Area (GMA): the area of greater Sydney defined under the Protection of the Environment (Clean Air) Regulation 2010 (Part 1 s.3) and comprising the:

(a) Central Coast Metropolitan Area

(b) Newcastle Metropolitan Area

(c) Sydney Metropolitan Area

(d) Wollongong Metropolitan Area

(e) local government areas of Blue Mountains, Cessnock, Kiama, Lithgow, Maitland, Mid-Western Regional, Muswellbrook, Port Stephens, Shoalhaven, Singleton, Wingecarribee and Wollondilly

Greater Metropolitan Region (GMR):

GMR_1: the area of greater Sydney defined by the Australian Bureau of Statistics comprising all statistical local areas and local government areas in the Sydney Statistical Division, Newcastle Statistical Subdivision, and Wollongong Statistical Subdivision

GMR_2: comprising the Sydney, Illawarra and Lower Hunter Regions

GMR_3: (Air Emissions Inventory) the area of NSW having Australian Map Grid (AMG) coordinates at the south-west corner at (Easting: 210000, Northing: 6159000, Zone 56) and north-east corner at (Easting: 420000, Northing: 6432000, Zone 56)

Greater Sydney: extends from Wyong and Gosford in the north, to the Royal National Park in the south; towards the west, the region includes the Blue Mountains, Wollondilly and Hawkesbury

greenhouse gases: atmospheric gases, including carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone and water vapour, which trap heat reflected from the Earth's surface

groundwater: the water beneath the Earth's surface that has filtered down to the zone where it is captured and the sediments or rocks are fully saturated

groundwater-dependent ecosystem (GDE): ecosystems where the species composition or natural functions depend on the availability of groundwater

growth form: (vegetation) the general morphology or form of a plant type

hypoxia: depletion of dissolved oxygen in an aquatic environment to a level detrimental to aquatic organisms

Indian Ocean Dipole (IOD): a coupled oceanic and atmospheric phenomenon in the Indian Ocean that affects Australia's climate

invasive species: a plant or animal that has been introduced into a region in which it does not naturally occur and that becomes established and spreads displacing naturally occurring species

invertebrates: animals without backbones, such as insects, worms, snails, mussels, prawns and cuttlefish

key threatening process (KTP): under the *Threatened Species Conservation Act 1995*, a process that significantly threatens, or may have the capability to significantly threaten, the survival or evolutionary development of species, populations or ecological communities

La Niña: the positive phase of the El Niño-Southern Oscillation, involving extensive cooling of the central and eastern tropical Pacific Ocean, often accompanied by warmer than normal sea surface temperatures in the western Pacific, and to the north of Australia. La Niña events are associated with increased probability of wetter conditions over much of Australia, particularly over eastern and northern areas

likely: in descriptions of the effect of climate change, indicates that there is a greater than 66% probability of occurrence, based on the definitions in IPCC 2007

long-term average annual extraction limit (LTAAEL): the average level of groundwater that can be extracted annually from an aquifer for extraction to be sustainable over the longer term

longwall mining: the main method of underground coal mining in Australia, it involves progressively shaving slices of coal from a longwall face under the protection of hydraulic roof supports. The coal is removed on a conveyer and as the machinery and roof supports move forward the roof and overlying rock collapse into the void left behind

macroinvertebrates: invertebrates visible to the naked eye, having a body length exceeding 1 millimetre

mafic: describes a mineral or rock that is rich in magnesium and iron

monitoring investigation level (MIL): the concentration of an air toxic which if exceeded requires an appropriate form of further investigation and evaluation (National Environment Protection (Air Toxics) Measure)

montane: of or inhabiting mountainous country

more likely than not: in descriptions of the effects of climate change, indicates that there is a greater than 50% probability of occurrence, based on the definitions in IPCC 2007

mosaic: (vegetation) a combination of distinct vegetation types within a spatial unit that often cannot be discriminated by the mapping techniques employed

non-woody vegetation: for vegetation monitoring using Landsat MSS satellite sensors, vegetation formations that are less than two metres high or with less than 20% canopy cover (mainly grasslands, arid shrublands and woodlands)

NO_x: a generic term for a combination of the gases nitric oxide (NO) and nitrogen dioxide (NO_2); other oxides of nitrogen (e.g. nitrous oxide, N_2O are usually not regarded as a component of NO_x

off-gassing: the slow release of a gas from a solid material, such as by evaporation, desorption or chemical alteration

pathogen: a disease-causing organism

phreatic aquifer: the body of groundwater closest to the surface, the upper boundary of which corresponds to the water table

phreatophytic vegetation: deep-rooted plants that obtain a significant portion of the water they need from below the water table

planned environmental water: water committed to the environment by environmental water rules in water sharing plans

point source pollution: a source of pollution that can be pinpointed, such as a pipe outlet or chimney stack; see also diffuse source pollution

potable: water safe enough for drinking and food preparation

potential acid sulfate soils: soils generally found less than five metres above sea level that produce sulfuric acid when drained; the acid can affect groundwater and surface waters, with impacts on urban areas, farming productivity, plants and animals

primary production: (biology) the transformation of chemical or solar energy into organic matter and its accumulation in an ecosystem

productivity: (biology) the rate of accumulation of organic material in an ecosystem

projections: in the context of climate change, projections are estimates of future conditions and their effects on the environment, based on the application of a climate change model

recharge: the process whereby surface water from rain, irrigation or streams infiltrates into groundwater; the amount of water added to or absorbed into a groundwater system; or groundwater that feeds surface waters (also known as baseflow)

regulated rivers: (NSW) those rivers proclaimed under the *Water Act 1912* as having their flows controlled by the major dams; 'regulated' means that flows along the length of these rivers are controlled by releases from major dams to meet the needs of licensed users; (hydrology) rivers affected by major dams, weirs, canalisation and water transfers

remnant: (ecology) a small, fragmented portion of vegetation that once covered an area before being cleared

remote sensing: a means of acquiring information using airborne equipment and techniques to determine the characteristics of an area, commonly using aerial photographs from aircraft and images from satellites

riparian: occurring on or adjacent to a river, stream or other waterway

riparian zone: situated on or belonging to a river or a stream bank

runoff: water from rain or snow (and the substances it carries) which flows off the surface of the land into catchments

sclerophyll: vegetation with hard leaves and short internodes, adapted to dry conditions and often low levels of soil phosphorus, usually with an over-storey of eucalypts

sequestration: the long-term storage of carbon dioxide

siliceous: describes a rock which has silica (SiO_2) as its principal constituent

suspended solids: any solid substances present in water in an undissolved state, usually contributing directly to turbidity

sustainability: environmentally sound resource use; use that does not degrade ecosystems or affect the quality of the resource

Sydney Metropolitan Area: comprises 41 local government areas – Ashfield, Auburn, Bankstown, Blacktown, Blue Mountains, Botany, Burwood, Canada Bay, Camden, Campbelltown, Canterbury, Fairfield, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kogarah, Ku–Ring–Gai, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, North Sydney, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Strathfield, Sutherland, Sydney, The Hills, Warringah, Waverley, Willoughby, Wollondilly and Woollahra; does not include Gosford and Wyong Local Government Areas

temperature anomaly: the difference between an annual average temperature and the climatological average, which by World Meteorological Organisation convention is the average over 1961–90

total suspended solids (TSS): a measure of the inorganic salts (and organic compounds) dissolved in water

translocated native species: a plant or animal that occurs naturally in some part of Australia but has been introduced to another region in which it does not naturally occur

transpiration (evapo-transpiration): the loss of water by evaporation from the leaves of plants

turbidity: a measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus the degree of scattering or absorption of light in the water

unregulated rivers: (NSW) rivers without major dams or regulating structures (cf. regulated rivers)

upwelling: divergence of water currents or the movement of warm surface water away from land leading to a 'welling up' of deeper water that is commonly richer in nutrients, with the combination of nutrients and warmth leading to abundant algal growth

vegetation class: a more detailed description of vegetation than formations, based on the dominant structure or growth-form, supplemented by selected details of plant composition, location or environmental characteristics that help to best identify it – in NSW, one of 99 classes defined by Keith 2004

vegetation community: a group or assemblage of plant species that tend to grow together in similar environmental conditions where the association of species helps to identify or describe the plant community

vegetation condition: the health of native vegetation communities which reflects the level of naturalness and is commonly assessed against a benchmark taking account of factors such as structural integrity, species composition, presence or absence of weeds and diseases and reproduction of species

vegetation formation: a very broad classification of vegetation based on the structure or growth-form of the dominant plants in the formation – in NSW, one of 16 formations defined by Keith 2004

vegetation structure: the organisation of plants within a plant stand or assemblage consisting of one or more layers or strata

vehicle kilometres travelled: a function of the number of motor vehicles on the road and the average distance travelled by each vehicle

vertebrates: animals with backbones and spinal columns – vertebrates include fishes, sharks and rays, amphibians, reptiles, mammals, and birds

very likely: in descriptions of the effects of climate change, indicates that there is a greater than 90% probability of occurrence, based on the definitions in IPCC 2007

virtually certain: in descriptions of the effects of climate change, indicates that there is a greater than 99% probability of occurrence, based on the definitions in IPCC 2007

vulnerable species: a species (or population or ecological community) facing a high risk of extinction in NSW in the medium-term future, but not considered to be endangered

wilderness: an area which, together with its plant and animal communities, is in a state that has not been substantially modified by humans, or that is capable of being restored to such a state, and is of sufficient size to make its maintenance in such a state feasible; it can provide opportunities for solitude and self-reliant recreation

woody vegetation: for vegetation monitoring using Landsat MSS satellite sensors, vegetation formations (mainly woodlands and forests) that are over two metres high and with more than 20% canopy cover; also known as ‘detectable native forest’

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