New South Wales

State of the Environment 2012

NSW EPA

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2012

NSW EPA

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Foreword

I am pleased to present *New South Wales State of the Environment 2012*. The report has been prepared by the Environment Protection Authority using information from a wide range of government agencies and authorities with input also provided from independent experts as part of a review process and oversight from the joint EPA and Office of Environment and Heritage State of the Environment Executive Committee.

NSW State of the Environment 2012 is the eighth such report for NSW and continues the series as a comprehensive document that considers the status and condition of the major environmental resources of NSW and examines the associated environmental trends, including the implications for the environment and human health. Key pressures on the condition of our environmental resources are identified and discussed, and programs and activities, including policies and legislation, that assist with improving environmental outcomes are outlined.

There have been a number of improvements to environmental outcomes since the last SoE report in 2009. With most of the state experiencing above-average rainfall over the last three years, the impact on the overall condition of NSW wetlands has been positive, along with an increase in waterbird populations. Our rivers have also benefited with an improvement in hydrological condition and a dramatic increase in the water supply held in storage.

Since *SoE 2009*, the reserve system has also been enhanced with the establishment of Dharawal and Berowra Valley national parks. Dharawal National Park reserves more than 6000 hectares in south-western Sydney and recognises the important Aboriginal cultural values of the area, while Berowra Valley National Park ensures the protection of the outstanding conservation values of this area in northern Sydney. These and many other positive outcomes are discussed in detail in the five chapters of *SoE 2012*.

However there are also areas that provide ongoing challenges. Energy use, particle pollution, invasive species, and the distribution of native animals and number of threatened species in NSW are all areas that require continued management to arrest further declines in status.

These challenges also provide opportunities. I am confident that the reinvigorated Environment Protection Authority will work with industry to improve its environmental performance. In addition, the Government has recently released its draft Renewable Energy Action Plan that outlines actions to help NSW meet the 20% renewable energy target by 2020.

The NSW Government is committed to working with communities, industry and other stakeholders in ensuring better outcomes for the environment.

Robyn Parker MP
Minister for the Environment

Preface

In November 2011, the NSW Government passed legislation to strengthen and reinvigorate the Environment Protection Authority. In February 2012, an independent Board was appointed to oversee the work of the EPA, modernising the authority and making it more accountable to the community of NSW. I was appointed Chair and CEO of the EPA in April 2012. One of the principal requirements of the reforms to the EPA is to increase its transparency through clear reporting and thus improve the community's access to information.

New South Wales State of the Environment 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 first SoE report to be prepared by the EPA since the recent reforms and, being the eighth NSW SoE report, provides valuable time-series data.

NSW State of the Environment 2012 details the condition of the environment and describes the major environmental issues across the state and how they affect human and environmental health. It provides an overview of the NSW environment using the most recent scientific information available. The report reviews the status and condition of the NSW environment, the pressures that affect the environment and responses to those pressures. *SoE 2012* is a valuable addition to the body of knowledge we are building on the environment in NSW.

Preparation of the SoE report relies on extensive contributions both from within the EPA and from many other NSW Government departments and agencies. The presentation of the data and information provided was appraised and validated by contributing organisations by way of a Verification Review. My sincere thanks to all of those concerned in providing information and advice during its compilation. I would especially like to offer my appreciation to a number of independent experts who have made invaluable contributions to this report by providing a range of perspectives and helpful advice.

SoE 2012 reflects the continuing trend of improvement and refinement shown over the eight iterations of the report. It assembles a wide breadth of information from a large array of sources into a format that is both accessible to the wider community yet able to withstand scientific rigour.

For *SoE 2012*, the indicators have been simplified to provide a more efficient and objective evaluation of trends. The 86 indicators now relate to over 20 major environmental issues in NSW and enable readers to examine their status in a more concise form than in any previous report.

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

Barry Buffier
Chair and Chief Executive Officer
Environment Protection Authority

About SoE 2012

Purpose

New South Wales State of the Environment 2012 (SoE 2012) reports on the status of the main environmental issues facing NSW. The report has been prepared in accordance with the requirements of section 10 of the *Protection of the Environment Administration Act 1991*. This is the eighth SoE report since 1993 and it was prepared by the NSW Environment Protection Authority (EPA).

SoE 2012 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

SoE 2012 is structured differently from previous SoE reports. The first chapter, People and the Environment, considers the key drivers and pressures that can have an impact on the environment. This chapter incorporates sections on Urban Water, Energy, Transport, Waste and Noise that formerly appeared in an SoE chapter called Human Settlement. The remaining chapters of Atmosphere, Land, Water and Biodiversity are thematic and largely unchanged. An exception is that this year's Biodiversity chapter no longer reports on fisheries resources. This is because the *Status of Fisheries Resources in NSW 2008/09* (K. Rowling, A. Hegarty & M. Ives (eds) 2010, NSW Industry & Investment, Cronulla) provides a general overview of the state of marine and estuarine fish populations harvested by commercial and recreational fishers in NSW.

Although *SoE 2012* has been prepared by the EPA, much of the material it contains results from extensive input by 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 heavily on receiving this support from contributing agencies.

The specialist input also includes reviews and advice from independent experts as well as members of the SoE Executive Committee from the EPA and NSW Office of Environment and Heritage.

Indicator summaries

SoE 2012 assesses each environmental indicator's current status, its trend since *SoE 2009*, and the availability of information used to make an assessment against the indicator. The status and trend ratings depend on the extent and appropriateness of available information, both qualitative and quantitative, and the information availability rating signifies the level of information used to make the assessment.

Indicator presentation

Indicator and status	Trend	Information availability
Indicator status refers to the environmental condition of the indicator. **Green** – Good: the data shows a positive or healthy environmental condition **Yellow** – Moderate or fair: the data shows that the environmental condition is neither positive nor negative and results may be mixed across the state **Red** – Poor: the data shows poor environmental condition or condition under significant stress **Grey** – Unknown: insufficient data to make an assessment	The trend describes the direction of significant change in indicator measures. It has generally been judged over the reporting period since the previous SoE report in 2009 and in the future may impact on the overall status of the indicator. The following descriptors have been used in *SoE 2012*: **Decreasing** – The indicator measure is getting smaller. **Increasing** – The indicator measure is getting larger. **Stable** – There has been no ***significant*** change in the measure of the indicator. **Unknown** – There is not enough information to determine a trend for the indicator.	Information availability describes the statewide extent, condition and 'fitness for use' of the data used for the indicator. It is represented by the symbols below. ✓✓✓ = **Good** ✓✓ = **Reasonable** ✓ = **Limited**

Contents

Summary

New South Wales State of the Environment 2012 covers 22 different environmental issues across five chapters with data and information that addresses 86 indicators. In *SoE 2012*, 20 indicators are rated as good, 49 are rated as fair, 14 are rated as poor and the condition of three indicators is classed as unknown due to a lack of available information to inform an assessment.

The summaries for each chapter below outline key issues and trends over the last three years.

1. People and the Environment

- Public transport patronage continues to increase, especially for commuting to work in Sydney.
- NSW greenhouse gas emissions per person have fallen below the Australian average with energy production and transport the two largest contributors.
- Waste recycled in NSW continues to increase with 59% of all waste recycled in 2008–09.
- Regional residential water consumption has fallen by more than half over the last 20 years.
- The state's renewable energy supply has doubled since 2008 and residential electricity demand is now at its lowest since 2000, although energy production is still overwhelmingly dependent on the burning of fossil fuels.
- The area of public land protected for Aboriginal cultural values continues to increase.

This first SoE chapter provides the broad context for environmental issues in NSW and discusses some of the key drivers that can affect the state of the environment.

The NSW population was estimated to be 7.21 million in June 2011 and is projected to grow to 9.1 million people by 2031. On current trends, 40% of this growth is expected to come from migration. Natural increase (the excess of births over deaths) has been steadily increasing its contribution to population growth since 2003–04, reaching 46,311 in 2009–10, the highest level in two decades. Most growth will be centred in Sydney, with other coastal urban areas experiencing modest growth and some parts of the far west a small population decline.

Increasing population density can create environmental challenges. Noise in particular is a persistent problem with a 39% increase in noise complaints to Environment Line in 2010–11 compared with 2007–08. A number of large-scale studies have linked the community's exposure to environmental noise with adverse health effects.

Overall household spending in NSW increased by more than 82% over the last 20 years. Environmental impacts associated with a growth in consumption are being offset in part by greater energy efficiency and waste recycling initiatives and NSW should continue to ensure that its environment and natural resources are not negatively affected. Approximately 59% of all waste produced in NSW was recycled in 2008–09 and the use of renewable sources of energy doubled in the two years to 2009–10. Overall electricity demand per household has declined to 2000–01 levels, demonstrating the effect of both cost increases and environmental concerns on the community at large.

More than any other factor, the production of energy has been identified as the greatest emitter of greenhouse gases in NSW: over 40% of NSW emissions were the result of electricity production in 2009–10. While per capita emissions in NSW are decreasing and were below the Australian average in 2009–10, the country's emissions are still increasing overall and are now higher than many other developed economies. Transport is the third-largest producer of greenhouse emissions in NSW – just behind the industrial sector, but growing.

Private vehicle ownership now exceeds 1.5 vehicles per household even though the total number of kilometres travelled by car has declined in recent years. Some changes in transport choice were evident in the decade to 2009–10. During this time, the proportion of public transport use increased for commuting to work and work-related trips, but fell for all other purposes: commuting by public transport was up 3.4% while that by car fell 4.4% over the same period. Freight transport in NSW remains overwhelmingly road-based and is expected to continue to increase by over 16% in the 10 years to 2018–19.

One of the greatest challenges facing NSW is continued reliable access to water. Ensuring a secure, sustainable and equitable water supply for people, agriculture, industries and the environment is important. Urban water for NSW cities and regional centres meets the Australian Drinking Water Guidelines nearly 100% of the time. With ongoing schemes to reduce its use, such as NABERS, water recycling and Water Wise Rules, water consumption has decreased throughout the state. In Sydney, it stood at 303 litres per person per day in 2010–11, down from 343 litres in 2004–05.

Responding to the new and increasing environmental challenges presented by a growing NSW economy will require improved understanding of how the economy and the environment interact. This will be supported by the use of appropriate evaluation methods to assess environmental policies and investment decisions, as well as innovative market-based instruments to manage pollution. It is important that new technologies and land-management practices are developed and refined so that the increasing consumption of energy, water and land does not have a negative impact on the state's environment and natural resources. This is a clear imperative in current patterns of energy use, which rely largely on high greenhouse gas-emitting fossil fuels.

It is now clear that community opinions are essential in achieving positive environmental outcomes. Public concern around environmental issues has translated into both direct and indirect actions by individuals and local groups to achieve real reductions in waste and energy use. Social research has underpinned a range of practical government-funded education and engagement programs to help communities adopt sustainable behaviours and learn about local environment protection. These programs support business, government and non-government agencies to use innovative strategies that save costs in energy, water and waste management and engage their staff to use resources more efficiently.

Aboriginal culture and heritage are linked closely with the natural environment and the traditions and assets it contains, both tangible and intangible. The strong relationship between Aboriginal people and their lands makes culturally appropriate management of Country and its resources a critical part of protecting Aboriginal cultural values. Joint management of NSW public land with Aboriginal groups has proved effective with over 1.6 million hectares now managed this way. The NSW Government is currently reviewing Aboriginal heritage legislation to improve the protection and management it affords and is consulting widely with Aboriginal communities, government agencies and key stakeholders.

2. Atmosphere

- Air quality in NSW continues to improve.
- National standards for most regulated air pollutants are met in NSW, but there are continuing exceedences of the goals for ground-level ozone and particles.

Air quality in NSW has improved since the 1980s with full compliance with national air quality standards for four of the six major 'criteria' air pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. However the national standards continue to be exceeded in some regions for the two other pollutants: ground-level ozone and particle pollution.

Ground-level ozone (a key component of photochemical smog which appears as white haze in summer) remains an issue for Sydney, with concentrations generally continuing to exceed national air quality standards on up to 16 days a year between 2009 and 2011. Particle pollution (appearing as brown haze) has recently exceeded the standards on up to 18 days a year across Sydney and up to 21 days a year in some regional areas. Bushfires and dust storms are major causes of these exceedences, along with stubble burning, coal mine dust, and woodheaters in regional areas.

Controlling pollution has improved, with low concentrations of a number of the most common dangerous air pollutants (such as ammonia, carbon monoxide, lead and sulfur dioxide): since the early 1990s emissions of these and other pollutants (such as oxides of nitrogen and volatile organic compounds) have fallen by 20–40% across the Sydney region.

Levels of air toxics are generally low and stable, with periodic assessment required to verify that all remain at acceptable levels.

Air quality indoors can be worse than it is outside and may pose health risks in many enclosed environments. Investigations into the impacts of indoor air quality on health are continuing.

3. Land

- The soil resources of NSW are in fair condition overall, both at the state and regional level.
- Current land management practices are broadly sustainable and generally lead to only a moderate risk of degradation but this varies across soil health indicators and catchment management areas.
- More widespread use of conservation farming practices is helping to counteract pressures on soil resources.
- On a statewide basis, the chemical contamination of land, food and produce is low and stable.
- The presence of hazardous chemicals in consumer products has been identified as an emerging issue.

Healthy soils are necessary for both landscape health and to provide the basis for the productive capacity of the land. While soil resources across NSW are in fair condition overall, significant specific issues of land degradation remain: 74% of 124 priority soil monitoring units examined were rated as poor or very poor for at least one degradation hazard.

Across NSW, gully and sheet erosion have been found to be the least problematic of the soil health indicators, while decreasing organic carbon and soil structure decline present the greatest challenges. Potential acid sulfate soils are also a long-term management issue in some coastal areas.

Mapping of land and soil capability across NSW has been combined with land-use maps for the first time to show the capability of the state's soil resources and the land-use pressures on those soils. Current land management practices are broadly sustainable and the greater use of conservation farming is helping to counteract the pressures on soil resources from an intensification of agriculture to meet the needs of growing populations. These land management practices generally lead to only a moderate risk of degradation but this varies across soil health indicators and catchment management areas.

Contamination of land, food and produce can occur through the use of chemicals either directly or as a by-product of manufacture. Contamination rates in food and produce is low and stable, while the pace of remediation of industrially contaminated land has increased. In contrast, the presence of hazardous chemicals in consumer products has been identified as an emerging issue.

4. Water

- Widespread rains after the prolonged drought have increased river flows and the availability of water held in storage for both water users and the environment.
- Significantly increased amounts of environmental water are now being delivered to improve the health of rivers and wetlands.
- Increased natural flows and more environmental water have led to improvements in river health, wetland vegetation and waterbird numbers, but fish communities have been slower to respond.
- Demand for groundwater has eased significantly and sustainable levels of extraction in some aquifers are now being managed under water sharing plans.
- The marine environment is generally considered to be in good health although localised contamination of water quality due to stormwater runoff still occurs during heavy rains.
- Estuaries and coastal catchments are coming under increasing pressure from coastal development and their condition is highly variable.

With the breaking of the drought in 2010–11, substantial rains across NSW brought widespread flooding in many river valleys and the filling and spilling of most major storages for the first time in a decade. Water sharing plans are now balancing access to the water available for water users while maintaining the health of river systems. Sixty-three water sharing plans have been introduced progressively since 2004, covering 95% of water use in NSW. Significantly increased amounts of environmental water have been delivered to priority aquatic ecosystems to improve the health of rivers and wetlands: an annual average of about 1 million megalitres over the past two years.

Since 2009, improved flows in most inland and coastal rivers have eased some of the stresses experienced by the systems during the prolonged drought and enhanced the productivity of aquatic ecosystems. While the condition of macroinvertebrate communities has shown some improvement, fish communities have been slower to respond. The majority of inland rivers are still affected by the ongoing pressures of water extraction and altered flow regimes and the overall river health ratings have largely remained poor, although the algal blooms of previous years have dissipated with increased flows. Coastal rivers are less affected by these pressures and, while they have not been fully assessed, are likely to be in better health overall.

The condition of wetlands has improved markedly since 2009 also due to increased rainfall and water availability and higher river flows. The area of inundated wetlands has expanded dramatically with most inland floodplain wetlands currently undergoing a cycle of enhanced productivity in wetland vegetation and waterbird breeding not experienced for over 10 years. This recent boom contrasts with the more general pattern found in long-term surveys of a decline in the extent and productivity of inland wetlands due to the effects of water extraction and altered flow regimes. Habitat degradation as the result of changes in catchment land use, clearing and modified drainage patterns are other significant pressures on wetland health. Since 2009, the area of inland wetlands protected within the terrestrial reserve system has more than doubled to 7%, while 19% of coastal wetlands are also protected.

Demand for assigned groundwater resources in NSW has eased significantly over the past three years as more surface water has become available following the widespread rains. Groundwater levels have risen in most areas in response to the higher rainfall, enabling aquifers to recharge and usage levels to drop. While extraction from some groundwater sources has been above the long-term sustainable yield in the recent past, use is now being managed to align with the sustainable yield through the implementation of 34 groundwater sharing plans. These plans will be extended to cover all groundwater sources in the Murray–Darling Basin by the end of 2012.

The overall health of the NSW marine environment and ecosystems is generally considered to be good. Recreational water quality at NSW beaches is also good and has improved over the past 10 years, though quality is lower in enclosed waters and estuaries where localised contamination from stormwater runoff still occurs after heavy rains. The survival of some species in coastal water is also under threat, particularly seabirds and some larger aquatic mammals and fish. The main pressures on marine species include destruction of vital habitats, overfishing, entanglement in disused fishing gear, chemical contamination and refuse, such as plastic bags and ring pulls.

The condition of estuaries and coastal lakes in NSW varies greatly, from near-pristine to highly disturbed. Condition generally reflects the level of disturbance in the catchment and the degree of flushing of the water body. Disturbance of estuary catchments and waterways results in habitat modification and changes in stormwater flows and runoff characteristics, increasing the loads of sediments and nutrients which can affect estuarine water quality and ecosystem health. Population growth and coastal development continue to put pressure on estuaries and coastal lakes and it is anticipated that these pressures will intensify along the NSW coast in the future.

5. Biodiversity

- The overall diversity and richness of native species in NSW remain under threat with another 35 species listed as threatened under NSW legislation since 2009.
- Habitat destruction, including clearing, and invasive species are the greatest threats to biodiversity in NSW.
- The clearing of native vegetation has stabilised in NSW over the past six years but the condition of most vegetation has deteriorated.
- The terrestrial reserve system now covers 8.8% of NSW and a higher percentage of bioregions and vegetation classes are represented in reserves than ever before. This system is increasingly being supplemented by off-reserve conservation across other land tenures.
- Many invasive pest and weed species are now widespread across NSW and have a major impact on native species, while fungal diseases are a growing threat.

Native species remain under threat due to the clearing of vegetation, habitat degradation and invasive species. Over longer time frames, birds have been more resilient than other vertebrate groups, having experienced the lowest proportion of declines in distribution, while mammals have experienced the highest as well as the greatest number of extinctions.

Since 2009, 35 additional species have been listed as threatened under NSW legislation and the number of listed populations and ecological communities has also increased. While a general pattern of decline is evident, many species have maintained their levels of distribution. Sixty-six per cent of terrestrial vertebrate species are not considered to be threatened.

The current condition and extent of native vegetation is considered to be fair. Land clearing is recognised as the greatest threat to native vegetation but clearing levels have stabilised over the past six years and the total extent of woody vegetation appears to have remained stable since 2003. Changes in the condition of vegetation are much harder to monitor than the effects of clearing. While 61% of NSW is still covered by naturally occurring vegetation, only 9% of this is in relatively natural condition and condition has deteriorated significantly in the remainder. Many revegetation and restoration activities are occurring regionally and the condition of vegetation is expected to improve as the results of these activities take effect.

The area of terrestrial reserves has increased by 5.7% since 2009, with significant additions to previously under-represented terrestrial areas. An increased focus on conservation on private land is facilitating greater involvement by landowners in private land conservation, providing improved connectivity across landscapes. Conservation on private and other (non-reserve) public lands complements the public reserve system by protecting a greater range of values. The extent of marine protected areas remains unchanged since 2009, covering 34% of NSW waters and managed under multiple-use zoning plans.

Widespread invasive species, including foxes, feral cats, rabbits, goats, carp and an increasing number of weeds, are a major threat to the survival of many native species. Deer are expanding their range and impacts, and fungal diseases, such as chytrid fungus and myrtle rust, are newly developing threats. Over half the listed key threatening processes in NSW relate to invasive species, while pests and weeds have been identified as a threat to more than 70% of the state's threatened species. Once established, there is little prospect of eradicating invasive species and broadscale control is rarely effective. Controls are therefore targeted to areas where the benefits will be greatest and on preventing the introduction and spread of new species.

Fire plays an important role in maintaining the health of many natural ecosystems, but at the same time altered fire regimes constitute a significant threat to the structure and function of ecosystems. The incidence and extent of fires vary from year to year and are strongly related to adverse weather conditions. The levels of hazard reduction burning and remote area fire suppression across NSW have risen sharply over the past three years as new fire management techniques are implemented.

People and the Environment

1

1.1 Population, transport and noise

At June 2011, the population of New South Wales had reached approximately 7.21 million with an average annual growth rate of 1.1% since June 2006. For most of the last decade the use of public transport has grown faster on average than the population and much faster than private travel. Noise pollution is the second most common type of complaint call received by Environment Line.

The state's population is forecast to grow to 9.1 million by 2031, with most living in urban areas. Long-term strategies are designed to plan for the expected increases in population in a way that maximises the environmental, social and economic sustainability of NSW.

Commuter trips represent about one-in-six of all journeys in Sydney on weekdays. During 2009–10, almost 25% of trips to and from work across Sydney were on public transport, the highest proportion of any Australian capital city. The use of public transport for commuter trips to and from the Sydney CBD during peak hours stood at over 76%.

The use of motor vehicles for people movements has been relatively stable since NSW State of the Environment 2009. On an average weekday, around 25% of vehicle driver trips are short: two kilometres or less.

The number of noise incident reports to Environment Line increased by nearly 40% between 2007–08 and 2010–11, while calls requesting information about noise issues fell 21%.

NSW indicators

Indicator and status	Trend	Information availability
Public transport use (overall and trips)	Increasing	✓✓✓
Vehicle kilometres travelled (total and per person)	Stable	✓✓
Mode of transport to work (GMR key centres)	Stable	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Demands for housing, transport, employment and infrastructure for waste disposal all increase as population grows, along with the use of water and energy. Population growth can also increase fragmentation of fragile ecosystems, especially where per capita consumption is on the rise (see People and the Environment 1.7).

Transport involves the movement of people and freight. It provides access to jobs, education, markets, leisure and other services, and thus plays a key role in the economy. However, travel has environmental impacts as it consumes significant amounts of non-renewable resources, especially fossil fuels, produces greenhouse gas emissions, and generates air pollution that has impacts on human health and the environment. Runoff from roads affects water quality, while the construction of roads in bushland areas can have an impact on biodiversity where it fragments natural ecosystems.

Unwanted sound, noise defined as offensive, and noise that unreasonably intrudes on daily activities can have a major impact on general urban amenity and is more likely to be an issue in more densely populated areas.

Status and trends

Population

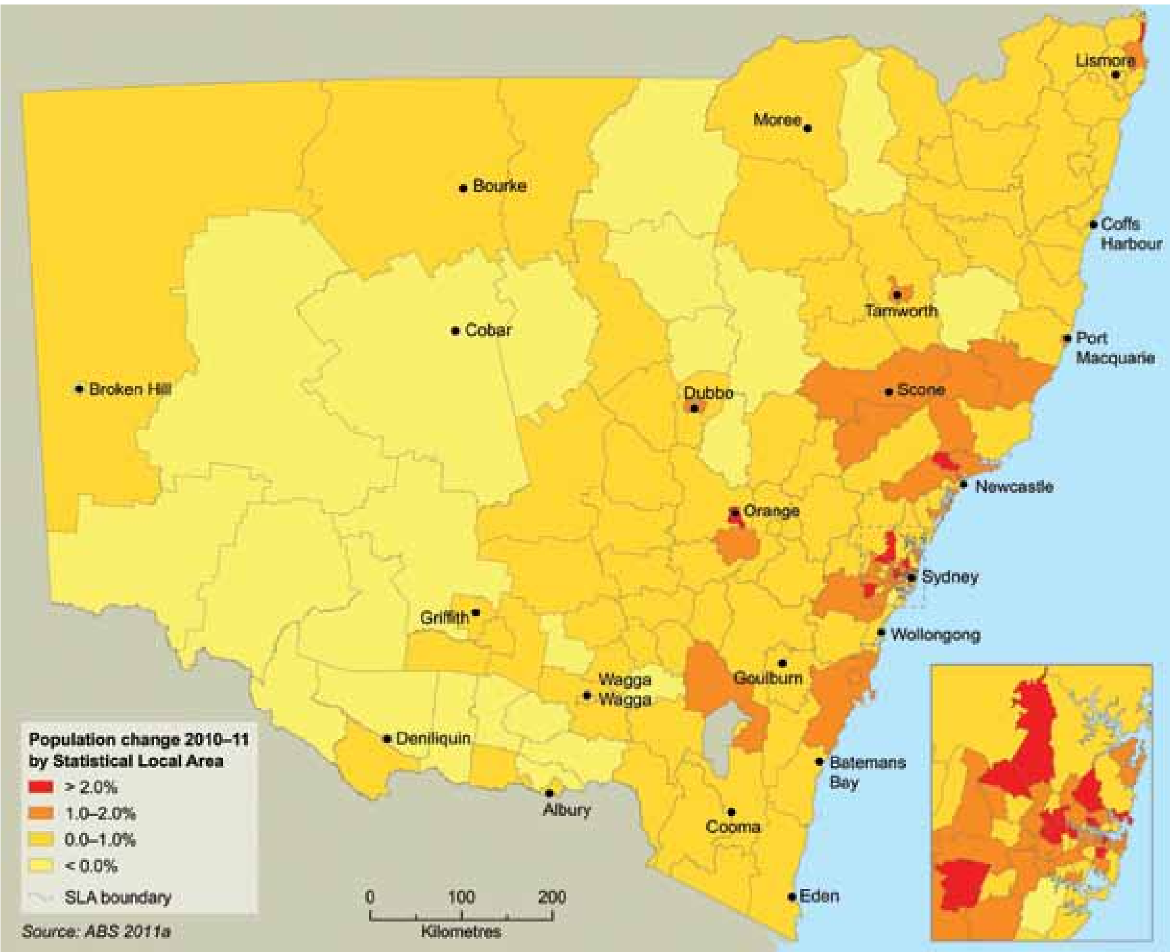
Population distribution and residential density

The preliminary estimated resident population of NSW in June 2011 was 7.21 million, representing just under a third of the total Australian population of 22.32 million (ABS 2012). In recent years, population growth in NSW has picked up from the relatively low growth rates of the early 2000s. NSW grew by 395,400 people between 2006 and 2011, an average annual rate of 1.1%. This was below the growth rate for Australia as a whole of 1.5%. Changes in population growth are affected by fluctuations in fertility rates and the cyclical nature of net migration (both interstate and overseas migration). As **Map 1.1** shows, NSW population growth is not evenly distributed with most centred on Sydney and this has regional implications for the environmental impacts of ongoing population increases.

In the early 2000s, net migration contributed less to overall population growth in NSW than natural increase (the excess of births over deaths) (**Figure 1.1**). More recently, the share of net migration has risen due to significant increases in the levels of overseas migration and a reduction in losses from interstate migration (DoP 2008a; ABS 2011b). Natural increase has been a consistent underlying factor behind Sydney's growth since the 1970s. In 2009–10, it reached 46,311, the highest level in 20 years.

The demographic drivers for population change differ between Sydney and other regions in NSW. For example, Sydney is the main destination for international migrants, while coastal areas attract internal migrants from elsewhere in NSW and Australia, particularly retirees and those close to retirement.

Map 1.1: Regional variations in population change in NSW, 2010–11



Overall population gains from overseas migration and losses through interstate migration are long-established migration trends for NSW. Assuming that such patterns continue in the future, the state's population is projected to increase to over 9 million by 2031, with 60% of this growth due to natural increase (births minus deaths) and the remainder to migration (DoP 2008a).

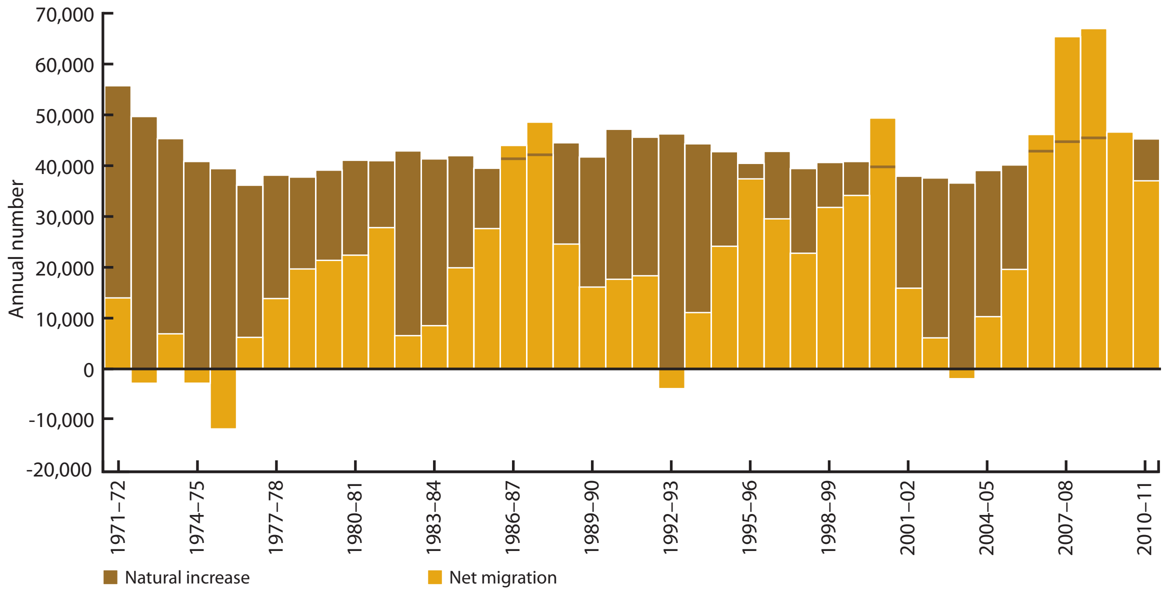
The regional variation in annual population growth is highlighted in **Table 1.1**, which shows historical growth across four major regions of the state. The Greater Metropolitan Region (GMR_1) encompasses only 2.2% of the total NSW landmass but has 75% of its population. This concentration of population in Sydney is expected to continue into the future. The population of the Sydney Statistical Division is projected to grow from 4.3 million in 2010 to 5.6 million in 2031 and the GMR_1 population from 5.3 to 6.7 million over the same period. Growth rates in the coastal regions outside the GMR_1 have declined over time while population growth in inland NSW remains at particularly low levels. Some inland regions, such as the Murrumbidgee, Murray and Central West, are expected to experience population growth to 2031, but others, including Northern and North-Western regions, are expected to experience population decline (DoP 2008a).

Demographic change and household and family structure

The age distribution of the NSW population is shifting as a result of past changes in the fertility rate and increasing life expectancy, mirroring trends in other developed countries. This leads to an increase in both the number and proportion of the population in the older age groups, 65 years and over. The population pyramids in **Figure 1.2** show the state's ageing population as well as the growth that has occurred in all age groups since the 1990s. Just as population growth is unevenly distributed across the state, so too is ageing. Rural and regional areas have much older age structures, often exacerbated by the movement of young people elsewhere.

One effect of the ageing population in NSW is changes in household composition with older people more likely to live alone or with only one other person. This has implications for the environmental impacts caused by the need for more housing and flow-on effects from demand for housing materials and increases in energy and water consumption per capita (see People and the Environment 1.4 and People and the Environment 1.5). Preferences for different household types vary considerably by age and thus the different age profiles across the state will influence demand for housing type and size (ABS 2005a; ABS 2005b).

Figure 1.1: Natural increase and net migration in NSW, 1971–72 to 2010–11



Source: ABS 2011b

Notes: In some years shown on the graph, natural increase is below net migration and is indicated by a line across the relevant net migration bars.

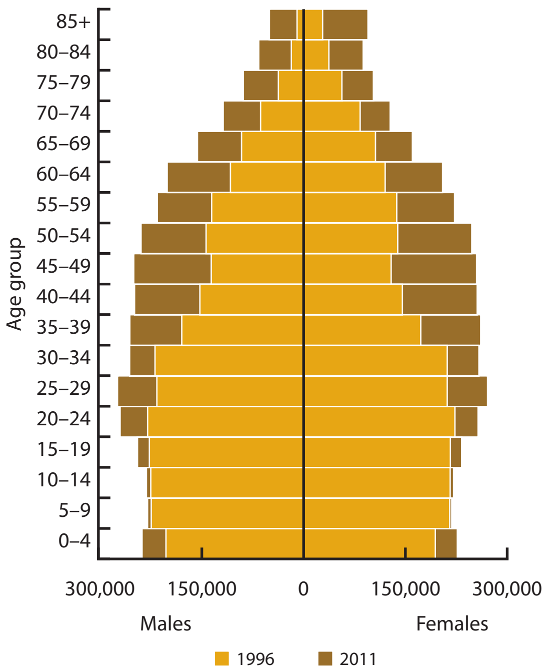
Table 1.1: Average annual population increase and growth rates in NSW regions, 1981–2011

Regions	Average annual population increase (growth rate)					
	1981–86	1986–91	1991–96	1996–2001	2001–06	2006–11
Sydney Statistical Division	38,400 (1.1%)	40,300 (1.1%)	41,700 (1.1%)	49,400 (1.2%)	30,700 (0.7%)	64,785 (1.5%)
Greater Metropolitan Region (GMR_1)	41,400 (1.0%)	48,200 (1.1%)	47,500 (1.1%)	58,000 (1.2%)	37,400 (0.8%)	71,307 (1.4%)
Coastal regions outside GMR_1	14,100 (3.2%)	17,800 (3.4%)	11,900 (2.0%)	10,400 (1.6%)	8,200 (1.2%)	4,498 (0.6%)
Inland	3,800 (0.4%)	7,500 (0.8%)	1,700 (0.2%)	5,700 (0.6%)	2,500 (0.3%)	2,940 (0.3%)
New South Wales	**59,300 (1.1%)**	**73,400 (1.3%)**	**61,200 (1.0%)**	**74,100 (1.2%)**	**48,200 (0.7%)**	**79,076 (1.1%)**

Source: ABS 2006; ABS 2012

Notes: 'GMR_1' comprises all statistical local areas (SLAs)/local government areas (LGAs) in the Sydney Statistical Division (SD), Newcastle Statistical Subdivision (SSD) and Wollongong SSD.
'Coastal regions outside GMR_1' comprises all SLAs/LGAs in the Richmond–Tweed SD, Mid-North Coast SD and the following LGAs: Great Lakes, Shoalhaven, Eurobodalla and Bega Valley.
'Inland' comprises all SLAs/LGAs not included in either the GMR_1 or coastal regions outside GMR_1.

Figure 1.2: Age-sex structure of the NSW population, 1996 and 2011



Source: ABS 2011c

Transport

Travel patterns in Sydney

The various forms of transport, such as air, car, train, bus, ferry, tram, bicycle and walking, are called 'modes'. In 2009–10, Sydney residents made 16.2 million trips each weekday across all modes. This was a slight decrease from the peak of 16.3 million trips in the previous two years. From 1999–2000 to 2009–10, total distance travelled on weekdays on all modes increased by an annual average of 0.7% and annual average vehicle kilometres travelled (VKT) grew by 0.6% (**Figure 1.3**). In contrast, over the same period, total public transport passenger kilometres travelled grew at nearly double the annual average rate of VKT at 1.1% per year (BTS 2011).

In 2009–10, Sydney residents travelled a total of 133.6 million kilometres on an average weekday. After a period of growth from 2005 to 2006 (the strongest in a decade), kilometres travelled was relatively static (and even declined) between 2007–08 and 2009–10, as did VKT (Figure 1.3). Growth in both these measures is below the 11-year trend. The distance travelled on public transport also stopped increasing between 2007–08 and 2009–10, due to a decline in distance travelled by train, offset slightly by a slight growth in distance travelled by bus (BTS 2011).

Despite a modest easing in growth around 2005–06 and 2006–07, private vehicle ownership has increased overall since 1999–2000, generally in line with rising gross state product. Both measures grew by 25% over the 11-year period. The number of vehicles per household has continued to rise and now exceeds 1.5 on average.

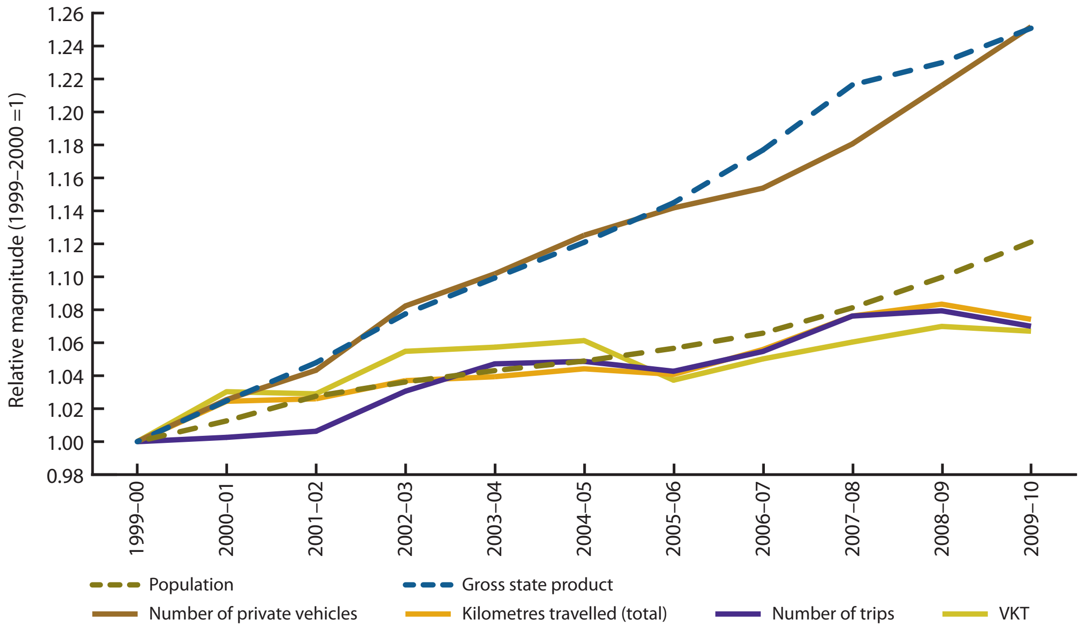
How people travel: The majority of people and freight movements across NSW are by road. The number of trips taken on the various modes of transport on an average weekday in Sydney has trended upwards since 1999–2000, with the notable exception of those by vehicle drivers. Between 1999–2000 and 2009–10, the number of train trips grew while bus trips fell: the percentage of trips taken on buses dropped from 6.2% of all trips to 5.8% in 2009–10, while train trips increased from 4.9% to 5.3% (BTS 2011). Walking as a form of 'transport' in Sydney now represents over 18% of average weekday trips.

While the number of trips in Sydney has been growing, the proportion of trips using private vehicles peaked in 2004–05 and is now the lowest it has been in 11 years. The proportion of vehicle-based passenger trips remained at 21–22% over the period to 2009–10. The 47% of total trips made by drivers in 2009–10 accounted for 59% of the total distance travelled on an average weekday (BTS 2011).

Trains also tend to be used for longer trips, with these trips in Sydney accounting for a larger percentage of total distance (12% for 2009–10) than total trips by all modes (5.3%). However, compared with two years earlier, a greater number of shorter train trips were being taken (BTS 2011, p.24). Walking trips, not surprisingly, comprised a much smaller proportion of distance travelled (2%) compared with their 18.5% share of total trips in 2009–10 (BTS 2011).

Why people travel: Since 1999–2000, the number of trips for recreational purposes has exceeded 20% of all weekday journeys across Sydney (BTS 2011). Commuter trips to and from work showed consistently strong growth between 1999–2000 and 2009–10, expanding by an average of 1.16% annually to now equal the number of shopping trips taken on weekdays: both 15.9%. However trips to and from work contribute the highest share of distance travelled, increasing in 2009–10 to over 28%, followed by recreational trips (20.1%). Commuting trips to and from work have accounted for over one-quarter of total kilometres travelled in each year since 1999–2000 (BTS 2011).

Figure 1.3: Trends in travel by Sydney residents on an average weekday, compared with key NSW statistics, 1999–2000 to 2009–10



Source: BTS 2011

Notes: Year estimates are based on three years of pooled data. For example, the 2009–10 estimate uses data collected from July 2007 to June 2010 weighted to the 'Estimated Resident Population' issued by the Australian Bureau of Statistics for June 2009.

In 2009–10, as in previous years, private vehicles continued to be the most frequently used mode for all trips in Sydney (BTS 2011). Car use was highest for 'serve-passenger' trips (those where a passenger is dropped off, picked up or transported), accounting for 88.2% of them, followed by work-related trips (86.1%) (**Figure 1.4**). For commutes to work, car use was also sizeable at just over two-thirds of all trips, while public transport patronage (train and bus) was also high (with nearly one-quarter). Compared with other purposes, private vehicle use was lowest (53.8%) and public transport use highest (24.5%) for educational trips. The share of 'other modes' (mainly walking) is largest for recreational and shopping trips (both around 30%).

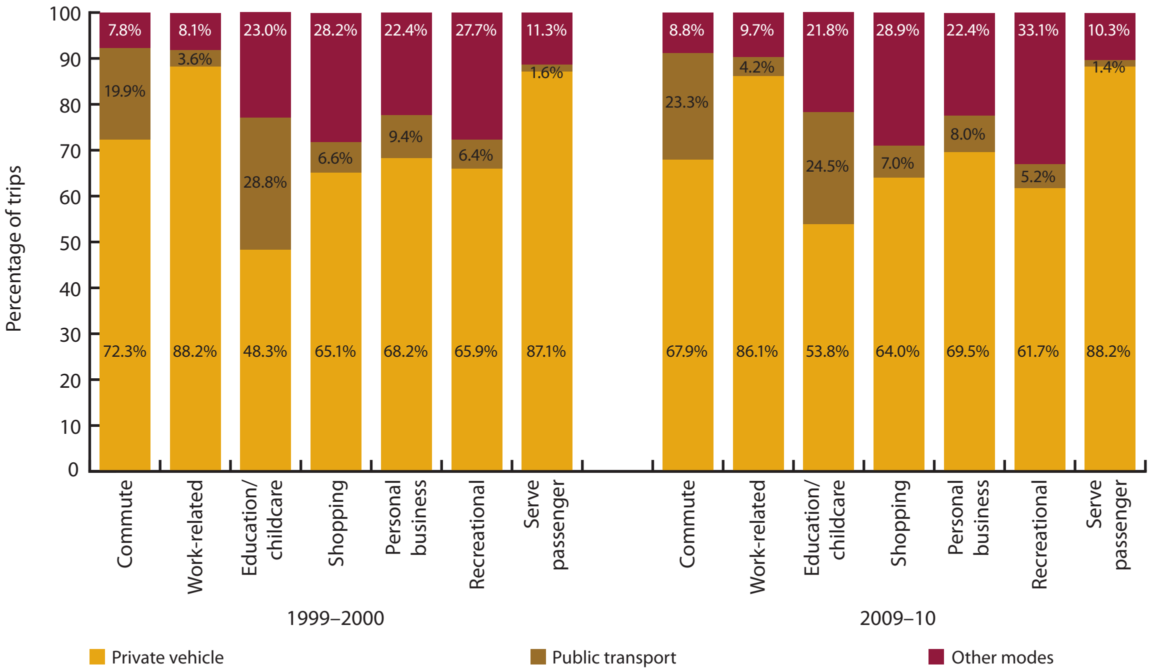
Some changes in transport choice are evident between 1999–2000 and 2009–10 (Figure 1.4). During this time, the proportion of public transport use grew for commuting to work and work-related trips, while all other purposes had a declining share of public transport. Commuting by public transport increased 3.4%, while by car it decreased 4.4%. Car use for recreational purposes was also down. Compared with 1999–2000, the greatest increase in car use in 2009–10 was for educational and childcare trips (up 5.5%). These trends are the same as those reported in *SoE 2009* (DECCW 2009a), but less pronounced.

In Sydney, an average of 75% of the population can access the city or a major centre within 30 minutes by public transport, although this varies across subregions (NSW Government 2009). Around 25% of vehicle driver trips on an average day are less than two kilometres in length, which provides opportunities for the further development of transport options to reduce private vehicle use.

In 2009–10, public transport was used for just over three-quarters of commuter trips to and from the Sydney CBD during peak hours (**Figure 1.5**). This represents a small decline from the peak of 77% in 2007–08. In 2009–10, 23.9% of residents across the Sydney metropolitan region used public transport (train, bus and ferry) to commute to and from work, again a small decline from the peak of 2007–08 (BTS 2011).

Across the main centres in Sydney, and the Newcastle and Wollongong CBDs, the only area where public transport has recently improved its share of peak hour commuter trips is to Liverpool city centre (Figure 1.5).

Figure 1.4: Percentage of trips by purpose and mode on an average weekday, Sydney, 1999–2000 and 2009–10



Source: BTS 2011

Notes: Year estimates are based on three years of pooled data. For example, the 2009–10 estimate uses data collected from July 2007 to June 2010 weighted to the 'Estimated Resident Population' issued by the Australian Bureau of Statistics for June 2009.

'Other modes' is predominantly walking, cycling and taxis.

Figure 1.5: Proportion of journeys to work by public transport to various CBDs in the Sydney–Newcastle–Wollongong area, 1999–2000 to 2009–10

Source: BTS 2011

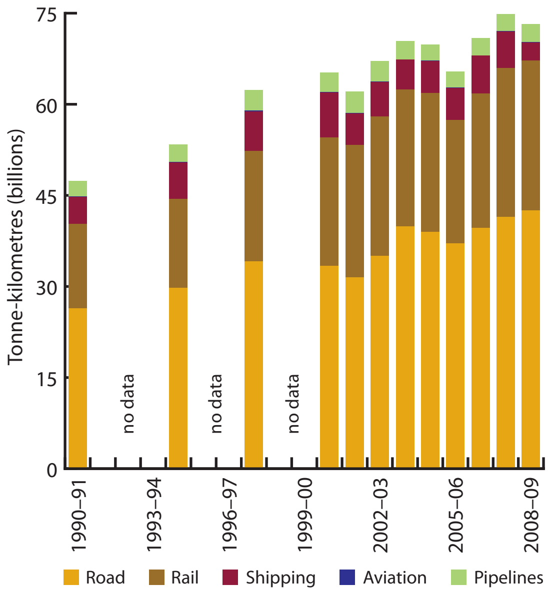
Notes: Year estimates for Sydney CBD are based on three years of pooled data. For example, the 2009–10 estimate uses data collected from July 2007 to June 2010 weighted to the 'Estimated Resident Population' issued by the Australian Bureau of Statistics for June 2009. Other centres are based on five-year datasets.

Public transport patronage: Public transport patronage tends to track population growth with peaks and troughs mostly reflecting those of the economic cycle. This relationship has remained relatively stable from 1980–81 to 2010–11 (**Figure 1.6**). The combined patronage of the Government bus services (Sydney Buses), private bus operators, and the Liverpool–Parramatta Transitway amounts to more than 200 million passenger trips annually in the Sydney metropolitan region (excluding the School Student Transport Scheme). During 2010–11, patronage on the CityRail network (which is bounded by Dungog, Scone, Lithgow, Goulburn and Bomaderry) grew 1.8% to more than 294 million passenger journeys. Sydney Ferries operates close to 170,000 services each year, transporting more than 14.5 million people across Sydney Harbour and the Parramatta River.

Freight transport in NSW

NSW domestic freight in 2008–09 amounted to 73.2 billion tonne-kilometres with a growth rate since 1994–95 of about 2.1% per year. Road transport continues to dominate the freight task, with 58% of domestic freight carried by road (up from 56% in 2006–07). In the same year, rail transport's share reached its highest level since 2000–01, but shipping declined to its lowest in nearly 20 years (**Figure 1.7**).

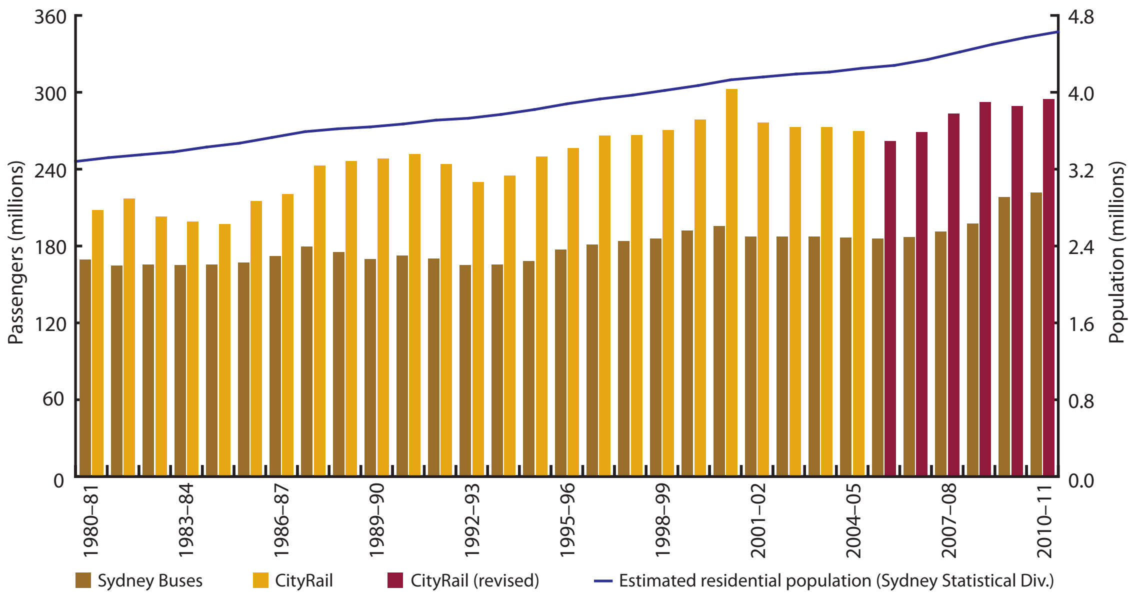
Figure 1.7: Domestic freight transport by mode in NSW, 1990–91 to 2008–09



Source: CTEE & APC 2011, Table 6-3

Notes: Includes interstate freight movements, but not international freight movements.
Data for 2008–09 is estimated.

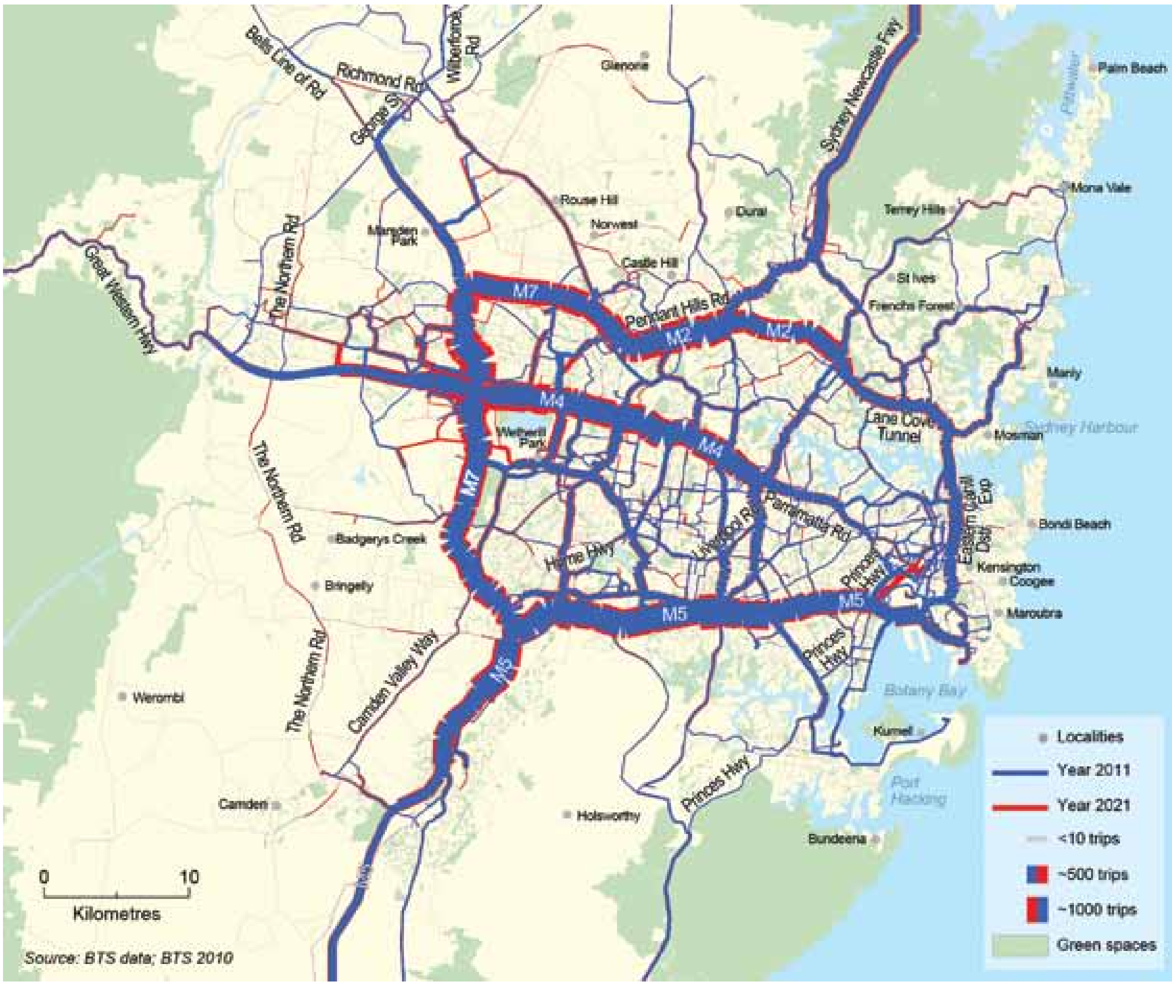
Figure 1.6: Patronage of Sydney Buses and CityRail, 1980–81 to 2010–11



Source: ABS 2012; BTS 2012; BTS data 2012; STA Annual Reports; RailCorp Annual Reports

Notes: Sydney Buses data covers the bus contract regions of northern Sydney, the northern beaches, eastern suburbs and inner western Sydney. Data includes private bus services on the Liverpool–Parramatta Transitway from February 2004, as well as those private services in the west and north-west taken over by the Government since mid-2007. Sydney Buses provides approximately 62% of all bus trips in the Sydney Statistical Division on an average weekday (T&I 2009).
The exceptional peak in rail patronage occurred during the 2000 Olympics.
Measurement of CityRail patronage underwent a major review in 2010–11. The revised measure covering 2005–06 to 2010–11 more accurately estimates patronage and improves the consistency of the figures with other rail data such as station gate counts.

Map 1.2: Sydney freight growth, heavy commercial vehicle trips, average weekday, 2010–11 to 2020–21



Forecast economic growth in NSW is expected to see the state's road freight movements reach 40.4 million tonnes per year by 2018–19 (an expansion of 16.4% over 10 years). The overall road freight task is projected to increase even more over this period to 50.6 billion tonne-kilometres per year (up 20.6% over 10 years) because of an increase in the average length of trip taken (CTEE & APC 2011).

For Sydney, trips by light commercial vehicles, such as delivery vans, are predicted to increase by about 14% between 2010–11 and 2020–21 (similar to the expected rate of population growth), while rigid and articulated heavy vehicle movements are forecast to grow by about 30% (**Map 1.2**) (BTS 2010).

Noise

The level of annoyance or discomfort caused by noise depends on the type, timing, duration, frequency and other characteristics of the noise. Noise pollution can affect people's quality of life and health and should be minimised as far as possible by good planning and pollution control. Evidence from large-scale epidemiological studies links the population's exposure to environmental noise with adverse health effects (WHO 2011). However, not enough baseline data is available to establish acceptable benchmarks to gauge whether noise levels are changing with increasing urbanisation and industrial development.

Complaints about noise are managed by a number of organisations but are mainly dealt with by local councils, the Environment Protection Authority, NSW Police and Roads and Maritime Services. The incident reports received are not considered to be an accurate indicator of the extent of noise pollution and typically understate it. As a result, the data on complaints received by Environment Line below is indicative only.

Reports to Environment Line

Noise pollution is the second most common type of complaint call received by the NSW Office of Environment and Heritage Environment Line (DPC 2011, p.222). In 2010–11, Environment Line received 2635 noise incident reports (or complaints). Noise from scheduled premises was the most common complaint (46% or 1210 incident reports), followed by noisy vehicles (39% or 1035 incident reports) and noise from non-scheduled premises (15% or 390 incident reports).

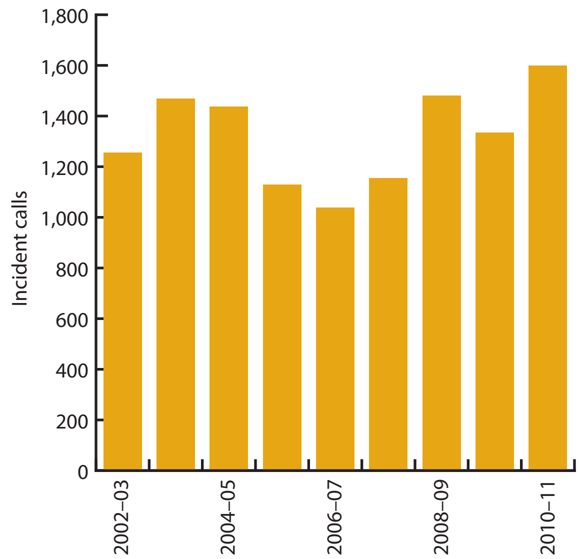
Figure 1.8 shows the number of calls made about non-vehicle related noise to Environment Line since 2002–03. These calls represent only a fraction of total complaints about noise, as most complaints are directed to councils, police and other agencies that are also responsible for dealing with noise issues in NSW. The number of noise incident reports to Environment Line has varied over the years but is now at its highest level in the period shown.

In 2010–11, Environment Line also received 3687 requests for information about noise issues, which accounted for 9.5% of all environmental inquiries received. This compared with 4686 or 11% of requests for information in 2007–08.

Noise complaints to NSW Police

NSW Police record all calls received by their Computerised Incident Dispatch System (**Table 1.2**). Reports about alarms have declined by 63% since 2008–09, perhaps partly due to vehicle immobilisers replacing vehicle alarms as the preferred technology to prevent vehicle theft. Another factor may be the police practice to no longer respond to call-outs in connection with alarms unless they receive confirmation that a crime has occurred.

Figure 1.8: Non-vehicle noise incident reports to Environment Line, 2002–03 to 2010–11



Source: DECC 2007a, Appendix 13; DECC 2008, Appendix 13; DPC 2011, p.222

Table 1.2: Noise and alarm incidents attended by NSW Police, 2008–09 to 2010–11

Type of incident	2008–09	2009–10	2010–11
Noise complaint	106,243	106,236	100,889
Noise complaint attended	8,595 (8.1%)	8,636 (8.1%)	7,801 (7.7%)
Alarm (vehicle or building)	33,434	13,672	12,367
Alarm attended	5,907 (17.7%)	2,149 (15.7%)	1,661 (13.4%)
Noise abatement direction issued	6,796	6,733	5,924
Legal action arising from noise abatement direction	473 (7%)	554 (8.2%)	551 (9.3%)

Source: NSW Police data 2011

Pressures

A range of measures is required to deal with the complex pressures arising from population growth and short-term tourists visiting NSW. Long-term planning strategies by government are designed to mitigate the negative impacts of growth and visitation. Further pressures resulting from population growth, such as water and energy consumption, and waste disposal are discussed in People and the Environment 1.3, People and the Environment 1.4 and People and the Environment 1.5.

Transport pressures that affect the environment include:

- the distance people travel to their place of work or essential facilities
- mode of transport used or the number of travellers using a transport option
- transport technology and fuel efficiency
- fuel prices
- the availability and quality of public transport and pedestrian and cycling facilities.

These pressures influence the amount of fuel consumed and the volume of emissions created (see Atmosphere 2.1), noise pollution, and other impacts which directly affect the environment.

Transport noise, especially from road traffic, affects a significant portion of the community as well as the environment. Questions about the impact of road traffic noise on human health were included in the 2009 NSW Health Survey, an ongoing telephone survey of NSW residents that monitors the self-reported health of the population. A total of 10,719 interviews with adults in rural and urban locations revealed that 45.8% of respondents considered they were exposed to road traffic noise. However, 66.8% indicated no disturbance from this exposure (Centre for Epidemiology & Research 2010).

Aircraft noise is also a significant issue for some sections of the community. Sydney Airport is Australia's busiest, accounting for 42% of the country's international aircraft movements and 22% of domestic passenger movements in 2010–11.

Other pressures contributing to increased noise pollution include:

- population growth and expanding urbanisation
- industrial development in former rural areas
- the growth in use of mechanised labour-saving devices.

Responses

Established responses

Integrated land-use and transport planning

Coordinated and consistent planning at state, regional and local levels for population growth, infrastructure and services is a priority for the NSW Government.

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, has identified five areas in which to advance integrated land-use and transport planning:

- Goal 7 – 'Reduce travel times'
- Goal 8 – 'Grow patronage on public transport by making it a more attractive choice'
- Goal 9 – 'Improve customer experience with transport services'
- Goal 19 – 'Invest in critical infrastructure'
- Goal 20 – 'Build liveable centres'.

The *Metropolitan Plan for Sydney 2036* (NSW Government 2010a) provides key directions for making Sydney more connected, sustainable and competitive and sets residential and employment targets for Sydney local government areas. *State Environmental Planning Policy (Urban Renewal) 2010* identifies three potential urban renewal precincts: Redfern/Waterloo, Granville town centre and the Newcastle CBD. The key principle of the policy is to integrate land-use planning with existing or planned infrastructure to create revitalised local communities.

Metropolitan and regional strategic planning

The NSW Government prepares planning strategies which provide the framework for integrating land-use and transport planning in metropolitan Sydney and regional NSW. Between 2012 and 2014, new strategies are being released to reflect government priorities. The strategies are long-term documents with a 25-year vision for their regions. They include actions to conserve biodiversity, protect air quality, manage with less water, move towards cleaner energy, protect viable agriculture and resource land, and respond to the risk of climate change. By managing and coordinating growth, the strategies minimise impacts on the natural and cultural environment.

Strategies are in place for Sydney, the Central Coast, Far North Coast, Mid-North Coast, Lower Hunter, Illawarra, South Coast and the Sydney–Canberra corridor, and a draft strategy has been prepared for the Murray region. Local councils are required to consider and be consistent with the vision, policies and actions of the relevant strategy when preparing their local environmental plans.

NSW 2021 Goal 20 – 'Build liveable centres' has set a target to increase the percentage of the population living within 30 minutes by public transport of a city or major centre in the Sydney metropolitan area. The aim is to create compact urban areas which preserve environmentally important land and assist residents to reduce their reliance on non-renewable resources, such as oil. Planning strategies will provide the framework for housing and employment growth that supports this aim.

The metropolitan area of Sydney has also been arranged into subregions that combine local government areas sharing similar issues and challenges in planning for growth and managing change. Subregional strategies will be prepared outlining housing and employment growth targets and key planning principles to facilitate the urban development necessary to increase employment and housing within public transport catchments. The strategies will provide the context for preparation by councils of local environmental plans, which guide local land-use planning. The preparation of subregional strategies is a priority action under Goal 20 of *NSW 2021*.

The Government released Strategic Regional Land Use Plans for the Upper Hunter and New England North West in 2012 to balance the growth of the mining and coal seam gas industries with the protection of strategic agricultural land. The plans are consistent with the Strategic Regional Land Use Policy, which also includes the *NSW Aquifer Interference Policy* (DPI 2012) and Code of Practice for Coal Seam Gas Exploration. The Central West and Southern Highlands have been selected as the next regions to receive strategic plans which will deliver a tailored approach to the specific needs, challenges and opportunities of the areas they cover and provide local communities with greater certainty about how their regions will change over time.

Redirecting freight from road to rail

The vast majority of freight movements in NSW are road-based, with rail's share of the east coast interstate freight task low when compared with roads. Rail only provides a significant proportion of freight movements between the east and west coasts of Australia.

The need to increase the transport of freight by rail is an identified priority. Under Goal 19 of *NSW 2021*, the State Government has committed to the following target: 'Enhance rail freight movement: double the proportion of container freight movement by rail through NSW ports by 2020'. This would take the proportion of freight carried to and from NSW Ports by rail to around 28% by 2020–21.

To support this goal, an intermodal terminal is being developed at Enfield in Sydney. This is in addition to the Southern Sydney Freight Line which provides a dedicated rail line for freight between Macarthur and Sefton; another intermodal terminal development proposed at Moorebank; and works to improve the reliability and capacity of freight trains on the Main North Line between North Strathfield and Broadmeadow in Newcastle.

Traffic congestion

Another focus of *NSW 2021* is improving the efficiency of the road network to ease transport congestion and reduce travel times for those travelling by car, bus or truck. Actions to achieve this include:

- delivering road infrastructure to relieve congestion
- improving safety and increasing the capacity of road corridors (such as through the Pinch Point and Congestion initiatives which target peak hour traffic hot spots in 23 Sydney corridors)
- providing better real time travel information to motorists
- improving accident clearance times.

Alternative transport is important in reducing congestion on the roads. During 2010–11, the Roads and Maritime Services (RMS) increased the length of bus and transit lanes to 200 kilometres as well as the length of off-road cycleways to almost 2000 km (RTA 2011).

FleetWise is a NSW Government program to help organisations reduce running costs and the emissions of greenhouse gases and other pollutants from their passenger and light commercial vehicles under 3.5 tonnes, as well as heavy vehicles. These reductions are achieved through a combination of:

- improved vehicle procurement
- adopting alternative vehicle and fuel technologies
- improving fleet management practices
- improving driver practices.

By the end of 2011, around 8000 vehicles from 35 fleets were participating in FleetWise, with some fleet managers reporting fuel and cost savings of up to 12%.

Public transport

NSW 2021 sets long-term goals and immediate actions that will help deliver better outcomes for transport. Action to increase patronage on public transport includes improving train, bus and ferry reliability; minimising waiting times for customers; and increasing the availability of real time travel information.

Bus initiatives: During 2010–11, continued investments in bus services included 253 to serve growth areas such as the Hills District worth $114.9 million; 114 articulated buses ($86.9m); and 198 new buses – 93 for the State Transit fleet and 105 for private operators ($97.6m)

Since its introduction in October 2008, the Metrobus network with its high-frequency, high-capacity links between major destinations across Sydney has grown quickly to 8000 services per week on 13 routes.

A hybrid bus went into service in mid-2011 to trial the potential for energy and greenhouse gas savings from this new technology. This project contributes to the development of a clean energy future for NSW.

Rail initiatives: Sydney's geographic expansion has been faster than that of the city's rail network. The Government is supporting urban growth, especially in the North-West and South-West growth centres, through additional investment in rail infrastructure. Two new heavy rail lines in these areas and a light rail extension in the inner west will increase the reach, capacity and patronage of public transport for Sydney.

The South-West Rail Link will create two new stations at Leppington and Edmondson Park (both with commuter car parking) and the construction of two additional tracks between Kingsgrove and Revesby will also support this new line.

Significant investment in rolling stock is continuing. By the end of 2014, Waratah trains comprising 626 new air-conditioned carriages will be in service on the Sydney network. The Oscar project for inter-urban trains will see 221 double-decker carriages in place by March 2013.

Ferry initiatives: In May 2011, the NSW Government announced the reform of Sydney Ferries by franchising existing services with the aim of delivering improved and expanded services to commuters.

Walking and cycling

A range of green travel initiatives is being implemented. Encouraging people to leave their car at home and use alternatives will help to reduce carbon pollution, improve air quality and maximise the capacity of the existing road network. This balances the needs of public transport passengers, bicycle riders and motorcyclists, pedestrians, motorists and commercial operators.

Regulating noise

In NSW, the Environment Protection Authority (EPA) administers the *Protection of the Environment Operations Act 1997* and Protection of the Environment Operations (Noise Control) Regulation 2008, which provide the legal framework for managing environmental noise. No single government authority is responsible for managing noise pollution.

The *Liquor Act 2007*, administered by the NSW Office of Liquor, Gaming and Racing (OLGR), provides for the management of licensed premises, including noisy behaviour by patrons.

Government agencies responsible for dealing with noise issues include:

- local councils (for barking dogs, and noise from building and construction, garbage collection, and sporting and entertainment venues)
- the EPA (for noise from large industrial complexes, key public infrastructure and concerts at major state venues)
- NSW Police and local councils (for noisy car alarms, garden equipment and musical instruments in residential properties)
- NSW Police and OLGR (for noise from clubs and pubs).

The NSW Government provides guidance to regulators, industry and acoustic practitioners about how to manage different types of noise and limit land-use conflicts likely to result in noise complaints.

Motor vehicle noise

Noisy vehicles account for a significant proportion of noise complaints to Environment Line. Because motor vehicle ownership is increasing in NSW, general levels of road traffic noise throughout NSW have risen. Government responses include:

- targeting individual noisy vehicles
- enforcing nationally agreed noise standards
- expanding the network of stations that test noisy vehicles
- setting noise standards for road traffic on new and redeveloped roads
- providing guidance for developers building residences near busy roads and rail corridors.

The *NSW Road Noise Policy* (DECCW 2011a) specifies noise criteria that define acceptable road traffic noise when road projects are being assessed to protect the community from the impact of road traffic noise. A new relative increase criterion has been introduced to minimise significant increases in road traffic noise in quiet areas.

A study of best-practice planning for noise and vehicle air emissions along road and rail corridors led to preparation of the *Development Near Rail Corridors and Busy Roads: Interim guideline* (DoP 2008b) to support specific rail and road provisions of *State Environmental Planning Policy (Infrastructure) 2007*. The policy introduced goals for internal noise levels for residential and other sensitive developments alongside busy road and rail corridors to protect health and amenity in line with World Health Organization guidelines. The planning guidelines recognise that judicious land-use planning, architectural design, building orientation and good internal layout can achieve acceptable acoustic amenity in close proximity to busy transport corridors.

Since 2008, NSW Roads and Maritime Services (RMS) has developed the Noise Abatement Program (NAP) to mitigate noise impacts associated with existing state and federal roads. The NAP provides noise mitigation treatment for dwellings and noise-sensitive land uses, such as schools, hospitals and churches, that are exposed to high levels of road traffic noise as measured by specific criteria. Noise abatement treatments available under the program include noise barriers, noise mounds and architectural treatments. RMS allocated $3 million to the program in 2010–11 and $8 million in 2011–12.

Developing responses

Review of the planning and development system

Goal 29 under *NSW 2021* is to restore confidence and integrity in the planning system with the target of rewriting the state's main planning law. An extensive listening and scoping phase between July and November 2011 informed preparation of an issues paper which was released in December 2011. Based on this consultation, a 'green paper' was exhibited recommending a preferred planning system structure. This will lead to the exhibition of a 'white paper' prior to a legislative Bill being submitted to the NSW Parliament in early 2013.

The aim of the reforms is to move from an overly regulated and prescriptive planning system to a simpler, strategic and more flexible performance-based framework with community participation and strategic planning as its focus. Rather than detailed prescriptions on how planning and development assessment should be carried out, the new system will include delegated instruments (or 'practice notes') and guidelines, providing greater flexibility and an ability to respond to change.

A new metropolitan strategy for Sydney will be prepared as a 20-year plan to build liveable centres across the city. It will guide future planning and investment decisions covering housing, economic development and jobs, open space, and the transport needed to connect homes, jobs, education and recreation facilities.

A review of the system for managing Crown land has commenced and is due for completion in 2013.

Transport

Central to the NSW Government's strategic planning framework for transport is the NSW Long Term Transport Master Plan currently being developed by Transport for NSW (TFNSW 2012) and which will reflect the consolidation of the state's urban and regional strategies as well as the Freight Strategy. Underpinning the top-level strategies will be a strong focus on land-use planning, corridor strategies, access plans, modal plans and other supporting plans. The master plan will use agreed forecasts about where people will be living and working, as reflected in land-use and other local and regional planning strategies, and integrate with NSW's 20-year Infrastructure Strategy and national strategies and plans.

Informing the Long Term Transport Master Plan will be transport and mode strategies, including a Freight Strategy and regional strategies. These will outline short, medium and long-term transport projects based on an assessment of existing and future demand and needs as well as service requirements, costing, economic appraisal, and environmental and engineering information.

As part of its submission to Infrastructure Australia in November 2011, the NSW Government released the draft options paper *Rail Options for the Sydney Greater Metropolitan Area* (TFNSW 2011). When endorsed, the master plan will identify future infrastructure priorities to increase capacity on the rail network. Current Government projections indicate that demand for rail transport will continue to grow, making it important to protect corridors that will allow for future expansion. Precinct planning around stations will guide the improvements required to assist connectivity and provide equitable access.

Rail initiatives: The North-West Rail Link will feature eight new stations over a 23-kilometre arc from Epping to Rouse Hill. In addition, track duplication on the Richmond Line between Quakers Hill and Schofields will cater for future passenger demand. To encourage additional public transport patronage, four commuter car parks at Blacktown, Schofields, Macarthur and Kingswood rail stations and seven interchange upgrades at Narwee, Werrington, Allawah, Panania, North Strathfield, Kingswood and Kogarah will be opened in 2011–12. The Government's Parking Space Levy is intended to discourage car use in business districts by imposing a levy on off-street commercial and office parking spaces. Part of the revenue raised goes towards additional car parking facilities across the CityRail network.

Light rail initiatives: Under the Sydney Light Rail Program, existing light rail will be extended 5.6 km from Lilyfield to Dulwich Hill. The extension will provide additional public transport services through nine new stops in the inner western suburbs. The Sydney Light Rail Strategic Plan, when complete in 2012, will assess the wider network benefits and needs of customers to achieve the best public transport services for passengers in the CBD, University of NSW and University of Sydney corridors.

Walking and cycling: A whole-of-government Cycling Action Plan is being implemented, which represents the largest program of bicycle initiatives and construction projects ever prepared for NSW. The plan combines investment in cycling infrastructure with a range of social programs and policy reforms designed to ensure riding a bike becomes as easy as walking or driving for short local trips. The action plan will be reviewed and updated as part of work to prepare the Long Term Transport Master Plan.

A draft NSW Walking Strategy has been developed as part of the transport master plan to address pedestrian needs and encourage more people to walk. In the meantime pedestrian facilities, including bridges over major roads and local access improvements, are being delivered in partnership with local councils and other Government agencies. One such project includes the Wynyard Walk, a fully accessible pedestrian link between Wynyard Rail Station, the developing CBD western corridor and Barangaroo.

Rail noise

Efforts are also being made to better manage the environmental impacts of noise from the rail system. This requires action by rail infrastructure owners and developers, rail operators, train manufacturers, regulatory and planning authorities, and the community (OEH 2012). The current approach includes noise criteria for new and redeveloped rail lines, a rail noise abatement program, environmental planning guidelines for new residential developments along rail lines, and rolling stock noise-emission standards (DoP 2008b).

Industrial noise

The key *NSW Industrial Noise Policy* (EPA 2000) is scheduled for review to ensure it reflects best-practice mitigation and management measures for noise-generating industrial activities.

The NSW Government has overseen a study into methods for estimating the strength of temperature inversions. This is important because noise levels can increase markedly in these meteorological conditions. The implications of this research for assessing industrial noise will be taken into account in the forthcoming review of the Industrial Noise Policy.

An EPA study of the level and character of low frequency noise and infrasound in the environment will inform its review of the assessment methodologies for low frequency noise from industrial sources.

Wind farm noise

The NSW Government released draft planning guidelines for wind farms in December 2011 for community feedback (DP&I 2011a; DP&I 2011b). The draft guidelines have enhanced noise criteria, noise assessment and noise compliance requirements.

Neighbourhood noise

Neighbourhood noise is another significant source of noise pollution, with responsibility mainly residing with local councils and the NSW Police. Noise pollution is effectively controlled locally or regionally, depending on the source. For example, NSW is working with other jurisdictions to develop a scheme for Australia and New Zealand which would require residential air conditioners and household garden equipment to have noise labels to assist consumers to select appropriate models.

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. Between 2012 and 2014, existing strategies will be revised and new strategies prepared to provide a 20-year vision for NSW.

More baseline data about noise would assist planners and compliance officers to deal effectively with noise problems. State and local governments need coordinated strategies to ensure that land-use compatibility is considered upfront in all planning processes to prevent the generation of new noise sources that have an adverse impact on public health and amenity. Planning for new developments should aim to avoid noise-related land-use conflicts through initial planning, with appropriate separation of incompatible uses. Urban renewal should be located and designed to minimise noise impacts on residents while recognising the benefits of concentrating housing around transport nodes or corridors. The planning of new release areas should consider existing adjoining land uses, such as small farm holdings.

1.2 Greenhouse gas emissions

Annual New South Wales greenhouse gas emissions have remained relatively steady since 1989–90, with per capita emissions below the national average.

Using the UN accounting methodology, the state's greenhouse gas emissions (including those from land use) were equivalent to 157.4 million tonnes of carbon dioxide (CO_2-e) in 2009–10. This has been relatively steady since 1989–90 and at 21.8 tonnes per person, these emissions are below the national average of 25.1 tonnes per person.

Eighty-five per cent of NSW emissions are from the use of energy, which includes the equivalent of 62 million tonnes of CO_2 coming from the burning of coal for electricity generation and 18 million tonnes CO_2-equivalent from methane released during the mining of coal.

Since 1989–90, emissions from fugitive emissions, agriculture, land clearing and waste disposal all declined, while those from transport and industry have increased. Emissions from electricity generation grew on average at just under 2% per year.

NSW indicators

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

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

The greenhouse effect is a well-understood process. Greenhouse gases in the atmosphere, along with a number of physical processes, act to reduce the loss of heat to space, allowing the Earth to maintain an average global surface temperature of about 14°C. This is about 33°C warmer than if there were no greenhouse gases in the atmosphere (IPCC 2007, p.946). The increased use of fossil fuels since 1750, land-use changes, agriculture and other activities have resulted in a growing accumulation in the atmosphere of such greenhouse gases as carbon dioxide, methane, nitrous oxide, ozone and manufactured gases like chlorofluorocarbons (IPCC 2007; CSIRO 2011). As a result, extra heat is being trapped by the atmosphere as evidenced by an increase in global surface temperatures (IPCC 2007, p.4).

Global greenhouse gas concentrations and Australasian temperatures

For most of the past 2000 years, global atmospheric concentrations of greenhouse gases have been fairly stable and only since the Industrial Revolution have they increased significantly (**Figure 1.9**).

Concentrations of atmospheric carbon dioxide are known to have risen from the natural range of ~170–300 parts per million (ppm) observed over the last 800,000 years (Lüthi et al. 2008) to an average in 2011 of about 390 ppm (CSIRO 2011): northern hemisphere concentrations (such as at Mauna Loa, Hawaii) have been measured at 2–3 ppm higher than those in the southern hemisphere (such as at Cape Grim, Tasmania). Mauna Loa data shows that carbon dioxide concentrations are now increasing at about 2 ppm per year.

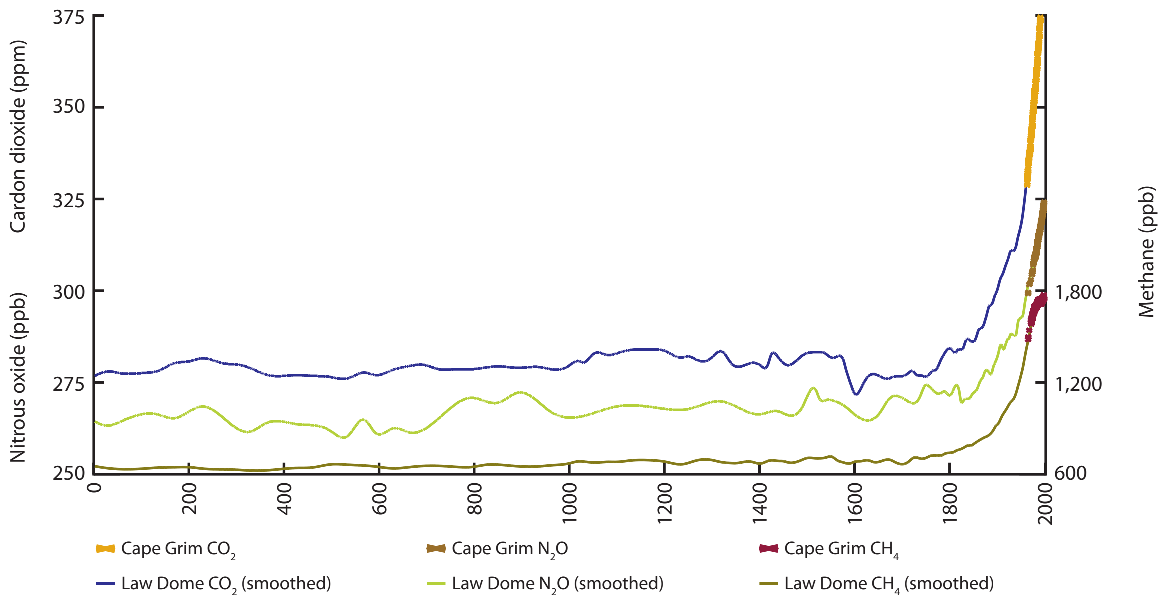
Current atmospheric methane concentrations of 1789 parts per billion (ppb) are more than double the levels present at any other time during the past 800,000 years, while nitrous oxide concentrations are about 20% higher (Spahni et al. 2005; MacFarling Meure et al. 2006; Loulergue et al. 2008; Schilt et al. 2009; Montzka et al. 2011).

The last time that carbon dioxide concentrations were comparable to these modern levels was 10–15 million years ago, when the world climate was significantly warmer than at present (3–6°C on average) and sea levels were much higher (Tripati et al. 2009; Allison et al. 2011).

Temperatures in the Australasian region are already rising quickly to their highest levels in more than a thousand years (**Figure 1.10**). Over the last century, Australia has experienced an average warming of about 0.9°C, slightly above the worldwide average of 0.8°C.

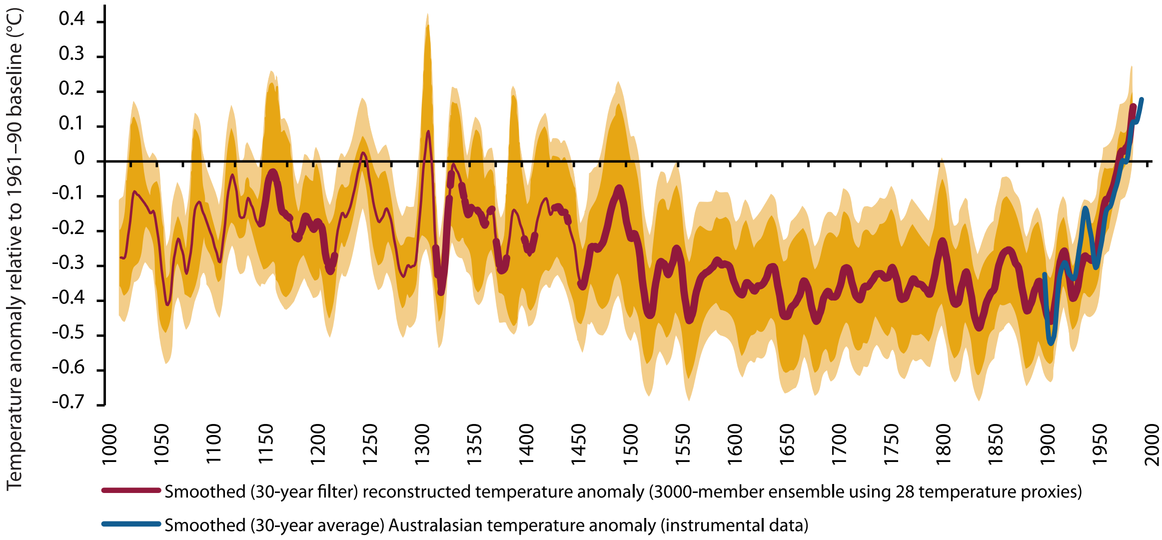
Carbon dioxide is the largest single contributor, being responsible for approximately 63% of the change in the climate observed since pre-industrial times (CSIRO 2011).

Figure 1.9: Greenhouse gas concentrations from ice cores (Law Dome, Antarctica) and direct measurement (Cape Grim, Tasmania), AD 1–2012



Source: CSIRO data

Figure 1.10: Australasian September–January mean temperature reconstruction, AD 1000–2001



Source: Gergis et al. in revision

Notes: This reconstruction is based on 28 temperature proxies from the Australasian region and was generated using multivariate principal component regression. The dark brown line represents the average of an ensemble of 3000 reconstructions, which are based on varying reconstruction parameters. The reconstruction uncertainties are denoted by the lighter brown shadings; they are defined as twice the ensemble (mid-brown) and combined calibration and ensemble Standard Error (light brown; 2×SE).

The most reliable periods of the reconstruction are shown by the thick sections of the dark brown line with less reliability indicated by the thin dark brown line. The blue line represents the instrumental data.

Status and trends

Global greenhouse gas emissions

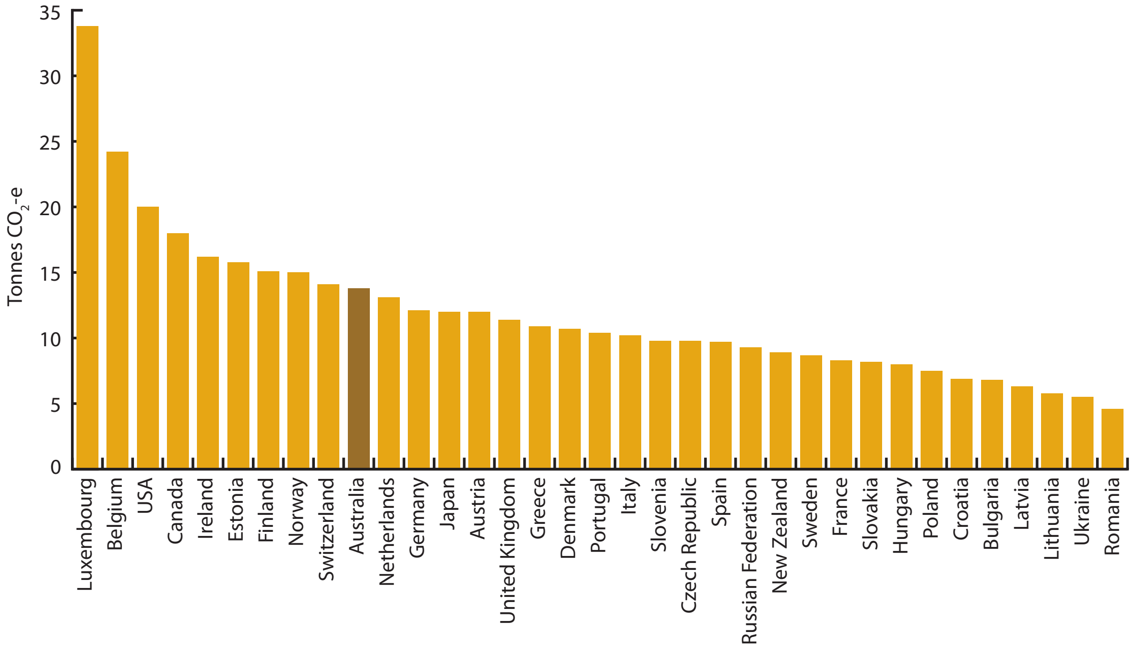
Total greenhouse gas emissions are quantified using carbon dioxide equivalent (CO_2-e), a measure used to compare the global warming potential of various greenhouse gases relative to the concentration of carbon dioxide.

In 2010, global greenhouse gas emissions were estimated to be 36,700 million tonnes of carbon dioxide equivalent (Mt CO_2-e), the highest level in history (Peters et al. 2012). The use of fossil fuels accounted for 90% of all emissions. This was 49% higher than the 1990 Kyoto reference year, with developed countries emitting just over half of the total (GCP 2011).

Australian greenhouse gas emissions

Using the same accounting guidelines as the Intergovernmental Panel on Climate Change (IPCC) and United Nations Framework Convention on Climate Change (UNFCCC), an estimated 561 Mt CO_2-e of greenhouse gases were emitted in Australia in 2010 (DCCEE 2012). This makes Australia one of the highest per capita emitters of greenhouse gases in the world, ranked above Saudi Arabia, Canada and the United States (IEA 2011, pp.97–99). However, when emissions are tallied taking into account the production of traded goods and services within Australia and the consumption of those goods in other countries, Australia's per capita emissions (14 tonnes CO_2-e per person) are only slightly higher than the average for all developed countries (12 tonnes CO_2-e per person) (**Figure 1.11**) (Davis & Caldeira 2010; Peters et al. 2011). This is due primarily to Australia being one of the few developed countries that is a net exporter of energy (Syed et al. 2010).

Figure 1.11: Per capita greenhouse gas emissions in developed countries, based on consumption of goods and services, 2008



Source: Adapted from Peters et al. 2011 and UNFCCC population estimates.

NSW greenhouse gas emissions

Using the UNFCCC accounting methodology, total NSW greenhouse gas emissions for 2009–10 were 157.4 Mt CO_2-e (28% of the national total) (DCCEE 2012). Despite NSW being the largest contributor to national emissions, the state's balance of industrial, commercial and service activities mean its annual per capita emissions (21.8 tonnes) are below the national average (25.1 tonnes). However they are nearly double the average across all of the developed nations of 11.3 tonnes (DCCEE 2012).

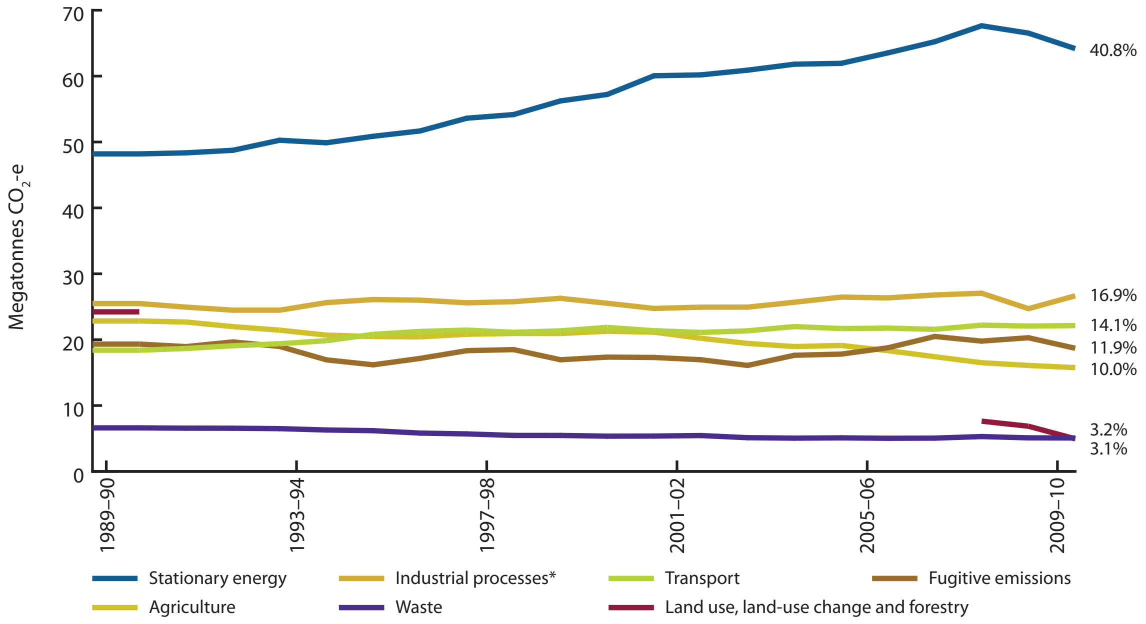
The majority of NSW emissions are carbon dioxide (73%), followed by methane (23%), nitrous oxide (3%) and other gases (1%) (DCCEE 2012). Emissions from the combustion of fossil fuels (coal, oil and gas) increased about 275% between 1960–61 and 2009–10 and accounted for nearly 75% of NSW emissions at the end of that period. At 62 Mt CO_2-e, emissions from NSW local coal consumption is about 40% of the state total. Almost 80% of local coal is used in electricity generation and most of the remainder in industry (see also People and the Environment 1.5).

The production of coal also releases methane equivalent to 18 Mt CO_2-e (12 Mt from underground mines and 6 Mt from surface mines). This represents 97% of all NSW 'fugitive emissions', with small contributions from oil and gas recovery, transport and storage. Fugitive emissions depend on the production methods used in mining: a pilot plant at Vales Point Mines can capture and use methane (or convert it to a less potent greenhouse gas by flaring).

NSW emissions components

Stationary energy emissions (primarily electricity generation) have grown one-third since 1989–90 (**Figure 1.12**) (an annual average growth rate of just under 2%), reflecting the growing NSW population and economy. Greenhouse gas emissions from this sector stood at 64.2 Mt CO_2-e in 2009–10. Growth in electricity generation and use in recent years has been tempered by energy efficiency improvements by users, a move towards lower emissions generation from gas-fired power stations and renewable sources, and reduced demand due to the impacts of the Global Financial Crisis (Figure 1.12). Electricity generation and use in NSW is expected to resume growing (see Figure 1.22 in People and the Environment 1.5).

Figure 1.12: NSW greenhouse gas emissions components, 1989–90 to 2009–10



Source: DCCEE 2012

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

Accounting of emissions from land use, land-use change and forestry is interim and will be finalised at end of the Kyoto Protocol commitment period (2008–12). This will account, for example, for reafforestation that may have occurred since 1990, but was cleared before the end of the commitment period.

Emissions from the second-largest greenhouse component, industrial processes, include a variety of mainly chemical processes in a wide range of industries: iron and steel, cement clinker, lime production, limestone and dolomite use, chemical manufacturing and aluminium production. Industrial process emissions have been relatively steady since 1989–90.

Transport emissions are currently the next fastest growing component of NSW-generated greenhouse gases, with road transport accounting for 90% of all NSW transport emissions. This reflects the importance of motor vehicles for both passenger and freight transport within the state. Between 1989–90 and 2003–04, emissions increased by 3.6 Mt and have remained relatively steady since then.

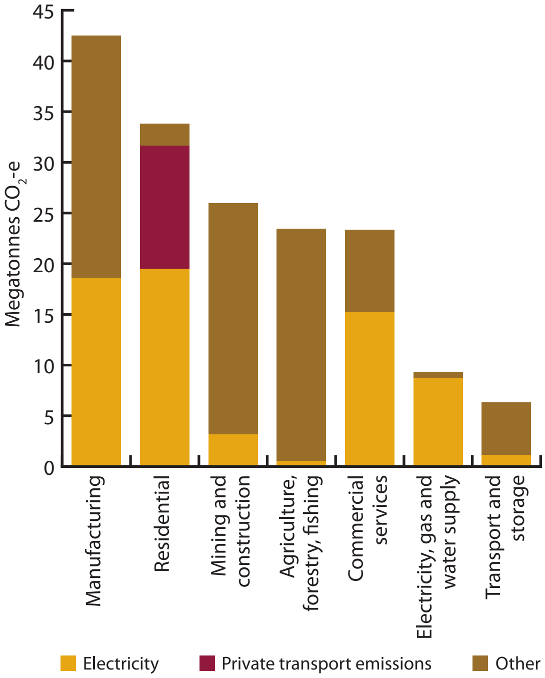
Fugitive emissions also contribute more than 10% of NSW emissions, amounting to 18.7 Mt CO_2-e in 2009–10.

The primary source of agricultural emissions is methane produced as cows and sheep digest their food. At about 12 Mt CO_2-e in 2009–10, these emissions account for approximately three-quarters of all NSW agricultural emissions (15.8 Mt CO_2-e in 2009–10). Emissions from agriculture have fallen by 30% since 1989–90. This trend has accelerated since 1999–2000 with an average annual decline of over 3% per annum as production fell during the prolonged drought across much of the state. Sheep numbers, for example, have fallen by over 40% since 1999–2000 (DCCEE 2012).

Emissions from the waste sector (5 Mt CO_2-e in 2009–10) are made up of solid waste disposal on land (landfills) and wastewater handling (sewage treatment). Since 1989–90, emissions from waste decreased by almost a quarter as increased waste associated with growing populations and industrial production were offset by higher recycling rates (see People and the Environment 1.3), methane recovery and improved use of the gases for productive purposes at landfills.

Estimates of greenhouse gas emissions from land use, land-use change and forestry are based on the emissions from deforestation, less carbon that is sequestered by reforestation projects. With land clearing rates falling considerably in NSW in the 1990s and remaining relatively stable over the past decade (see Biodiversity 5.2), emissions from land clearing have also fallen. In 1989–90, 24 Mt CO_2-e of greenhouse gases were emitted because of land clearing. Since then, changes to the management of land use, land-use change and forestry have reduced related emissions by nearly 80%. In parallel, NSW forestry projects undertaking plantings for carbon

Figure 1.13: NSW greenhouse gas emissions by end use sector, 2009–10



Source: NSW Office of Environment and Heritage (OEH) estimates based on Australian Department of Climate Change and Energy Efficiency data

Notes: The economic sectors presented above and used for national climate change reporting do not match the four economic sectors presented in People and the Environment 1.5 and should not be directly compared.

sequestration have accelerated, removing over 3 Mt CO_2-e of greenhouse gases from the atmosphere in 2010. Importantly, accounting of emissions from this sector is interim and will undergo finalisation at the end of the first Kyoto Protocol commitment period (2008–12).

When all sectoral emissions are added together (including the interim figures for emissions from land use, land-use change and forestry), NSW greenhouse gas emissions have remained relatively steady since 1989–90, being 0.6% higher than the base year in 2007–08 and 2.1% lower in 2009–10.

NSW emissions by economic sector

Greenhouse gas emissions produced during electricity generation can also be attributed to the final consumer of the generated electricity. Using this approach, the manufacturing sector makes the largest contribution to greenhouse gas emissions in NSW (43 Mt CO_2-e), followed by the residential sector (34 Mt CO_2-e) (**Figure 1.13**). Residential emissions include emissions from electricity use (20 Mt CO_2-e), private transport (12 Mt CO_2-e) and other emissions, primarily from the use of gas for cooking and heating (2 Mt CO_2-e).

Pressures

Global emissions

Ongoing growth in the world economy, together with a relative increase in the level of greenhouse gas emissions, has effectively raised the planet's overall 'carbon intensity' (Canadell et al. 2007; Peters et al. 2012). This has led to rapid growth in fossil fuel (CO_2) emissions and accelerating broadscale land-use changes. Natural systems provide an array of 'ecosystem services', including CO_2 sinks in the land and oceans that offset about half the greenhouse emissions generated by human activities (CSIRO 2011, Ch.2). However recent scientific research suggests that natural CO_2 sinks are not increasing as quickly as emissions, with particular concern about terrestrial sinks in the Arctic and northern hemisphere systems and ocean sinks in the Southern Ocean (Le Quéré et al. 2009; Jung et al. 2010; Hayes et al. 2011; Lourantou & Metzl 2011).

The Copenhagen Accord declared that deep cuts in global emissions are required 'to hold the increase in global temperature below 2°C' (UNFCCC 2009). Recent research suggests that to have any reasonable prospect of meeting this target, carbon dioxide emissions will have to stop rising within this decade, then fall below 90% of 2010 levels by 2020, and be wholly or mostly eliminated before cumulative worldwide emissions reach the equivalent of one trillion tonnes of carbon (Allen et al. 2009; Meinshausen et al. 2009; Raupach et al. 2011). The world has already emitted the equivalent of more than 500 billion tonnes of carbon since the Industrial Revolution and, at current growth rates for CO_2 emissions, the remaining 400–500 billion tonnes will be emitted by about 2050 (CSIRO 2011, Ch.2).

Meeting the 2°C target will require sustained emission reductions well beyond 2020. Such reductions can be achieved through restructuring primary energy use to decouple emissions from economic growth (Le Quéré et al. 2009). However, the decades-long service life of much of the world's energy-related infrastructure means that a large part of the global emissions expected over the next few decades are already locked in (Davis et al. 2010).

NSW emissions

The growth in emissions from energy use in NSW is linked to an increase in per capita income and a growing population (**Figure 1.14**).

Although total NSW emissions have remained relatively steady since 1990, this is expected to change with demand for electricity forecast to resume growing by about 1.6% annually to 2019–20 and beyond (AEMO 2012) (see Figure 1.22 in People and the Environment 1.5). As a result, emissions from electricity generation are forecast to keep growing to 2020 and beyond unless there is a move to lower emission sources (DCCEE 2011). In contrast, agricultural emissions are forecast to either remain stable or increase slightly up to 2019–20 and beyond as livestock numbers gradually recover from the prolonged drought conditions (DCCEE 2011).

Responses

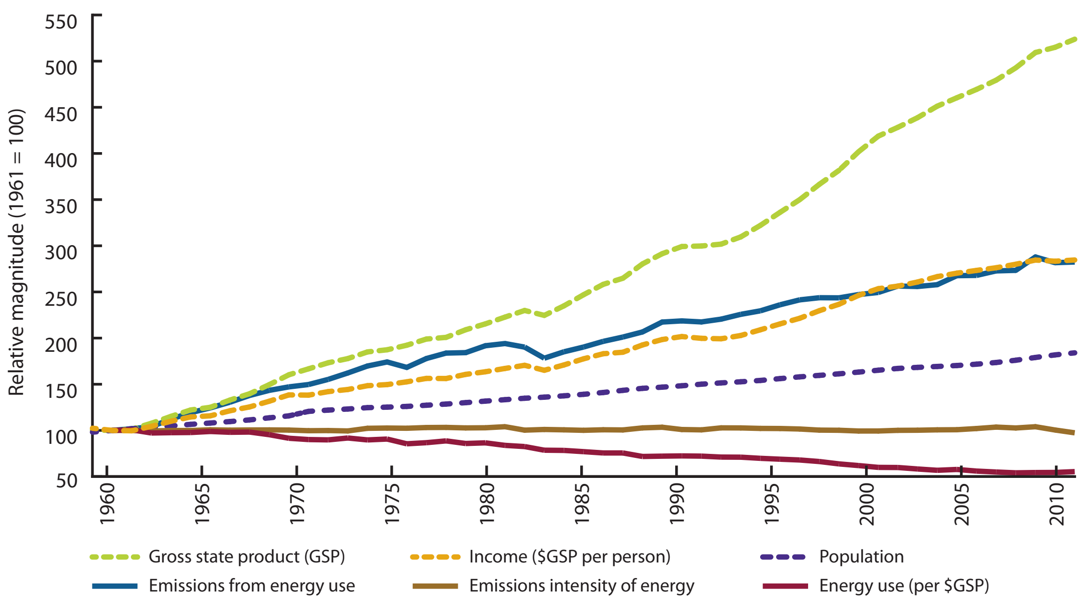
As part of their Copenhagen Accord pledges, all industrialised countries have submitted economy-wide emission reduction targets, while major developing nations have agreed to limit the growth of their emissions (UNFCCC 2011). Emissions will be reported annually and progress in emission reductions every two years. These pledges are consistent with emissions pathways that lead to likely temperature increases of between 2.5°C and 5°C by the end of this century (UNEP 2010), well above the 2°C target identified in the Copenhagen Accord.

Existing responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, includes initiatives aimed at using energy more efficiently and moving to sources of electricity with lower emissions. The increased use of sustainable energy sources is one priority, with the following target under *NSW 2021* Goal 22 – 'Increase renewable energy: 20% renewable energy by 2020'. The federal renewable energy target of 20% by 2020 creates a broader national objective and contributing to this is a priority action under Goal 22.

Figure 1.14: Trends in NSW energy use, compared with key NSW statistics, 1960–2010



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

Notes: The Kaya identity analysis for emissions from energy use (after Raupach et al. 2011) is: [Emissions from energy use] = [Population] × [per capita $GSP] × [Energy use per $GSP] × [Emissions intensity of energy].

Using energy more efficiently is a priority action under *NSW 2021* with a target to assist business and households to realise annual energy savings of 16,000 gigawatt-hours (GWh) by 2020. Emissions reduction will also receive indirect support from Goal 7 – 'Reduce travel times' and Goal 8 – 'Grow patronage on public transport by making it a more attractive choice'. Importantly, these actions aimed at reducing greenhouse gas emissions also reduce air pollution.

Clean Energy Futures package

The reduction of greenhouse gas emissions will be primarily addressed through the Commonwealth's Clean Energy Futures package (see below), rather than through effort by individual states and territories.

The introduction of the NSW Greenhouse Gas Reduction Scheme (GGAS) in 2003 resulted in the abatement of nearly 100 Mt CO_2-e of greenhouse gas emissions between January 2003 and December 2010 (IPART 2011, Table 3.3). The scheme fostered the development of new green industries and delivered valuable skills in emissions trading and green finance to the NSW economy.

The commencement of the Australian Government's Clean Energy Legislative Package introduced a fixed price for the carbon emissions produced by Australia's top 315 polluters from 1 July 2012. The NSW Government closed GGAS on the commencement of the federal carbon pricing mechanism (GGAS SA 2012; MR&E 2012).

Using energy more efficiently

Energy efficiency is about improving energy productivity and achieving more with less by using energy wisely and avoiding energy waste. Increased energy efficiency in homes, businesses and industry can provide financial benefits by lowering electricity bills as well as costs to the economy through more economically efficient energy consumption and supply patterns.

NSW 2021 commits to improving the efficiency of energy use and assisting business and households to save 16,000 GWh of energy a year by 2020 compared with business-as-usual trends. A range of strategies that support households, businesses and government agencies to reduce energy use across the state are being developed and implemented.

NSW Energy Efficiency Strategy: NSW has developed this strategy to implement energy efficiency measures that will reduce the cost of consumers' power bills and improve economic performance. These goals can be achieved because there are considerable opportunities to save money by reducing energy consumption rather than increasing its supply.

A number of energy efficiency programs, covering small businesses, lower income households and community organisations, are funded from the NSW Climate Change Fund (CCF) under the Energy Efficiency Strategy. Since July 2007, the $700-million fund has provided financial support for households, businesses, communities, schools and government to save energy and reduce greenhouse gas emissions.

In 2010–11, the CCF spent $63m to save water and power, cut greenhouse gas emissions, and reduce water and energy utility bills. On average, every $1 the CCF invests in energy and water saving initiatives delivers more than $5 in utility bill savings (OEH 2011). By 30 June 2011, the fund had supported projects cutting an estimated 0.992 Mt CO_2-e of greenhouse gas emissions per annum, saving 0.924 GWh of electricity and reducing peak demand by 67 megawatts (MW) (OEH 2011). Sustainable reductions in peak demand help to partially offset the need for new generation capacity or an increase in the size of the network in some areas.

Specific CCF-financed community and business energy efficiency programs include:

- The Energy Saver program provides subsidised energy audits and technical and project advice to assist with implementing energy saving projects. At December 2011, participating organisations had achieved annual savings of 138 GWh of electricity and 717,000 gigajoules (GJ) of gas, with cost savings totalling $29.1m per year.
- The Energy Efficiency for Small Business Program helps small businesses implement energy-efficient improvements by offering subsidised energy assessments, Energy Action Plans, and matched funding and installation assistance for new plant and equipment. At December 2011, over 16,000 small businesses had achieved ongoing annual savings of 0.042 Mt CO_2-e with reduced electricity costs of $9.7m per year.
- The Energy Efficiency Training Program (linked to the NSW Green Skills Strategy) has delivered vocational training to over 2600 people with 37 free courses for architects, engineers, facility managers and manufacturers developed and piloted with industry and university partners.

- The Energy Efficiency Community Awareness Program provides the NSW community with information and practical advice on how to reduce electricity use at home and work. It acts as an umbrella for other government programs targeting energy efficiency for households, business and the community (see People and the Environment 1.6).
- The Home Power Savings Program offers free home energy assessment, energy refit and tailored advice to 220,000 lower income households across NSW. By February 2011, over 80,000 assessments had been completed, providing annual savings of approximately 78 GWh of electricity and 0.082 Mt CO_2-e.

The CCF has also stimulated investment in both emerging and proven clean energy technologies in NSW. In 2010–11, the CCF provided $82m to programs such as the NSW Clean Coal Fund (now known as the 'Coal Innovation Fund') (see 'Lower emissions energy' below), national energy market projects, and communication and education projects (OEH 2011). It has also provided $138m to the Solar Bonus Scheme to support the adoption by households and small businesses of renewable energy technologies.

Energy savings schemes: Investments in cost-effective energy efficiency measures are being encouraged through the *Electricity Supply Act 1995* (ES Act) and *Energy and Utilities Administration Act 1987*.

Starting in 2005, all businesses and government agencies that used more than 10 GWh of electricity per year at a site (along with designated local councils) were required to develop Energy Savings Action Plans. Plans from all 267 entities required to prepare them were approved by 30 June 2009. These set out 2359 measures that aimed to save 0.825 Mt CO_2-e of greenhouse gas emissions each year. By 30 June 2011, 48% of the measures had been implemented.

The Energy Savings Scheme started under the ES Act on 1 July 2009. Complementing the achievements of the Greenhouse Gas Reduction Scheme (which closed in July 2012), the scheme sets annual energy savings targets for electricity retailers, providing clear financial incentives for them to develop creative, cost-effective programs that reduce energy use and provide energy efficiency services to consumers. The scheme is expected to drive energy efficiency gains supplementary to those under the national carbon tax which commenced on 1 July 2012. Work is currently under way between the NSW and Victorian Governments to improve alignment between the Energy Savings Scheme and the Victorian Energy Efficiency Target scheme.

Other schemes

The following programs also provide opportunities for environmental savings:

- The Building Sustainability Index (BASIX) was introduced by the NSW Government in 2004 to ensure that new homes are designed and built to high energy and water efficiency standards (see also People and the Environment 1.3, People and the Environment 1.4 and People and the Environment 1.5).
- The National Australian Built Environment Rating System (NABERS) is a performance-based rating system that promotes more efficient use of existing buildings (see also People and the Environment 1.4 and People and the Environment 1.5).
- The Australian Government's Smart Grid, Smart City initiative will trial smart grids/meters that provide information for business and households about the cost of power on the grid at any time. The initiative is also supporting trials of energy efficiency technology, such as the CSIRO's new smart meter technology and intelligent heating, ventilation and air conditioning systems (see also People and the Environment 1.5).

Developing responses

Lower emissions energy

The majority of the proposed new electricity generation facilities in NSW do not involve the use of coal as an energy source. This has the dual effect of reducing the state's dependence on coal and aiding the move to lower emission energy sources. Gas is being increasingly used for electricity generation, as are renewable energy sources, especially wind, with most new renewable energy over the next decade expected to come from wind power (see People and the Environment 1.5).

NSW 2021 commits the state to achieving a 20% renewable energy target by 2020. In 2009–10, about 12% or 8557 GWh of the state's energy consumption was from renewable energy sources (see People and the Environment 1.5). This is a significant increase in renewable energy consumption since *SoE 2009* (DECCW 2009a) when energy consumed in NSW from renewable energy sources was 6%. By March 2012, more than 160,000 households and small business customers had installed solar photovoltaic systems in NSW which contributed 358 GWh of energy (IPART 2012a).

To support the 20% national renewable energy target, a state Joint Industry–Government Taskforce has been established to develop a Renewable Energy Action Plan for NSW. In conjunction with the Renewable Energy Precinct Program and Renewable Energy Development Program (funded under the Climate Change Fund), the action plan will position the state to increase the use of energy from renewable sources at least cost to the energy customer and with maximum benefits for NSW (see People and the Environment 1.5).

Emissions from land management (and carbon storage opportunities)

Public lands in NSW store approximately 1.5 billion tonnes of carbon. The NSW Government administers almost 50% of land in NSW (including the Western Division, which itself comprises 42% of the state's land). Appropriate management of the carbon stored on public lands will help maintain landscape values and reduce NSW carbon emissions. The NSW Government is working to manage carbon across all types of public land (e.g. OEH in prep.[a]).

The establishment of markets such as the Carbon Farming Initiative will support the expansion of carbon farming and allow land managers to diversify their income streams. The initiative provides an opportunity for land managers to create income from activities which avoid greenhouse gas emissions or sequester (store) carbon on the land. Other programs, such as the Biodiversity Fund, support landholders to establish new native vegetation, maintain existing plantings, and manage invasive species in native vegetation. NSW will work to ensure that farmers and land managers maximise the opportunities from carbon farming while also protecting biodiverse carbon stores and securing positive environmental outcomes from carbon farming.

The NSW Office of Environment and Heritage is working with the Department of Primary Industries and Lachlan Catchment Management Authority on a soil carbon pilot project in which Lachlan catchment farmers can tender a price to change their management practices for five years to sequester more carbon in the soil. The projects aim to test a market mechanism that encourages changes in land management to increase soil carbon sequestration, while still achieving sustained production.

Future opportunities

As a means of maintaining supply of electricity while reducing emissions, research and development is currently being conducted in NSW into suitable, cost-effective technologies that can be added to conventional energy systems. The NSW Government established the Clean Coal Fund (now 'Coal Innovation Fund') and has invested $100m in a fund to research, develop and demonstrate low-emission coal technologies.

Areas of research and development include:

- Carbon capture and storage: The possibility of retrofitting post-combustion capture and storage of carbon dioxide to existing power stations is being explored, although this is not yet commercially available for power stations emitting in the order of 15 Mt CO_2-e per annum or more.
- Combustion efficiency improvement technology: Developments in Integrated Gasification Combined Cycle technology and hybrid combined cycle power stations (where the exhaust heat from a gas turbine assists combustion in a conventional coal furnace) are being monitored by NSW Trade & Investment, as part of its Coal Innovation Fund program.
- Drainage of mines to reduce emissions: With the sponsorship of the Coal Innovation Fund, the CSIRO is researching options to enhance methane drainage of 'gassy' mines or remove methane from ventilation air with the aim of potentially using the drained gas for power generation.

There are also opportunities in NSW to improve resource recovery and energy efficiency by reducing or capturing and using fugitive emissions, such as those from landfill waste decomposition or mines, and through the recovery and use of waste heat from industrial processes.

1.3 Waste and recycling

Overall waste recycled in New South Wales climbed to 59% in 2008–09, an increase of 7% on 2006–07 levels. Recycling has improved in all regions of the state and for all three waste streams. Construction and demolition waste is close to achieving the 2014 target recycling rate of 76%.

Total waste disposed of in the Sydney Metropolitan Area and surrounding Extended Regulated Area fell 15% in the 12 years since 2000. This was driven by marked reductions in two waste streams – municipal waste and commercial and industrial waste – which fell 22% and 30%, respectively.

Several community programs have proved effective in tackling waste issues. The Household Chemical CleanOut program collected and safely treated almost one million kilograms of hazardous waste from householders in 2010–11, while the Western Sydney RID Squad, with the participation of seven local councils, investigated close to 5000 illegal dumping incidents and took follow-up action by issuing 93 clean-up notices and 733 penalty notices.

NSW indicators

Indicator and status	Trend	Information availability
Total and per person solid waste disposal	Decreasing	✓✓
Total and per person solid waste recycled	Increasing	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Waste is generally defined as any product or substance that has no further use and which is, or will be, discarded. It is what is thrown away because it is no longer needed or wanted and is a by-product of almost every human activity. Australia faces a significant challenge in managing its wastes, given a long-term national trend to increase the generation of solid waste. In 2008–09, a total of 46.8 million tonnes of waste was generated nationally with approximately 52% of this being recycled. However, despite steady increases in the rate of recovery, the waste generated between 2002–03 and 2008–09 grew by 40% while population increased 9.8% (ASoEC 2011, Box 2.1).

The generation and improper disposal of waste can cause air and water pollution, land contamination and the loss of land which is used for landfill sites. The extent and nature of environmental or health threats from waste depend on the type of waste and the way it is managed.

Status and trends

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

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

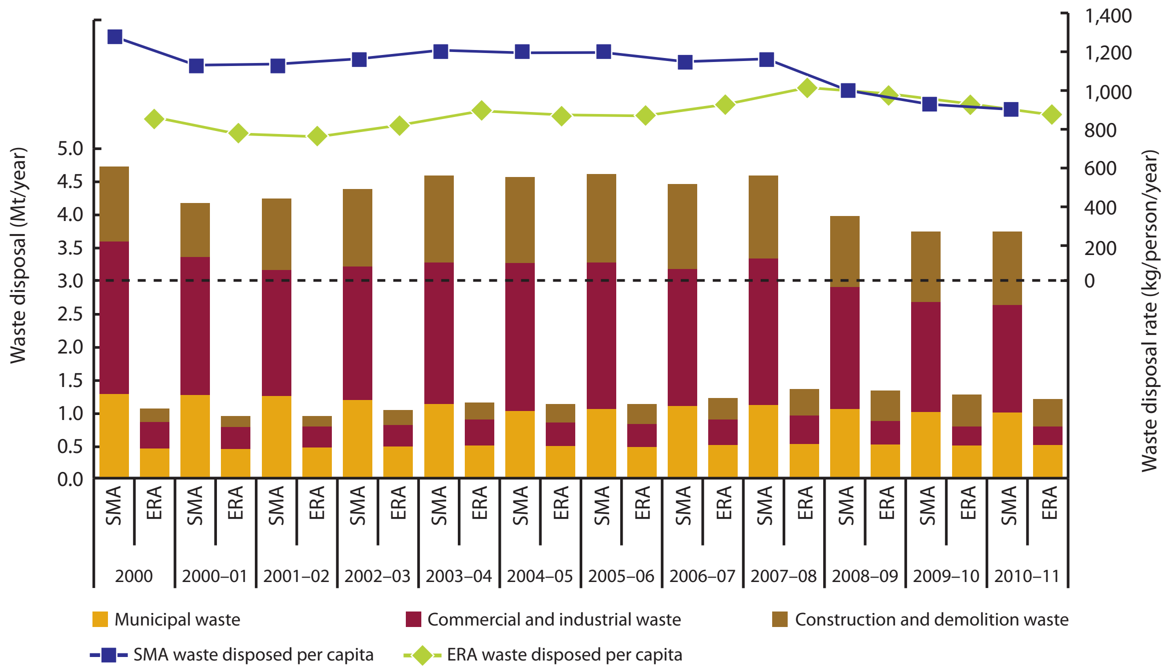
Under the Protection of the Environment Operations (Waste) Regulation 2005 (section 4), waste disposal and resource recovery is regulated regionally across the state through the:

- Sydney Metropolitan Area (SMA)
- Extended Regulated Area (ERA), which comprises the Hunter, Central Coast and Illawarra regions
- Regional Regulated Area (RRA), which comprises 21 coastal councils north of Port Stephens to the Queensland border, as well as the Blue Mountains, Wollondilly and Upper Hunter regions – this area was added to the regulated areas in 2009 and waste disposal and resource recovery data is not yet available
- Non-Regulated Area (NRA), which compromises the remainder of the state – waste data is limited and therefore not discussed in detail in this report.

Waste disposal rates and trends

In 2010–11, total waste disposed of in the SMA plus ERA was 15% lower than the 2000 base year shown in **Figure 1.15**. This decrease in waste disposal was driven by a reduction of 21% (986,500 tonnes) in waste disposed of in the SMA since 2000. While disposal tonnages of C&D waste remained stable over this period, there were marked reductions in waste disposal in the municipal and C&I streams: 22% and 30%, respectively. The overall decline in waste disposed of in the SMA, however, has been offset to some extent by a 14% (144,500 tonnes) increase in disposal in the ERA. This increase can be largely attributed to a doubling of C&D waste in the region. A more modest increase of 11% was also observed in the municipal sector. However, the disposal of C&I waste decreased considerably by 29% compared with 2000 figures.

Figure 1.15: Waste disposal rates by waste stream and waste disposal per person, SMA and ERA, 2000 to 2010–11



Source: NSW Office of Environment and Heritage (OEH) data December 2011.

The 2010–11 data shows that waste disposal per capita in the SMA has remained fairly stable since 2009–10 with a modest decrease of 2%. This is despite population growth of 2% in the region. There has been a continual trend downwards in per capita disposal in this region since 2007–08. A small decline of 7% in waste disposed per capita was observed in the ERA between 2009–10 and 2010–11.

Waste trends are published in financial years to allow comparison against significant socio-demographic and economic indicators which are available on a financial year basis. The 2000 calendar year is the base year against which the targets of the *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC 2007b) are measured.

Hazardous waste

Hazardous waste is generated in relatively small quantities and cannot be disposed of to landfill untreated. It encompasses a broad range of material which presents potential threats to health and the environment, particularly if mishandled. Hazardous waste includes spent chemicals, processing residues, contaminated raw materials, soil contaminated with chemicals, by-products from manufacturing and waste treatment, and unwanted (expired or damaged) raw materials. The handling, transport, storage and treatment of hazardous waste are regulated by licensing. Movement of this waste off-site must be tracked under the Environment Protection Authority's on-line waste tracking system.

As a signatory to the *Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal* (the 'Basel Convention'), Australia has international obligations regarding hazardous waste. This includes ensuring that the generation of hazardous (and other) wastes within Australia is reduced to a minimum, taking into account social, technological and economic aspects. This commitment is reflected in the *National Waste Policy: Less waste, more resources* (EPHC 2009a), which noted that the generation of hazardous waste (as defined under the Basel Convention) doubled from 0.64 million tonnes in 2002 to 1.19 million tonnes in 2006 (though now appears to have stabilised). Data on the generation of hazardous waste in NSW is not available. However, there is information regarding the collection and disposal of household hazardous waste in NSW.

The Household Chemical CleanOut program provides a free service to households to collect and safely treat a range of common household hazardous materials throughout the SMA and ERA. The program helps to reduce community and environmental exposure to chemicals and other hazardous materials in the waste stream (DECC 2009a). In 2010–11, this program collected and safely treated 982,751 kilograms of household hazardous waste in 43 collections attended by 26,690 householders. An analysis in 2010 indicated that it is the largest and most efficient program of this type in Australia.

Voluntary regional council waste groups are responsible for administering household chemical collections in rural and regional NSW. Between 2009 and 2011, over 253,292 kg of household chemical waste was collected and safely disposed of. The regional groups have also facilitated events for the collection of discarded televisions and computers from households across their regions, collecting over 1000 tonnes of e-waste for recycling over the same period.

Recycling rates

Recycling is an important aspect of strategies to minimise waste and recover resources with a range of benefits that include conserving resources, reducing releases of greenhouse gases, and saving energy and water. **Table 1.3** shows the net benefit of recycling one tonne of various waste materials.

The *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC 2007b) sets the following targets for increasing recycling in three regulated waste streams by 2014:

- municipal waste from baseline 26% to 66%
- C&I waste from 28% to 63%
- C&D waste from 65% to 76%.

Of the 16.3 million tonnes of waste generated in 2008–09 in NSW, 59% (9.5 million tonnes) was recycled, up 7% on 2006–07 (DECCW 2010a). This was over 1.5 million tonnes more material recycled than in 2006–07. The greatest improvement was in the amount of C&I waste recycled, with an increase of 539,000 tonnes over the period. Municipal recycling also went up 381,000 tonnes and C&D recycling increased almost 613,000 tonnes.

Table 1.3: Net benefit of recycling one tonne of various waste materials

Materials	Global warming (tonnes CO_2-e)	Energy gigajoules (low heating values)	Water (kilolitres)
Concrete	0.02	0.28	1.28
Cardboard/paper	0.06	9.32	25.41
Glass	0.56	6.07	2.30
Mixed plastics	1.53	58.24	-11.37

Source: EPHC 2009b

Over this period, 44% of municipal waste, 52% of C&I waste and 73% of C&D waste was recycled. Thus NSW is tracking well towards its 2014 recycling target for C&D waste. This is because the materials involved are relatively easily separated at the source; markets for the recycled materials in civil construction are well established; and the Waste and Environment Levy provides significant cost incentives that discourage disposal.

Table 1.4 shows waste stream recycling performance for the SMA and ERA. In 2008–09, Sydney recycled 62% of its waste, compared with 54% in 2006–07. The rest (3.98 million tonnes) mainly went to landfill. In Sydney in 2008–09, 51% of the municipal waste generated was recycled, compared with 42% in 2006–07. On the same measure, recycling of C&I waste rose by 8% to 50% and C&D recycling also increased by 7% to 77%.

The ERA also improved its recycling performance. In 2008–09, these regions recycled 59% of their waste, up by 3% from 2006–07. C&I waste led the way with an increase of 12% in the recycling rate over this period to 60%. Recycling of municipal waste jumped 3% to 44%. However the overall improved recycling performance was offset by lower C&D waste recycling: just 68% in 2008–09 compared with 72% in 2006–07.

Recycling and disposal rates per person for key regions and the whole of NSW in 2006–07 and 2008–09 show that there was a greater proportion of waste being recycled, although more waste was generated across the state in 2008–09 than 2006–07.

For the rest of NSW, the total amount of waste recycled is estimated to have increased by 2% between 2006–07 and 2008–09 to 42% (DECCW 2010a). A decline in the amount of materials recovered per person from an estimated 0.66 tonnes per person in 2006–07 to about 0.58 tonnes per person in 2008–09 reflected a lower generation of waste per person.

Table 1.4: Recycling performance by waste stream and recycling, SMA and ERA, selected years

Financial year	Region	Waste recycling (tonnes/year)			Waste recycled (kg/person/year)	Waste recycled (% total waste from region)
		Municipal waste	C&I waste	C&D waste		
2002–03	SMA	595,000	1,022,000	2,505,000	1,116	48%
	ERA	189,500	269,500	473,000	736	47%
2004–05	SMA	605,000	1,214,500	2,508,000	1,155	49%
	ERA	239,000	401,000	504,000	891	50%
2006–07	SMA	801,500	1,528,000	2,978,500	1,397	54%
	ERA	351,500	354,406	851,380	1,199	56%
2008–09	SMA	1,076,000	1,816,500	3,684,500	1,683	62%
	ERA	389,500	546,500	994,500	1,454	59%

Source: OEH data November 2011

Regional planning has facilitated regional recycling contracts, which are proving to be effective and efficient in expanding recycling services to remote areas of the state. From 2009 to 2011, the regional contracts resulted in:

- recovery of over 47 tonnes of scrap metal and 673,500 farm drums
- collection of 1.4 million litres of used oil
- reprocessing of more than 543,400 cubic metres of organic waste.

Dry recyclables

Kerbside collections for dry recyclables, which include newsprint, cardboard, paper, and food and beverage containers, are provided by 152 councils across NSW. The overall quantity of dry recyclables collected continues to grow, up from 450,000 tonnes in 2000–01 to 704,000 tonnes in 2010–11, an increase of 57%. Mobile garbage bins are the most common collection system (with 50% of councils using them in 2001 rising to 94% in 2010–11). In 2010–11, the 103 councils offering a kerbside recycling system used the Government's preferred collection systems for dry recyclables (one 240-litre fully commingled mobile garbage bin or two 120-L mobile garbage bins, one for paper and one for containers).

In 2010–11, each person in the SMA on average set aside approximately 99.2 kilograms of material for recycling, compared with 81.3 kg in 2000–01 (**Figure 1.16**) (OEH in prep.[b]). The average per capita amount recycled in the ERA was a little higher than the SMA at 104.6 kg per person per year. These amounts are slightly down from the 2009–10 per capita figures, in the case of the SMA almost 2%. However, the per capita amount of waste disposed of to landfill through the kerbside system fell by 2.7% over the same period, indicating an overall decrease in waste generation rather than a decrease in the kerbside recycling rate.

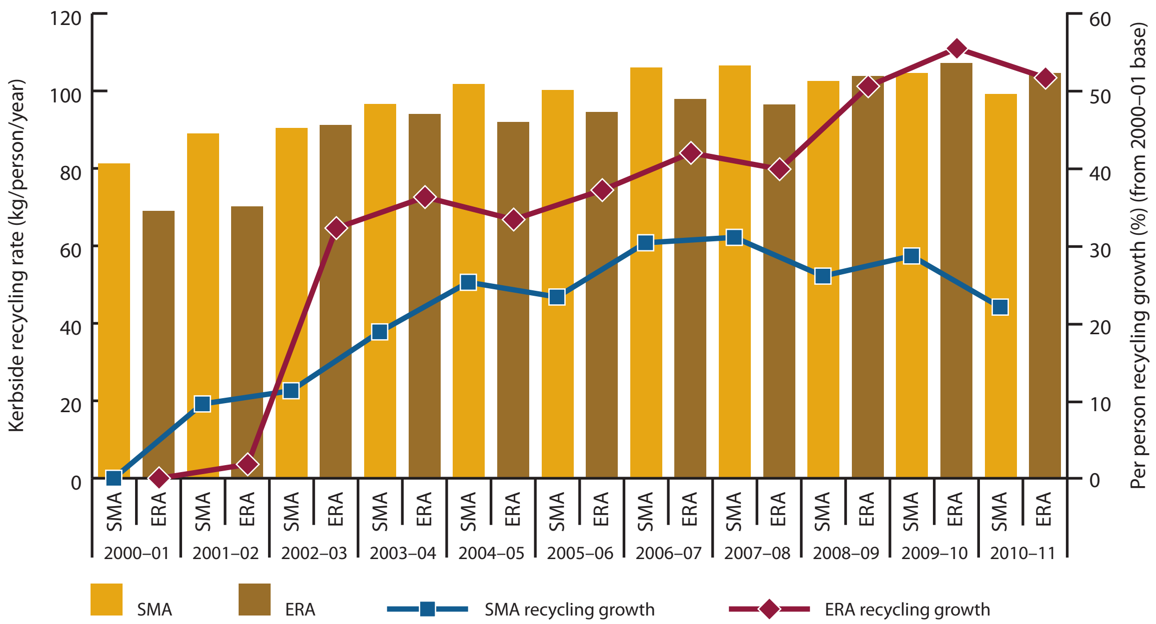
The per capita amount of dry recyclables collected from kerbside recycling in the ERA has increased by over 50% since 2000–01 (Figure 1.16), a reflection of the substantial increase in the provision of recycling services in this area. The total amount of dry recyclables has increased to 69% (OEH in prep.[b]).

On average in 2010–11, each NSW resident recycled:

- 53.7 kilograms of paper and paper products
- 26.2 kg of glass
- 6.1 kg of plastic
- 2.81 kg of steel cans
- 0.6 kg of aluminium cans.

These figures are for recyclables after contaminants were removed.

Figure 1.16: Annual kerbside collections for dry recyclables, SMA and ERA, 2000–01 to 2010–11



Source: OEH in prep.[b]

Table 1.5: Amount of garden organics recycled in the SMA and ERA combined

Year	Total generated (tonnes)	Total recycled (tonnes)	Total recycled (%)
1998	680,000	269,000	40
2002–03	1,140,000	550,000	48
2004–05	866,000	482,000	56
2006–07	820,500	561,500	68
2008–09	946,000	683,000	72
2010–11	936,000	686,000	73

Source: DECC 2009a; EPA data May 2012

Recycling of organics

Seventy-three per cent of garden organics ('green waste') across the SMA and ERA was collected and recycled in 2010–11 (**Table 1.5**).

Other results relating to the recycling of organics include:

- in 2010–11, 64 councils across NSW provided a garden organics collection service compared with 59 in 2008–09
- in 2010–11, 34 out of 38 Sydney councils provided a garden organics kerbside service
- across NSW a 25% increase in the amount of organic material recycled from kerbside collections between 2008–09 and 2010–11.

Pressures

Adverse impacts on public health and the environment can arise at many points in the life cycle of materials, including resource extraction, manufacture, use, resource recovery and disposal.

The link between economic growth and population demographics and the growth in per capita waste production is ongoing (see, for example, ABS 2007). In Australia, growth in waste generation per person is driven by population demographics and economic factors. Australians are tending to live in smaller household groups, with increases in both the ownership of more durable goods per person and the consumption of goods that have higher packaging-to-product ratios (ABS 2007). Municipal waste generation is mainly affected by population changes whereas C&D and C&I waste generation rates are strongly linked to economic conditions.

In addition to impacts on the environment associated with the consumption of resources and the generation of waste, there is growing recognition of the impacts of hazardous chemicals contained in products (see Land 3.2). The Australian Bureau of Statistics (ABS) noted that over the past decades there has been a large increase in the number and diversity of products available in Australia, along with an increase in the diversity, toxicity and complexity of waste. Electronic goods, in particular, have been identified as posing challenges to resource recovery and waste management. This is because they have shorter life spans, ownership of them is increasing, they contain hazardous substances, and there is a lack of facilities to process these products at the end of their useful life (DECCW 2009a).

Additional pressures come from hazardous substances newly listed under the *Stockholm Convention on Persistent Organic Pollutants*, such as certain brominated flame retardants which are present in small quantities in older consumer products like furniture and computers. The Convention requires persistent organic pollutants and objects containing them to be destroyed or treated prior to disposal. However, it is not clear whether the current practice of disposal to landfill meets these conditions or if this requirement can be met by other waste disposal facilities currently available in Australia (EPHC 2010). As the population of NSW grows, the consumption and disposal of products increases and, as additional hazardous chemicals are targeted for phase-out, the need for appropriate treatment and disposal facilities for chemical waste and products containing these substances will intensify.

Responses

Established responses

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, includes initiatives aimed at increasing the efficiency of consumption (of electricity, for example) and further reducing waste outputs.

Waste Avoidance and Resource Recovery Strategy

The *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC 2007b) is the main instrument used by the NSW Government to respond to the issues surrounding waste management. Reducing the generation of waste and turning it into recoverable resources are priorities for NSW. To meet this challenge, a number of programs have been established under the strategy, which also sets overall recycling targets for 2014 that are reinforced in *NSW 2021*.

In 2010, the *Review of Waste Strategy and Policy in NSW* (DECCW 2010b) examined the implementation of the Waste Strategy, focusing on progress in meeting the strategy's 2014 recycling targets. The review proposed 23 enhancements to waste policies and strategies to provide stronger drivers for achieving the targets. Following that review, an implementation strategy was developed: *Reducing Waste: Implementation Strategy 2011–2015* (DECCW 2011b) refocuses efforts to achieve the targets in the Waste Strategy and beyond and identifies five areas for particular attention over the ensuing four years:

- make it easier for households to separate and recover their waste
- make it easier for businesses to separate and recover their waste
- reduce or remove problem wastes to improve resource recovery and produce environmentally safe recyclable materials
- facilitate investment in waste infrastructure
- reduce litter and combat illegal dumping.

Goal 22 in *NSW 2021* is to 'Increase opportunities for people to look after their own neighbourhoods and environments'. Targets listed to help achieve this goal include: 'By 2016, NSW will have the lowest litter count per capita in Australia' and 'Increase recycling to meet the 2014 NSW Waste Recycling Targets'.

Waste is regulated under the state's primary environment protection legislation, the *Protection of the Environment Operations Act 1997* (POEO Act), together with the *Waste Avoidance and Resource Recovery Act 2001* and the *Protection of the Environment Operations (Waste) Regulation 2005*. These key statutes contain the requirements for managing, storing, transporting, processing, recovering and disposing of waste in NSW.

The POEO Act requires licensed waste facilities in NSW to pay a contribution for each tonne of waste received for disposal at the facility. The Waste and Environment Levy aims to reduce the amount of waste being disposed of and promote recycling and resource recovery. An independent review of the levy commenced in 2012, having been identified as a priority action under Goal 23 of *NSW 2021*. The review is canvassing stakeholder views on how the levy operates as well as ensuring that it continues to increase recycling and reduce the waste that goes to landfill.

Reducing and recycling municipal waste

The NSW Government continues to work closely with local councils to reduce municipal waste and increase recycling. Councils play an important role in managing waste in NSW. Not only do they manage the household waste stream, but councils have the potential to influence other sectors as well through, for example, community education.

The NSW Government supports local councils and improved management of household waste through various programs including those discussed below.

Improving resource recovery: The Local Council Waste and Sustainability Improvement Payments Program provides direct assistance to support the 72 councils in the regulated area to invest in new and enhanced projects and actions that will improve resource recovery and environmental sustainability outcomes within their local government area.

Voluntary regional waste groups: The NSW Government provides secretariat and funding support to Renew NSW, a forum of eight voluntary regional waste groups across 96 rural councils with a population of over 2 million people. As a result of the program, recycling from household kerbside services in 2010–11 in rural regional NSW stood at 42.5%, almost triple the 2002–03 recycling rate.

Love Food, Hate Waste: This program aims to significantly reduce the 1.1 million tonnes of food waste produced by households and businesses in NSW each year (see People and the Environment 1.6).

Support tools and information

The NSW Government continues to provide a range of tools and information to support councils to improve waste services including:

- the on-line Environmental Benefits of Recycling Calculator to let councils and communities know how much their recycling contributes to environmental improvements
- Preferred Resource Recovery Practices by Local Councils – a best bins guide that is based on audit data and clearly sets out the best systems for collection of recyclable material, including food and garden waste
- a model waste and recycling collection contract that helps councils to effectively seek and engage services that will improve their recycling and waste management.

Reducing and recovering commercial and industrial waste

The NSW Government has a range of programs for tackling the commercial and industrial (C&I) waste stream. This includes programs aimed at individual businesses to help them change their practices by using fewer materials, avoiding the generation of waste, and taking up recycling. Other programs are aimed at the system level, at points of collection or reprocessing, to increase the recovery of useable materials. Further programs target potential users of recycled materials to build demand by demonstrating performance and cost-competitiveness. Key programs include those discussed below.

Business Recycling: Through a partnership with Planet Ark, the on-line recycling directory *Business Recycling* has proved very popular with businesses, with more than 400,000 website visits and 1.3 million page views since its launch in June 2010.

Growing markets for recycled organic material: Food and garden material accounts for around 51% of the waste that households throw away. It is also a major component of business waste. Government and industry aim to increase the collection and recycling of organic material and the development of markets for it. This program has been very successful in expanding markets for recycled organic material at a rate of 7% per year over the past 10 years and is a NSW success story with more than 40 organics recycling facilities now installed across the state.

Market development (timber, glass, plastics, paper and cardboard): These materials make up significant parts of the business waste stream. Programs target barriers to recycling, which may be different for each material. This includes investing in new market areas, such as crushed glass in roadmaking and shredded timber pallets for poultry bedding.

Working with communities

The NSW Government continues to work with local communities and key partners to support recycling and waste reduction and avoidance. For example, the Government is working with schools, teachers and students to promote recycling, waste avoidance and waste reduction through the Sustainable Schools NSW program. Bilingual educators of the Ethnic Communities Sustainable Living Project have worked with local community organisations and councils to help diverse communities with recycling and waste reduction, using in-language materials, field trips and demonstrations (see People and the Environment 1.6 for more information on these initiatives).

Tackling litter and illegal dumping

RID Squads: *NSW 2021* identifies the RID Squad program as a key part of tackling illegal dumping. The RID Squads investigate incidents and take action against offenders, organise clean-ups, track down illegal landfills, identify changes and trends in illegal dumping across a regional area, and deter and educate community members about illegal dumping. Their strength is in ensuring illegal dumping issues are tackled across a region, rather than stopping at council boundaries.

For example, in 2010–11, the Western Sydney RID Squad (of seven local councils) investigated 4716 illegal dumping incidents involving approximately 226,000 tonnes of waste. Investigations resulted in the issue of 93 clean-up notices and 733 penalty notices. RID Squad activity led to around one-third of the illegally dumped waste being recycled.

The NSW Government has also worked with Aboriginal land councils and local government to support Aboriginal communities to clean up and deter illegal dumping and littering on community land as part of the Aboriginal Lands Clean-Up Program.

Litter programs: Tackling litter involves programs spanning community education, supporting local government to take action, and enforcement programs. The successful 'Don't be a tosser' litter campaign continues to be effective through kits available for councils and others that contain campaign materials targeting the community. The NSW Government has made it easy to report littering offences from vehicles through on-line reporting as well as via the Environment Line phone service. Community awareness is increased through warning letters and penalty infringement notices.

Developing responses

National action on product stewardship is a key direction under the *National Waste Policy: Less waste, more resources* (EPHC 2009a), agreed to by all Australian environment ministers in November 2009. Product stewardship and extended producer responsibility initiatives involve producers taking greater responsibility for the environmental impacts of their products throughout the product life cycle. This includes making choices of materials during product design and minimising the impacts of the product during use and at the product's end of life.

In 2011, the Commonwealth *Product Stewardship Act 2011* commenced. This landmark legislation provides the opportunity to drive other national product stewardship arrangements for priority materials. It establishes for the first time a national framework for setting up product stewardship schemes, either voluntarily by industry or through regulation. The first products to be regulated under the Act are televisions and computers. As a result, a new national TV and computer collection and recycling scheme, run by industry, will commence in 2012. Industry will have to meet targets set under the regulations. The legislation is the result of national work over a number of years, including work on television and computer recycling led by NSW.

Other products where industry is working with government to develop or implement product stewardship schemes include used tyres and fluorescent lamps. The potential to deal with other priority waste products under the legislation is very real.

National state and territory collaboration is also dealing with other priorities under the National Waste Policy, including managing and reducing the toxicity of waste, increasing recovery of commercial and industrial waste, reducing organic material to landfill and improving the collection and consistency of data across Australia.

Future opportunities

The recommendations of the independent review of the waste levy in 2012 will provide focus and direction for waste priorities going forward. A new Waste Strategy will be developed, built on the significant progress so far to springboard NSW to the next level of outcomes for waste.

1.4 Urban water

The quality of drinking water in New South Wales remains very good. The efficiency of water use and security of supply continue to improve.

Water from the state's two major metropolitan water utilities meets the Australian Drinking Water Guidelines. Drinking water supplied by regional local water utilities also meets the guidelines in over 99% of samples.

Progress on reducing water consumption per person continues: while the population across Sydney Water's operating area has grown about 21% over the past two decades, total water use has declined by about 25%.

Regional local water utilities have reduced average annual residential water use by 52% over the last 20 years.

NSW indicators

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

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

One of the greatest challenges facing NSW is a continued reliable access to water. Ensuring a secure, sustainable and equitable water supply for people, agriculture, industries and the environment is a key goal of government. In the context of the recent drought and the projected impact of climate change, the importance of securing a sustainable water supply has never been greater.

Status and trends

Urban drinking water quality

The NSW Government has endorsed the *Australian Drinking Water Guidelines* as the benchmark for the provision of water to the people of NSW (NHMRC & NRMMC 2004). These guidelines promote a preventative risk management approach for drinking water quality, from the catchment to the household.

NSW drinking water quality in metropolitan areas has continued to meet the standards set by these guidelines, with all water supplied by Sydney Water and Hunter Water meeting the microbiological and chemical water quality guideline requirements. Drinking water compliance with microbiological indicators has been maintained, while compliance with chemical indicators for most local water utilities (LWUs) improved between 2004–05 and 2010–11.

Ninety-nine per cent of the over 25,000 samples taken at 95 LWUs complied with the chemical standards. Similarly, 99% of more than 21,000 samples from LWUs also complied with the microbiological standards. Overall, 88 LWUs had 100% compliance with the standards (NOW 2012a, Table 12).

Table 1.6: Total urban water volumes by source for Sydney Water, Hunter Water and LWUs

Utility	Financial year											
	2007–08			2008–09			2009–10			2010–11		
	Surface water	Ground water	Recycled water	Surface water	Ground water	Recycled water	Surface water	Ground water	Recycled water	Surface water	Ground water	Recycled water
Sydney Water	480,642	–	10,101	497,612	–	8,264	485,698	19,952*	10,253	419,593	77,102*	10,606
Hunter Water	64,311	3,025	2,174	61,814	5,504	2,872	63,433	7,100	2,899	65,676	2,333	2,186
Albury	5,534	–	–	6,319	–	–	6,881	–	–	5,542	–	–
Ballina	3,422	–	107	3,445	8	119	4,030	–	717	3,590	–	123
Bathurst Regional	6,155	–	–	7,528	–	–	6,617	–	–	5,415	–	–
Bega Valley	1,556	1,691	–	1,634	3,710	–	1,450	2,017	613	1,560	1,665	391
Byron	2,557	–	315	2,635	–	235	3,009	–	218	2,754	–	241
Clarence Valley	6,949	–	79	7,987	–	127	7,057	–	165	5,893	–	25
Coffs Harbour	5,458	–	–	5,153	–	–	5,976	–	346	5,570	–	328
Country Energy	5,464	–	649	4,845	–	523	4,959	–	622	4,199	–	320
Dubbo	5,952	2,050	–	5,984	3,614	–	6,398	1,663	–	4,483	2,049	–
Eurobodalla	4,256	–	243	3,825	–	237	4,034	–	281	3,405	–	141
Gosford	11,959	145	–	12,519	216	229	13,596	96	14	15,470	127	37
Goulburn Mulwaree	2,362	–	–	2,433	–	–	2,443	–	–	2,328	–	153
Kempsey	974	2,741	46	1,628	3,932	32	1,396	2,338	40	1,952	1,467	–
Lismore	3,350	–	–	3,521	–	–	3,795	–	–	3,305	–	–
Midcoast	8,566	665	–	8,537	1,256	4	8,477	687	–	7,728	603	–
Orange	4,730	54	3,367	4,125	134	3,218	3,896	55	3,033	3,878	50	1,674
Port Macquarie–Hastings	6,237	–	88	6,117	–	64	6,283	–	109	6,016	–	92
Queanbeyan	3,416	–	–	3,658	–	–	3,747	–	–	3,442	–	–
Riverina	3,996	10,844	–	6,079	22,574	–	4,485	10,517	–	2,354	8,363	–
Shoalhaven	14,214	–	125	14,936	–	161	14,811	–	144	14,300	–	764
Tamworth Regional	7,131	500	–	7,239	2,910	–	8,966	678	–	8,716	330	–
Tweed	9,429	–	262	9,564	–	645	10,564	–	778	8,947	–	386
Wingecarribee	5,273	–	49	5,255	–	64	5,140	–	73	4,386	–	42
Wyong	16,215	230	1,164	16,972	572	1,295	17,075	292	940	14,551	162	570

Source: DWE 2009a, Table 8; NOW 2010, Table 8; NOW 2011a, Table 8; NOW 2012a, Table 8

Notes: All volumes are in megalitres (ML)

Does not include water supplied for non-urban uses, such as irrigation.

LWUs included have more than 10,000 connected properties. Data for the smaller LWUs are available in the source tables.

* Desalination water

Sources and volume of water drawn

Tracking the volumes of water from a range of sources, such as surface water storages (drinking water supply dams), groundwater aquifers and recycled water schemes, provides the basis for sustainable water management. Except for the water utilities servicing the greater metropolitan region (GMR_2) and central coast, most NSW water utilities have reduced the total volume of water they draw from environmental sources (groundwater and surface waters, such as reservoirs and pumping from rivers) since 2007–08 (**Table 1.6**). Across the western slopes and plains, and in the larger coastal catchments, groundwater is often a significant component of urban water supplies. In areas where groundwater availability is low, recycling of water tends to be more developed.

Recycled water

While recycled water contributes a small portion of the total water supply, metropolitan water utilities are increasing their recycling efforts (Table 1.6). Around 14.8% of water supply came from recycling in 2010–11, up from 2.9% in 2005–06 and 4.7% in 2007–08. In 2010–11, recycled water projects in Sydney Water's area of operations produced approximately 50 gigalitres (GL) of recycled water (1 GL = 1000 ML). These projects include:

- the largest residential recycled water scheme in Australia at Rouse Hill which currently supplies around 2.2 GL a year to more than 20,000 homes, eventually expanding to around 36,000 homes
- recycling of 7.1 GL of water per year for industrial use by BlueScope Steel in Wollongong, together with a further 500 ML of highly treated, disinfected recycled water supplied to the Port Kembla Coal Terminal and the local golf club and sports fields
- supplying water from the St Marys water recycling plant to help maintain the flow of the Hawkesbury–Nepean River, reducing the volume of nutrients in the river and making more water in Warragamba Dam available for drinking
- the supply of recycled water by Sydney Water to irrigate farms, golf courses, sports fields, parks and a racecourse in the Sydney region (about 5.6 GL in 2009–10).

In 2010–11, 81% of non-metropolitan LWUs recycled effluent (NOW 2012a, Table 8). A total of 37 GL of water was recycled, about 20% of the volume of sewage collected. Most of this recycling was for agricultural purposes, with 7.6 GL recycled for urban uses. The highest volume recycled by a non-metropolitan utility was 5.25 GL at Tamworth (although none was for urban use).

Pressures

Climate variability and climate change influence the availability of water, its sources and its consumption. Water availability depends on rainfall and temperature: the volume of water held in storages varies with climatic conditions, partly because of changes to rainfall, evapo-transpiration and runoff (see Water 4.1) and also because hotter, drier conditions increase the watering of lands and use of evaporative coolers.

In addition, there is constant pressure on water supplies from the demands of a growing population.

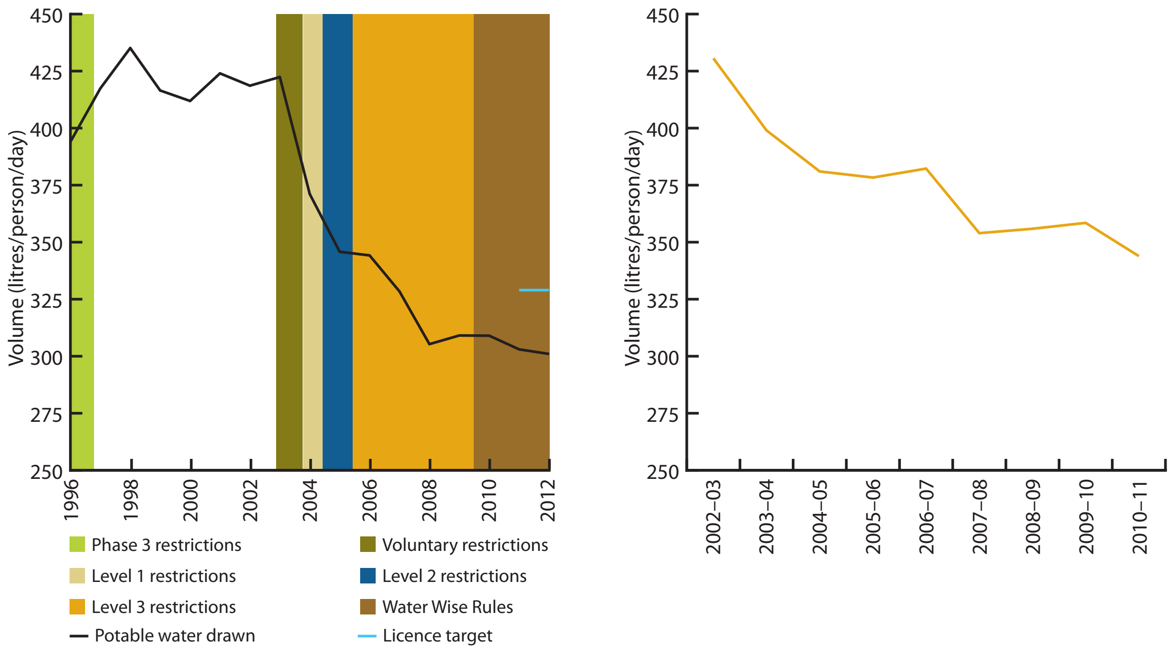
Water demand

Water has not always been used efficiently by all sectors. However, as a result of education campaigns by the NSW Government and water authorities in recent years, along with new water pricing arrangements, community attitudes are changing and water is more likely to be viewed as a valuable resource. For example, the Sydney metropolitan community has responded well to water restrictions and demand management programs and this has contributed significantly to water savings. However, further reductions in water use in all sectors of the community are required to meet future demand in NSW.

Sydney and Lower Hunter metropolitan areas

Between 1990–91 and 2003–04, Sydney Water delivered between 550 and 650 GL per year of potable water to all users (residential, industrial, commercial and government) across its areas of operation – Sydney, the Illawarra, Blue Mountains and adjacent areas. This declined to a low of 481 GL per year in 2007–08 (excluding recycled water) and has been about 500 ± 5 GL since. This sustained decline is primarily due to restrictions and demand management programs, which include water efficiency and leakage reduction programs, and water recycling.

Figure 1.17: Demand for potable water, Sydney Water (1996 to 2011) and Hunter Water (2002–03 to 2010–11)



Source: NWC 2009; Hunter Water 2011; NWC 2011; Sydney Water data 2012
Notes: For Sydney Water data, the year shown is as at 1 January; for Hunter Water data, financial years are shown.

Water consumed as a proportion of the long-term sustainable yield has fallen from over 100% prior to 2004–05 to 88% in 2010–11. This translates to a daily potable water consumption pattern that has been steadily declining, down from 343 litres per person in 2004–05 to 303 L in 2010–11. This figure is well below the water conservation target in Sydney Water's operating licence of 329 L per person per day by 30 June 2011 and was achieved five years early. Despite a population increase of about 21% over the past two decades, total water use has declined by about 25%.

The trend in potable water consumption per person from 1995–96 to 2010–11 shows the effect of voluntary and mandatory water restrictions and demand management programs over this period. The data demonstrates the success of sustainable water-use programs in preserving water supplies (**Figure 1.17**).

Over the past 10 years, Hunter Water has drawn between 69.5 and 79.6 GL of potable water per year across its areas of operation, comprising the local government areas of Newcastle, Lake Macquarie, Maitland, Cessnock, Port Stephens and Dungog. Over the past nine years, daily potable water consumption has declined by about 12% despite population growth of 10% and per-person potable water consumption falling around 20% (Figure 1.17).

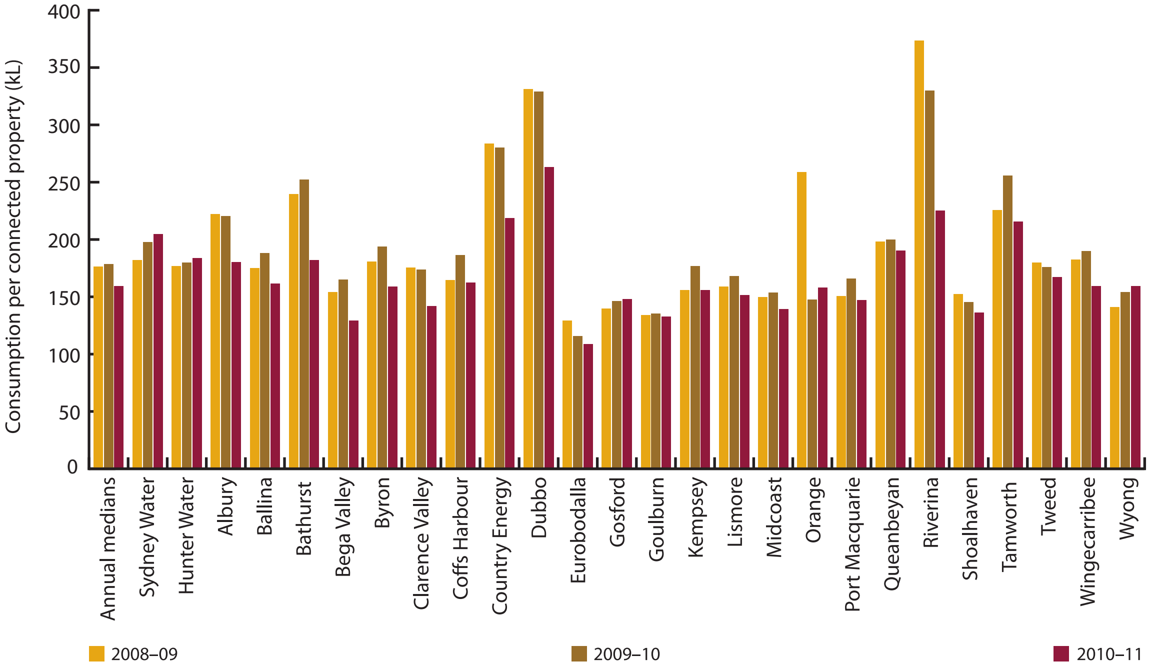
Residential water use

The average annual volume of residential water supplied by local water utilities (LWUs) to connected residential properties in regional NSW has fallen 52% over the last 20 years (from a median of 330 kilolitres per connected property in 1991–92 to 159 kL in 2010–11). This equates to a water saving of 140 GL per year.

In Sydney, the Illawarra and Lower Hunter, the residential sector is the largest water user, accounting for around 65–75% of total water consumed. In regional NSW, the residential sector accounts for two-thirds of total water consumed (NOW 2012a, Table 8).

In regional areas, the average annual residential water consumption per connected property decreased significantly for most LWUs between 2004–05 and 2010–11 (**Figure 1.18**). For example, the median residential water use in 2004–05 was 200 kL per connected property, compared with 159 kL in 2010–11.

Figure 1.18: Average annual per-property residential water consumption by LWU



Source: DWE 2009a, Table 10; DWE 2009b, Table 10; NOW 2010, Table 10; NOW 2011a, Table 10; NOW 2012a, Table 10

Notes: 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.

Responses

Existing responses

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, addresses the challenge of water management by describing a delivery framework and targets to guide decision-making in water resource allocation and management. There are three distinct components to water management in NSW:

- metropolitan water use (Sydney, the Illawarra, the Blue Mountains and adjacent areas)
- urban water use in regional areas (Hunter Region, Central Coast and country towns)
- rural water use (see Water 4.1).

One of the most significant changes to the management of water in NSW has been the adoption of statewide goals and targets through *NSW 2021*. For both metropolitan water use, and urban water use in regional areas, this includes Goal 21 – 'Secure long-term potable water supplies for towns and cities supported by effective effluent management'.

The relevant priority action under the goal is: 'Deliver the Country Towns Water Supply and Sewerage Program which supports the provision of water and sewerage services, including funding towards the capital cost of priority backlog water and sewerage infrastructure; providing emergency drought assistance; monitoring and reviewing the performance of utilities and advising on improved operation of utilities; and managing dams, weirs, water treatment, and sewage treatment facilities.'

Water sharing plans

Water sharing plans provide the statutory framework for allocating water to different types of users (town water supply, industry and irrigation) and the environment. By setting the rules for how water is shared, these plans provide a decade of security for the environment and water users. Sixty-three water sharing plans have already been developed for many areas in NSW, covering both surface and groundwater systems. About 95% of water use in NSW is now covered by a water sharing plan (see Water 4.1).

Metering of water extraction from rivers by large- and medium-scale users with entitlements is currently being implemented with large-scale users now reporting water use every three months and medium-scale users preparing regular estimates of water use.

Metropolitan water use

Metropolitan water plan: *2010 Metropolitan Water Plan* (NSW Government 2010b) 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. There are four major parts of this plan to secure 'Water for Life': dams, recycling, desalination and water efficiency. These measures, together with the plan's adaptive management approach, mean that Sydney's water needs are secured for future drought, a changing climate and a growing population.

The NSW Government has a target of being able to deliver 70 GL of recycled water in greater Sydney by 2015. Existing or planned large-scale recycling schemes include those at the Rouse Hill, Hoxton Park, St Marys and Wollongong sewage treatment plants (see 'Recycled water' under Status and Trends).

From January 2010, the desalination plant at Kurnell in Sydney became operational in line with the terms of the *2010 Metropolitan Water Plan*. The plant will operate at full capacity when dam levels fall below 70% and continue to supply water until storages reach 80%. The plant is currently able to deliver up to 250 ML of water a day, although the intake and delivery pipes have been sized so output can be doubled if necessary.

Water efficiency measures are another important response component. 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 restrictions and Water Wise Rules: In June 2009, the NSW Government introduced permanent Water Wise Rules for Sydney, the Blue Mountains and the Illawarra (see Figure 1.17). The rules are simple, commonsense actions designed to ensure that the water conservation measures adopted during times of drought continue. Sydney Water estimates that the enforcement of its Water Wise Rules saves approximately 19 million GL of water every year. Other parts of NSW also experienced an extended period of water restrictions.

Along with restrictions to keep more water in dams during droughts, work has also been undertaken to gain access to deep water in dams and replenish storages with groundwater reserves if needed.

Lower Hunter region: In 2003, Hunter Water prepared its first Integrated Water Resource Plan (IWRP) under the 2002–07 operating licence. The subsequent licence issued by the NSW Government required Hunter Water to review the IWRP. Following the review, the *$H_2$50 Plan* (Hunter Water 2008) was released, outlining the long-term drinking water supply strategy for the Lower Hunter region.

A new Lower Hunter Water Plan is currently being developed by the Metropolitan Water Directorate in line with the Council of Australian Government's agreed National Urban Water Planning principles. It will ensure there is adequate water for the region's needs, both in drought and in the longer term, to support predicted growth in population and industry.

Demand management initiatives

Water pricing for urban customers has undergone significant reform, with a shift in tariffs away from a reliance on fixed annual charges to 'pay-for-use' pricing. This pricing reform is overseen by the NSW Independent Pricing and Regulatory Tribunal (IPART) and has contributed to the reduction in water consumption by more accurately reflecting the value of water resources and the true costs of supplying water.

During drought, education and training programs targeted all sectors across the Sydney metropolitan region. The Water for Life education program is an integral component of the Metropolitan Water Plan. The focus of Water for Life is to support and encourage the Sydney community to play its part in water planning and use water wisely.

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 by 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. All 298 action plans were approved by 30 June 2009. They contained 2329 cost-effective measures that organisations could implement to save an estimated 8272 ML of water each year. By 30 June 2011, 48% of cost-effective water measures had been implemented.

Year-by-year water efficiency programs and recycling have saved an increasing volume of drinking water across Sydney Water's areas of operation, with 55.839 GL saved in 2010–11 (Sydney Water 2011a). Sydney Water has implemented residential demand management programs, including WaterFix, to assist households to conserve water. This involves specialists from Sydney Water visiting residents and helping them make changes to their homes and gardens to use water more efficiently. The Every Drop Counts Business Program involves targeted water conservation programs for small business users and offers free one-on-one partnerships to larger businesses who use more than 80,000 litres of water per day.

Another Sydney Water initiative is a program to actively detect and repair leaks. In 2010–11, leakage was estimated to account for 106 ML per day (38.6 GL per year), about 7.77% of potable water used. This was a significant reduction on the leaks in 1999–2000 which wasted over 180 ML of water a day. Since 2008, Sydney Water has been within its target band for water lost by leakage (105 ± 16 ML per day) (Sydney Water 2011b).

Sydney Water has 18 recycled water schemes. In 2010–11, more than 9% of total wastewater collected was recycled (47.521 GL). The St Marys Water Recycling Plant, which began operating in mid-2010, is Sydney's largest water recycling project. It is a key element of the NSW Government's Metropolitan Water Plan, which includes increasing water recycling capacity in Sydney Water's area of operations to 70 GL per year by 2015. Water from the plant currently replaces water that would otherwise be released from Warragamba Dam for environmental flows. As well as saving drinking water, it reduces nutrient discharge, which in combination with increased environmental releases from upstream dams, contributes to the downstream health of the Hawkesbury–Nepean River system.

Urban water use in regional NSW

Country Towns Water Supply and Sewerage Program: This program is a major State Government reform that aims to assist NSW regional local water utilities (LWUs) provide appropriate, affordable, cost-effective and sustainable urban water supply and sewerage services.

Through the comprehensive NSW Best-Practice Management of Water Supply and Sewerage Framework (NOW 2011b), the program provides leadership, guidance and technical assistance to LWUs and oversees and monitors their performance. The key requirements of the framework include:

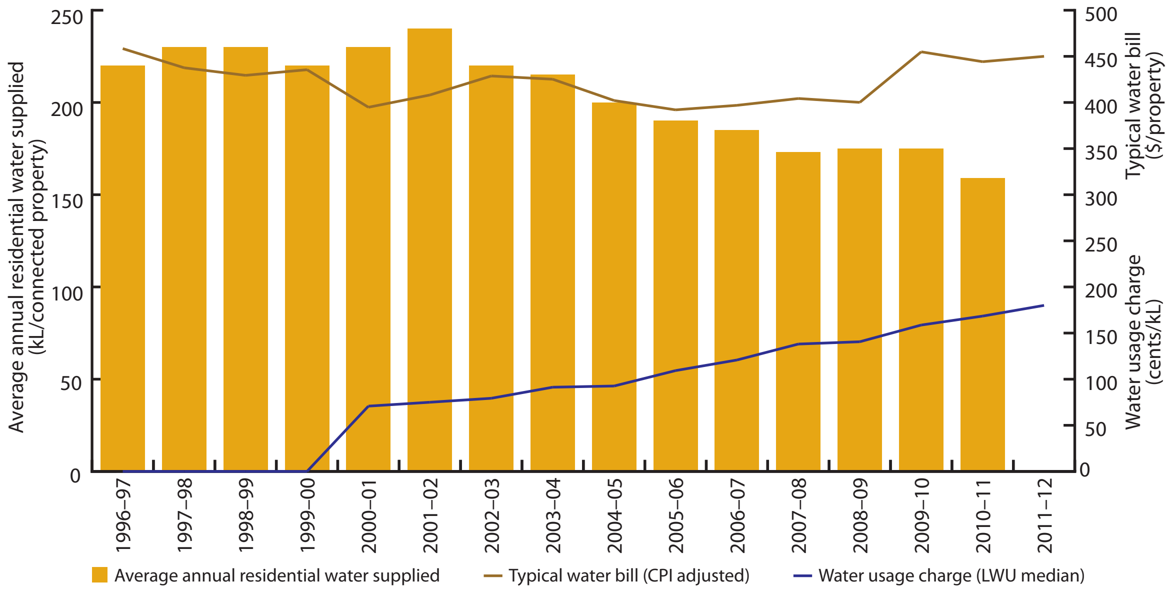
- strategic business planning
- sound pricing of water supply, sewerage and trade waste services to achieve full cost recovery and provide strong pricing signals to encourage efficient use of the services
- performance monitoring by each LWU using the NSW performance monitoring and benchmarking system
- integrated water cycle management to assist local water utilities achieve sustainable, affordable and cost-effective water supply, sewerage and stormwater services over 30 years or longer.

Financial support is also provided in the form of grants towards the capital cost of works to address any backlogs in water supply and sewerage infrastructure needed to deliver improved public health, environmental outcomes and security of supply to more than one million people in NSW country towns.

Since its commencement in 1994, the program has spent over $945 million to complete more than 475 water supply and sewerage projects with a projected spend exceeding $1.2 billion by the scheduled end of the program in 2016–17.

Pricing: Having strong water pricing signals has been of strategic benefit in achieving efficient water use in regional NSW and has even resulted in a slight reduction in the typical water supply residential bill over the last 16 years. In 1996–97, 68% of the regional NSW LWUs had a 'free water allowance'. However following its gradual removal by July 2007, the median residential water usage charge rose slowly to 180 cents per kilolitre in 2011–12 (**Figure 1.19**). 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. Moreover, prices that reflect the true value of water have helped drive its efficient use to the point that the 'typical' residential customer has, overall, maintained the real price of their water supply bill over the past 16 years, about $445 per connected property (Figure 1.19).

Figure 1.19: Average annual residential water supply vs residential water costs



Source: NOW 2012b

Notes: Inflation corrected dollar values (as at January 2012).

Other government responses

NSW Government: 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 commitments being reported through BASIX, the average potable water use in a compliant NSW home is approximately 135 L per person per day. For commitments made on BASIX certificates issued between July 2004 and December 2011, new BASIX-compliant homes are saving NSW an additional 13 GL per year with cumulative water savings across the state forecast to reach 55 GL in 2012. These figures do not include water efficiencies from BASIX-compliant alterations and additions, which will add further savings.

Established in 2007, the NSW Climate Change Fund provides funding for business, households, schools, communities and government to save water and energy. The NSW Home Saver Rebates program, which ended as scheduled on 30 June 2011, provided rebates for water-efficient washing machines, dual-flush toilets, hot water circulators, and rainwater tanks (see also People and the Environment 1.6). Water recycling and stormwater harvesting schemes, and water saving projects have been funded through the Water Savings Fund, Central Coast Water Savings Fund, the Rainwater Tanks in Schools, NSW Green Business and Public Facilities programs. To 30 June 2011, the Climate Change Fund had supported projects that will save more than 19 GL of water per year (OEH 2011) (see also People and the Environment 1.2).

The Urban Sustainability Program aims to facilitate projects of significant environmental benefit that are delivered by local councils in partnership with other government agencies, local businesses, community organisations and householders. It provides funding for urban water management projects that have a particular focus on stormwater and urban runoff to achieve sustainable water quality and conservation outcomes.

Sustainability Advantage is designed to leverage the growing business interest in sustainability, particularly among medium and larger organisations. It focuses on industrial ecology projects among businesses keen to exploit opportunities for the exchange of materials, energy, water and by-products. The program integrates water conservation issues into broader sustainability projects, with an emphasis on 'business value', such as reduced costs, improved reputation and increasing productivity, while making environmental gains (see also People and the Environment 1.6).

Federal Government: The National Australian Built Environment Rating System (NABERS) is a NSW program which rates buildings on the basis of their measured environmental impacts, such as energy, water, stormwater runoff and pollution, sewage, landscape diversity, waste and toxic materials, and provides an indication of how well they are being managed. NABERS is managed by the NSW Office of Environment and Heritage (OEH) on behalf of the National Steering Committee (comprising state and federal governments).

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 and the introduction of water efficiency labelling of combined clothes washer–dryers is currently being considered (DEWHA 2008a). 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 (NWC 2008). 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 and reported on their performance in the *National Performance Report 2010–11: Urban water utilities* (NWC 2012).

Developing responses

Local water utilities inquiry: In September 2007, the NSW Government commenced an independent inquiry into secure and sustainable urban water supply and sewerage services for non-metropolitan NSW. The inquiry is part of an evolving process of reform for the provision of water supply and sewerage services to non-metropolitan NSW. It builds on the reform agenda of the National Water Initiative that is currently being implemented through the Best-Practice Management of Water Supply and Sewerage Framework (NOW 2011b) used in the NSW Government's Country Towns Water Supply and Sewerage Program.

The report from the inquiry (DWE 2009c) recommends the consolidation of water supply and sewerage providers and the adoption of new organisational structures. The report also recommends strengthening the regulation of water supply and sewerage providers, streamlining regulatory reporting and procedures, and appointment of an ombudsman to enhance consumer protection if it can be demonstrated that there are net benefits in doing so. The NSW Government is currently developing a response to the recommendations of the inquiry.

1.5 Energy consumption

Fossil fuels currently meet 94% of New South Wales final energy use, down from 97% in 2008. Around one-quarter of this demand is met by electricity, with supplies from renewable sources doubling between 2007–08 and 2009–10.

NSW meets most of its demand for energy from non-renewable sources, mainly coal, along with petroleum products and gas. The production and use of energy have significant environmental impacts, including being the main source of greenhouse gas emissions in NSW.

Diversification of NSW electricity supplies is growing strongly with an increase in gas-based electricity generation capacity and supply, reducing the need for coal-derived electricity. Electricity supplied from renewable sources (other than Snowy Hydro) had been around 6% from 2001 to 2008, but then doubled to 2010.

Residential electricity consumption per person (and per household) peaked in 2005–06 and has recently been just below the levels of 2000–01. Demand for electricity appears to have stabilised for now and remains at about the same level as five years ago.

NSW indicators

Indicator and status	Trend	Information availability
Total NSW energy use	Increasing	✓✓✓
NSW non-renewable energy supply	Increasing	✓✓✓
NSW renewable energy supply	Increasing	✓✓✓
Energy use per capita	Decreasing	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Energy is essential to the functioning of an advanced industrial society. NSW uses approximately one-quarter of Australia's total energy, with large reserves of black coal and a substantial mining industry. As a result, the state enjoys a reliable and secure energy infrastructure, important factors underpinning the stability and growth of the economy.

In the absence of effective planning and environmental management controls, a range of environmental impacts can be associated with coal mining and gas extraction, including surface water and groundwater pollution, erosion, dust and noise pollution, and disruption to plants and wildlife.

Energy production and conversion, such as coal and gas to electricity in power stations, are the main emission sources of greenhouse gases (carbon dioxide, methane and nitrous oxide) as well as local and regional air pollutants (oxides of nitrogen, oxides of sulfur and particle emissions) (see People and the Environment 1.2 and Atmosphere 2.1). Greenhouse gases contribute to climate change, which is projected to cause more extreme weather with higher temperatures, changing rainfall patterns, more storms and rising sea levels in NSW (CSIRO & BoM 2007). The process of electricity generation (or energy conversion to various end uses) is also highly inefficient because of the energy that is lost.

Status and trends

Final energy consumption

Figure 1.20 shows the trend in final energy consumed by major sectors of the economy in NSW and the Australian Capital Territory. In 2010–11, the industrial sector used 41.8% of the total final energy of 1171 petajoules (PJ). This includes all fuel used for transport in the industrial, residential and commercial sectors. The share of the transport sector was similar at 39.1%, while the residential and commercial sectors used 11.5% and 7.6%, respectively (BREE 2012).

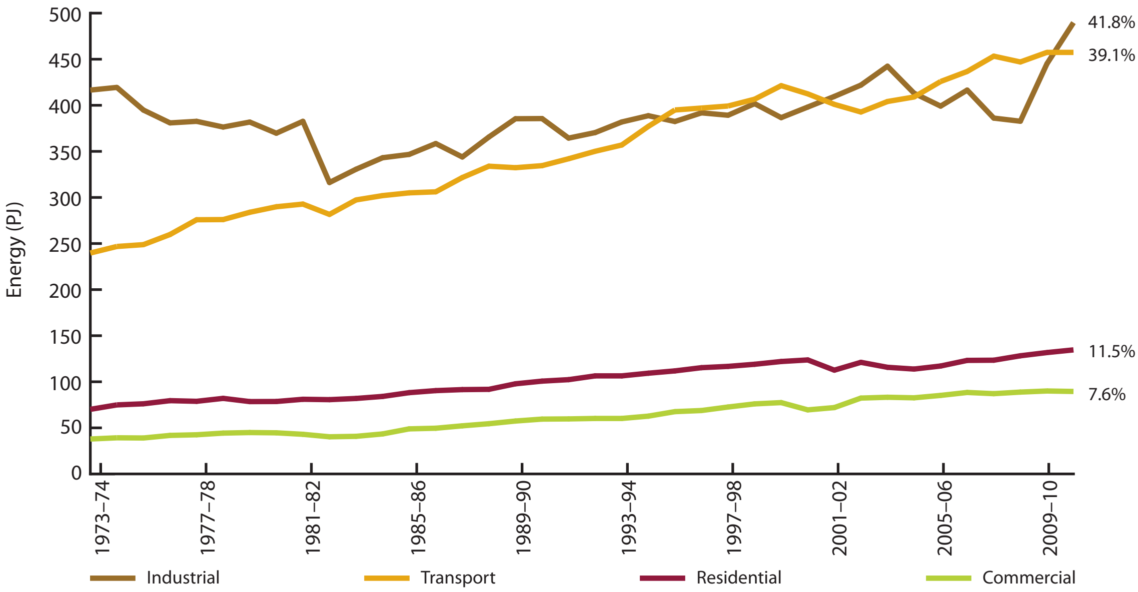
'Final energy' is the energy supplied to the end user (Figure 1.20). Final energy consumption includes secondary energy, such as electricity, and therefore excludes the coal used to generate electricity. Not included in these figures are heat and conversion losses in power plant facilities and refineries, as well as transmission and distribution losses. In 2010–11, waste heat from power plants (and other losses) amounted to about 437.4 PJ, equivalent (and additional) to 37.4% of the state's total final energy use (see also People and the Environment 1.2).

For nearly 40 years, the consumption of energy in the transport sector has grown markedly at an approximate rate of 6 PJ per year (Figure 1.20). Energy consumption in residential and commercial sectors has also steadily increased but at a slower rate. Overall, the final energy consumption of the industrial sector has been increasing since the mid-1980s, although prior to that there was a declining trend.

Figure 1.21 shows final energy consumption by fuel and sector for 2010–11. Petroleum comprises the largest component of final energy used in NSW and the ACT. The transport sector was the major user of petroleum in NSW in 2010–11, with some used in the other sectors. Electricity use was highest in the industrial sector. The overall proportions of these fuels are:

- petroleum 45.4%
- electricity generation (fossil fuels) 19.9%
- coal (excluding electricity generation) 17.0%
- natural gas 11.0%
- renewables (hydroelectricity, wood, wood waste, bagasse and biofuels) 6.7% (compare note under Figure 1.23).

Figure 1.20: Final energy consumption by sector in NSW and the ACT, 1973–74 to 2010–11



Source: Derived from BREE 2012

Notes: The data source combines data for NSW and the ACT in a way that cannot be disaggregated.
'Industrial' includes agriculture, mining and manufacturing.
'Commercial' includes general commercial, construction, and water, sewerage and drainage industries.

Gas use

Across all sectors (Figure 1.21) the total per capita use of gas (excluding LPG) in NSW increased from 17,793 megajoules (MJ) in 2007–08 to 22,285 MJ in 2010–11 (DTIRIS data 2012). The bulk of gas used in NSW is for manufacturing and electricity generation. Residential use (mainly for heating, hot water and cooking) was around 21,546 MJ per household in 2010–11.

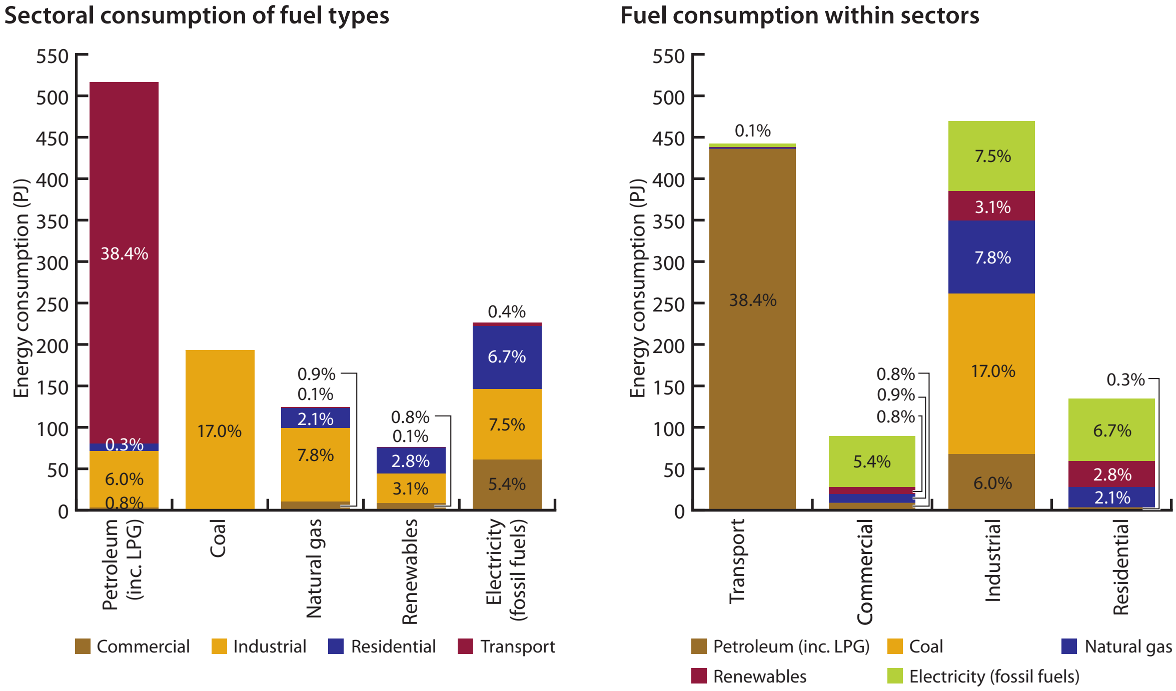
Gas is Australia's fastest growing energy source, with investment in gas-fired electricity generation a key driver. About 11% of the NSW installed electricity generation capacity of 2238 megawatts (MW) is powered by natural gas or coal seam gas (CSG). Gas consumption for power generation and the capacity of installed gas-fired generation are both expected to continue to grow in NSW (AEMO 2011a).

Electricity generation

NSW imports electricity from interstate during times of peak demand via the National Electricity Market (and exports it at other times). This shares the generation load, reduces the need for local generation, and allows customers to benefit from lower wholesale prices. NSW is a net importer and on average imports electricity to meet around 10% of its annual demand.

In 2011, NSW generated 74,544 gigawatt-hours (GWh) of electricity, the majority from coal (85.8%, a slight increase from 82.6% in 2010, but down from 93.4% in 2007–08). Another 6.4% of the electricity generated comes from gas. The remaining 7.8% is from renewable energy sources (up from 7.2% in 2010 and 5.3% in 2007–08) – the main sources are hydroelectricity (5%) and other renewables such as wind (0.9%), landfill gas (0.5%), solar photovoltaic (0.9%), bagasse (0.3%) and other biomass (0.3%) (DTIRIS data 2012). Despite a 45.6% decrease in output from Snowy Hydro (from 5450 GWh in 2010 to 2964 GWh in 2011), there have been significant increases from all other non-Snowy renewable generation. (Note that generation data for recent years has been presented on a calendar year basis for compatibility with the renewable energy targets and reporting.)

Figure 1.21: Final energy consumption in NSW and the ACT by fuel and sector, 2010–11



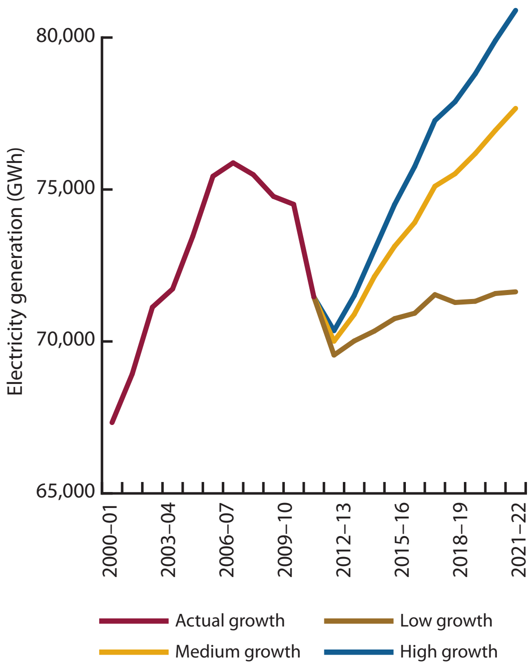
Source: Derived from BREE 2012

Notes: The data source combines data for NSW and the ACT in a way that cannot be disaggregated.
'Coal' excludes inputs to generation of electricity (from fossil fuels)
'Renewables' includes bagasse, solar, wood, wood waste and hydroelectricity.
Certain consolidation and modifications of the BREE data were provided by the NSW Department of Trade and Investment, Regional Infrastructure and Services to avoid double-counting and allocate energy use into appropriate sectors.
Final energy consumption includes electricity, and so consumption by the electricity generation sector is not shown.
Data includes estimates for bagasse, solar, hydroelectricity and wood, but excludes wind, solar 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.

Figure 1.22 shows actual and forecast trends in electricity generation under three growth scenarios (TransGrid 2011; AEMO 2012). Annual energy generated peaked in 2007–08 and showed a reduction of 1.8% over the last three years. Changes to the NSW economic climate, such as the global financial crisis that triggered a severe economic downturn in late 2008, resulted in lower demand for electricity between 2008–09 and 2011–12 compared with the forecasts presented in *SoE 2009* (DECCW 2009a). Additional factors that contributed to lower demand included forecasts of significantly higher electricity prices, the phase-out of energy-intensive water heaters and incandescent light bulbs, and implementation of the NSW Energy Savings Scheme.

Despite this recent drop, NSW electricity demand is projected to grow at 1.2% per annum under the medium growth scenario and 1.6% and 0.3% under the high and low scenarios, respectively, over the 10-year outlook period from 2012–13 to 2021–22.

Figure 1.22: Actual growth and forecast trends in electricity generation in NSW under various growth scenarios



Source: TransGrid 2011; AEMO 2012

Notes: This data is based on energy sent from major power plants and smaller generators located in the distribution network.
AEMO 2012 data is used from 2005–06 onwards.

Trends in maximum demand are largely the same as annual energy demand. Peak summer or peak winter demands are forecast to rise by 1.2% per annum over the next decade. Both energy and maximum demand forecasts are lower than previous forecasts due to the closure of the aluminium smelter at Kurri Kurri, increasing penetration of rooftop photovoltaics, lower manufacturing output in response to the higher Australian dollar, consumer response to rising electricity costs and energy efficiency measures.

Renewable energy consumption and growth

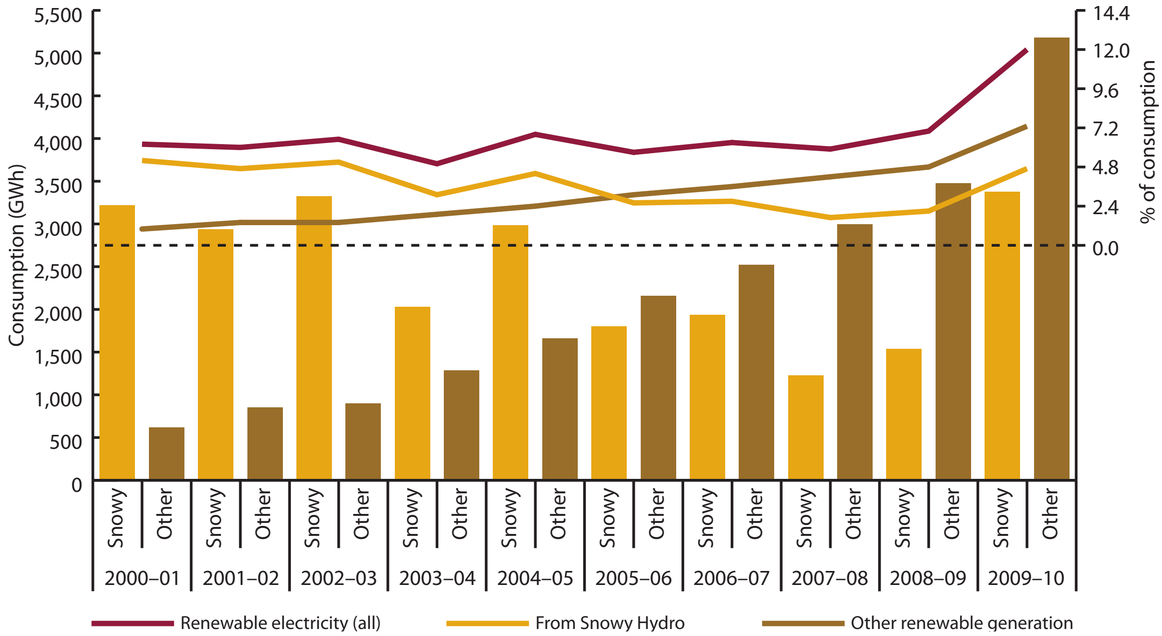
In 2009–10, renewable energy sources provided for 12% of the state's total electricity consumption (4.7% from Snowy Hydro). Renewable sources have the following shares of the remaining 7.3%: solar photovoltaic systems (29%); wind (19%); biomass (19%); solar water heaters which displace electricity use from electric hot water systems (15%); landfill gas (12%); and other hydropower (6%). The interstate movement of electricity under the National Electricity Market, and other factors, means that NSW generation figures (as reported above) do not match consumption figures (for both renewable and non-renewable sources).

Solar, wind and biomass resources are increasingly being developed, largely due to energy sector reforms introduced by the NSW and Australian Governments. For example, supply from wind has jumped 10-fold since *SoE 2009* (DECCW 2009a) and solar photovoltaic supply has increased six-fold.

In 2011, NSW generated over 800 GWh of electricity from bioenergy sources, such as bagasse and landfill gas. Wind plants in NSW (280 MW installed capacity) generated 652 GWh of energy (DTIRIS data). The generation of power from solar photovoltaic systems in NSW more than doubled between 2010 and 2011 to 684 GWh (about 2.5 PJ) in 2011.

Figure 1.23 shows the trend in estimated consumption of electricity from renewable sources since 2001. Electricity supplied from renewable sources other than Snowy Hydro (such as wind, biomass and landfill gas) has increased significantly over the decade to 2009–10. These increases were offset by reduced generation from the Snowy Hydro Scheme until 2008–09 because of a lack of water due to the drought.

Figure 1.23: NSW consumption of electricity from renewable sources, 2000–01 to 2009–10



Source: DTIRIS data 2011

Notes: Although about 28% of current NSW electricity generation capacity is powered by renewables, the availability of supply from renewable sources is lower and varies from year to year.

Estimating renewable energy consumption is complicated by the interstate trading of electricity (especially for Snowy Hydro production which has always been available for use by both NSW and Victoria). Also supply from the smaller renewable generation facilities is often not available easily and the Renewable Energy Certificate (REC) registry data is used to estimate the consumption by various fuel types. REC registry data for NSW does not equate to the actual renewable generation in NSW due to various factors, including the baselines and multiplier factors.

Pressures

Growth in energy demand

Three key pressures are facing the energy sector in NSW. These are the ongoing, increasing demand for fuel for transport and the long-term growth in demand for both electricity and gas (which is in part driven by strong growth in gas-powered electricity generation). As noted previously, the electricity generation industry is the largest user of energy, but as electricity is used as a form of secondary energy, the fossil fuel inputs to the generation of electricity fall outside of the discussion of end-user energy consumption.

The strongest growth in energy consumption in NSW has been in the commercial sector (136% growth over 37 years), while the residential sector (92%) has grown at about the same rate as transport (91%) (Figure 1.20). Overall, final energy consumption by industry was 18%, with stronger recent growth masked by earlier negative growth.

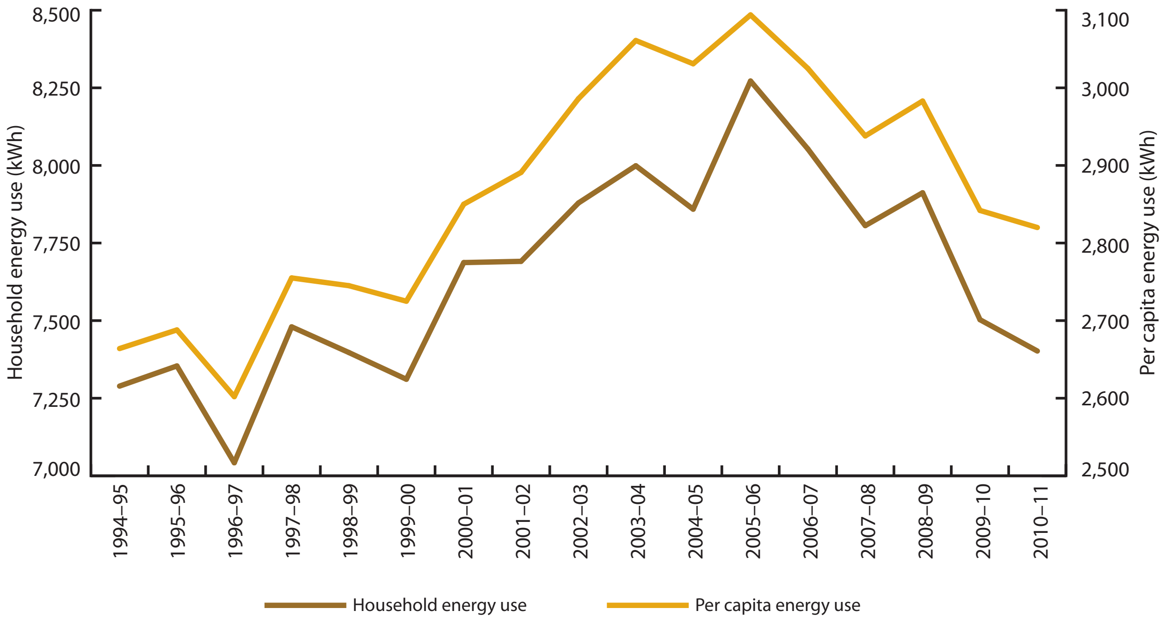
Petroleum

As well as being the economic sector with the greatest end-user consumption of petroleum fossil fuels (Figure 1.21), transport has a slow rate of uptake of alternative fuel sources. Heavy reliance on the combustion of fossil fuels has environmental and health impacts, including greenhouse gas emissions (People and the Environment 1.2) and air pollution (Atmosphere 2.1). NSW has the largest number of vehicles of any Australian state (ABS 2009) and is the largest market for petroleum in Australia. Electric vehicles show considerable promise for improved environmental performance for road vehicles, especially if supplied from renewable energy sources.

Gas

Gas demand in NSW is forecast to grow at an average rate of 7.1% per annum over the next 20 years (AEMO 2011a) and is expected to triple from 160 PJ per annum to 505 PJ per annum (excluding LNG exports).

Figure 1.24: Residential electricity consumption in NSW and the ACT, 1994–95 to 2010–11



Source: ABS 2011a; Energy Supply Association of Australia data 2011

Notes: Information from the Energy Supply Association of Australia combines data for NSW and the ACT in a way that cannot be disaggregated.

Electricity

In 2009–10, NSW and the ACT used 69,778 gigawatt-hours of electricity. The industrial sector accounted for 37.7% of the state's overall consumption, followed by the residential (33.4%), commercial (27.2%) and transport (1.9%) sectors (ABARES 2011a). In 2009–10, the major sources of fuel for this electricity were non-renewable, such as coal and gas (88%), while renewable energy sources provided 12% of the state's total electricity consumption (see Figure 1.23).

Since 1994–95, electricity consumption per household has increased significantly, but has decreased since a peak in 2005–06 (**Figure 1.24**). Household sizes in NSW are very gradually decreasing so the household and per capita trends are almost identical.

As electricity is the most common energy source used by NSW households to power home heating and cooling systems, year-to-year climatic variations, such as the exceptionally hot and dry summers of 2006 and 2007, significantly influence the demand for space conditioning energy. A recent estimate found that 55% of Australian households use reverse-cycle air-conditioning or other electric heating in their homes (ABS 2011e, Table 8) with ownership of air-conditioners more than doubling since the mid-1990s (DEWHA 2008b).

Computer-related equipment and large flat-screen TVs have also increased energy use recently. These household-level increases have been more than compensated for by energy efficiency improvements and generation from embedded renewables, such as solar PV.

Responses

Established responses

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, identifies the increased use of renewable energy as a priority in its Goal 22 – 'Increase renewable energy: 20% renewable energy by 2020'. The target is designed to support the national renewable energy target, expanding renewable energy in NSW at least cost.

NSW 2021 also identifies the need to use energy more efficiently under Goal 5 – 'Contain electricity costs through efficient energy use'. This includes a target to improve energy efficiency by achieving 16,000 GWh of annual savings by 2020.

Renewable energy developments

The NSW Government has policy initiatives in place to promote favourable conditions for the development and use of alternative and renewable energy technologies as outlined below.

- Supporting the national renewable energy target of 20% by 2020: The NSW Government has developed a draft Renewable Energy Action Plan to guide NSW's renewable energy development and outline how the state can support achievement of the 2020 target at least cost. The plan will be informed by the workings of the NSW Solar and Renewable Energy Summit, along with community consultation.
- The NSW Renewable Energy Development Program and the Australian Clean Energy Finance Corporation are both funding and promoting investments in low carbon dioxide-emitting technologies, such as biogas, geothermal and large-scale solar thermal generation. As well as helping to demonstrate these new energy technologies and support their early commercialisation, they will help to meet the 2020 renewable energy target.
- Six Renewable Energy Precincts have been established in areas of the state that show the greatest potential to generate electricity from wind. A supporting program is facilitating well-sited renewable energy projects and building community understanding, involvement and uptake of renewable energy. New planning guidelines for wind farms were exhibited in early 2012 (DP&I 2011a; DP&I 2011b). These were prepared in consultation with the community and energy industry to ensure effective dialogue with local communities and deliver improved consistency, transparency and rigour in the planning assessment process. The guidelines provide a regulatory framework to guide investment in wind farms across NSW, while minimising and avoiding any potential impacts on local communities.
- The installed capacity of small-scale solar photovoltaic generation has grown rapidly over the past few years and demand remains high: in the six months following the closure of the Solar Bonus Scheme for new applicants in April 2011, a further 20,315 customers applied to connect solar photovoltaic systems to the electricity grid. In addition to this, over 54,000 NSW businesses and households have installed photovoltaic systems in the absence of any government subsidies. The NSW Government is exploring ways to provide a sustainable and predictable future for the solar industry with IPART completing a review of the feed-in tariffs for small-scale solar energy generation in March 2012 (IPART 2012b).
- The NSW Government continued in its role as Program Manager of the National GreenPower Accreditation Program in 2011–12. The GreenPower Program allows electricity customers to purchase renewable energy for their home or business through their energy retailer. The latest audited figures from the 2010 calendar year show that support for the program is steady with approximately 2200 GWh of accredited renewable energy sold nationwide and sales in NSW accounting for around a quarter of this (519 GWh) (DTIRIS data 2012).

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.

NSW established Australia's first mandated biofuel component in 2007. Since then, the petrol sold in NSW has been required to contain a steadily increasing content of ethanol, rising to 6% by volume on 1 October 2011. This does not mean that all fuel sold will contain ethanol, but customers are provided with a choice at the pump to fill up with E10 petrol, which contains a blend of up to 10% ethanol. A 2% biodiesel mandate was also introduced in 2009 and is to be increased to 5% when sufficient local supply of biodiesel is available.

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

The NSW Government is also trialling a new diesel–electric hybrid bus. The fuel-efficient hybrid bus uses state-of-the-art technology and is being tested by State Transit on various routes in Sydney. The results of the trial will contribute to the development of a clean energy future for NSW.

As well as technological advance, the uptake of electric vehicles may be assisted by developments in infrastructure, policy and legislation in NSW as well as the Australian Energy Market Commission review into energy market arrangements for electric and natural gas vehicles that is currently under way.

Using energy wisely

BASIX: The Building Sustainability Index (BASIX) was introduced by the NSW Government in 2004 to ensure that new homes, and 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 carbon dioxide-equivalent (see also People and the Environment 1.2).

National initiatives

The Australian Government has been encouraging the development of renewable and sustainable technologies through programs such as the Renewable Energy Target and Generator Efficiency Standards Measure.

The National Australian Built Environment Rating System (NABERS) is a NSW program that has been extended nationally that rates a building on the basis of its measured environmental impacts (see also People and the Environment 1.4). NABERS Energy ratings are available for commercial office buildings, hotels, shopping centres and homes. A NABERS Energy rating for data centres and NSW schools is also under development.

By June 2011, 68% of NSW office space had been rated with NABERS Energy for offices. A further 46 NABERS Energy for hotels ratings were conducted along with 31 NABERS Energy for shopping centres ratings. Close to 600 businesses are engaging with NABERS to rate their premises. Office buildings using NABERS as a management tool have improved their greenhouse performance by an average 11.5%, with combined carbon dioxide-equivalent savings of 257,000 tonnes per year.

From November 2011, most office buildings over 2000 square metres in size have been required to disclose their NABERS Energy rating at the point of sale or lease under the Commercial Building Disclosure 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.

Smart meters/grids: Effective metering of end-user consumption, when coupled with appropriate price signals or other incentive measures, can encourage customers to more actively manage their electricity use. The Council of Australian Governments is committed to the cost-effective rollout of smart meters and the National Electricity Market is developing a supporting framework.

The NSW Government participates in the interjurisdictional Smart Meter Working Group, which reports to COAG's Standing Council on Energy and Resources (SCER). The working group is reviewing the electricity regulatory framework to facilitate potential future implementation of smart meters. The key issues for the group are ensuring the greatest benefit for consumers by increasing their opportunities to participate in energy saving and demand management activities, while maintaining consumer protection.

The Australian Government has contracted Ausgrid to undertake the Smart Grid, Smart City initiative. This $100-million project involves the installation of Australia's first commercial-scale smart grid with customers across northern Sydney, Newcastle and Scone. The aim is to demonstrate the technical and commercial viability of a number of smart technologies, such as electric vehicles, energy storage and smart metering services.

Developing responses

Diversifying energy supply

With the state's energy supply dominated by coal (locally produced, but highly carbon-intensive) and petroleum and gas (mostly imported and also carbon-intensive), there are sound strategic economic and environmental reasons to diversify the mix of energy supplied. Individual industries and companies can be expected to review their own energy supply choices, but at a broader scale two key areas of ongoing action should be the diversification of energy sources for electricity generation and the development of alternative transport fuels and new vehicle technologies.

According to updated forecasting (AEMO 2012), NSW will maintain or install enough energy generation capacity to meet a growing demand for power until well into the late 2020s, even if faced with 1-in-10 extreme weather conditions. The updated forecasting also concluded that new generation capacity will not be required for at least the next 10 years even under a high economic growth scenario. This is several years later than the forecast need for an additional 190 MW capacity by 2018–19 made in *Electricity Statement of Opportunities 2011* (AEMO 2011b), mainly due to lower demand forecasts.

Following 45 years of operation, Delta Electricity announced in July 2012 the closure of its Munmorah power station, the oldest coal-fired plant with 600 MW capacity. The station has been maintained on standby but has not been in production since August 2010 due to the ageing infrastructure and high maintenance costs. Munmorah has development consent for rehabilitation as either a coal- or gas-fired generator with 700 MW capacity, but this would require substantial new capital investment by a future owner.

New generation proposals with a total capacity of 12,600 MW have development approval (9900 MW conventional, 2300 MW wind, 400 MW solar) and a further 7600 MW are in the planning system (1200 MW conventional, 6200 MW wind, 200 MW other renewables). However not all of these may progress to completion, depending on future economic conditions.

The 20% renewable energy target, carbon price and other low emission-related policies are expected to assist the renewable generation proposals progressing to completion. The large amount of new renewable generation proposed could meet the general energy demand requirements, with the Australian Energy Market Operator (AEMO) determining that the design of the National Electricity Market will be able to integrate large amounts of wind generation (AEMO 2011c). However, AEMO has also concluded that these new renewable generation proposals are unable to meet peak demand requirements and some new fossil-fuel-powered generation capacity is likely to be necessary.

Reducing dependence on coal and moving to lower emission energy sources

The majority of the proposed new electricity generation facilities in NSW do not involve the use of coal as an energy source. This will reduce the state's dependence on coal and aid the move to lower emission energy sources.

Gas is increasingly used for electricity generation, mainly to fuel intermediate and peaking generators. If, as forecast, gas-fired generation capacity grows at 7.1% per annum (AEMO 2011a), the fuel's share of generation in NSW would increase from around 11% to 37% by 2030–31 and coal's share would fall from 61% to 40%.

Given strong local and international demand for gas, ensuring security of a cost-effective supply is a key aim of the NSW Government. In September 2010, a national wholesale gas market platform was established in the eastern states (operated by AEMO). The NSW Government is working cooperatively through COAG's Standing Council on Energy and Resources to support further development of a national gas market. A more harmonised interjurisdictional framework for the regulation of the coal seam gas (CSG) industry is also being investigated.

To ensure CSG development projects are able to gain community support, the NSW Government is implementing its Strategic Regional Land Use Policy which will help reduce conflicts between the mineral and petroleum resource industries, agricultural production and environment protection. The *NSW Aquifer Interference Policy* (DPI 2012) has been developed as a component of the Strategic Regional Land Use Policy. Furthermore, the Government intends to develop a Gas Industry Development Plan to ensure the necessary NSW-based policy frameworks are in place to support the appropriate development of all aspects of the gas industry. A Legislative Council inquiry into the environmental, health, economic and social impacts of CSG activities was completed recently.

Future opportunities

As a means of maintaining supply of electricity 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:

- Carbon capture and storage: The possibility of retrofitting post-combustion capture and storage of carbon dioxide to existing power stations is being explored, although this is not yet commercially available for power stations emitting in the order of 15 megatonnes carbon dioxide equivalent per annum or more.
- Combustion efficiency improvement technology: Developments in Integrated Gasification Combined Cycle technology and hybrid combined cycle power stations (where the exhaust heat from a gas turbine assists combustion in a conventional coal furnace) are being monitored by NSW Trade & Investment, as part of its Coal Innovation Fund program.
- Drainage of mines to reduce emissions: With the sponsorship of the Coal Innovation Fund, the CSIRO is researching options to enhance methane drainage of 'gassy' mines or remove methane from ventilation air with the aim of potentially using the drained gas for power generation.

1.6 Social trends

Research shows that the people of New South Wales continue to be concerned about the environment, particularly the use of energy and water, climate change and the protection of the environment.

The most recent 'Who Cares About the Environment?' survey has shown that water management, energy issues and climate change rank as major environmental issues for the people of NSW. Water management and biodiversity have both decreased in importance since the last survey in 2006 but still rank among the top eight environmental issues.

The drivers behind public concern over energy efficiency have changed from mainly environmental in 2006, especially climate change, to being more focused on cost in 2009.

Introduction

Social research has underpinned a range of practical government-funded education and engagement programs to help communities learn about and adopt sustainable behaviours and engage in local environment protection. These programs support the use of innovative strategies by business, government and non-government agencies that save costs through more efficient use of energy, water and resources; improve waste management; and adopt sustainable practices in general.

Status and trends

Community attitudes and actions

Who Cares About the Environment?

Every three years since 1994, the 'Who Cares About the Environment?' program has surveyed the environmental knowledge, attitudes and behaviours of NSW people. The research shows that people in NSW generally have high levels of concern about environmental issues, although the 2009 survey indicated a slight fall in interest.

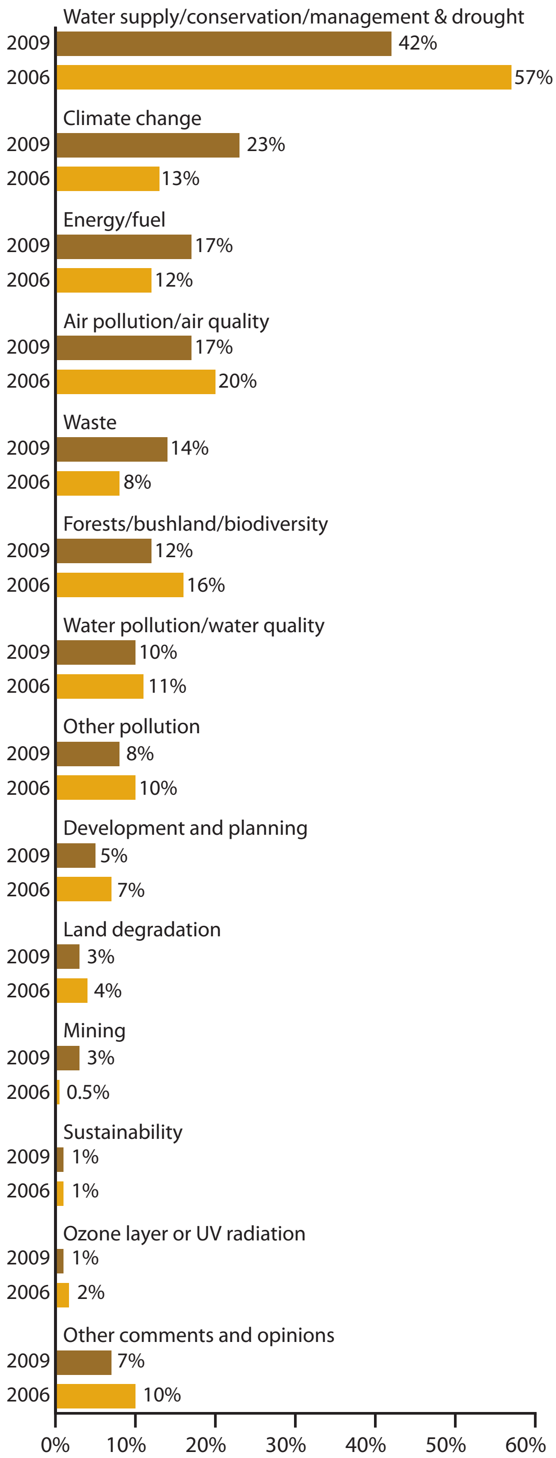
In 2009, 78% of the people surveyed indicated they were concerned to some degree about environmental problems, a decline from 87% in 2006; 22% indicated they were not concerned at all, an increase from 13% in 2006.

The longitudinal nature of the surveys has shown steady increases over time in knowledge about particular environmental issues. For example, the proportion of people able to correctly differentiate the greenhouse effect from the hole in the ozone layer has increased from 24% in 1994 to 51% in 2009. However significant knowledge gaps continue: for example only about one-third of respondents in 2009 knew about the water- and energy-saving benefits of recycling.

Water-related issues and climate change continued to be the most prominent environmental issues for NSW people in 2009, although those nominating water issues decreased from 57% in 2006 to 42%, while climate change mentions rose from 13% to 23% (**Figure 1.25**). Energy- and fuel-related issues were the third most nominated environmental issues in 2009, increasing to 17% from 12% in 2006. Furthermore, in 2009 energy- and greenhouse-related initiatives were also identified as the most important action the NSW Government could take to protect the environment, replacing water initiatives which was the most mentioned in 2006.

The proportion of people who reported that they had often taken active steps to reduce energy consumption rose from 73% in 2006 to 82% in 2009. The main reason given for reducing energy consumption was to save money, although other commonly mentioned reasons included environmental awareness and education through advertising and media reports. In contrast, the proportion of respondents who said they had often reduced water consumption fell from 75% in 2006 to 70% in 2009. Overall, engagement in environmental behaviours declined slightly between surveys: 51% of respondents in 2009 said they had often adopted six or more of the 10 environmental behaviours surveyed in the previous 12 months compared with 58% in 2006.

Figure 1.25: Environmental issues 'most important' to NSW respondents, 2006 and 2009 Who Cares? surveys



Source: DECCW 2009b

Energy efficiency survey

Research by the NSW Office of Environment and Heritage (OEH) indicates some positive changes in the NSW community's views and practices relating to energy efficiency. Since a pre-campaign benchmark survey for the Save Power scheme in 2009 more households:

- have become 'very' or 'extremely' mindful of the amount of electricity they use (58% in 2011 compared with 53% in 2009)
- think the community in general is becoming more aware of energy efficiency (31% in 2011 compared with 23% in 2009).

This is a strong indicator of the development of 'social norms' around energy efficiency and is also supported by the results of OEH qualitative research in 2010. There has also been a positive shift in energy-efficient behaviours across the NSW community with 62% of people surveyed in January 2011 claiming positive behaviours to try to reduce their electricity use. Of 10 everyday energy-saving behaviours, the average number that people say they perform 'mostly' or 'sometimes' increased from 7.8 at the benchmark in 2009 to 8.3 in January 2011.

Drivers of energy efficiency have shifted over time from a mix of financial and environmental motivations to being predominantly cost-focused. The $63-million Home Power Savings Program offers assistance and advice to 220,000 lower income households across NSW to help them reduce their use of power by up to 20% and help the environment (see also People and the Environment 1.2).

Food waste

In December 2009, the Love Food, Hate Waste program studied 1200 NSW households to better understand their attitudes towards food waste and associated behaviours. The research found that NSW households waste over $2.5 billion in uneaten food each year. This is comprised of $848 million in fresh food; $694m in leftovers; $372m of packaged and long-life food; $231m in drinks; $231m in frozen food; and $180m of home delivered/take away food. This translates to the average NSW household throwing away $1036 of edible food and drink each year.

The most common reasons for edible food being wasted include that too much is bought, too much is cooked, and people are unsure how to store food correctly.

Education

Education and engagement are key tools to achieving sustainability in NSW. They help people to understand and share knowledge about complex environmental issues and build their ability to take positive action at home, work and play to live more sustainably and protect the environment.

NSW environmental education priorities and approaches have been coordinated through successive NSW Environmental Education Plans, the most recent being *Learning for Sustainability: NSW Environmental Education Plan 2007–10* (CEE 2006). In late 2010, research commenced to review the current status and uptake of sustainability education and engagement strategies across all sectors in NSW and investigate the best support framework for learning for sustainability into the future. This work has included collection of data and feedback from the community, education, government and business sectors through in-depth interviews and an on-line survey, which engaged more than 300 respondents. The research has identified the attitudes and opinions on learning for sustainability as discussed below.

The top four goals of sustainability education mentioned by respondents in the on-line survey were:

- building knowledge about sustainability
- influencing people to adopt practices or behaviours
- developing skills for the workplace or daily life
- developing positive attitudes.

Based on key informant interviews, the emphasis of sustainability education should be on enabling behaviour change and actions at the local and 'place-based' level. Sustainability education and engagement tools and strategies are still regarded as important in achieving the key goals of sustainability in NSW: to support the community to protect the environment and live more sustainably.

The context and drivers for sustainability education and engagement have been evolving ever since the first Environmental Education Plan in 2002–05. Business and industry consider it important for sustainability to be linked to broader business innovation and to see sustainability as a means of securing business advantage. Seventy-one per cent of survey respondents favoured the government providing some strategic direction and coordination to help organisations with education and engagement of internal and external colleagues, staff, clients and customers.

Respondents to the survey indicated that:

- Sustainability education and engagement need to be actively integrated with other sustainability approaches and programs, such as infrastructure planning and the use of economic instruments.
- New alliances are needed to reflect the growing diversity in sustainability education which is now being practised and promoted across sectors, ranging from business and industry to formal education to community organisations.
- All sectors need more help to build their own understanding on how to both develop and deliver effective programs, including forming support networks and alliances, and integrate learning for sustainability with all other tools for change.
- Rigorous research and evaluation about what works is needed, including showcasing best practice and sharing knowledge and approaches in sustainability education and engagement using, where appropriate, new communications technologies and channels.

Pressures

Many factors influence social behaviour and community attitudes towards taking positive environmental action, including values, knowledge and intrinsic motivation. The status or condition of the environment may also influence social behaviour.

The 'Who Cares About the Environment?' survey in 2009 shed light on why people take this type of action and the factors that discourage them. This research found that people are more likely to protect the environment if they have both an awareness and understanding of the positive and negative consequences of their behaviour.

Legislation appears to be a powerful driver for people taking up positive environmental behaviours. Whether a peer or social group regards behaviour as normal can also encourage or deter behavioural change. Local community education and engagement is also being increasingly recognised as a key factor to equip and support community members with the knowledge, skills and motivation they need to manage their property, household, business and lifestyle in a more sustainable way. Councils and community organisations are in a unique position to engage with and educate at the local level.

Responses

Established responses

A range of new projects to reduce the use of water and energy and increase sustainability reflects the NSW Government's responses to increased public concern about water shortage and climate change. A number of long-running programs have also been reoriented similarly. Programs are focusing on creating partnerships between the NSW Government and local government, communities and businesses to achieve common and beneficial environmental outcomes. Education and information resources are increasingly being made available through on-line channels, including websites, e-newsletters, SMS, website banners and Twitter, to support partnerships with local government, community organisations, businesses and individuals across the state.

Sustainability Advantage

Medium-to-large organisations can draw on the support provided by Sustainability Advantage to identify and implement environmental projects that also add business value. This program helps participants identify and implement projects in practical areas, such as resource efficiency (energy, water, waste and raw materials); supply chain; staff engagement; and carbon management. It provides support in the form of workshops and training, technical advice and facilitated networks.

By December 2011, the program had 605 members drawn from industry sectors as diverse as agribusiness, building products, aged care, education and government. Members were reducing emissions of the greenhouse gas carbon dioxide by 194,000 tonnes per year and saving over $80 million a year as a result of productivity gains, reductions in the use of energy, raw materials, water and fuel, and improved waste management.

NSW Energy Efficiency Strategy

In 2008, the NSW Government announced the NSW Energy Efficiency Strategy (see People and the Environment 1.2), which includes the following programs targeting business and community actions:

- the Energy Saver program
- Energy Efficiency for Small Business Program
- the Energy Efficiency Training Program
- the Energy Efficiency Community Awareness Program.

The $15-million Energy Efficiency Community Awareness Program provides the NSW community with information and practical advice to reduce electricity use at home and work. The program provides an umbrella for other government programs targeting energy efficiency for households, business and the community, including through the media campaign Save Power: What can you do in your world? The program has three key components: social research and evaluation; education and training; and communication and engagement.

Love Food, Hate Waste

Food waste is a complex environmental, social and economic problem. The Love Food, Hate Waste program aims to raise awareness about the environmental and economic consequences of food waste in NSW and reduce the 1.1 million tonnes of good food being sent to landfill. By promoting easy and practical solutions for buying, cooking and storing food, the program will help the NSW community to waste less food, save time and money, and reduce environmental impacts (see People and the Environment 1.3 for more information on waste programs). While Love Food, Hate Waste primarily focuses on household food waste at the moment, there are plans to also address commercial food waste in the future. The core elements of the program include research, communications materials, and an education grants program.

Other programs

NSW Home Saver Rebates: This program was funded under the NSW Government's Climate Change Fund and provided rebates to encourage residents to make their homes more water- and energy-efficient. Before the program ended on 30 June 2011, it was adopted by one in eight households across NSW. The program helped NSW households save approximately 46 billion litres of water and $347 million on household water and energy bills over the life of each installation and reduce greenhouse gas emissions by more than 4 million tonnes.

Environmental Trust grants are offered to community groups, schools, universities and state and local government agencies to support exceptional environmental projects that do not receive funds from the usual government sources. In the 2010–11 financial year, almost $91 million was made available for projects, including those focusing on urban sustainability, restoration and rehabilitation, support and restructuring, education, Eco Schools (see 'Education' below) and research.

Education

Educational programs continue to be delivered to support communities, schools, government agencies and businesses in adopting more sustainable practices. Some highlights are outlined below.

The NSW Office of Environment and Heritage coordinates a number of Discovery programs under the banners 'Discovery for schools', 'Walks, talks and tours' and 'Aboriginal discovery'. The Discovery programs run in NSW national parks provide an important vehicle for environmental education and a unique opportunity for community participation in learning activities focused on understanding and appreciating the conservation of nature, cultural heritage and historic heritage in NSW. Since Discovery was established in 1993, annual community participation has increased from 40,000 to 290,561 in 2010–11.

Half of all NSW schools are now participating in Sustainable Schools NSW which helps them to be more energy- and waste-efficient and supports teachers, students and school communities to adopt sustainable practices. The program takes a whole-school approach and works across curriculum, school grounds, management and the schools community.

With funding from the Environmental Trust, the Eco Schools Program provides grants to schools to involve their students and community in developing and implementing environmental management projects. A total of 180 Eco Schools projects were funded between 2009 and 2012, totalling $450,000.

The NSW Government has also funded the $20-million School Energy Efficiency Program and the $20-million Rainwater Tanks in Schools Program as part of the Climate Change Fund.

Water for Life

Water for Life is an integrated educational component of the *2010 Metropolitan Water Plan* (NSW Government 2010b). Community campaigns, innovative on-the-ground water education projects, and training and resources are being delivered as part of Water for Life to secure Sydney's water supply (see People and the Environment 1.4).

Developing responses

In responding to feedback from the broader community, the education sector, other government agencies and business, the NSW Government will focus on further building the capacity of business, the community and individuals to act locally on their priority environmental issues. Programs will be improved with offerings customised to stakeholder needs, providing better and easier access, and delivering an integrated and effective mix of education, infrastructure, regulation and economic tools.

Future opportunities

A continued focus on social trends and support for integrated community engagement and action programs will ensure that the community is well supported to address its environmental concerns. Ongoing monitoring of social trends will assist in the development of timely and effective government policies and programs. Key challenges persist about how best to motivate people to commit to and maintain sustainable actions within the context of an ever-growing range of pressing economic and social issues, including employment, health, raising a family and paying the bills. This is true for businesses as well as individuals, households, government and community organisations.

1.7 Economics and the environment

Since 1992, the New South Wales economy has sustained positive annual growth of around 2.7% per annum, with gross state product increasing by approximately $16,000 per capita over the same period.

Economic instruments, such as taxes, subsidies, deposit-refund schemes, tradeable permits and financial enforcement incentives, offer a flexible way to meet environmental quality objectives with fewer regulatory costs by facilitating market responses to address environmental concerns.

A range of measures is being used to improve both economic efficiency and environmental outcomes, including load-based licensing, which provides a financial incentive for polluters to reduce the level of their emissions, and the Hunter River Salinity Trading Scheme, which allows participants to trade with each other for the right to discharge saline wastewater.

The NSW economy is primarily service-based and thus has far less environmental impact than economies based on extraction or primary industries. Service industries contribute over 70% of the NSW gross state product, with financial and insurance services, professional, scientific and technical services, information media and telecommunications making a large contribution.

Introduction

Economic growth (the increase in the production and consumption of goods and services in an economy over time) is intrinsically interrelated with the environment. The interaction is not a simple one, with different aspects of economic growth having different impacts on the environment.

Economic growth is related to various factors, such as population growth, increasing wealth, improving standard of living, the technologies in use, and productivity improvements. A growing population has environmental impacts (such as increased resource use and waste), while increases in the standard of living normally imply that each person is 'consuming' more resources. On the other hand, improved productivity and technologies mean that we are able to produce more with potentially less impact, while greater wealth increases society's willingness-to-pay for better environmental outcomes.

Status and trends

NSW is the largest contributor to the Australian economy, generating just under a third of Australia's gross domestic product. The state has experienced steady economic growth over the last two decades, with real gross state product (GSP) increasing at an average of around 2.7% per year. This is slower than the Australian average of around 3.1%, although the stronger national growth rate has largely been fuelled by the expanding Western Australian and Queensland mining sectors.

Service industries contribute over 70% of the state's GSP, including large contributions from financial and insurance services; professional, scientific and technical services; and information media and telecommunications (AE 2010). While manufacturing remains a major industry in NSW, contributing 8.6% of GSP in 2011, its growth has eased over the past two decades and was overtaken by the financial and insurance services sector as the state's largest sector at the turn of the century. Primary industries (agriculture, forestry and fishing, and mining) have experienced steady growth since 1990, with gross added value almost doubling, although the contribution of these sectors to annual GSP has remained relatively constant over this period at around 4%.

Population growth in NSW has occurred at a slower rate than economic growth, averaging 1.4% since June 2006 (see People and the Environment 1.1). In real terms, cumulative GSP growth has been about 47% greater than the growth in population, suggesting increasing levels of affluence in the NSW population. Since 1990, real GSP per capita increased by approximately $15,600 to $58,000.

Economic growth and the environment

Increasing levels of economic activity can place pressures on land and other natural resources or assets, often referred to as 'natural capital'. For example, the NSW mining sector depends on access to natural capital for growth. Mining's gross value added to GSP has increased by 86% since 1990: as of April 2011, $8.25 billion was earmarked for investment in major NSW minerals and energy sector projects (ABARES 2011b), further strengthening the sector's contribution to GSP. However, the cost of this expansion is the depletion of natural resources in the project regions and environmental impacts, such as particulate pollution.

Energy supply (at a reasonable price) is essential to economic growth. Fossil fuels currently meet around 94% of the primary energy demands of NSW. Government-led initiatives and technological developments have promoted an increase in the use of renewable and low-carbon non-renewable energy sources in recent years. The introduction of a charge for carbon emissions is likely to support this further. For example, there is considerable potential for investment in coal seam gas production in NSW in the near future. The industry has the potential to increase economic growth and provide a cost-effective energy supply, with lower greenhouse gas emissions than coal-based energy production. However there are significant environmental concerns with the gas extraction process, mainly associated with the risk of chemical contamination of surface and groundwater sources. Despite these developments, high-carbon non-renewable sources, such as coal-fired electricity generation, are likely to continue to dominate the state's energy supplies for the foreseeable future (Wood et al. 2012).

Economic growth may threaten the capacity of the environment to break down or receive waste without causing significant ecological harm. In densely populated areas, waste products, such as solid waste, sewage, hazardous waste, and atmospheric emissions, place increased stress on the environment. Such impacts have been observed in the Hawkesbury–Nepean River, where population growth and changing land-use activities have had a negative impact on the health of the river. This has occurred through increased runoff from agricultural, horticultural and urban land uses, and discharges from services such as sewage treatment plants, which are under greater loads as the population they service increases. This in turn can adversely affect other economic activity in the area, such as recreation, tourism and fisheries (HNCMA 2007).

While environmental impacts can result from increasing population and economic growth, it is important to note that they do not necessarily occur proportionately to these growth rates. Policy decisions, technological innovation and changes to individuals' behaviour can effectively reduce the rate of environmental damage over time as population and economic growth continues.

The share of total spending by NSW households over the past two decades has stayed about the same. However total household spending on transport has grown by 96%, more than the growth in overall household spending of 82%. This suggests that NSW households are becoming more mobile, thereby using larger amounts of fuel. The increase in transport spending may result from workers having to commute longer distances to work. Growth in transport spending may also reflect growing affluence and greater disposable income. See also People and the Environment 1.1, People and the Environment 1.4 and People and the Environment 1.5.

Economic analysis of environment protection

There are practical and methodological difficulties in applying economic tools to decisions about the environment. Economic tools are used to:

- assess the costs and benefits of proposed environmental standards, policies or investments to achieve net gains for society while minimising the regulatory burden on business and the community
- identify least-cost options for achieving specific environmental outcomes
- assess the economic impacts of environmental pressures
- provide advice on, and assessment of, regulations, market-based instruments and economic incentives
- support efficient and effective land management
- provide advice on the efficient and effective conservation and use of natural resources.

Economic tools are used to support appropriate policies 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 (NSW Government 2011). In addition, economic instruments can provide policymakers with alternatives to traditional regulation for delivering environmental outcomes at minimal cost to businesses and the community.

Environmental regulations in NSW undergo a cost-benefit analysis (CBA) to ensure that key principles of good regulation are met. It must be demonstrated that new or revised regulations will maximise the net public benefit. CBA identifies the marginal costs and benefits of a given program and other options, quantifies them in monetary terms, and compares them to arrive at a net benefit. There are often challenges in quantifying the environmental impacts of policy decisions. Where costs or benefits cannot be quantified, they can be presented in qualitative terms and considered when interpreting the measured net benefit (or cost) of the program. Informed public policy requires environmental goods and services to be fully documented and assessed, even where precise quantitative monetary values cannot be readily or accurately estimated.

The economic value of environmental goods and services can be estimated using various techniques. For example, the net economic benefit obtained by visitors to a national park can be estimated using the travel-cost method (TCM). This uses the costs that visitors incur in travelling to a particular location (such as a national park) as a proxy for the amount they are willing to pay to obtain the recreational experience from that location. Data for TCM studies is obtained from surveys of national and marine park visitors. A 2007 travel-cost study of four marine parks estimated the economic benefits of these protected areas ranged from between \$16 and \$50 per visit (ignoring the cost of travel time). The total economic benefit from recreation at all four marine parks was estimated at between \$5.1 million and \$7.3 million per annum (DECC 2007c).

Economic techniques can also be used to estimate the value of reducing pollution on health. The CBA for the review of the Protection of the Environment Operations (Clean Air) Regulation 2010 used the damage-cost approach to estimate reductions in health costs from measures that reduce air pollution in NSW (DECCW 2010c).

Finally, there is a growing body of literature on the use of stated preference techniques, such as contingent valuation, that identify consumer preferences for non-market goods (such as the value of species preservation). Contingent valuation techniques have recently been used in regulatory impact assessments of the disposal of televisions and other electrical equipment.

Use of economic instruments in environment protection

Economic instruments, including taxes, subsidies, deposit-refund schemes, tradeable permits and financial enforcement incentives, offer a flexible way to meet environmental quality objectives with fewer regulatory costs by facilitating market responses to address environmental concerns. These instruments can be applied to stimulate the adoption of more efficient pollution abatement technologies and ensure resources are allocated efficiently.

An example of an economic instrument used by the NSW Government is the Hunter River Salinity Trading Scheme, a type of emissions trading scheme. The Hunter scheme allows participants to trade with each other for the right to discharge saline wastewater into the Hunter River without exceeding environmental thresholds. A similar but smaller scheme is the South Creek Bubble Licensing Scheme, which involves trading of emissions between three sewage treatment plants into South Creek, a tributary of the Hawkesbury–Nepean River.

Another economic instrument used in NSW is load-based licensing. This provides a financial incentive for industry to reduce pollution by charging fees that depend on both the toxicity of pollution emitted and its proximity to exposed populations. In a similar way, the NSW Waste and Environment Levy provides a financial incentive for commercial and residential premises to reduce the amount of waste they send to landfill.

Pressures

Economic factors and the environment

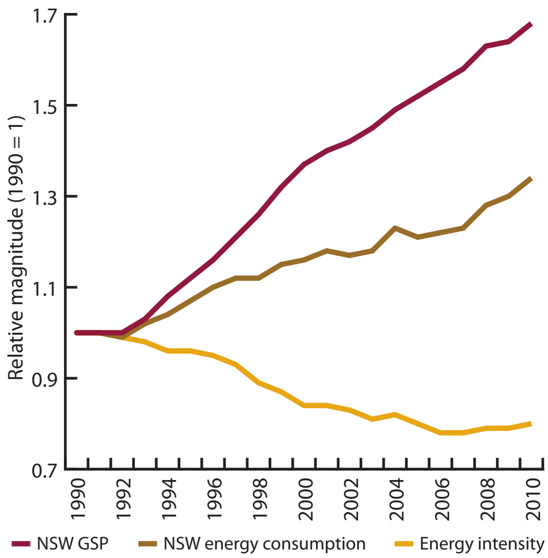
Greenhouse gas emissions and energy

The largest contributions to NSW greenhouse gas emissions are the use of fossil fuels for electricity generation (approximately 41%), industrial processes (17%) and transport (14%) (see Figure 1.12 in People and the Environment 1.2). In general, the expansion of production around the world has been accompanied by outputs that often have significant ecological impacts.

As concerns about the impacts of climate change have become more widespread, there has been increasing adoption of cleaner fuels, such as natural gas for public transport, and the generation of wind and solar electricity, as well as a general reduction in the energy-intensity of production.

Although the flow of raw materials through the economy is unlikely to slow in the near future, the quantity of energy used per unit of output (energy intensity) is expected to decline (**Figure 1.26**). To date, reductions in the energy intensity of output have been driven by changes in the behaviour of individuals and businesses, as well as through complementary policies, such as demand-management education and rebates for solar panels (see People and the Environment 1.5).

Figure 1.26: Energy intensity of NSW production indexed to 1990



Source: ABARES 2011a, Table B; ABS 2011d, Table 1.

In coming years, a tax on carbon emissions is likely to further change behaviour by ensuring that market prices reflect the full costs of production, including the costs to the community from climate change (see People and the Environment 1.2).

Air quality

With population density rising in Sydney, the community is at greater risk from adverse health effects associated with air pollutants. People are also moving to larger regional centres elsewhere in NSW. The increasing population density of urban and regional centres combined with the growth in incomes and spending, including spending on private transport, is placing pressure on outdoor air quality.

In regional areas, air quality problems are being driven by similar demographic trends and broader economic growth, in particular the expansion of mining, agriculture and industrial processing. For instance, population growth in Tamworth has increased the exposure of residents to surrounding agricultural and industrial processing facilities. In the Hunter Valley, high international demand for coal and the statewide demand for low-cost electricity are driving increasing development of coal mines. This in turn creates dust and vehicle emissions that may have an impact on local residents.

Land management

As the resource demands of the NSW economy grow, there is likely to be more interaction (and possibly conflict) between alternative land uses for residential, commercial, agriculture, mining and conservation purposes.

Land-use conflicts in urban areas usually result from population growth driving demand for residential development, which places pressure on remnant green space, including land used for agriculture and conservation. More recently, residential development has transformed old industrial sites into residential areas. Appropriate planning and design considerations can reduce the environmental impacts of growing urban populations. The population in NSW has increased by approximately 25% since 1990, while the number of occupied private dwellings has grown by 43% (though with changing sizes) (ABS 1991, p.43; ABS 2011f). **Table 1.7** shows the extent of growth in various land uses in NSW over the last two decades.

Changes in world commodity prices and the exchange rate also determine the profitability of mining some types of materials in NSW. The value of NSW mining output has risen by 86% in real terms since 1990. But despite the mining boom elsewhere in Australia, the contribution of mining to NSW has remained relatively unchanged since 1990 at approximately 2–3% of GSP.

Table 1.7: Issues affecting land use in NSW

Year	Population	Occupied private dwellings	Protected areas (ha)	Agriculture, forestry, fishing (industry value)	Mining (industry value)	Manufact-uring (industry value)
1990	5.8 million	1.9 million*	3,888,950*	$3.4 billion	$5.7 billion	$30.3 billion
2011	7.2 million	2.7 million	7,077,757**	$7.1 billion	$10.6 billion	$36.0 billion
Sources	ABS 2012	ABS 1991, p.43 ABS 2011f	Sattler & Glanznig 2006	ABS 2011d – chain volume measures		

Notes: * 1991 ** 2010

Water

Economic factors affecting the demand for agricultural produce will have the largest impact on water use in NSW, although water consumption is largely driven by environmental factors affecting supply.

The agricultural sector has played an important role in Australia's economy and currently accounts for approximately two-thirds of water consumption in NSW. Although the economic value of the NSW agricultural sector is relatively low (less than 2% of GSP), the sector contributes over $4 billion worth of exports annually (I&I 2010). Domestic demand for agricultural products is relatively stable and is expected to increase in line with population growth. While changes in the Australian dollar and world commodity prices have a large impact on the type (and value) of NSW agricultural production, another important driver is the availability of water.

The importance of water is no more apparent than in the Murray–Darling Basin where prolonged drought had until recently stressed farming communities, production, and river and wetland ecosystems. The return of water to the system over the last two years, including significant flooding, highlights the important role that rainfall plays as a driver of agricultural production. Meanwhile most farmers have benefited recently from rising world food prices, which despite the appreciating Australian dollar, grew by 40% in A$ terms between 2004 and 2011 (RBA 2011).

Responses

Established responses

NSW 2021: A plan to make NSW number one (NSW Government 2011), the Government's 10-year plan for NSW, sets ambitious targets for the economy and, while realisation of these will see great benefits for the people of NSW, they also pose significant challenges for the environment. Specific targets set out in the 'Economy' section of *NSW 2021* that might pose environmental challenges include:

- growth in business investment by an average of 4% per year to 2020
- growth in GSP per capita by an average 1.5% per year to 2020 with specific industry growth targets
- growth in employment by an average 1.25% per year to 2020
- improved efficiency and effectiveness of expenditure with all capital projects to be assessed through a cost-benefit analysis
- protection of strategic agricultural land and improved agricultural productivity
- containment of electricity costs through efficient energy use.

Reviews of environmental legislation

NSW agencies are required by the *Subordinate Legislation Act 1989* to consider the economic costs and benefits of environmental regulations every five years or at the time they are amended. Regulations and environmental standards in NSW are required to have well-defined objectives, based on robust evidence of the costs of compliance and the benefits that will be generated.

Table 1.8: Summary of recent economic assessments

Instrument	Benefits	Costs	Net benefit	Sources
Underground petroleum storage systems	$110 million	$40 million*	$70 million	DEC 2006
Stage 2 vapour recovery	$231 million	$106 million	$125 million	DECC 2009b – costs and benefits are over 30 years, discounted to present values
Solaria controls	$10 million**	$1.6 million	$8.4 million	DECC 2009c
Hunter River Salinity Trading Scheme	$49.4 million	$2.2 million	$47.2 million	Pu 2008, p.243

Notes: Costs and benefits are over five years (unless stated otherwise), discounted to present values
* Upper range of costs
** Lower range of benefits

This process improves our understanding of the links between economic activity and environmental improvements and ensures that policies explicitly take these into account to achieve optimal outcomes for current and future generations. **Table 1.8** summarises some recent assessments of the costs and benefits of environmental regulations in NSW.

Developing responses

There has been increasing interest in improving and streamlining regulatory practice in Australia through the work of the Council of Australian Governments (COAG) and the Productivity Commission, and in NSW through the Independent Pricing and Regulatory Tribunal (IPART) and Better Regulation Office. Areas with environmental implications such as waste, urban congestion, chemicals and plastics, and radiation have been specifically targeted by these reforms.

Future opportunities

If NSW continues to experience economic and population growth similar to recent decades, the state will have an annual GSP of around $490 billion by 2020 and a population of 7.8 million.

Responding to the new and increasing environmental challenges presented by a growing NSW economy will require a better understanding of how the economy and the environment interact, supported by the use of appropriate evaluation methods to assess environmental policies and investment decisions and innovative market-based instruments to manage pollution.

1.8 Aboriginal culture and heritage

The area of public lands in New South Wales that are protected for Aboriginal cultural values has increased as have the number of culturally significant objects and places. The first major changes in 30 years were made to strengthen the Aboriginal culture and heritage provisions of the National Parks and Wildlife Act in 2010.

The NSW Government is committed to the protection and management of Aboriginal cultural heritage and providing Aboriginal people with opportunities to protect their culture and heritage and retain access to traditional lands. These commitments form part of Goal 26 in NSW 2021.

Since SoE 2009, the following Aboriginal listings have been added to the State Heritage Register: the Myall Creek Massacre and Memorial Site, Wooleybah Sawmill and Settlement, and Warangesda Aboriginal Mission and Station.

NSW indicators

Indicator and status	Trend	Information availability
Increase in the number of hectares of public lands that Aboriginal people are actively involved in managing	Increasing	✓✓
Increase in the number of Aboriginal culturally significant objects and places protected	Increasing	✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

'Heritage' is the collective environment, traditions, objects and places that we inherit from the past and preserve for the use and inspiration of future generations. 'Culture' refers to the way we relate to and understand the world – both the present and the past. Together, culture and heritage frame our understanding of the past and influence the decisions we make about which values to preserve for the future.

Aboriginal people have a holistic perspective of culture and heritage. For Aboriginal people, culture and heritage are intrinsically linked with belonging to 'Country', the term used to describe both the land and waters, including the sea, to which they have a strong cultural connection. Protection, use and access to Country are therefore central to the wellbeing of Aboriginal people. Culturally appropriate management of Country and its resources is an essential part of protecting Aboriginal culture and heritage.

Status and trends

Heritage and cultural values are protected through a suite of mechanisms that include the gazettal of Aboriginal Places, regulation by legislation, statutory registers and permit systems, government policies, programs, grants, non-statutory agreements and partnerships, and local community activities.

The heritage objects, places, structures, landscapes, movable collections and archaeological remains (collectively termed 'items') which are protected by the *Heritage Act 1977* are managed and protected through their listing on registers and schedules.

The *National Parks and Wildlife Act 1974* is the primary legislation that provides protection for Aboriginal cultural heritage in NSW. The Act establishes offences for harming Aboriginal objects and provides for the declaration of Aboriginal Places and Aboriginal Areas. The Act also contains provisions relating to the repatriation of Aboriginal objects and places and for joint agreements with Aboriginal communities to manage national parks and reserves.

Heritage listings

Responsibility for heritage management in NSW is largely shared between local government, State Government agencies and the Heritage Council of NSW. Local councils are responsible for managing the bulk of heritage items through listings on heritage schedules in their local environmental plans. State agencies also have a statutory requirement to prepare a Heritage and Conservation Register of assets under their care and management under section 170 of the Heritage Act. The Heritage Council, with the support of the NSW Government, is responsible for recommending to the Minister for Heritage items of state significance to be included on the State Heritage Register and the subsequent management of them.

The Australian Government manages listings (including World Heritage List properties) on the National Heritage List and Commonwealth Heritage List under the *Environment Protection and Biodiversity Conservation Act 1999*. Additionally, community and professional bodies, such as the National Trust, Aboriginal land councils and some professional associations (Australian Institute of Architects and Engineers Australia) also maintain heritage registers. While these have no statutory effect, they are an important record of community support for individual items.

State Heritage Register

The State Heritage Register recognises the most significant heritage places and objects across NSW. These are items of 'state heritage significance' and reflect the diversity of heritage sites in NSW. A total of 78 new items was added to the register from January 2009 to December 2011, taking the overall number of listings to 1616.

The number of additions to the register nearly doubled compared with the previous three years. This has been partly due to introduction of the Thematic Listings Program, launched in February 2009. The program provides a strategic and systematic framework for managing accessions to the register.

Since *SoE 2009* (DECCW 2009a), Aboriginal listings on the State Heritage Register have been the Myall Creek Massacre and Memorial Site, Wooleybah Sawmill and Settlement, and Warangesda Aboriginal Mission and Station.

Other lists

The Australian Heritage Council manages the National Heritage List, which includes places of outstanding heritage significance to the nation. Over 100 sites were on the list in February 2012, with recent additions including the Myall Creek Massacre and Memorial Site.

Aboriginal culture and heritage management

Aboriginal culture and heritage are linked closely with the natural environment and contain traditions and assets, both tangible and intangible. The strong relationship between Aboriginal people and their lands makes culturally appropriate management of Country and its resources a critical part of protecting Aboriginal cultural values. Aboriginal cultural heritage is protected and managed through mechanisms such as Aboriginal Places, Aboriginal Areas, Conservation Agreements, Memorandums of Understanding, Joint Management Agreements and State Heritage Register listings.

Aboriginal Places

Declaration of Aboriginal Places is an important way of recognising and protecting Aboriginal culture and heritage. Under the National Parks and Wildlife Act, any land may be declared an Aboriginal Place if the area is, or was, of special significance to Aboriginal people. Aboriginal Places have tangible or intangible value to Aboriginal people and show physical evidence of Aboriginal occupation or use. However they are not evaluated against a rigid set of criteria or against other places. Declaration of an Aboriginal Place does not change the status of the land or affect ownership rights, but it is an offence to harm an Aboriginal Place. To date, 82 Aboriginal Places have been declared across NSW.

The NSW Government has developed a web-based Atlas of Aboriginal Places, which features a map of declared Aboriginal Places in NSW and information describing the significance of them to Aboriginal people and culture.

Table 1.9: Area of land protected for Aboriginal cultural values

Type of protection	2006	2007	2008	2009	2010	2011
Aboriginal Places	15,791	15,954	18,259	19,570	19,605	19,667
Aboriginal Areas	33,329	33,335	33,335	33,648	34,238	35,832
Conservation Agreements	5,047	5,047	5,616	5,894	8,272	9,960
Joint Management Agreements including:	376,984	1,216,641	1,216,641	1,216,641	1,541,505	1,541,140
– Memorandums of Understanding	(279,676)	(1,030,905)	(1,030,905)	(1,030,905)	(1,355,127)	(1,354,762)
– Indigenous Land Use Agreements	(1,443)	(85,434)	(85,434)	(85,434)	(85,434)	(85,434)
– Part 4a NPW Act Agreements	(95,865)	(100,302)	(100,302)	(100,302)	(100,944)	(100,944)
State Heritage Register-listed places	849	849	849	849	935	955
Total land protected	432,000	1,271,826	1,274,700	1,276,602	1,604,555	1,607,554

Source: NSW Office of Environment and Heritage data 2012
Notes: Areas shown are in hectares.

Heritage registers

Heritage registers assist the NSW Government to manage heritage information. The Aboriginal Heritage Information Management System (AHIMS) contains information on 69,600 recorded Aboriginal sites and 11,000 archaeological and Aboriginal heritage reports. AHIMS is used by government, industry, heritage professionals and Aboriginal communities to inform land-use planning, regulation and conservation management.

The Historic Heritage Information Management System (HHIMS) is a register under section 170 of the Heritage Act of all NSW heritage assets.

Joint management of parks

The creation of jointly managed national parks enables Aboriginal people to manage Country by participating in park planning and decision-making processes. To date, the NSW Government's program of Aboriginal joint management of parks is the most successful program ensuring Aboriginal people are fully involved in identifying and protecting Aboriginal cultural values on public land. Co-managed parks and reserves represent the highest proportion of public land protected for cultural values (**Table 1.9**).

NSW has 23 Aboriginal joint management arrangements covering around 28% of the park system from Mungo and Mutawintji national parks in the far west to Arakwal National Park and the Worimi Conservation Lands on the eastern seaboard. The NSW Government plans to negotiate several new Aboriginal Joint Management Agreements and two new Indigenous Protected Areas with Aboriginal communities over the next two years.

Over 200 Aboriginal people have been formally appointed to boards of management and committees for jointly managed parks.

Pressures

A number of factors have an impact on the way heritage is protected and managed in NSW, including population and industrial growth, economic changes and socio-cultural trends. In metropolitan areas and coastal zones, population growth causes increased development which may present challenges for the protection of heritage. Conversely, population and job decline in some rural and regional areas can cause a shortage of active uses for heritage items, limit conservation capacity, and also reduce their protection.

Simplification or streamlining of planning and development processes have the inadvertent result of making it easier to inappropriately modify heritage places or fail to identify them for protection on schedules.

Mixed land tenure in NSW requires a cohesive suite of mechanisms for protecting cultural values. A particular challenge is ensuring cultural values on private land are identified so they can be protected.

A balance is required between increasing the public's awareness of, and visits to, natural and cultural sites with ensuring the preservation and protection of those sites. It is essential that heritage sites are actively managed with cultural sensitivity.

It is very important that Aboriginal culture and heritage is appropriately recognised and protected through legislation, government policies and ongoing relationships with Aboriginal people. At present, NSW remains the only jurisdiction in Australia without separate Aboriginal heritage legislation.

Responses

Established responses

The NSW Government is committed to the protection and management of Aboriginal cultural heritage and providing Aboriginal people with opportunities to protect their culture and heritage and retain access to traditional lands. These commitments form part of Goal 26 – 'Fostering opportunity and partnership with Aboriginal people' in the Government's 10-year plan, *NSW 2021: A plan to make NSW number one* (NSW Government 2011).

Legislative review

In 2010, the *National Parks and Wildlife Act 1974* (NPW Act) was amended to strengthen its provisions for the protection of Aboriginal culture and heritage. This included the introduction of a new strict liability offence for harming or desecrating an Aboriginal object or place, a 'due diligence' defence to the strict liability offence of harming an Aboriginal object, and an increase in penalties for offences.

The 2010 amendments were the first major changes to the Aboriginal culture and heritage provisions in the NPW Act since they were enacted more than 30 years ago. They were an important contribution towards improving Aboriginal heritage protection in NSW. However, Aboriginal people in NSW continued to champion the need for a complete review of Aboriginal heritage legislation to address the needs and challenges for better protection of Aboriginal culture and heritage.

In response, the NSW Government has commenced a review of existing laws to decide what options are available for further improving protection and management of Aboriginal culture and heritage. The review and reform process included a broad consultation with Aboriginal communities, government agencies and peak stakeholders from the property, heritage, environment, industry and other sectors. The NSW Government appointed an advisory Working Party composed of individuals with industry, legal, planning and heritage expertise to coordinate the review process. The Working Party will provide options and recommendations for reform of Aboriginal heritage legislation to the Government by late 2012.

In addition to the NSW legislative review, a review by the Commonwealth Government of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* has also been under way since 2009.

Amendments to the *Heritage Act 1977* were also passed by State Parliament in late 2011. The amendments included:

- reducing the number of members on the Heritage Council to nine by the removal of two government officials
- introducing extra time frames for the Heritage Council to submit recommendations to the Minister for Heritage for the listing of items on the State Heritage Register
- introducing a time frame for referral of recommendations for listing by the Minister to the Planning and Assessment Commission
- ensuring that the reasons for the Minister's decisions on listing matters are placed in the public arena.

Heritage programs

Thematic Listings Program: The State Heritage Register Thematic Listings Program 2009–10 aims to provide a balanced and credible register that accurately records the most significant places and objects in NSW and reflects the cultural richness and diversity of the state. This revised approach introduced the following four agreed priority themes to assist in filling gaps in the register and ensure adequate representation of each theme when listings are being considered:

- Aboriginal heritage – to ensure this important aspect of the state's history continues to be recognised (seven items listed)
- convicts – to acknowledge work associated with the Australian Convict World Heritage nomination (eight items)

- Governor Macquarie – to mark the bicentenary of Macquarie's tenure as NSW Governor from 1810 to 1821 (10 items)
- World Wars I and II – to acknowledge the important contribution of servicemen and women during both wars and the 70th anniversary of the beginning of WWII (17 items).

While the Thematic Listings Program was the priority, nominations for places that did not fall within the themes were also accepted. These were identified as Priority Places and a total of 36 items were listed.

Heritage Grants Program: The Heritage Grants Program, managed by the Heritage Council of NSW, supports highly valued, cared for, and well-maintained and managed heritage items of significance to NSW. The program's focus is to assist heritage owners and managers to look after their heritage items and places and maximise leverage of the successful delivery and uptake of Heritage Act and Heritage Council funding initiatives. The funding is targeted to State Heritage Register items protected under the Heritage Act or as part of Aboriginal and local government heritage management programs.

A comprehensive evaluation of the 2009–11 Grant Funding Program was completed in June 2011. Project outcomes and key performance indicators were established for program reporting and evaluation, which will be used to assess and improve future NSW Heritage Grants Program funding offers.

Aboriginal cultural values

Strengthening Aboriginal Community Wellbeing Toolkit: The NSW Government has developed a toolkit to assist Aboriginal communities to plan for a stronger future. The Strengthening Aboriginal Community Wellbeing Toolkit is a software-based support tool designed to assist community governance groups. The toolkit enables communities to assess their strengths and needs and to prioritise and set local goals to address those needs. Aboriginal community groups, government and other partners will use the toolkit to negotiate actions that help Aboriginal communities achieve their priority goals.

Repatriation of ancestral remains: The NSW Government works with Aboriginal communities to return ancestral remains and cultural material to the community. This repatriation program coordinates the collection of those cultural materials and ancestral remains held in collections by universities, museums or other institutions; identified or uncovered by other parties (such as ground works during development); and received from the public. These ancestral materials and remains are temporarily stored, while working with Aboriginal communities to return them to Country or 'keeping places' within local Aboriginal communities. In 2010–11, Aboriginal communities were assisted to repatriate 34 remains and cultural objects and 139 sets of remains and objects in 2011–12.

Grants programs for Aboriginal Country, culture and heritage projects: The NSW Government issues a number of grants to assist the management and protection of Aboriginal cultural heritage. These include:

- the Environmental Trust's Protecting Our Places Program which provides grants for Aboriginal communities to undertake environmental education, restoration and rehabilitation projects
- Aboriginal Lands Clean-up Program which funds action by local Aboriginal land councils and local councils to prevent waste from being illegally dumped on Aboriginal-owned lands and safely clean up such waste
- NSW Heritage Grants (2011–13) which provide funding for projects that conserve, promote and increase understanding of Aboriginal heritage in NSW.

Future opportunities

A better approach in acknowledging how Aboriginal people interact with and value the environment is required to ensure holistic management of Country and environmental assets.

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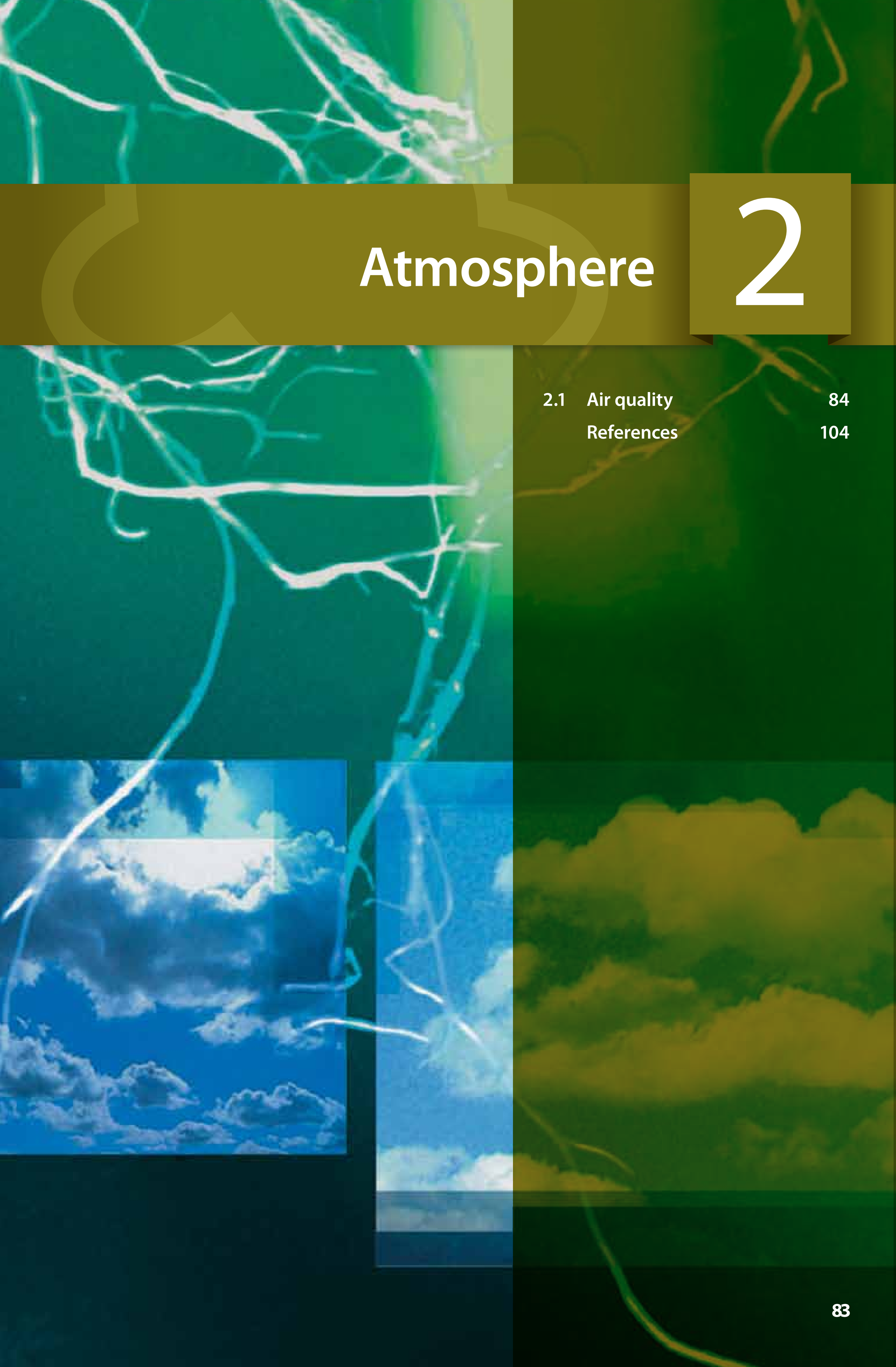


Atmosphere 2

2.1 Air quality

New South Wales complies with national air quality standards for four of the six major 'criteria' air pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. However the national standards continue to be exceeded in some regions for the other two pollutants – ozone (on up to 16 occasions a year) and particle pollution (up to 21 times a year). Levels of air toxics are generally low, with periodic assessment required to verify that all remain at acceptable levels.

Air quality in NSW has improved significantly since the 1980s with initiatives to reduce urban air pollution implemented across industry, business, homes and motor vehicles. The concentrations of a number of the most common air pollutants (such as ammonia, carbon monoxide, lead and sulfur dioxide) are low and since the early 1990s emissions of these and other pollutants (including oxides of nitrogen and volatile organic compounds) have been reduced by 20–40% across the Sydney region.

Ground-level ozone (a key component of photochemical smog which appears as white haze in summer) remains an issue for Sydney and concentrations generally continued to exceed national air quality standards on up to 16 days a year between 2009 and 2011.

There is growing evidence about the adverse health impacts of airborne particles. Particle pollution (appearing as brown haze) generally meets standards in Sydney except when bushfires or dust storms occur, though concentrations exceeded national air quality standards on up to 18 days a year from 2009 to 2011. Some areas in regional NSW exceeded the particle standards on as many as 21 days a year over the same period, with bushfires, stubble burning, dust storms, coal mine dust and woodheaters the major causes.

NSW indicators

Indicator and status	Trend	Information availability
Concentrations of ozone	Stable	✓✓✓
Concentrations of particles (PM_{10})	Stable	✓✓✓
Concentrations of carbon monoxide	Stable	✓✓✓
Concentrations of nitrogen dioxide	Stable	✓✓✓
Concentrations of sulfur dioxide	Stable	✓✓✓
Concentrations of lead	Stable	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Clean air is fundamental to everyone's wellbeing. Poor air quality can be particularly critical to the health of children, older people, pregnant women and those with pre-existing health conditions, while also affecting the natural environment and liveability of the communities in which we work and reside.

An air pollutant is any substance in the air that can harm humans or the environment. Pollutants arise from both natural processes, such as plant respiration, dust storms and bushfires, and human (anthropogenic) activities, and may take the form of solid particles, liquid droplets or gases.

Air pollutants may be classified as *primary* or *secondary*. A primary pollutant is a substance directly emitted from a process, such as carbon monoxide from a motor vehicle exhaust. Secondary pollutants form in the air when primary pollutants react with other substances or interact with each other. An example of a secondary pollutant is ground-level ozone, one of the many secondary pollutants that make up photochemical smog. Some pollutants may be both primary and secondary: examples include formaldehyde, particles, ozone and nitrogen dioxide.

Toxic chemicals are an additional class of air pollutants that can have an impact on human health and the environment. These are generally only found in trace amounts in airsheds across NSW and so are subject to less intensive monitoring.

The status and trend of carbon dioxide and other greenhouse gases, including manufactured chemical pollutants, are discussed in People and the Environment 1.2.

Australians spend approximately 85% of their time indoors, much of it in the home (EPHC 2004). As a result, personal exposure to airborne substances may be more closely related to those encountered indoors than outdoor air pollution. This is accentuated by the close proximity of indoor emissions to people and because the small amounts of pollutants emitted can accumulate to higher concentrations than they would outdoors due to ineffective dispersion and dilution.

The primary concern with indoor air pollution is the link between pollutants and human health. Some of the pollutants found in indoor air are suspected of contributing to long-term human health effects (and even premature death), such as cancer and damage to the nervous, immune and reproductive systems. Other pollutants (nitrogen dioxide, formaldehyde and fine particles) can cause more immediately observable health effects, such as irritation of the upper respiratory system and breathing difficulties, especially for at-risk groups like those with asthma or other lung problems, very young children and older people. Pollutants from tobacco smoke can lead to respiratory and heart disease, cancer and foetal harm.

Costs of poor air quality

Air pollution is a persistent health concern in major cities in Australia and around the world. Those particularly susceptible to the health impacts of air pollution are the very young (because they are generally more active outdoors and their lungs are still developing), the elderly and those with pre-existing health conditions.

Since the early 1990s a substantial body of research has been published about the adverse health effects of air pollution. The research suggests that air pollution – even at the relatively low levels common in many urban environments of industrialised countries – is a risk factor for health. An increasing range of adverse health effects has been linked to air pollution, especially fine particles.

Short-term exposure to elevated air pollutants exacerbates existing respiratory and cardiovascular problems and increases the risk of acute symptoms, hospitalisation and death (EPHC 2010). Long-term repeated exposure increases the risk of chronic respiratory and cardiovascular disease and mortality, has an impact on birth weight, and can permanently affect lung development in children (Pope 2004; Pope & Dockery 2006).

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). Looking at motor vehicle pollution alone, the Australian Bureau of Transport and Regional Economics estimated health costs of \$3.3 billion per year in the country's capital cities with Sydney's share \$1.5 billion (BTRE 2005).

Defining the major pollutants

A range of air pollutants is commonly found across many parts of Australia. Certain key air pollutants that are regulated or subject to standards based on criteria related to health and/or environmental effects are known as 'criteria' air pollutants.

To help protect the health of the Australian population, the National Environment Protection Council in 1998 set ambient air quality standards and goals for six criteria pollutants in the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM). The six pollutants in the AAQ NEPM are ground-level ozone, particles (as PM_{10}), carbon monoxide, nitrogen dioxide, sulfur dioxide and lead.

In addition, an Advisory Reporting Standard for $PM_{2.5}$ was introduced in 2003. The AAQ NEPM was recently reviewed and the recommendations are to be incorporated into the development of a National Plan for Clean Air (see 'National responses' below).

To measure compliance with national goals, NSW has established an extensive air quality monitoring network across the state (see 'Responses' below). The network provides up-to-date air quality information to the community through the Environment Protection Authority (EPA) website and a linked system of email and SMS health alerts for high pollution days as well as the Sydney forecast.

Status and trends

The AAQ NEPM goal for each pollutant sets the maximum number of days on which the relevant standard (a specified concentration of the pollutant) may be exceeded. NSW consistently meets the goals for carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. Ozone and particles continue to be problematic.

Ozone

Ozone is present in both the upper atmosphere (stratosphere) and the lower atmosphere (troposphere). The ozone in the stratosphere (commonly called the 'ozone layer') protects human, animal and plant health by reducing the levels of the Sun's damaging UV-B radiation reaching the Earth's surface. Stratospheric ozone is not a pollutant and is not included in this chapter.

In contrast, ozone at ground level is an air pollutant that is harmful to human health and the environment. People exposed to elevated concentrations of ozone for several hours at a time are at increased risk from respiratory irritation and changes in lung function, particularly if they are already suffering a respiratory illness (WHO 1998).

Ozone is formed in the lower atmosphere when a number of 'precursor' compounds – mainly oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) – react in warm, sunny conditions. (Carbon monoxide is a lesser source of ozone as well.) Major anthropogenic sources of NO_x and VOCs include emissions from industrial facilities, electric power stations and motor vehicle exhausts, and fumes from engines used in garden equipment and recreational boats as well as paints, aerosols and solvents used in homes and businesses. It is also important to note that natural sources, such as eucalyptus trees, contribute approximately 55% the total emissions of volatile organic compounds in the GMR_2.

Elevated ozone concentrations occur in the Sydney and Illawarra regions during the warmer months when meteorological conditions and the surrounding topography prevent the NO_x and VOC constituents from dispersing. Ozone concentrations across Sydney and the Illawarra can be significantly affected by weather patterns: cloudy cool weather tends to lead to low levels, while hot sunny days result in more exceedences (DECCW 2010). Since days with high ozone occur more frequently in summer, the incidence of elevated ozone concentrations may be exacerbated by future climate change, which is expected to bring more hot sunny days.

The AAQ NEPM sets two standards for ozone: a 1-hour standard of 0.10 parts per million (ppm) and a rolling 4-hour standard of 0.08 ppm. The NEPM goal for ozone stipulates that by 2008 the maximum allowable number of exceedences for each of these standards is one day per year. Between 2008 and 2011, the NEPM ozone goals were met only once in Sydney – in 2008 for the 1-hour standard.

While 2011 was generally a good year for air quality in Sydney due to milder weather conditions, both of these ozone standards were exceeded. Indeed, either or both of the standards have been exceeded in Sydney every year since 1996 (**Figure 2.1**). Between 1994 and 2011, ozone concentrations in Sydney exceeded the 1-hour standard on up to 19 days per year, with four exceedence days in 2011. Over the same period, exceedences of the rolling 4-hour standard occurred on up to 21 days, with five exceedence days in 2011. Peak exceedences for both standards occurred in 2001.

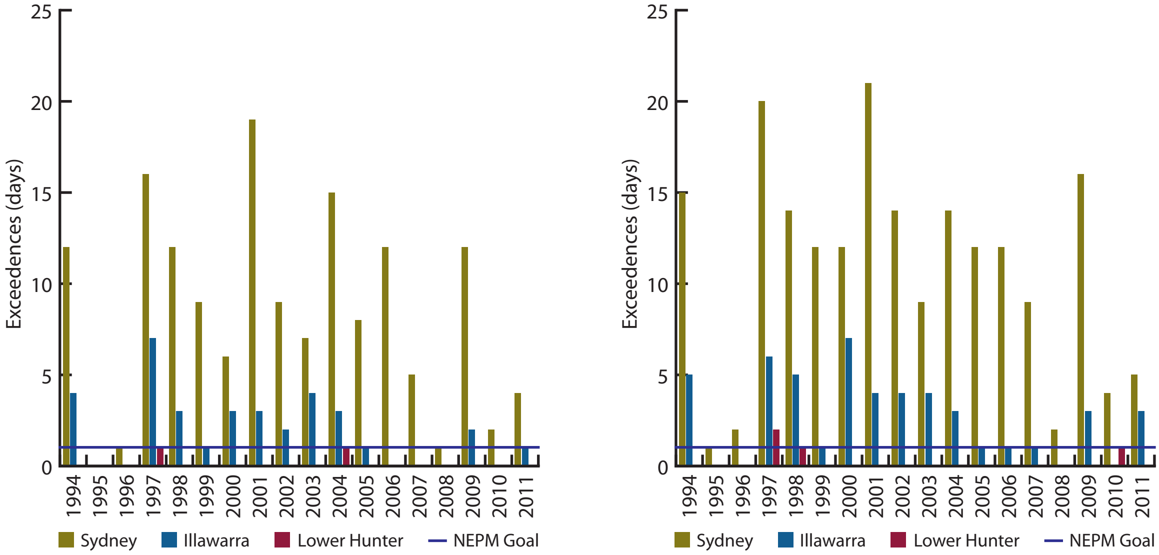
Over the same period, the standards were exceeded less frequently in the Illawarra, occurring on up to seven days per year for both standards (Figure 2.1). Either or both of the AAQ NEPM ozone standards were exceeded in the Illawarra on more than one day in 1994, 1997, 1998, 2000–04 and 2009. The Lower Hunter region recorded the fewest exceedences of the standards: neither standard has been exceeded more than once a year since 1997 (thus complying with the AAQ NEPM).

While all parts of Sydney can experience ozone concentrations above the AAQ NEPM standards at some time, 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).

Figure 2.2 shows the maximum recorded concentrations of ozone for each region from 1994 to 2011. Over the period, maximum concentrations have been highest in Sydney and lowest in the Lower Hunter.

Figure 2.1: Exceedences of the AAQ NEPM standards for ozone in the GMR_2, 1994–2011

1-hour exceedences   4-hour exceedences

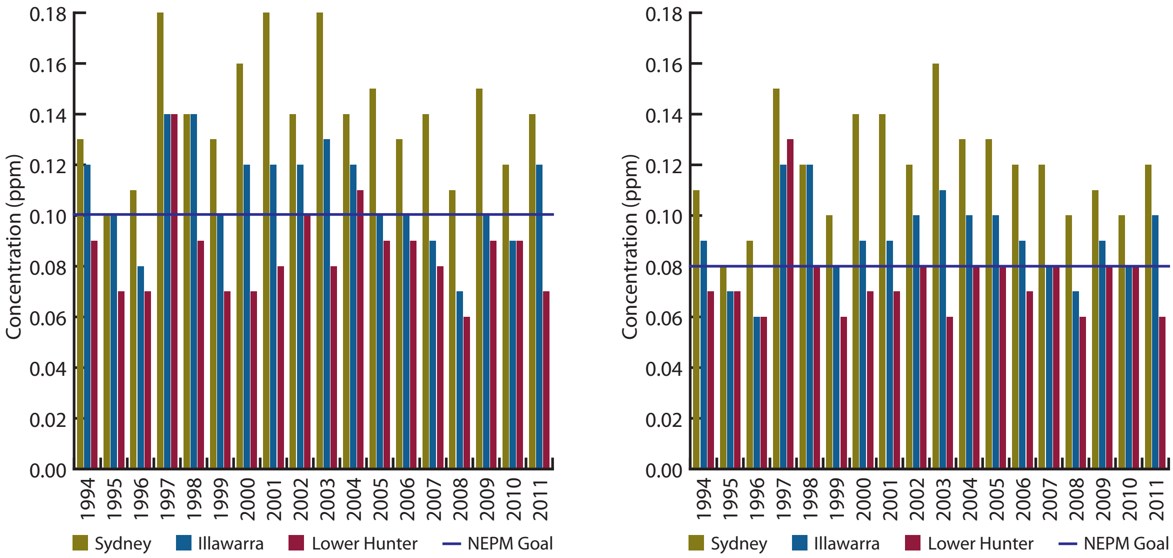


Source: EPA data 2012

Note: The majority of the 1-hour and 4-hour ozone exceedences occur as single-day events. Thus, if more than one monitoring site exceeded the standard on a particular day, that day is counted only once.

Figure 2.2: Annual maximum 1-hour-average and 4-hour-average concentrations for ozone in the GMR_2, 1994–2011

1-hour-average (annual maximum)   4-hour-average (annual maximum)



Source: EPA data 2012

No notable trends are discernible in either the number of exceedences or maximum concentrations. The number of days when ozone standards are exceeded in any given year is strongly dependent on meteorological conditions, which vary from year to year. A statistical analysis to filter out most of the meteorological variability shows ozone concentrations in Sydney are not decreasing (**Figure 2.3**).

Bushfire events and hazard reduction burns are potentially significant sources of ozone precursors and can have an impact on ozone pollution: for example, Sydney bushfires at the end of 2001 contributed to five of the 19 exceedences of the 1-hour ozone standard in 2001 and two of the nine exceedences in 2002. Many of the weather conditions that lead to high bushfire danger are also conducive to the formation of ozone. Importantly, however, even without bushfires, emissions from human activities are sufficient to cause regular exceedences of the AAQ NEPM standards at one or more monitoring station in the region on the one day (DECCW 2010).

Particles

Even relatively low concentrations of particle pollution can cause health impacts in some individuals (WHO 2003). The concentration and size of the particles are important (WHO 2007) and these can vary greatly between sources, regions and seasons.

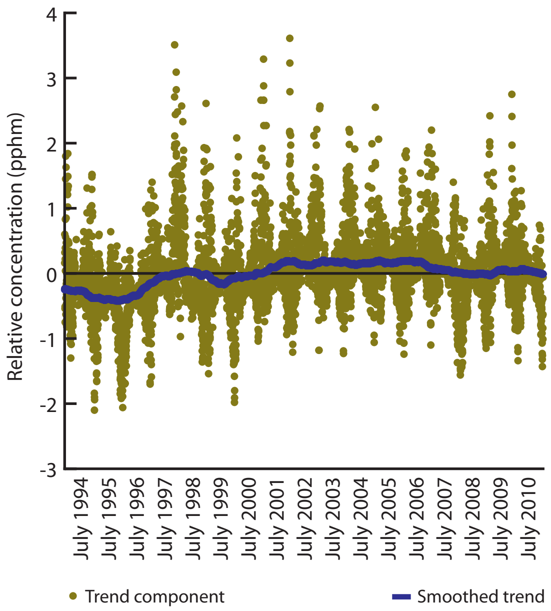
Particles smaller than 10 micrometres (µm) in diameter (PM_{10}) are consistently associated with increased mortality and hospital admissions for people with both heart and lung disease (Morgan et al. 1998a; Morgan et al. 1998b; Simpson et al. 2005a; Simpson et al. 2005b).

As an indication of how small these particles are, by comparison a human hair is around 70 µm in diameter. Research has demonstrated a link between chest colds in children and PM_{10} in the Hunter and Illawarra (Lewis et al. 1998) while long-term exposure to air pollution, including particles, has been linked to reduced life expectancy (Pope et al. 2002).

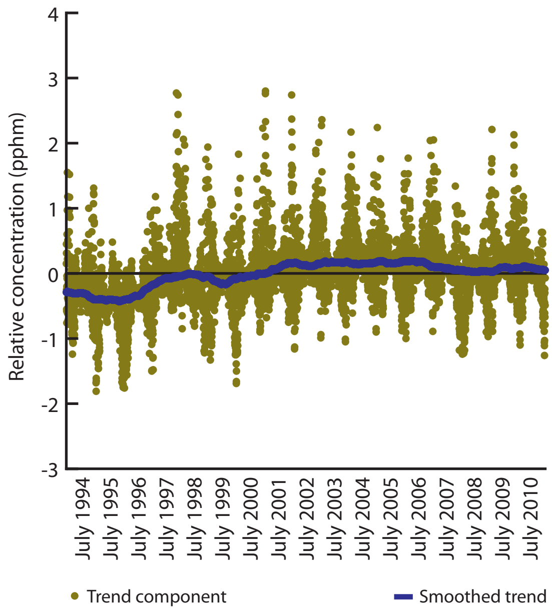
Health research identifies fine particles with a diameter smaller than 2.5 µm ($PM_{2.5}$) as a particular concern. In general terms, the smaller the particle the greater its impact on human health. Because of their smaller size, these particles can be inhaled more deeply into the lungs where the irritation can cause coughs, asthma and other lung conditions. Some are small enough to pass into the bloodstream through the finest blood vessels of the lungs where they can trigger heart attacks in people with existing lung or heart conditions and impact more severely on children and the elderly. These groups can be sensitive to even relatively low levels of particle pollution.

Figure 2.3: Long-term trend of daily maximum 1-hour-average and 4-hour-average concentrations for ozone in the Sydney Region, 1994–2010

Long range dependence modelling (1-hour average)



Long range dependence modelling (4-hour average)



Source: DECCW 2010

Notes: The trend is derived from a statistical analysis which removes major variations due to meteorological conditions and presents the variation in the trend in ambient ozone concentration relative to the data average.

Particles – as PM_{10}

The AAQ NEPM sets a standard for PM_{10} of 50 micrograms per cubic metre (µg/m³) (24-hour average). The goal set was that by 2008 the standard would not be exceeded on more than five days per year, thus making an allowance for the occurrence of extreme, potentially unavoidable events, such as dust storms, bushfires and hazard reduction burning.

The national standard for PM_{10} is generally being met in Sydney, the Illawarra and the Lower Hunter except in years with bushfires or dust storms (**Figure 2.4**). Bushfires in 1994 and 2001–03 were major contributors to the extremely high concentrations of particle pollution recorded in the GMR_2 in those years. Similarly, major statewide dust storms in September 2009 accounted for exceedences across the state. The number of exceedences varies greatly from year to year, as shown by the marked drop in 1999 and 2004. Hazard reduction burns on 10 March and 15 November 2011, along with local construction activity near some sampling stations, led to the 10 exceedences recorded that year.

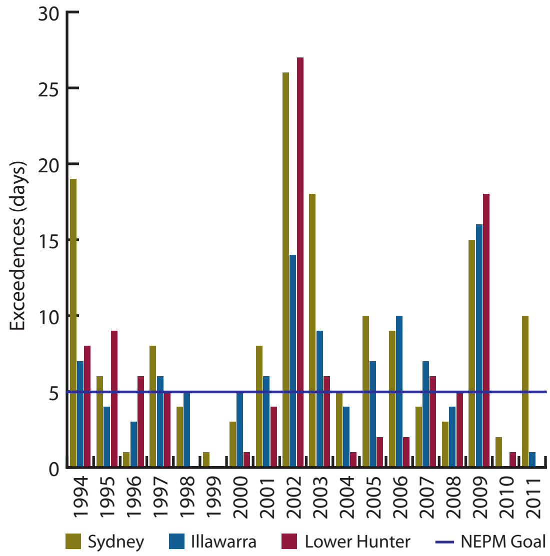
There is a strong seasonality in PM_{10} levels in the GMR_2: with bushfires and dust storms more prevalent in summer, the majority of exceedences occur in spring and summer (**Figure 2.5**).

The national goal for PM_{10} is not being met in some regional centres. The levels recorded in these centres are generally representative of the air quality in the surrounding regions. PM_{10} concentrations are monitored in Albury (NSW–Victoria border), Bathurst (Central Tablelands), Tamworth (North-West Slopes) and Wagga Wagga (South-West Slopes).

In 2003 and 2009, none of these regional cities met the PM_{10} goal of no more than five exceedences in a year (**Figure 2.6**). Albury, Bathurst and Tamworth have achieved the goal in some of the years shown, while Wagga Wagga has met the goal in only one, particularly wet, year – 2011.

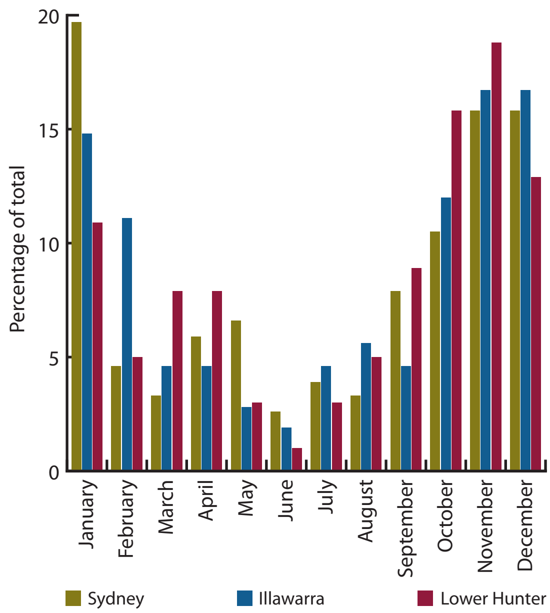
The general run of high exceedence years was due to factors such as dust storms, bushfires and other conditions associated with the prolonged drought, widespread agricultural stubble burning, and the use of woodheaters in the region. Elevated particle concentrations recorded at Albury and Wagga Wagga in January 2003 were the result of major bushfires in the ACT and NSW, and both also felt the impact of bushfires in Victoria in the summer of 2006–07.

Figure 2.4: Exceedences of the AAQ NEPM standard for particles (PM_{10}) in the GMR_2, 1994–2011



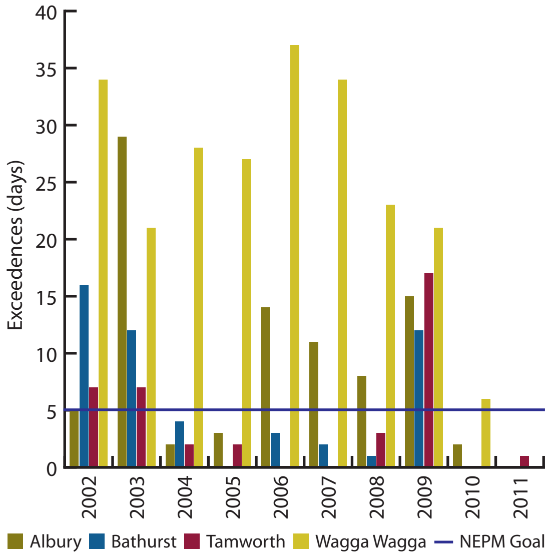
Source: EPA data 2012

Figure 2.5: Seasonal distribution of PM_{10} exceedence days in the GMR_2, 1994–2011



Source: EPA data 2012

Figure 2.6: Exceedences of the AAQ NEPM standard for particles (PM_{10}) in NSW rural cities, 2002–11



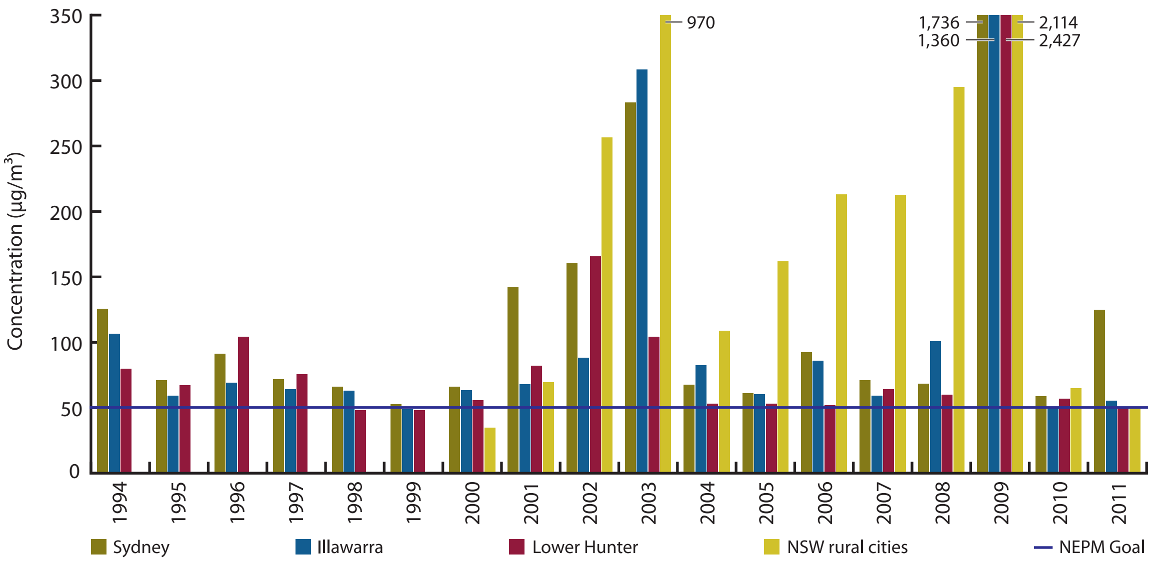
Source: EPA data 2012

While large-scale dust storms are uncommon events, they can result in widespread exposure to extreme levels of particles (DECCW 2010). For example, on 23 September 2009, the largest dust storm to hit NSW since air quality monitoring commenced resulted in extreme levels of particles over most of the state. The lower Hunter recorded the highest PM_{10} averages over 24 hours of 2427 µg/m^3, nearly 50 times the standard of 50 µg/m^3. Sydney, the Illawarra, Bathurst and Tamworth recorded PM_{10} concentrations ranging from 27 to 42 times the standard. This was followed three days later by a second, less intense dust storm across much of the state. The previous highest PM_{10} concentration recorded in NSW was at Wagga Wagga during a dust storm on 19–20 March 2003, when the PM_{10} 24-hour average registered 970 µg/m^3 (almost 20 times the standard) (**Figure 2.7**).

The incidence of dust storms is a function of soil dryness, ground-cover density and wind speed (Lu & Shao 2001). The frequency of dust storms increases with the frequency of droughts: the dust storms in 2003 and 2009 were both associated with drought conditions. The incidence of drought is projected to increase as a result of climate change (CSIRO 2007) and so dust impacts on air quality may also be expected to increase.

PM_{10} exceedences in regional centres are most common in summer in Albury, Bathurst and Tamworth, and during autumn in Wagga Wagga (**Figure 2.8**).

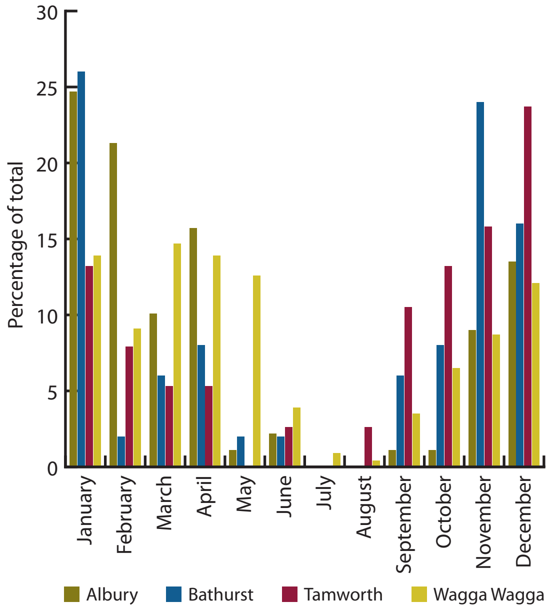
Figure 2.7: Annual maximum 24-hour-average concentrations for particles (PM_{10}) in the GMR_2 and NSW rural cities, 1994–2011



Source: EPA data 2012

Notes: Particles data prior to 2008, as presented in past NSW SoE reports, were calculated for the 24-hour period from 11 pm to 11 pm. For this report and in line with NEPM reporting standards, 24-hour-average PM_{10} concentrations have been recalculated to true calendar average (midnight to midnight).

Figure 2.8: Seasonal distribution of PM_{10} exceedence days in NSW rural cities, 2002–11



Source: EPA data 2012

Notes: Percentage is calculated for each city based on total exceedences of the AAQ NEPM standard for PM_{10} for the period 2002–11.

Particles – as $PM_{2.5}$

The AAQ NEPM was amended in 2003 to include two *advisory* reporting standards for $PM_{2.5}$ – a 24-hour average of 25 µg/m^3 and an annual average of 8 µg/m^3. NSW participated in the National Environment Protection Council's 2011 review of the AAQ NEPM. In part, this recommended making the $PM_{2.5}$ advisory reporting standard a compliance standard and introducing an exposure reduction framework for $PM_{2.5}$. The recommendations are being prioritised as part of the development of a National Plan for Clean Air (see 'National responses' below). The plan is due for submission to the Council of Australian Governments (COAG) by the end of 2014.

In NSW measured $PM_{2.5}$ concentrations have generally been at or below the 24-hour-average advisory reporting standard but above the annual average advisory reporting standard.

Figure 2.9 shows the highest daily average concentration of $PM_{2.5}$ recorded each year in the GMR_2 subregions. After four years of elevated maximums from 2000 to 2003, seven of the past eight years have seen the maximum measured 24-hour-average $PM_{2.5}$ concentrations return to levels closer to the advisory reporting standard for the daily average, except for 2009 which had the highest peaks ever recorded due to the September dust storms.

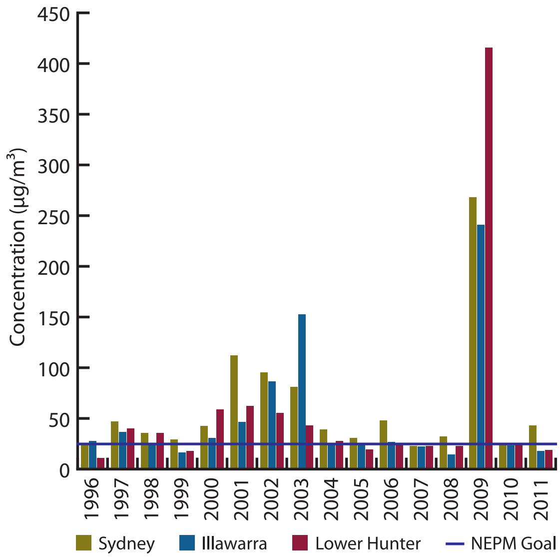
Other AAQ NEPM pollutants

NSW consistently complies with the national air quality standards for the other four criteria air pollutants under the AAQ NEPM – carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. For details of the standards and past NSW performance against them, see 'Atmosphere 3.4: Metropolitan Air Quality' in *NSW State of the Environment* 2000 (EPA 2000).

Carbon monoxide is produced by the incomplete burning of fuels, with motor vehicles and industrial premises the main sources. In NSW, elevated levels of carbon monoxide are generally only encountered in areas with high traffic density and poor dispersion. Concentrations of carbon monoxide have fallen over the past 20 years as a result of changes to motor vehicle technology.

Nitrogen dioxide is predominantly produced by motor vehicles (as well as being a secondary pollutant). The AAQ NEPM standard was regularly exceeded in the winter months of the early 1980s. Measured concentrations have not exceeded the 1-hour-average standard since 1998; from 2002–07 the highest 1-hour value recorded in Sydney was only 75% of the standard. Over this period, maximum concentrations were lower still in the Illawarra and Lower Hunter regions.

Figure 2.9: Annual maximum 24-hour-average concentrations for particles ($PM_{2.5}$) in the GMR_2, 1996–2011



Source: EPA data 2012

Notes: ARS = advisory reporting standard. It is proposed that the ARS will become a full NEPM Standard.

Sulfur dioxide in GMR_2 originates mainly from industries such as metal processing, oil refining and coal-fired power generation. As a result of regulatory efforts, from 1994 to 2011 concentrations of sulfur dioxide have been low, with no exceedences recorded in the GMR_2. Maximum hourly ambient concentrations in Sydney were less than 25% of the AAQ NEPM standard. Higher concentrations are observed in the Illawarra and Lower Hunter regions as a result of industrial emissions, although these are also below the NEPM standard.

Lead concentrations, which were predominantly produced by motor vehicles, have fallen greatly due to changes in the formulation of fuel. Annual averages in Sydney have been consistently less than 20% of the AAQ NEPM standard for some time. With a complete ban on lead in petrol now in force, the primary source of lead in air at the regional scale has been eliminated. Consequently, routine monitoring of lead no longer became necessary and ceased in December 2004.

Air Toxics NEPM pollutants

The Air Toxics NEPM applies to five air toxics: benzene, toluene, xylenes, formaldehyde and benzo(α)pyrene (as a marker for polycyclic aromatic hydrocarbons). The NEPM is primarily concerned with the measurement of ambient levels of these five pollutants. The significance of monitored levels of the air toxics is assessed by comparing results against monitoring investigation levels (MILs). MIL values are the concentration of an air toxic which, if exceeded, requires further investigation and evaluation.

Between 1996 and 2001, the Ambient Air Quality Research Project investigated concentrations of 81 air toxics in four distinct groups: 17 dioxins (including furans); 41 volatile organic compounds (VOCs); 11 polycyclic aromatic hydrocarbons; and 12 heavy metals (EPA 2002). More than 1400 samples were collected at 25 sites. Three air toxics – benzene, 1,3-butadiene and benzo(α)pyrene – were identified as requiring ongoing assessment to ensure they remain at acceptable levels in the future.

An additional round of data collection commenced in October 2008 and concluded in October 2009. The five NEPM air toxics and additional VOCs were monitored at two sites in Sydney (Turrella and Rozelle) using a 1-day-in-6 cycle.

The Turrella site collected data on formaldehyde and acetaldehyde; 19 polycyclic aromatic hydrocarbons, including benzo(α)pyrene; and 41 VOCs, including benzene, toluene and xylenes. The Rozelle site collected data on formaldehyde and acetaldehyde, as well as 41 VOCs, including benzene, toluene and xylenes. NEPM-compliant sampling and analysis methods were used.

The monitoring results (NEPC 2010, Tables 1–5) clearly showed levels of air toxics were below the monitoring investigation levels. The air toxics monitored did not exceed the MILs at either location on any occasion. Benzo(α)pyrene levels of approximately 65% of the NEPM monitoring investigation level were the most significant.

It is important to note that, while there have not been any exceedences of the monitoring investigation levels, there can be occasions where incidents, such as equipment failure or fire, occur at premises that result in emissions of air toxics to the environment. These discharges can be harmful to human health and the environment. The *Protection of the Environment Operations Act 1997* (POEO Act) has provisions, such as environment protection licences and clean-up and prevention notices, to ensure regulated industry premises contain, minimise and clean up pollution where incidents like these occur.

Under the POEO Act, the EPA can also require licensed activities to undertake mandatory pollution reduction programs to further minimise their emissions to the atmosphere. A pollution reduction program may include, but is not limited to, requirements to carry out works for the purpose of preventing, controlling, abating or mitigating pollution.

Indoor air quality

The quality of indoor air depends on various parameters including:

- type of building materials used
- types of products used indoors (such as paint, electrical appliances, furniture and cleaning products)
- proximity to outdoor sources of air pollution
- types of indoor heating or cooling used
- cooking methods
- building ventilation rates
- particular uses of the building (including whether smoking occurs)
- daily, seasonal and climatic conditions.

Indoor air pollutants contain biological and chemical contaminants. Examples of the former include dust mites, mould spores and pet hair. Examples of the latter include contributions from combustion products and gases released from indoor materials (off-gassing emissions). In older buildings, dust from the roof cavity and lead from the disturbance of lead-based paints during renovations can be problematic or hazardous. Along with particulate matter, gases such as ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, airborne microorganisms and VOCs, and secondary (or 'environmental') smoke are the most common types of air pollutants encountered indoors.

Measured indoor air pollution

Monitoring in NSW homes has identified secondary tobacco smoke and emissions from solid-fuel heaters (such as woodheaters) and unflued gas heaters as important indoor sources that contribute to poor air quality. These are problematic as they raise concentrations of fine particles, carbon monoxide and nitrogen dioxide (Sheppeard et al. 2002; DEH 2004).

Additional pollutants and air toxics can also be released into the indoor and local outdoor environment where waste wood from demolition sites and renovations of old buildings is burnt in solid-fuel heaters. This material has often been treated with lead paint or chemicals used to preserve the wood to prevent termite or fungus attack or as a marine anti-fouling agent. Chemicals used to treat timber may contain such toxic substances as copper chrome arsenate (CCA) and pentachlorophenol (PCP). Importantly, it is illegal under the Protection of the Environment Operations (Clean Air) Regulation 2010 to burn any timber treated with CCA or PCP in NSW.

In 2003, pollutant monitoring undertaken in Sydney homes found that those using unflued gas heaters frequently had nitrogen dioxide concentrations exceeding the WHO 1-hour guideline of 0.11 parts per million: the guideline was exceeded at least once on 67% of house-days tested (DEH 2004). A small number of homes also exceeded health guidelines for other emission by-products of unflued gas heaters – carbon monoxide and formaldehyde.

The NSW Health Survey Program monitors health behaviours, health status, use of, and satisfaction with, health services and other factors that influence the health of NSW residents. Data on health-related behaviours and other risk factors from the surveys showed that unflued gas heaters remain the primary form of heating in about 18% of homes, while solid-fuel heating was used in around 15% (Centre for Epidemiology & Research 2008).

The NSW Health Survey also reported that 92.6% of adults aged 16 years and over lived in homes that were smoke-free in 2010 (up from 84.3% in 2004 and 69.8% in 1997) (Public Health Division 2000; Centre for Epidemiology & Research 2005; Centre for Epidemiology & Research 2010). The proportion of smoke-free family cars is also improving, with 86% of people aged 16 years and over saying they did not allow smoking in their vehicles (Centre for Epidemiology & Research 2010). Smoking when a child under 16 years is in the car has been illegal since 2009.

Pressures

From the status and trends it can be seen that the pollutants of *ongoing concern* for air quality in NSW are the main precursor pollutants for ozone (oxides of nitrogen and volatile organic compounds) and fine particles.

Major sources of pollutants

The most important human-related causes of air pollution are motor vehicle use, industrial activity and some domestic and commercial activities. Dust from the landscape, spray from the ocean, and the release of vapours from plants can also be significant contributors to poor air quality, along with bushfires and hazard reduction burns. Once in the atmosphere some pollutants undergo further chemical reactions and they can be transported by air movement across regions.

The 2008 Air Emissions Inventory for the Greater Metropolitan Region of NSW (EPA 2012) is a detailed listing of pollutants discharged into the atmosphere by source type at specific locations over a given time period (previous studies having been published in 1996 and 2007). The study area covered 57,330 square kilometres, which includes the greater Sydney, Newcastle and Wollongong regions, known collectively as the Greater Metropolitan Region (GMR_3). Approximately 76% of the NSW population resides in this region.

The inventory includes emissions from biogenic (natural living organisms), geogenic (natural non-living) and anthropogenic (human) sources as follows:

- natural (bushfires, wind-borne dust, marine aerosols and vegetation)
- commercial businesses (such as spray painters, printers, quarries and service stations)
- domestic activities (such as residential lawnmowing, portable fuel containers and woodheaters)

- industrial premises (such as coal mines, oil refineries and power stations)
- off-road vehicles and equipment (such as dump trucks, bulldozers and marine vessels)
- on-road transport (buses, cars and trucks).

The inventory covers over 850 substances, which include:

- common pollutants – ammonia, carbon monoxide (CO), lead, oxides of nitrogen (NO_x), particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and total volatile organic compounds (VOCs)
- organic compounds, such as 1,3-butadiene, benzene and formaldehyde
- metals, such as cadmium, manganese and nickel
- polycyclic aromatic compounds (PAHs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)
- greenhouse gases – carbon dioxide, methane and nitrous oxide.

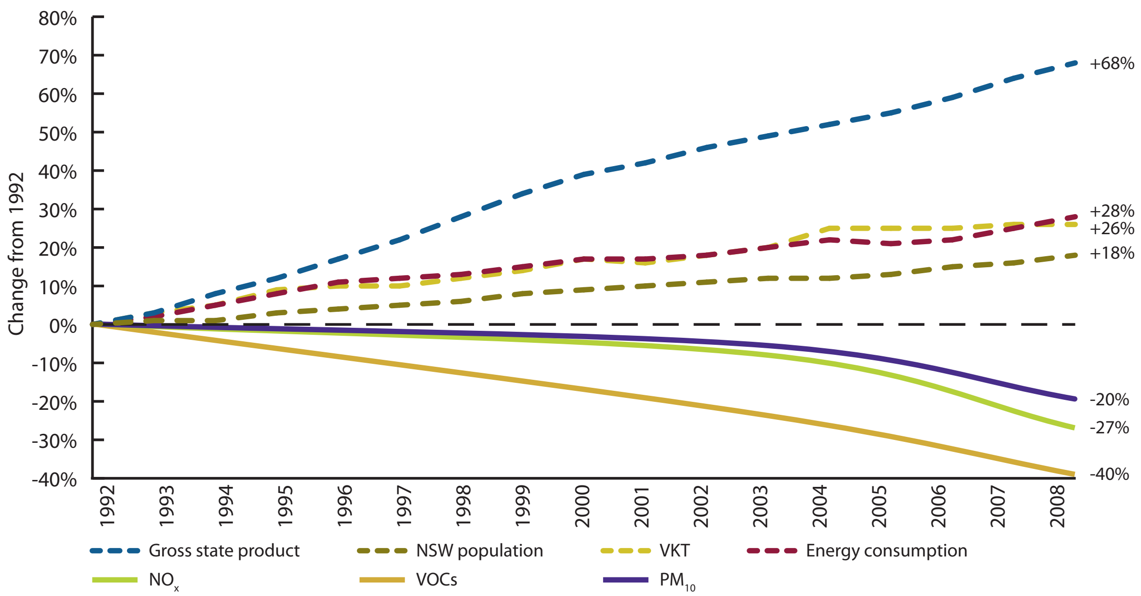
Figure 2.10 and **Figure 2.11** present trends in emissions for the Sydney region and GMR_3 compared with key NSW statistics. The inventory shows that, from 1992 to 2008, emissions have steadily decreased in the Sydney region (Figure 2.10), with NO_x decreasing by 27%, VOCs by 40% and PM_{10} by 20%. These declines occurred despite increases in key NSW statistics over the same period: gross state product up by 68%; vehicle kilometres travelled up 26% (see also People and the Environment 1.1); energy consumption (including electricity, petroleum, etc.) up 28%; and NSW population growth of 18%. The decrease seen in Sydney in NO_x and VOCs appears in part due to improved identification and control of emissions from industrial facilities.

In contrast to the Sydney region, emissions of NO_x steadily increased by 32% across the GMR_3 between 1992 and 2008, similar to the rate of increase in energy consumption which is mostly supplied from coal-fired power stations. Between 1992 and 2008, emissions of PM_{10} have risen increasingly quickly in the region by 48% overall, largely due to increased coal mining. Emissions of VOCs in the GMR_3 decreased overall by 6%, far less than the reduction that has occurred in Sydney.

Biogenic and geogenic sources are significant for several of the pollutants of ongoing concern. In 2008, 19.1% of PM_{10} emissions in Sydney were from natural sources, while 24.7% of VOC emissions had natural living and non-living sources. In contrast, only 1.7% of the oxides of nitrogen were from biogenic or geogenic sources.

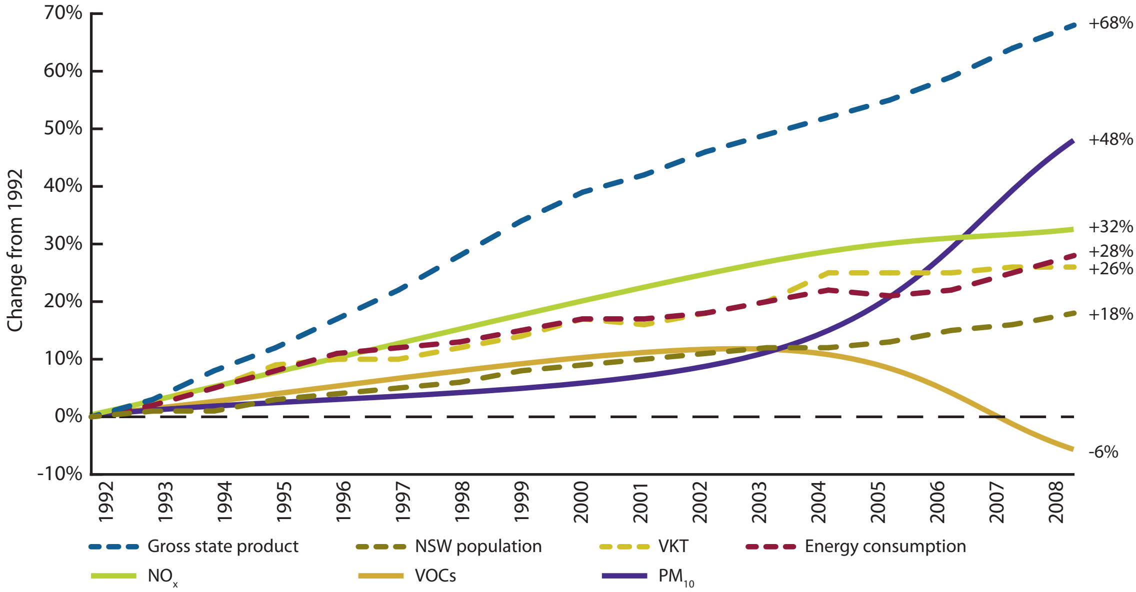
Figure 2.12 presents a detailed breakdown of anthropogenic air pollutant sources by sector and major activities in the Sydney region in 2008.

Figure 2.10: Trends in emissions in the Sydney region, compared with key NSW statistics



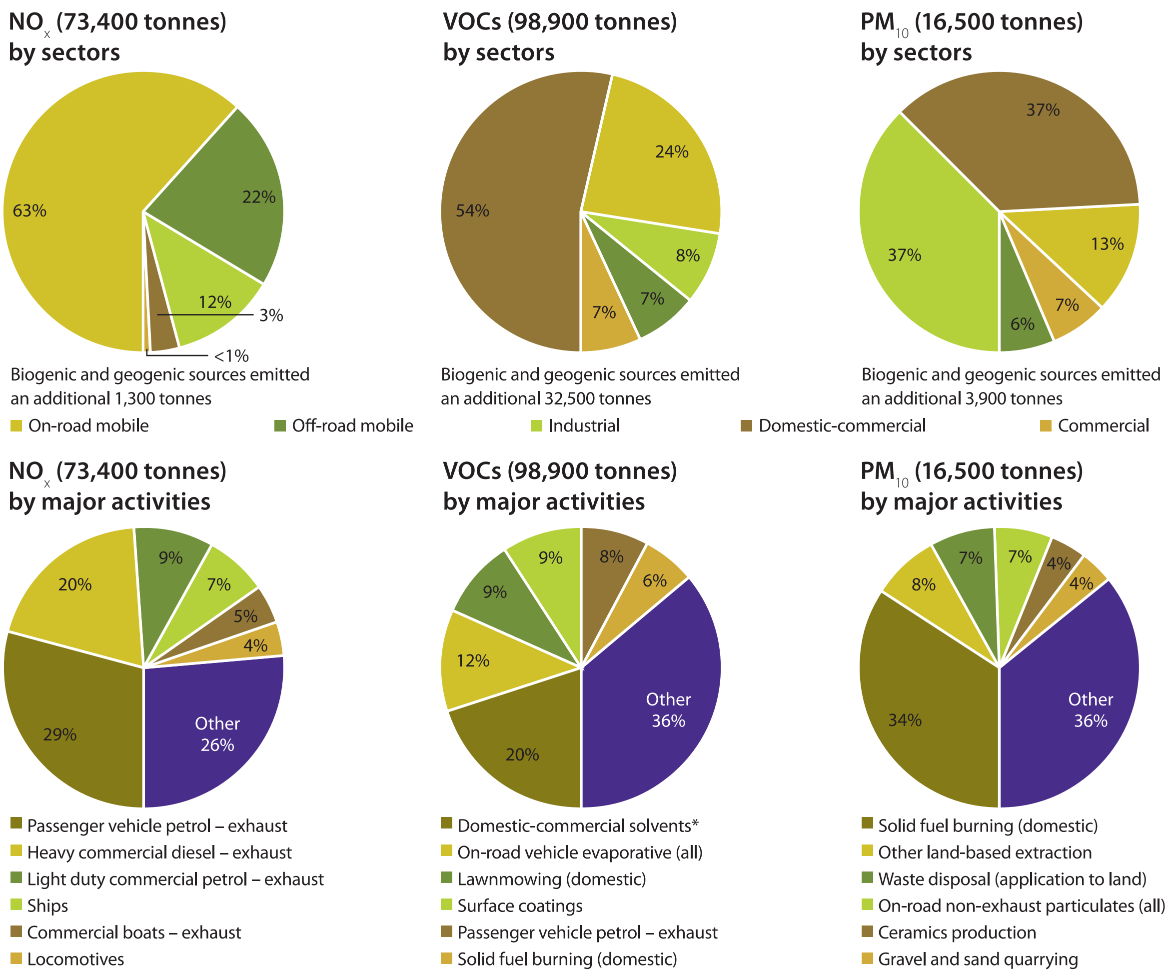
Source: ABS 2009; ABS 2010; ABARES 2011; BITRE 2011; EPA 2012

Figure 2.11: Trends in emissions in the GMR$_3$, compared with key NSW statistics



Source: ABS 2009; ABS 2010; ABARES 2011; BITRE 2011; EPA 2012

Figure 2.12: Detailed anthropogenic sources of NO_x, VOCs and PM_{10}, Sydney region, 2008



Source: EPA 2012

Notes: * 'Solvents' includes propellants and aerosols.

According to the 2008 Air Emissions Inventory (EPA 2012), on-road mobile sources are the largest source of NO_x emissions, contributing 63% of the total, while off-road mobile sources (such as construction and mining plant equipment) are the second largest single source at 22%. Major specific NO_x-producing activities were passenger vehicle petrol exhausts (29% of total emissions) and heavy duty commercial diesel exhausts (20%).

The largest single source of VOC emissions in Sydney (54%) is from the domestic-commercial sector, with on-road mobile sources such as the various evaporative emissions from both private and commercial vehicles contributing another 24% of the total. Domestic-commercial use of solvents and aerosols was the single largest major activity responsible for VOC emissions, contributing 20% of the total (or 23,500 tonnes).

The domestic-commercial and industrial sectors are the largest sources of PM_{10} emissions in the Sydney region, both contributing 37%. The single largest anthropogenic activity generating PM_{10} emissions was domestic solid-fuel heating, which accounted for 34% of the total (5700 tonnes), almost equalling all of the domestic-commercial emissions (6100 tonnes).

Reductions in emissions between 1992 and 2008 have largely resulted from the effectiveness of NSW Government regulation of industry, woodheater, fuel quality and motor vehicle standards. Any further improvements in emissions will require cost-effective programs targeted at unregulated sources since the contribution of emissions from these continues to grow. Unregulated sources typically include:

- aerosols and solvents
- surface coatings
- small engines, such as those used in lawnmowers and recreational boats
- off-road diesels, such as bulldozers, trucks and locomotives
- ships and port activities
- domestic woodheaters.

Air toxics

Air pollutant sources investigated by the 2008 Air Emissions Inventory (EPA 2012), such as commercial and industrial premises, are also often key sources of air toxics. The *Protection of the Environment Operations Act 1997* and regulations control toxic emissions to air from such premises.

Climate change pressures

Global emissions of greenhouse gases (see People and the Environment 1.2) will affect our climate and, in turn, this is likely to increase key air pollutants, such as ozone and particles. Climate change may influence the formation of ozone and secondary particles ($PM_{2.5}$) through elevated ambient temperatures and chemical changes in the atmosphere. There is ongoing investigation into the relationship between climate change and air quality (Cope et al. 2008; Jacob & Winner 2008; Walsh 2008).

Population pressures

Sydney's continued growth and expansion will have implications for air quality, requiring further action on transport emissions and the growing emissions from commercial, industrial and domestic sources. Increased development in western and south-western Sydney has the potential to expose more people to elevated ozone concentrations as the city's meteorology and topography cause these areas to be more affected by ozone pollution than coastal regions. Increased development at the interface with natural bushland also has the potential to increase exposure to the effects of smoke from bushfires and hazard reduction burns.

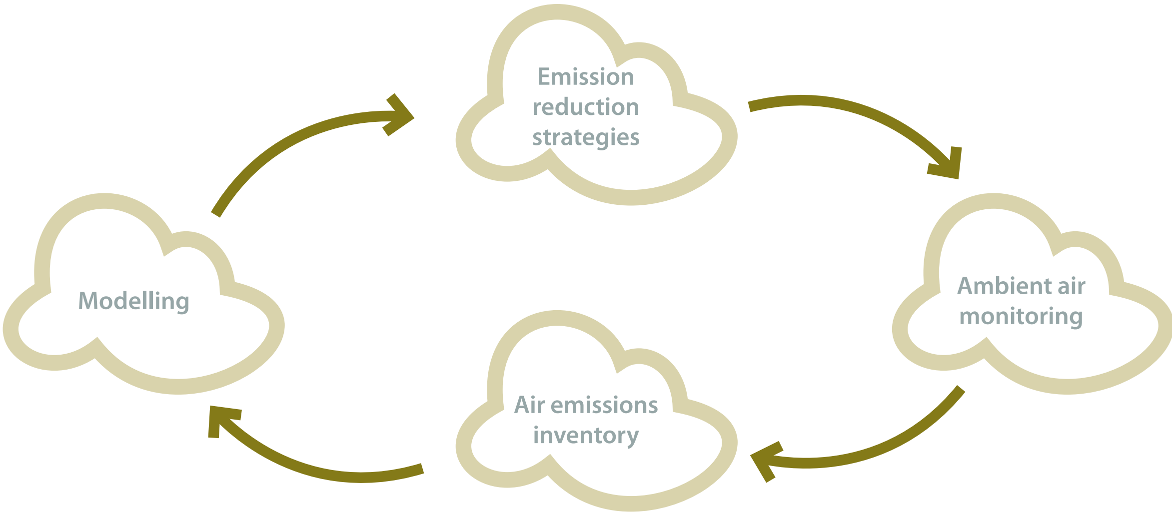
Responses

NSW 2021: A plan to make NSW number one (NSW Government 2011) recognises that clean air is important for the health of the NSW community and providing information on local air quality empowers local communities to engage in informed discussions on air quality.

Existing responses

An evidence-based approach is used to manage air quality in NSW (Figure 2.13). This approach uses a number of tools, including air quality monitoring, air emissions inventory studies, air quality modelling and economic analysis through updating information on the health impacts and costs of air pollution. The aim is to develop strategies and measures that deliver the greatest air quality improvements and health gains at a net benefit to the community.

Figure 2.13: Air quality management cycle



Controlling transport emissions: cleaner vehicles, fuels and engines

Transport is the main source of air pollution in Sydney. A number of key initiatives are being implemented to reduce emissions from motor vehicles by making fuels and vehicles cleaner, and encouraging people to use their cars less in favour of other transport options. These initiatives deliver significant health and liveability benefits.

Stage 1 vapour recovery (VR1): Capturing emissions of volatile organic compounds (VOCs) from underground storage tanks as they are filled by road tankers has been in place in most parts of Sydney for some time. More recently, this was extended to all parts of Sydney, as well as the Wollongong, Newcastle and Central Coast metropolitan areas.

Stage 2 vapour recovery (VR2): The next stage is to capture VOC emissions from vehicle petrol tanks during refuelling at petrol bowsers. VR2 has been introduced under the Protection of the Environment Operations (Clean Air) Regulation 2010 with vapour recovery equipment to be installed at the largest service stations in Sydney, Newcastle, Wollongong and the Central Coast by 2014 and at all but the smallest service stations in Sydney by 2017. Vapour recovery technology will reduce refuelling emissions by over 85% and its implementation will cut VOC emissions in the Greater Metropolitan Area (GMA) by 5000 tonnes per year by 2020 (about 1–2% of total VOC emissions in the GMA).

Summer petrol volatility: During the summer period – 15 November to 15 March – the volatility of petrol supplied in Sydney is limited to 62 kilopascals as a key means of managing the formation of ozone in Sydney. Petrol refiners, importers and blenders must test and report to the EPA on batch volatility.

Diesel Retrofit Program: Retrofitting existing diesel vehicles with exhaust treatment devices is a cost-effective strategy to reduce air pollutant emissions. This program involved the NSW Office of Environment and Heritage (OEH) and Roads and Maritime Services working in partnership with local councils and private enterprise to retrofit fleet vehicles. The program demonstrated that vehicle particle emissions could be reduced by around 46% for an average retrofit cost of $7600. At completion of the program in June 2011, over 520 vehicles from 71 fleets had been retrofitted. This delivered particle emission reductions of 4.7 tonnes per annum and will avoid approximately $1.05 million in health costs each year.

Clean Machine Program: The EPA is working with private and public organisations on a Clean Machine Pilot Program to reduce exhaust emissions from diesel plant and equipment used mainly in construction and industrial activities, such as cranes, dozers, loaders, graders, tractors and pumps. The program offers funding assistance for the installation of particle filters on older engines and advice on improved procurement and worksite practices. Nineteen organisations, including a number of local councils and private businesses, had joined the program as partners by June 2012 and more than 55 non-road diesel machines had been retrofitted. This will reduce diesel particle emissions in the GMR_2 by over 1.6 tonnes per year and avoid approximately $400,000 in annual health costs.

Controlling industry emissions

The *Protection of the Environment Operations Act 1997* (POEO Act), the POEO (Clean Air) Regulation and POEO (General) Regulation 2009 provide the framework for managing air pollution from major industry.

Strengthening industrial emission standards: Tighter industrial emission standards for oxides of nitrogen (NO_x), VOCs and particles were introduced when the POEO (Clean Air) Regulation was reviewed in 2005, along with a framework for the upgrade of old plant and equipment (see Parts 4 and 5 of the Regulation). Stage 1 of the framework required the phase-out by 1 January 2008 of plant and equipment installed before July 1979. An implementation program helped achieve compliance by older industrial premises, including some of the oldest and largest industrial facilities such as refineries and steel mills.

The NSW Government is continuing to work with industry to ensure continuous improvement in emission performance. The Regulation was remade in 2010 and the second stage of the program to upgrade old industrial plant and equipment as required by regulation implemented on 1 January 2012. It requires premises to upgrade old plant and equipment over a six-year lead-in period and further reduce emissions of particles and additional pollutants, including NO_x and air toxics.

Best practice measures for controlling emissions from coal mining: Awareness is growing about the impacts associated with particulate matter emissions from coal mining in NSW. In addition to maintaining a strong regulatory and compliance focus on mines, the NSW Government is continuing to encourage improved environmental performance with reference to best management practice. Recommendations from a report commissioned by OEH, *International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone Environmental 2011), are being implemented through the Dust Stop program. All operating coal mines in NSW are being progressively required to undertake site-specific best management practice reviews through pollution reduction programs attached to their environment protection licences. These will determine the best approach for reducing dust emissions at each mine with all practicable measures implemented through pollution reduction programs.

Reducing emissions of oxides of nitrogen from cogeneration: Cogeneration involves using waste energy from the production of electricity to provide either heating and/or cooling. Gas-fired cogeneration can be one of the most greenhouse-friendly forms of fossil fuel-generated electricity. However, cogeneration is also a source of NO_x which reacts with VOCs in the presence of sunlight to form ground-level ozone.

The *Interim DECC Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra* (DECC 2009) sets out a policy framework for emissions from cogeneration proposals. One of the concepts introduced in the interim policy is best available techniques (BAT) emission performance. Following consultation with stakeholders, a NO_x emission standard that constitutes BAT for new cogeneration plant in Sydney and the Illawarra was released in November 2009. The BAT emission standard is for natural gas-fired reciprocating internal combustion engines, the most common technology used in cogeneration/trigeneration applications.

Reducing volatile organic compound emissions from the printing industry: The NSW Government has continued work over the past years to ensure reductions in VOC emissions from the printing industry. This project identified premises that were not employing adequate means to minimise their emissions. Industry enterprises are being encouraged to purchase and install new pollution control equipment. It is estimated that installation of the new control equipment will result in a reduction of approximately 1300 tonnes of VOC emissions each year.

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 the state.

Woodsmoke reduction program: Woodsmoke is the largest source of $PM_{2.5}$ and PM_{10} in the Sydney region. Woodsmoke also contains a number of other air pollutants, including carbon monoxide, NO_x and a range of organic compounds, some of which (for example benzo(α)pyrene) are toxic or carcinogenic.

Woodsmoke is an issue that is predominantly managed by local government. The NSW Government is working with local councils to develop a set of options to more effectively manage woodsmoke. Developing strategies aimed at reducing woodsmoke and educating local government and the community about better management of it will help address particle and air toxic emissions simultaneously. The Government is also advocating for improved standards for woodheater emissions at the national level, a development that will benefit all of the cooler regions of the country.

Woodsmoke control consultation strategy: In early 2011, the Government commissioned an economic assessment of a range of policy options for controlling smoke from domestic woodheaters in residential locations with potentially high population exposure to woodsmoke. The findings of the study (AECOM 2011) will feed into the development of further measures to control woodsmoke.

In 2011, a survey of NSW local councils sought input into potential management measures for woodsmoke control. Responses from councils indicated overall support for developing new measures to improve the existing woodsmoke management framework.

The next stage of the consultation will be to release a discussion paper outlining a set of preferred woodsmoke control options supported by economic analysis.

Woodheater compliance audits: A Government audit of manufacturers, wholesalers and suppliers of woodheaters in 2009–10 found that 40% of the 454 heaters audited did not meet the regulatory requirement to have a valid compliance plate attached to the appliance when offered for sale. All businesses responsible subsequently rectified their non-compliance. The POEO (Clean Air) Regulation requires all new woodheaters sold in NSW to have a compliance plate which specifies that the particular model has been tested in accordance with the Australian Standard and complies with the emission limit.

Local government training: In 2011, OEH and the Clean Air Society of Australia and New Zealand held workshops for council officers who manage issues such as woodsmoke, odour and building site dust. The workshops were based on OEH's web-based Local Government Air Quality Toolkit.

Assessment and control of air quality impacts from licensed activities: The NSW Government works to assess, provide advice and place control conditions on the development and operation of air quality impacts from activities licensed by the EPA under the POEO Act. The guiding principles of this assessment process are that:

- emissions are effectively controlled to levels that protect the environment, human health and amenity; reflect reasonably available technology and good environmental practice; and reflect proper and efficient operation
- emissions of pollutants that have serious health effects and no safe threshold or that bioaccumulate are minimised to the maximum extent practicable by best management practice
- it is important to reconcile the needs of all key stakeholders, including NSW Government, proponents, licensees and the public.

Controlling air toxics

The POEO Act is a key control on the emissions of air toxics. Concentrations are managed by the POEO (Clean Air) Regulation, which controls backyard burning and sets emission limits for air toxics from industrial facilities. The POEO Act has measures such as clean-up, prevention and prohibition notices to ensure regulated industrial premises contain, minimise and clean up toxic pollution if an incident occurs.

Under the Act, the EPA can also require pollution reduction programs as licence conditions for regulated industrial premises to further minimise their emissions to the atmosphere. A pollution reduction program may include, but is not limited to, requirements to carry out works to prevent, control, abate or mitigate pollution.

In addition, the Commonwealth *Fuel Quality Standards Act 2000* and the Fuel Quality Standards Regulations 2001, manage air toxics emissions from motor vehicles.

Managing indoor air quality

Tobacco smoke: The *Smoke-free Environment Act 2000* progressively introduced smoking bans in NSW restaurants, pubs and bars, cafes and cafeterias, shopping centres, malls and plazas, community centres, and the dining areas of hotels. This culminated in a total ban on smoking in enclosed public areas of licensed premises from July 2007. Following passage of the *Public Health (Tobacco) Act 2008*, smoking was banned in motor vehicles with any passengers under the age of 16.

Legionnaire's disease: The Public Health (Microbial Control) Regulation 2000 continues to be the main tool by which air and water quality is controlled in relation to Legionnaire's and other diseases.

Heating in homes and schools: In 2007, the Australian Environmental Health Committee (enHealth) released a review on the use of unflued gas heaters in the indoor environment. *The Health Effects of Unflued Gas Heater Use in Australia* (enHealth 2007) was developed to provide evidence to guide policy on regulating and managing unflued gas heaters in Australia and New Zealand. The document reviews data on the levels of pollutants produced by unflued heaters and summarises the evidence for any links between the use of these heaters and adverse health outcomes (based on a review of the scientific literature).

Since 1990, the NSW Government's Gas Heater Replacement Program has been progressively replacing old-style unflued heaters in NSW public schools with low-NO_x emission unflued heaters: over 80% of the approximately 51,000 heaters have now been replaced.

Home maintenance: Asbestos products, lead paint, and accumulated contaminated dusts from domestic, industrial and road sources can be unknowingly disturbed during home maintenance and renovations, releasing harmful fibres, heavy metals and toxins to the indoor environment. The DIY Safe website contains information about the hazards and risks that home renovators may face from a range of chemicals or materials, while the Asbestos Education Committee's Asbestos Awareness website has been developed to increase awareness of the asbestos products that home renovators may encounter.

Monitoring and reporting urban air quality

The air quality monitoring network comprises 20 sites located in Sydney, the Illawarra and Lower Hunter regions and four sites in regional NSW (which measure particles only). The network is currently being expanded with 14 new (industry-funded) stations beginning operation in the Upper Hunter region in 2011–12. All will measure particles as PM_{10} with three sites also measuring particles as $PM_{2.5}$ and two sites also measuring sulfur dioxide and nitrogen dioxide. This is in addition to the monitoring required to be done by industry as part of their environment protection licences.

Two new multi-parameter stations will also be established – on the Central Coast and at Camden – with instruments for measuring meteorology, ozone, sulfur dioxide, carbon monoxide, particles (PM_{10} and $PM_{2.5}$) and visibility. Construction is expected to commence following development approvals in June 2012. These two additional stations will bring to 40 the total number of full multi-parameter monitoring sites.

Improving presentation and communication of air quality data: The NSW Government's air quality information system was upgraded in 2008 to make it more flexible and accessible. This upgrade, in conjunction with an improved data acquisition and telemetry system allowing monitoring stations to be on-line continuously, resulted in a number of significant changes in how air quality data is reported and presented. These changes included:

- a revised Air Quality Index calculation, increasing from three to six the number of pollutants used and bringing it into line with calculations in other jurisdictions
- hourly updates of the Air Quality Index for each monitoring station and region, instead of twice daily
- improved accessibility and functionality for air quality pages on-line, including greater use of maps and increased access to data through dynamic queries of historical summary data
- six air pollution categories instead of three – very good, good, fair, poor, very poor and hazardous
- a subscription service (via SMS and email) to allow the community to receive various alerts, including health alerts due to high pollution and regular pollution forecasts.

Clean Air Forums: Every three years, NSW hosts broadly based public forums to encourage public input on air quality trends and strategies. Clean Air Forums were held in 2001, 2004, 2007 and 2010. The theme of the most recent forum was 'Future-focused technologies to reduce greenhouse gas emissions and improve air quality'. The forum brought together over 200 representatives from the community, local councils, scientists, students, environment and transport advocates, and government to discuss ideas and showcase cutting-edge technologies that can help reduce greenhouse gases and air pollution.

Let's Clear the Air: The OEH air education support project 'Let's Clear the Air' commenced in 2009. This is a public environmental education and community awareness project promoting greater community understanding of air pollution and its impacts and encouraging the adoption of sustainable behaviours by individuals and businesses to help improve air quality in metropolitan and regional NSW. The project developed a range of education resources to increase local-level community support for initiatives under the Clean Air, Healthy Communities Program (CAHC) and included workshops and grant funding for local councils. CAHC was an initiative funded by the NSW Environmental Trust to reduce vehicle emissions, improve vehicle efficiencies and reduce dependence on cars with multiple benefits for public health, greenhouse gas emission, local air quality and the community. CAHC received $5 million in funding from the Environmental Trust over four years (2007–08 to 2010–11).

To help local councils deliver air education programs in their communities, the Let's Clear the Air website provides information and free awareness-raising and educational resources. The education projects promote simple actions to improve air quality for issues ranging from reducing woodsmoke to training in enviro-driving practices and encouraging commuters to use sustainable transport.

Grant funding was made available to councils to run local demonstration projects to further encourage people to improve local air quality. A total of $272,000 in funding was distributed to such councils as Armidale, Griffith, Lake Macquarie, Maitland, Parramatta and Willoughby.

Other supporting strategies

Rural particles: There are a number of potential contributors to the exceedences of the AAQ NEPM standard for PM_{10} in some regional centres, including dust storms, agricultural burning, woodsmoke and bushfires. The NSW Government is working with local government and local communities to develop a rural particles strategy. The strategy will focus on increasing our knowledge about the relative contribution of different sources to the exceedences of the PM_{10} standard through a pilot project in Wagga Wagga with the EH Graham Centre and local stakeholders. This urban centre was chosen because of the high number of exceedences of the standard between 2002 and 2010 (although there have been none since the end of the drought in mid-2010).

The primary objectives of the strategy are to:

- identify particle sources
- collate and analyse existing information about particle emissions from rural activities
- identify opportunities for cost-effectively reducing rural particle emissions through conservation farming and new technology, bushfire and hazard reduction burning controls, and general dust control
- develop priority management actions in collaboration with other government agencies, local communities and key agricultural stakeholders
- engage with the community to reduce pollution.

National responses

Many significant actions on air pollution can only be pursued at a national level. Emissions from the commercial and domestic sectors are growing, increasing their relative contribution to overall emissions. NSW will continue to work with other governments to develop appropriate controls at a national level. This includes product standards for woodheaters, non-road diesel engines and equipment such as lawnmowers, which cannot be enforced by the states due to Mutual Recognition Agreements between them and the Commonwealth.

National Indoor Air Project: The Australian Department of Sustainability, Environment, Water, Population and Communities has been examining indoor air issues, in consultation with health agencies. The aim is to assess whether there are grounds for a national response to Australia's indoor air problems. Under the Indoor Air Project, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was commissioned to study the levels of major indoor air pollutants inside the average Australian home, including looking at influences such as proximity to major roads (CAWCR 2010a; CAWCR 2010b).

The CSIRO study investigated:

- What is the indoor air quality of a typical Australian dwelling (using 40 homes across Melbourne)?
- What is the effect of busy roads on indoor air quality of a typical Australian dwelling?
- What is the effect of building construction, materials and activities on the indoor air quality of a typical Australian dwelling?

Pollutants investigated included carbon monoxide and carbon dioxide; PM_{10} and $PM_{2.5}$; carbonyl; VOCs; nitrogen dioxide and ozone; nicotine; fungi and bacteria; persistent organic pollutants (such as brominated fire retardants, phthalates, polychlorinated biphenyls, perflourates and pesticides); and heavy metals (mercury, cadmium, nickel and lead).

It was found that the specific air pollutants investigated were at concentrations that were either lower than or comparable with the concentrations observed in previous studies in Australia. Most were also found to be at concentrations tens to hundreds of times lower than those observed in cities overseas such as New York and Kyoto. Lead was an exception, with a significant minority of samples near to or exceeding guidelines, especially in buildings over 40 years of age. Mercury concentrations were also higher in the older buildings.

Older and well-ventilated buildings tended to have lower concentrations of pollutants. Dwellings with an internally accessed garage have significantly higher PM_{10} and VOC concentrations. However proximity to busy roads had a fairly limited impact on the levels of these pollutants in indoor air.

Building rating schemes: The National Australian Built Environment Rating System (NABERS) is a NSW program that has been extended nationally and rates buildings on the basis of their measured environmental impacts (see also People and the Environment 1.4 and People and the Environment 1.5). NABERS Indoor Environment ratings are available for offices. 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, 12 NABERS Indoor Environment ratings were certified. Close to 600 businesses are engaging with NABERS to rate their premises.

In 2003, the Green Building Council of Australia introduced Green Star, a voluntary environmental rating system which evaluates the performance of a building at the design stage.

Developing responses

State

Supporting climate change strategies: There are important links between activities that emit air pollutants and those that create greenhouse gas emissions:

- Air pollutants and greenhouse gases are often emitted by the same sources, such as fuel combustion.
- Technical measures to reduce greenhouse gas emissions may have a similar impact on emissions of air pollutants, and vice versa.
- Some pollutants, such as NO_x in the formation of ozone, contribute to both regional air pollution and climate change.
- 'Black carbon' – an air pollutant which is the product of the incomplete combustion of wood fires, biomass and diesel fuels – warms the planet by absorbing heat in the atmosphere and reducing albedo, the ability of snow and ice to reflect sunlight. In recent years, science has detected an increase in direct 'radiative forcing' due to black carbon, which exacerbates the greenhouse effect. Radiative forcing relates to the capacity of an agent, such as carbon black, to alter the balance of incoming and outgoing energy in the Earth's atmosphere and is an index of the importance of the agent as a potential climate change mechanism.
- Air pollution and climate change may have an effect on each other: for example, climate change influences the formation of ozone and secondary particles ($PM_{2.5}$) through chemical changes in the atmosphere, while an increase in background ozone and particle concentrations contributes to climate change.

Links can be made between policy responses to both issues. An example is the transport and energy sectors: both are key sources of greenhouse gases, NO_x and VOCs, and policies to reduce the impacts of one problem can also have significant benefits for the other (see also responses in People and the Environment 1.1, People and the Environment 1.2 and People and the Environment 1.5). In contrast, actions to reduce some pollutants may create possible global warming: for example, reducing fine particles can lower pathways for CO_2 absorption or reflecting incoming solar heat.

Heating in homes and schools: The Government commissioned research by the Woolcock Institute of Medical Research to investigate the possible health risks that may arise from the use of low-emission unflued gas heaters in government schools (Marks et al. 2010). The reports recommended that the heating chosen should avoid adverse effects on health but at the same time be effective and efficient and have a sound environmental profile. Options for alternative sources of heating in government schools are being investigated.

Interjurisdictional

As many significant actions on air pollution can only be pursued at a national level, NSW is working with other jurisdictions to develop a National Plan for Clean Air. This aims to integrate the setting of air quality standards with actions to reduce air pollution (including from unregulated sources) that both improves the health of people who live in NSW and reduces costs to the state's healthcare system.

As part of the plan, an exposure reduction framework for particles is being considered. The rationale for this approach lies in the limitations of traditional air quality compliance standards to account for exposed populations and encourage further air quality improvement once standards have been met. The exposure reduction framework would seek to drive continued improvements in particle levels and emissions, as well as exposure reduction actions that would maximise net benefits to society.

NSW is advocating that the plan include national actions and standards to reduce emissions such as those from diesel engines, boat engines, garden equipment and domestic woodheaters. The National Plan for Clean Air provides an opportunity to progress these measures. Similarly, NSW has supported the introduction of tighter national vehicle and fuel standards at the Commonwealth level as a key element in reducing urban air pollution. The plan is likely to consider strategies to reduce VOC emissions as part of examining the impacts of ozone. This could include emissions from surface coatings, aerosols and solvents, which have an impact on indoor air quality.

Cleaner vehicles, fuels and engines: In June 2011, the Commonwealth announced the timetable for the introduction into Australia of Euro 5 and Euro 6 standards for light vehicles (all new cars, four-wheel drives and utilities) (*Regulation (EC) No. 715/2007 of the European Parliament*). Euro 5 standards will be introduced in two stages, with any new model vehicles produced from 1 November 2013 required to meet them. All new vehicles will be required to comply with the Euro 5 standards by 1 November 2016, regardless of when they were first produced. All new models introduced from 1 July 2017 will need to comply with the Euro 6 standard and, by 1 July 2018, all new light vehicles sold in Australia will also need to meet the higher standard.

Future opportunities

Building codes and standards: There is growing interest in the potential to control areas such as building construction materials and management of indoor air quality at the design stage (such as via new building code rules). In 2004, the Australian Building Codes Board recommended that future building codes include sustainability criteria towards these ends (ABCB 2004), but new building code rules have not yet been implemented. Emissions from domestic appliances and surfaces, furnishings and consumer products are also areas of potential investigation.

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Land 3

3.1 Management of soils and land

Soil resources in New South Wales are in fair condition overall, both on a statewide basis and at the regional scale. Significant land degradation issues still remain. Increasing pressures on soil resources are a result of growing populations, increasing intensification of agriculture and degrading vegetation conditions.

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

Conservation farming practices such as reduced tillage have helped improve soil condition generally – soil structure in particular – and also control erosion. The extent to which they improve organic carbon levels and prevent acidification is less clear and these remain issues. Wind erosion is an ongoing concern in the western parts of the state. Both inland and coastal acid sulfate soils have improved in condition with wetter seasons recently and ongoing rehabilitation initiatives.

Land and soil capability and land use have been mapped across NSW for the first time showing the capability of the state's soil resources and the land-use pressures on those soils. Current land management practices are broadly sustainable and generally lead to only a moderate risk of degradation but the level of risk varies across soil health indicators and catchment management areas.

NSW indicators

Indicator and status	Trend (over decade)	Information availability
Soil health index (overall)	Stable	✓✓
• Soil acidity	Stable	✓✓
• Soil carbon	Stable	✓✓
• Soil structure	Stable	✓✓
• Acid sulfate soils	Stable	✓✓
• Soil salinity	Stable	✓✓
• Sheet erosion	Stable	✓✓✓
• Gully erosion	Stable	✓✓
• Wind erosion	Stable	✓✓
Land use within capability	Increasing	✓✓
Land management within capability	Increasing	✓✓
• Soil acidity control	Increasing	✓✓
• Soil carbon decline control	Increasing	✓✓
• Soil structure decline control	Increasing	✓✓
• Acid sulfate soils control	Increasing	✓✓
• Salinity/waterlogging control	Increasing	✓✓
• Sheet erosion control	Increasing	✓✓
• Gully erosion control	Increasing	✓✓
• Wind erosion control	Increasing	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

The economic and ecological prosperity of NSW depends in part on improving soil health and ensuring that land is managed and used sustainably. Despite improved soil health in some areas in recent years, human-induced soil degradation remains widespread due to the high levels of disturbance from traditional approaches to preparing the land for cropping. Major climatic events, such as high intensity rainfall and prolonged droughts, can also exacerbate land degradation processes. Soil degradation represents one of the most difficult environmental management problems facing NSW and reflects a global trend in the decline of finite soil resources (Bai et al. 2008).

A key factor constraining the sustainable use of soil is that it is essentially a non-renewable resource, as soil formation is an extremely slow process. Soil renewal rates are very slow and beyond human time frames (Bui et al. 2010).

Some impacts from land use, such as dryland salinity, have a time lag before changes become evident and may continue to unfold over a number of decades. Cumulative exposure of land to inappropriate practices increases the risk of incremental and often significant degradation. The consequences of some types of land degradation, such as soil loss from accelerated erosion, dryland and irrigation salinity, and subsoil acidity, are long term and often irreversible. Other forms of degradation, such as nutrient decline and surface soil acidification, can be remediated if addressed early, but this can be very expensive (Lockwood et al. 2003).

Status and trends

Soils make a significant contribution to the prosperity of NSW, but this comes at a considerable cost. A significant proportion of the state is experiencing at least one form of soil degradation and many areas are facing a number (NSW SSPWG 2008). Degradation in some areas was noted decades ago (SCS 1989). Although improvements in soil health have been evident in some areas in recent years, human-induced soil degradation continues elsewhere, remaining widespread due to historic factors and representing one of the most difficult environmental management problems facing the state (NSW SSPWG 2008).

There is a critical and ongoing need to better understand the impacts of land use and management practices on the state's soils and continuously improve them so NSW is able to meet the demands placed on its terrestrial ecosystems by current and future generations. The land's capacity to meet these demands is constrained by intrinsic factors (such as soil properties, water availability and climatic variability) and extrinsic social and cultural factors (for example, rural population decline).

This section presents a snapshot of the health of NSW soils, taking into account recent trends relating to weather. Note that the terms 'soil health' and 'soil condition' are used interchangeably.

Soil health across NSW

Soil health is the ability of soil to deliver essential ecosystem services, including decomposition, nutrient transformation, exchange and cycling, water partitioning, climate regulation (such as through carbon storage and cycling), provision of habitat for biota, and provision of media for primary production and food resources.

Soil health is characterised by testing key soil attributes that can be used as soil health indicators at appropriate sites. NSW uses eight indicators which relate to soil characteristics (soil acidity, soil carbon, soil structure, acid sulfate soils and soil salinity) and soil processes (sheet, gully and wind erosion) as described in **Table 3.1**. A quantitative value is derived by comparing the current state of the indicator with that of an undisturbed 'reference' soil under natural conditions (Chapman et al. 2011).

Soil health indicators can be combined in various ways to produce soil health indexes. For example, a soil health index for a particular region may be based on data for all the soil health indicators for that area; alternatively, data on a particular soil health indicator from many regions may be used to produce an overall index for that indicator. The state soil health index is an overarching index that combines all the soil health indicator data from regions across NSW. Indexes are a useful way of looking at what is happening overall. However, information can be lost when data is averaged and therefore indexes should not be used to make site-based management decisions.

The most recent systematic statewide assessment of NSW soil health was undertaken under the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (MER Strategy) (DECCW 2010a) and commenced in 2008. The monitoring program aimed to establish a baseline of NSW soil condition by setting up a permanent network of condition monitoring sites. For soil acidity, soil carbon and soil structure, this means up to 10 monitoring sites in each of 10 priority soil monitoring units (SMUs) in all of the 12 rural catchment management authority (CMA) regions and four SMUs in the Sydney Metropolitan area, a total of 1240 sites. SMUs were selected on the basis of their importance, expected changes in use and number of soil issues present. Where possible, sites were paired on the same soil type but across different land uses, including undisturbed reference sites. Approximately 6% of sites across the state (around 50) are in national parks, state forests and nature reserves and these are commonly used as reference or control sites (Chapman et al. 2011).

A program of soil data collection, with laboratory analysis, was undertaken at each site, together with the collection of land management data. By May 2009, 850 sites had been established and full laboratory testing took another two years to complete. The MER program provides most of the data used to assess soil condition and the extent of sustainable land management, as reported in this chapter. This dataset will provide a valuable baseline allowing changes in NSW soil resources and land management behaviour to be assessed into the future.

Table 3.1: Soil health indicators

Indicator	Degradation process
Soil acidity	Soil acidity is a major indicator of soil chemical health. Acidification can reduce soil health and productivity and ecosystem function. Acidity is associated with erosion, soil structure decline and salinity.
Soil carbon	Organic carbon is a prime biological determinant of soil health. Organic carbon is sensitive to land management practices, including those which sequester carbon from the atmosphere. Soil has the largest concentration in the carbon cycle (Bolin et al. 1979).
Soil structure	Soil structure is the arrangement of soil particles and voids. It governs soil water storage and movement and gas exchange and is the prime physical determinant of soil condition. Soil structural condition is sensitive to land management practices.
Acid sulfate soils	Coastal acid sulfate soils are low-lying coastal soils from previous marine environments which, when drained or exhumed, can discharge sulfuric acid. They have the potential to cause profound terrestrial and aquatic ecosystem damage. Sulfidic sediments have often been thought of as only a coastal phenomenon but are now known to be common in inland wetlands (MDFRC 2007). One study of 81 wetlands in the Murray–Darling Basin found 17 (roughly 20%) were characterised as actually or probably containing sulfidic sediments. Although most were adjacent to the Murray River, potential acid sulfate soils were also found in wetlands in the Murrumbidgee, Lachlan and Macquarie valleys (Hall et al. 2006).
Soil salinity	Soil salinity is the accumulation of salt on or near the ground surface. It has the potential to cause profound terrestrial and aquatic ecosystem damage, including massive erosion.
Sheet erosion	Sheet erosion is caused by rain splash and diffuse water flows. It removes topsoil and reduces productivity, terrestrial biodiversity and ecosystem functions. 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.
Gully erosion	Gully erosion is the erosion of topsoil and subsoil by concentrated overland water flow. It reduces land management options, water quality and terrestrial and aquatic ecosystem function through the delivery of sediment. Gully erosion is expected to be sensitive to climate change.
Wind erosion	Wind erosion reduces air quality, land management options and terrestrial ecosystem function. Burial and deposition of nutrients can harm biodiversity. Dust deposition can significantly alter aquatic ecosystems. Wind erosion is expected to be sensitive to climate change.

Notes: The NSW Government has not systematically monitored the condition of inland acid sulfate soils, but has surveyed land management actions that might cause their acidification.

Updated soil health indicator ratings for CMAs in NSW (seven ratings each for the south coast CMA and the nine inland CMAs, and eight ratings each for the remaining three coastal CMAs) and the state as a whole have been derived using the updated MER data. Additional data was collected for acid sulfate soils (Tulau 2010). Advances in modelling using improved digital elevation models and time series-based satellite monitoring of ground cover also allowed data on sheet erosion to be updated (Yang et al. 2011).

The results indicate that, on a statewide basis, soils in NSW are in fair condition. On average, there has been a noticeable and moderate decline in the condition of NSW soils relative to their undisturbed reference condition. There has also been a moderate loss in the ability of NSW soils to provide ecosystem services, including agricultural productivity.

Some parts of the state and some particular soil condition indicators, however, are in an overall poorer condition and exhibit a significant loss of soil function. When considering the 94 reported soil condition ratings, 38% are in good condition, 46% are fair and 16% are in poor condition. Of the state's 124 SMUs, 74% were rated as poor or very poor for at least one degradation hazard. This indicates that although most regions appear to have broadly stable soil conditions, significant specific issues of land degradation remain.

Figure 3.1 depicts the proportion of soil monitoring sites that fall into the four classes of soil health for each of the soil health indicators.

Map 3.1 presents the most dominant soil health issue, according to the relative cost of rectification, within each SMU. The results suggest that on a statewide basis, low soil carbon and sheet erosion are moderate issues of concern, with soil structure and salinity also being of concern. Acid sulfate soils are of significant concern in some coastal and drying inland riverine areas. Map 3.1 shows that sheet erosion and salinity are the critical soil condition issues in the eastern part of the state, while wind erosion and soil carbon decline dominate in the west. Further details on the apparent recent trends are provided in the following discussion.

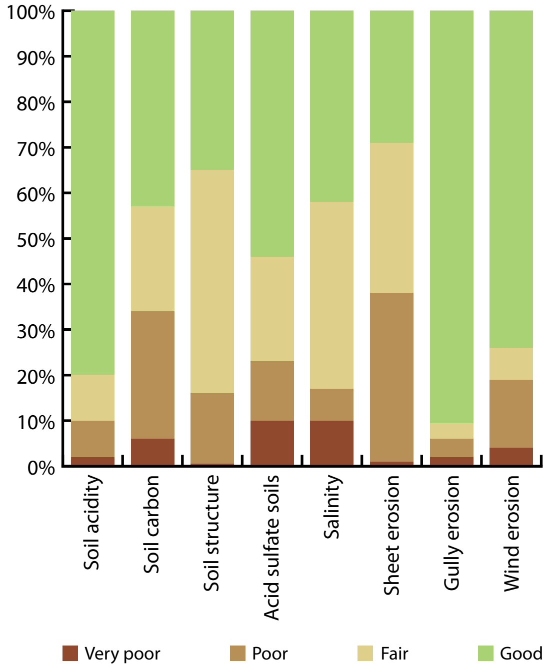
Recent trends in soil health

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 management, such as conservation farming and cell grazing, that can help minimise further loss of soil condition. The analysis of recent land-use and management practices over NSW reported in the 'Pressures' section below supports the ongoing improvement in sustainable land management.

The interaction of seasonal weather conditions with land use or land management actions can increase the risk of land degradation that affects soil health. Over the last two years, with the end of the drought, degradation hazards such as wind erosion and acid sulfate soils have diminished with the wetter conditions. However severe widespread flooding in the summers of 2010 and 2011 exacerbated erosion, mass movement and salinity because ground cover had not yet re-established after years of drought.

The impacts of recent events on selected soil health indicators, including wet conditions, are discussed below.

Figure 3.1: Proportion of soil monitoring sites within each soil health indicator category



Source: NSW Office of Environment and Heritage (OEH) data 2012

Notes: Data from the 2009 MER Strategy soils project published in *SoE 2009* (DECCW 2009) has been augmented with further testing of MER samples, re-analysis of the full MER dataset, and the inclusion of new unpublished data on inland acid sulfate soils and sheet erosion.

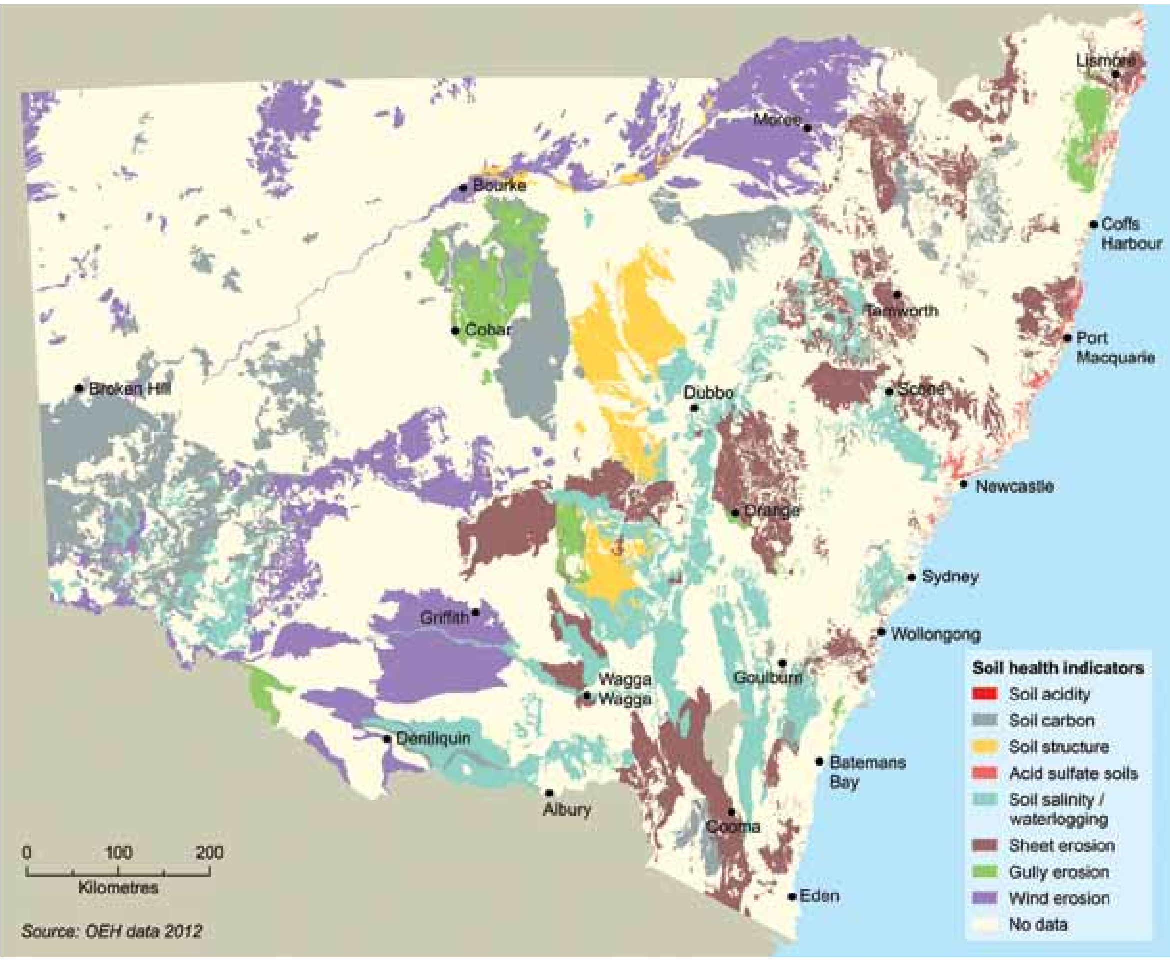
Soil acidity

Increased soil acidification is expected in southern NSW as a result of higher summer rains and a shift toward canola production. Grazing on fertilised annual pastures is also contributing to acidification. Agricultural lime is normally used to ameliorate acidity with usage increasing over recent years. 'Land management within capability' analysis reveals this issue is being managed the least sustainably of all potential land and soil hazards across NSW.

Soil carbon

Benign wet and milder growing conditions have led to increases in pasture and plant growth which, combined with low stock numbers after the drought, are generally expected to increase carbon levels in soil. Organic carbon is assessed as being a moderate issue of concern across the state, with land management for this issue being broadly sustainable.

Map 3.1: Dominant soil health issues within soil monitoring units in NSW



Notes: Areas of 'no data' fall outside the soil monitoring units' dataset, but other information may be available about them.

Soil structure

A generally increasing uptake of conservation farming techniques and low stocking rates after the drought have seen improvements in soil structure. Saturated soils are particularly prone to structure decline from mechanical disturbances, such as machinery traffic, stock movement and cultivation, but the extent of any recent damage is not known. Structure decline is a particular issue in areas with sodic surface soils.

Acid sulfate soils

Acid sulfate soils have generally improved in condition with rehabilitation initiatives, better land management practices and continuing wetter seasons.

Soil salinity

Above-average rainfall in 2010 and 2011 has caused groundwater levels to rise and remobilise the salt which had previously concentrated in the soil during drier conditions. As a result, increases in stream salinity levels have been observed and previously inactive salinity sites are becoming active again (Allan Nicholson, OEH, pers. comm., 24 May 2012). There is a lag time between climatic events and the expression of salinity symptoms, so the area of land affected may increase again in response to the recent wetter conditions. This is significant because agricultural productivity is substantially reduced in areas affected by salinity. Also salt present on the soil surface is more likely to be dispersed into the wider environment, including waters. Land management for this hazard is broadly sustainable on a statewide basis.

Sheet erosion

Sheet erosion has increased over most of NSW with the exception of the Murray, Murrumbidgee and Lachlan floodplains over the last 10 years. Following the breaking of the drought in 2010, continuing wet conditions have resulted in improved ground cover due to the soil moisture available. However, analysis of sheet erosion rates compared with the amount of bare soil vulnerable to erosion shows that over the last two years increases in ground cover have been insufficient to effectively reduce erosion. A reduction in severe bushfires has brought with it less erosion in bushland.

Land management for this hazard is broadly sustainable on a statewide basis using the 'land management within capability' analysis in the 'Pressures' section below.

Gully erosion

Increased rainfall from two consecutive La Niña events in eastern Australia since April 2010 has increased concentrated channel flow, worsening gully and streambank erosion. Gully erosion is a concern on the north coast and western slopes and tablelands. It is generally associated with unstable granite-based soils and dispersible (sodic) subsoils on rolling to moderate slopes. Over the longer time scale, however, land management for this hazard appears to be broadly sustainable.

Wind erosion

Wind erosion is a significant issue of concern in the western regions of the state. It is only an issue in limited areas of the central regions and is stable in eastern regions. Data from the DustWatch network shows that during the current reporting period, dusty conditions peaked in north-western NSW in spring 2009 and then declined substantially with 2010's record-breaking rainfall. In south-western NSW, retention of adequate ground cover during autumn, especially in years of below-average rainfall, remains a critical factor in the management of wind erosion (John Leys, OEH, pers. comm., 23 May 2012). 'Land management within capability' analysis reveals this issue as one of the least sustainably managed of all potential land and soil hazards across NSW, particularly in the western regions (see the 'Pressures' section below).

The worst dust storm to hit Sydney since reliable records began in 1940 lasted for nine hours from the morning of 23 September 2009 and reduced visibility at the airport to 400 metres. The dust storm was the product of drought and extreme wind conditions. The source of the dust was the red sandplains of western NSW and the sandplains, riverine channels and lakebeds of the lower Lake Eyre Basin and Queensland's Channel Country. The rate of dust loss off the coast near Sydney peaked at over 70,000 tonnes per hour with an estimated 2.54 million tonnes of total suspended particulate sediment deposited off the Australian coast along the 3000-kilometre-long storm front. Impacts and costs included increases in respiratory diseases and traffic accidents; cancelled air, road and ferry services; power supply disruptions; and the cost of cleaning homes, businesses, machinery and infrastructure (Leys et al. 2011).

Future trends in soil health

Climate changes – including higher temperatures and evaporation levels, along with generally lower but more erratic and more intense summer-dominated rainfall – are predicted to lead to various increased pressures on NSW soils.

Soil acidity

Changes in rainfall and evaporation are likely to affect leaching and therefore modify soil acidification in many areas. In the south of the state, reduced winter rainfall is expected to decrease the amount of deep drainage and, in turn, soil acidification (DECCW 2010b). However, acidification is likely to remain a problem because leaching is only one of its causes and changes in particular areas will depend on local factors.

Soil carbon

Hotter dryer conditions, especially in the south, are expected to reduce soil carbon (DECCW 2010b).

Acid sulfate soils

Major changes are likely in the character and development of acid sulfate soils on coastal plains. Initially, a change in the seasonality of rainfall is expected to increase the production and mobilisation of acid. However, reductions in acid development will occur over the next 50–100 years as watertables rise with sea levels (DECCW 2010b).

Soil salinity

Likely changes in rainfall and evaporation in all regions will have an impact on the balance between runoff and overland flows, and shallow drainage and deep drainage. These changes are expected to affect the mobilisation and concentration of salts, with responses differing between catchments. Impacts on soil salinity are likely to be complex and difficult to predict. Whether salinity will increase or decrease in particular areas will depend on local factors for each catchment (DECCW 2010b).

Soil erosion

Changing climatic conditions are likely to have implications for agriculture and food production in NSW because of an increased frequency of drought, a declining availability of water (from changes to both rainfall and evaporation), and altered storm and flooding patterns. The resulting poorer growing conditions will reduce vegetation cover and increase soil erosion, especially in the vulnerable sodic soils of the western clay plains of NSW. The consequent soil erosion will heighten the need to increase the resilience of water infrastructure and land management systems (Climate Commission 2011).

The combination of more intense storms, especially in summer and spring, and an overall reduction in vegetative ground cover (possibly exacerbated by changes to bushfire regimes) is likely to lead to more sheet and rill erosion and increased gully erosion if overland runoff increases. Wind erosion could also increase due to the loss of protective vegetation, especially grasses and other ground-cover plants (DECCW 2010b).

Pressures

Pressures on soil condition are primarily due in the short term to weather conditions and land management actions, often in combination. The extent of risk and type of degradation depends on the resilience of the soil and vegetation cover to withstand degrading processes. Over the long term, land management is the prime determinant of soil condition. Land management tools and techniques will need to be adapted to maintain or improve soils as climate change impacts become more apparent.

'Land use' is defined as the purpose to which land is put (such as forestry or cropping) whereas 'land management' operations are the detailed activities involved in undertaking the land use (such as tree thinning or stubble burning). 'Land capability' is the inherent capacity of land to sustain land use or land management risks or pressures. It is the intensity of disturbance – created by human intervention, coupled with seasonal conditions and features of the land (such as soil type and slope) – which carries a risk of land degradation. Prolonged exposure to risk increases the probability of a loss in soil condition. The degree of land degradation in turn depends on the resilience or capability of the land.

Pressures that influence land use and land management are numerous and involve economic, social and environmental factors. Land use and land management regimes can sometimes lead to improvements in soil condition or prevention of its deterioration (Strudley et al. 2008). On the other hand, inappropriate land management practices can place land at a risk of significant degradation. 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.

Land management decisions are often made with imperfect knowledge of future weather and markets. As fuel becomes more expensive and competition for essential resources like water and fertilisers increases, there will be significant challenges to sustainably managing the land (Cribb 2010). This will be exacerbated in the future by increased population pressures: for example, a 70% increase in global demand for food is predicted by 2050 (CSIRO 2012). These pressures will be coupled with the expected climate change effects of drying and extreme weather events for much of NSW (DECCW 2010b). Changes in climate are expected to lead to changes in land use as well as changes in land management.

This section considers how land capability is assessed and whether current NSW land use and land management practices are conducted within the land's capability.

Assessment of land capability

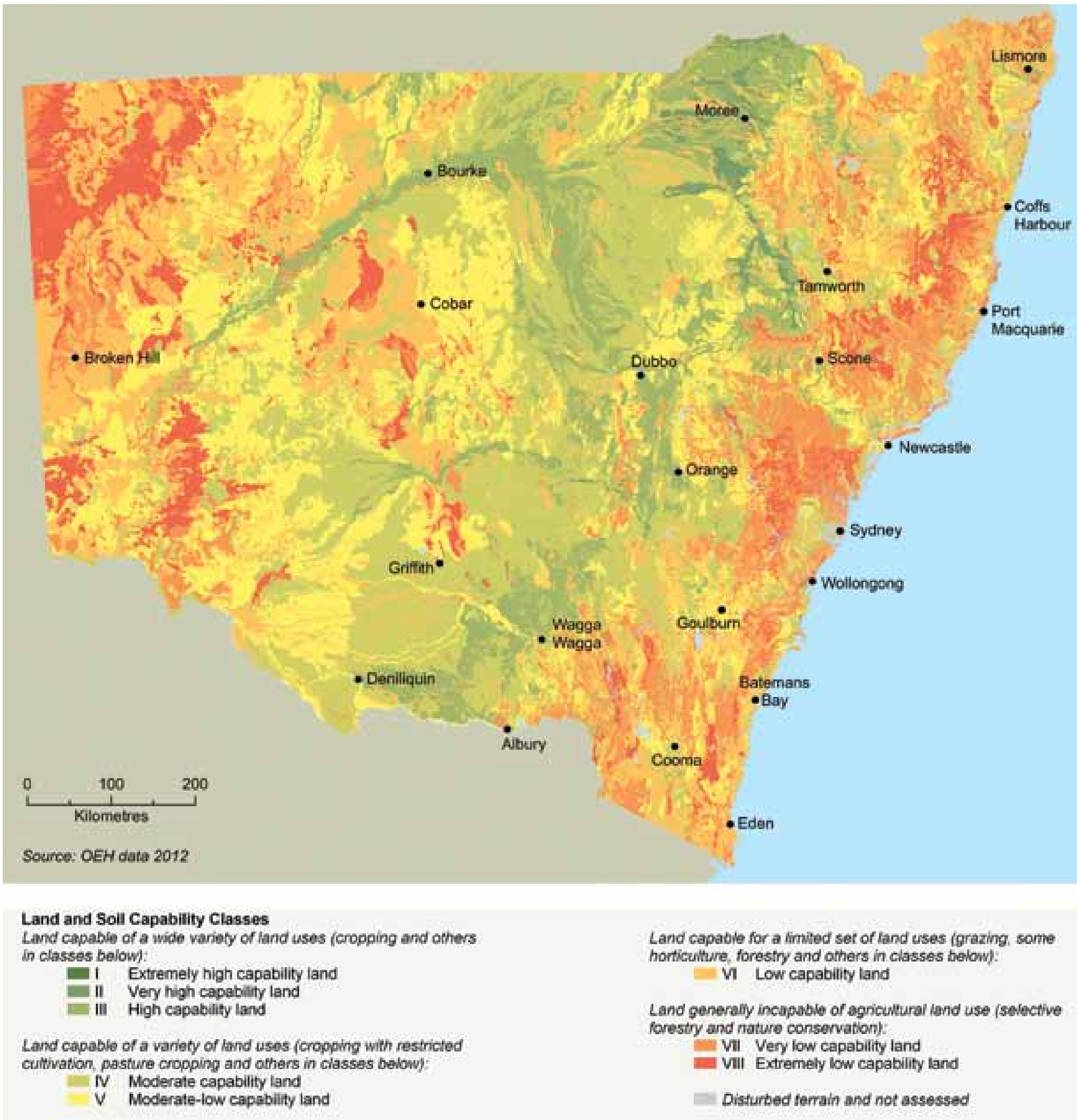
While many land degradation causes and processes are understood, the complex relationships between variable climate and interdependent land management risks and the cumulative impacts on soil condition are difficult to assess or readily quantify (Bennett et al. 2010).

To help assess these complex relationships, the NSW Government developed the Land and Soil Capability (LSC) classification system. This is a rules-based approach for allocating land into one of eight land and soil capability classes based on both on-site and off-site limitations of the land, that is, the resilience of land to withstand the various known impacts of land use and land management.

Within each class there are limitations caused by differences in climate, soil type, existing erosion, slope, landform position, acidity, salinity, drainage, rockiness and a range of other factors. Each limitation has its own sub-rule set and each has to be managed to avoid land degradation and make full use of the potential of the land.

Map 3.2 is the land and soil capability map for NSW. Land shown in green has the most resilience to withstand disturbance and land in red the least.

Map 3.2: Land and soil capability in NSW



The distribution of the most limiting types of land and soil hazard (including, for example, soil erosion, salinity and rockiness) using the land and soil capability map is shown in **Map 3.3**. Where more than one land and soil hazard is present within the same land and soil capability class, the most difficult to remediate is shown on the map.

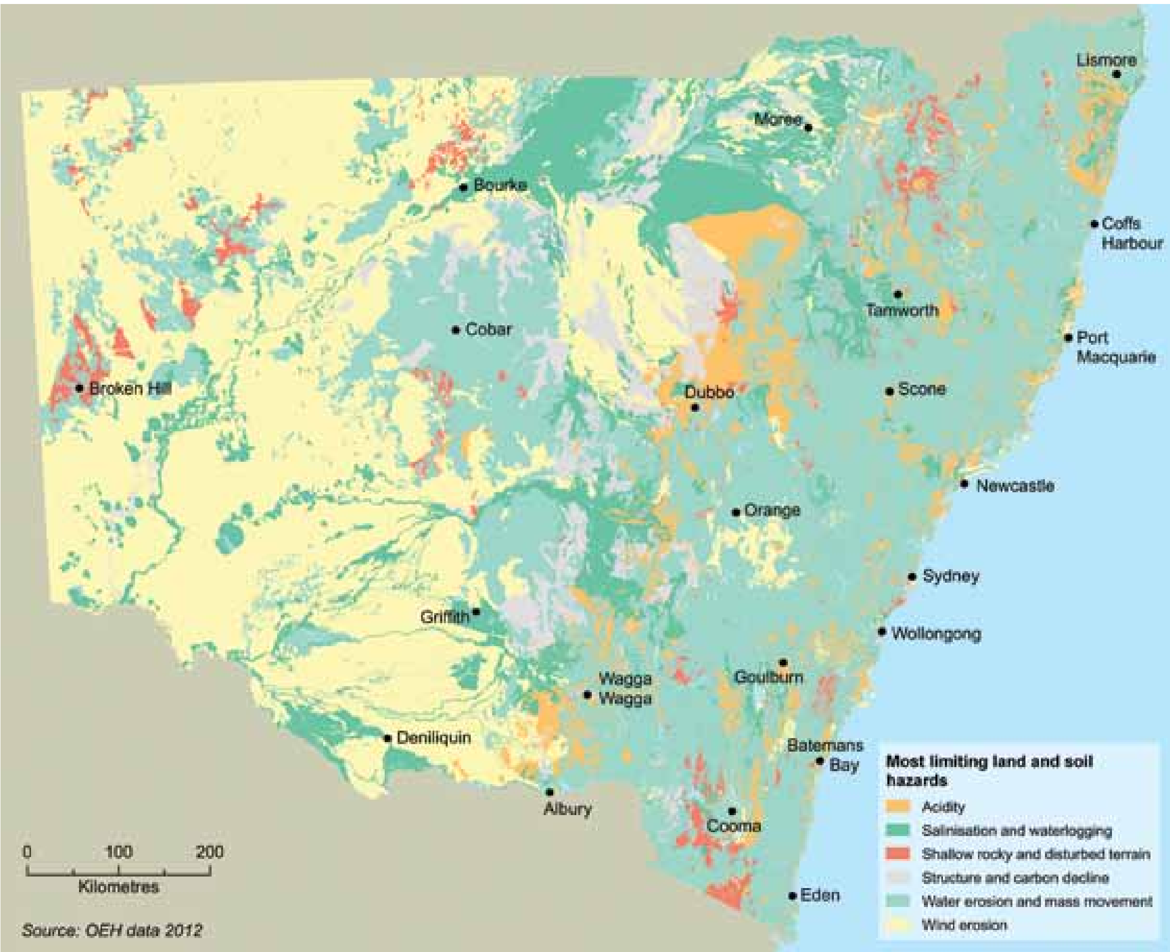
Unless land is used and managed within its natural capability, there is a risk of land degradation and permanent loss of many ecosystem services including biological (photosynthetic) productivity. For example, a parcel of land may be capable of being used for grazing but if not managed within capability, such as overgrazing by failing to reduce stock during drought, it would be placed at risk of degradation.

Land capability has been compared against current land use in NSW and then against land management actions using available records of land management practices by landholders from the network of soil condition monitoring sites.

Land use within capability

The land and soil capability and land-use maps for NSW have been combined for the first time in **Map 3.4** using technical limit rules developed for the assessment of land and soil capability classes for activities that are common to land uses. These rules give the 'upper sustainable' LSC class, that is, the class beyond which the land use is no longer sustainable (Gray et al. 2011). This was done to provide a statewide view of the extent of land use within capability in NSW. Land uses such as industrial, infrastructure, mining and urban (which together occupy about 2% of NSW) are not included as they are not primarily used for the provision of soil ecosystem services.

Map 3.3: Most limiting land and soil hazards in NSW



The areas assessed as being at significant risk of degradation as a result of land use are not large: rather there are clusters of locations where the land use is marginal for the district. Many of these are associated with irrigation on the western slopes and plains and are being degraded by salinity. They occur on the black soil plains of the Gwydir and Barwon rivers and in the Lachlan around Rankins Springs, the Murray irrigation areas south of Balranald, and lakebed irrigation areas of the Western Division. Other examples of significant risk are market gardening in coastal areas and sugar cane cropping on coastal acid sulfate soils. Slight to moderate risks of degradation are also due to cropping and grazing on marginal land that is either too steep or located in the drier parts of the Western Division.

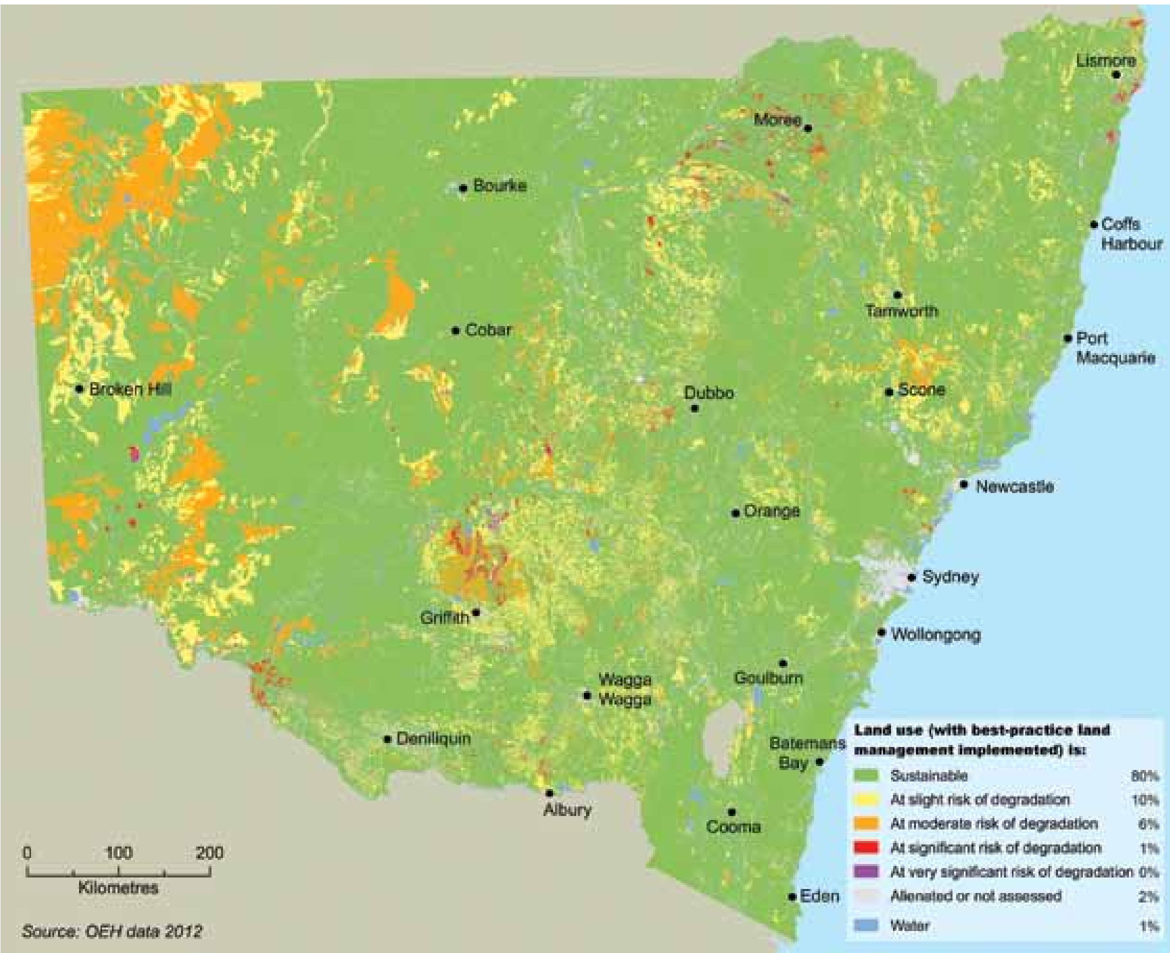
The vast majority of NSW is used for grazing/cropping, forestry and nature conservation. As is expected, more intensive land uses are at greatest risk of being used beyond natural capability.

Land-use trends

Land-use changes that involve greater levels of soil disturbance carry a high 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 areas. These areas have growing populations (see Table 1.1 in People and the Environment 1.1) and this can lead to intensification of soil disturbance on all types of land.

Conversely, isolated parts of the state are becoming less populated with fewer people of working age available to manage pests and weeds, thereby increasing the risks of further land degradation. In parts of western NSW, for example, the control of overgrazing by feral goats and loss of ground cover associated with invasive native scrub is becoming increasingly problematic (Ballard et al. 2011; Kimball & Chuk 2011). In addition, declining farm profitability and/or poor terms of trade can also lead to more intensive production activities (see *SoE 2009*, Land 5.1 'Status and trends' and Appendix 2 'Private landholder capacity to manage natural resources').

Map 3.4: Land use within capability in NSW



Land management within capability

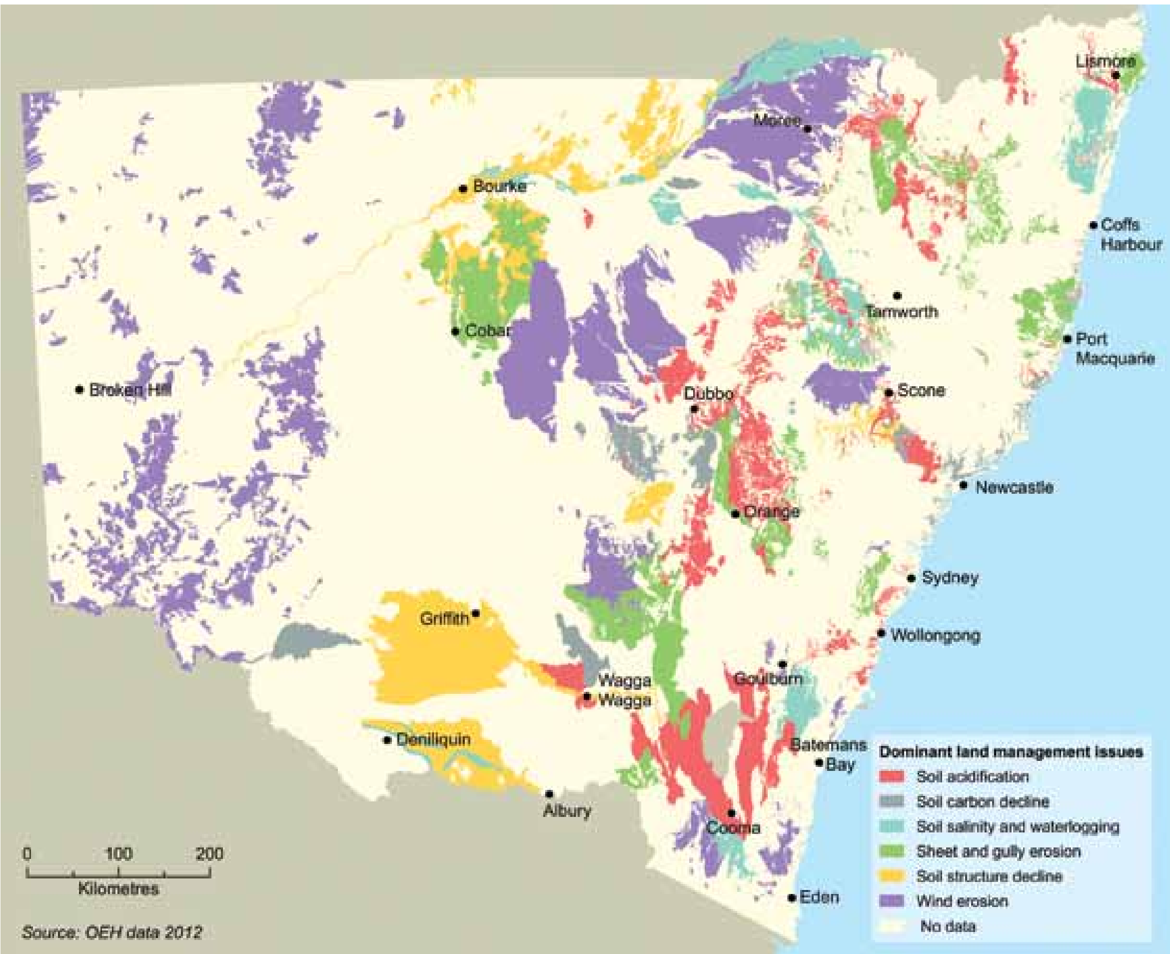
Appropriate land management is vital for the sustainable use of soil and land resources. Managing land within its capability is the primary means in NSW for maintaining soil condition and valuable ecosystem services. Although different land uses are associated with landscape and soil health, it is the suite of land management practices employed within particular land uses that is more directly associated with landscape and soil health. For example, different land management practices used in cropping systems (such as direct drill vs ploughing) may have a bigger impact than the choice of land use (such as irrigated vs non-irrigated cropping). Land management is often inappropriate where it does not adequately consider soil properties or seasonal conditions.

Eight soil health indicators are used to describe the current status of soil health, with a composite Soil Health Index providing a statewide summary. The same indicators (but with waterlogging combined with salinity) are used to describe the overall sustainability of current land use and land management practices and how well individual land degradation hazards are being managed to reduce the risk of them occurring. This is important, given the lag between changes in land use or management practices and the subsequent appearance of land degradation or recovery. Soil health indicators, in contrast, describe the current status of soil health.

Site-based 2008–09 landholder data, which has become fully available since *SoE 2009*, was recently assessed against rules provided in the MER land management technical report (Gray et al. 2011). The analysis involved the quantitative comparison of land management actions at the 662 sites against their Land and Soil Capability ratings.

Map 3.5 shows the main issues of concern for land management within capability, that is the *potential* land degradation hazards most likely to need control for various soil monitoring units in NSW, based on the re-assessment of 2008–09 data.

Map 3.5: Dominant land management issues within NSW soil monitoring units



Notes: The map only presents assessments for soil monitoring units with adequate data.
The map shows the land degradation hazards that potentially need to be controlled to ensure land is managed within its capability into the future. As such, the mapping should not be viewed as representing current, on-ground conditions.

On a statewide basis, the results suggest that, overall, land in NSW is being managed at a level in accordance with its inherent physical capability, although there are widespread issues of concern. The overall index for Land Management within Capability across the state is 3.7 (in a 1-to-5 rating scheme) suggesting overall 'fair' land management relative to capability. However, individual hazards are being unsustainably managed over many areas. Of the individual sites examined, 53% had a 'poor' or 'very poor' rating for at least one hazard. In these areas, there is a risk of ongoing land degradation from particular hazards that are not currently being adequately managed.

The results suggest that on a statewide basis, all hazards are being managed fairly sustainably. However, acidification, wind erosion, salinity/ waterlogging and organic carbon decline are the land degradation issues that are being managed the least sustainably.

Land management trends

Continuing improvement in the extent of sustainable land management throughout NSW is a broad, long-term trend, as reported in SoE 2009. The recent updated MER results presented here confirm this trend, but cannot provide precise information on trends since 2009.

Increasing use of practices, such as crop stubble retention, no-till farming, fallow weed control, precision farming and controlled traffic, are leading to improvements in soil structure, soil moisture storage, soil carbon utilisation and more efficient use of pesticides and fertilisers.

Stock levels that were depleted during the drought are being rebuilt on recovering pastures, reducing the prevalence of overgrazing. Increased adoption of cell grazing has led to improved ground-cover management in these areas. Some soil structural damage from trampling stock compacting wet soils may be expected.

Responses

Managing and protecting the soils of NSW involves initiatives and programs at the state, regional and federal levels. These all ultimately aim to promote the adoption of sustainable land management practices by all landholders across NSW.

Established responses

State level activities

The NSW Government guides natural resource management throughout the state through *NSW 2021: A plan to make NSW number one* (NSW Government 2011) and various legislation, policies, strategies and programs.

NSW 2021 is the Government's 10-year plan for NSW. Goal 22 in *NSW 2021* is to 'Protect our natural environment'. One of the targets listed to help achieve this goal is to 'Protect and conserve land, biodiversity and native vegetation.' The protection of NSW soil and land resources is a key component of the current plan for NSW. It contains commitments to protect and restore priority lands and strategic agricultural land, and improve agricultural productivity. The NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (MER Strategy) (DECCW 2010a) is being implemented to monitor progress towards all Goal 22 targets, with its associated program providing for the collection and analysis of information relating to soil condition and land management.

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 on all land in NSW, with some exceptions, 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. This methodology establishes specific criteria for the assessment of impacts on land and soils when clearing is being considered.

- The *Catchment Management Authorities Act 2003* established 13 catchment management authorities (CMAs) and outlined their responsibility for natural resource management.

Various other Acts provide direct and indirect mechanisms for soil protection and management, including the *Protection of the Environment Operations Act 1997*, *Environmental Planning and Assessment Act 1979* and *Crown Lands Act 1989*.

Policy instruments supporting soil management include *State Environmental Planning Policy (Rural Lands) 2008*, as well as the older *Policy for Sustainable Agriculture in NSW* (NSW Agriculture 1998), the *NSW Soil Policy: Looking forward, acting now* (1987) (currently being revised) and the *Total Catchment Management Policy* (1987).

Regional and local level activities

Many response activities are under way within the catchment management regions of NSW (see, for example, catchment action plans in 'Developing responses' below).

The SoilWatch performance monitoring system is being used by most CMAs. It complements and supplements surveillance monitoring throughout the state.

Locally, the Landcare network provides an invaluable contribution 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 weed control, revegetation, soil erosion by water, streambank erosion, river corridor/estuary corridor degradation, farmland improvements and urban environment protection. The projects and issues addressed by Landcare groups can often directly or indirectly assist in effective soil conservation and promoting the sustainable use of soils. The importance that Landcare plays in education and community awareness on natural resource issues, including soils, is also of extreme importance.

National level activities

The National Committee on Soil and Terrain coordinates and provides advice on soil and land assessment standards and policy. The committee previously commissioned a soil policy discussion paper (Campbell 2008), which was followed by a stakeholder survey and a stocktake of Australia's soil research development and extension capacity (DAFF 2011).

National protocols for monitoring water erosion, wind erosion, soil acidification and soil carbon have been developed and published (CSIRO 2011).

As part of the Clean Energy Futures project, the Federal Government has established and funded a Carbon Farming Initiative. This includes the soil carbon sequestration segment of a national carbon trading market which it is expected will lead to large additions to soil carbon and, as a result, improved soil condition.

Developing responses

The following policies and plans designed to protect land and soil resources are being developed.

- *Taking on the Challenge: NSW Salinity Strategy* (DLWC 2000) operated from 2000 to 2010. Although it has come to an end, it may be replaced by a new document for coordinating a whole-of-government response to salinity management within the state. Emerging issues that will need to be considered in the near future are the management of saline water released during the extraction of coal seam gas (CSG) and implementation of the Murray–Darling Basin Plan, which will require water quality and salinity management plans for each constituent river basin.
- As an update to the *NSW Soil Policy: Looking forward, acting now* (1987), the State Government is preparing a NSW Soil Strategy. The new strategy will guide the direction and strategic vision for the management, protection and, where possible, improvement of soils in NSW.
- Catchment action plans (CAPs) are currently being prepared for all of NSW's 13 CMA regions. The CAPs are key documents that coordinate and drive the effort to improve natural resources across their regions. They describe a whole-of-government approach to soil condition and sustainable land management targets at the regional scale and specify regional targets and activities to contribute to the achievement of statewide targets. The updated plans will set the direction for investment in natural resource management over the next 10 years.

Future opportunities

Opportunities for further protecting soils and landscapes in NSW include:

- rapid assessment of risks to assets as a result of rainfall events in areas burnt by wildfires
- incorporating acid sulfate soil management in local environmental plans.

3.2 Chemicals in the NSW environment

The presence of hazardous chemicals in consumer products has been identified as an emerging issue.

The National Waste Policy identified hazardous chemicals in consumer products as an emerging issue, while the Productivity Commission recently made recommendations for identifying and dealing with the risks of chemicals from consumer products.

Existing chemicals available for use in Australia are largely unassessed, with limited risk-based guidance available to provide chemical users and consumers with information on which chemicals are safer and less environmentally hazardous. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) has a goal to screen 3000 industrial chemicals for potential health and environmental risks within four years.

There has been an increase in reports of potentially contaminated sites in New South Wales – approximately 970 since December 2009 – following amendments to the *Contaminated Land Management Act 1997* which clarified notification reporting requirements. A majority of the significantly contaminated or potentially contaminated sites are associated with leaking underground petroleum storage systems.

NSW indicators

Indicator and status	Trend	Information availability
Number of regulated contaminated sites	Increasing	✓✓
Exceedences of maximum residue levels in food and produce	Stable	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Manufactured chemicals play an essential role in the production of foods, equipment, fuels, goods, cosmetics, medicines and many other products and services that maintain and improve our quality of life. Chemicals, however, can also present risks to human health and the environment during their manufacture, use and disposal.

NSW is part of a national chemicals management system that applies across various sectors of the economy, including primary production, industry, pharmaceuticals and construction. Management of chemicals involves assessing the risk of any potential hazards that may arise through a chemical's life cycle by examining the information available on its toxicity and how humans and the environment are exposed to it via intended uses and disposal pathways. Responsibilities for regulating chemicals are shared, with Commonwealth assessment and control of them up to point-of-sale and states and territories regulating their use, disposal and emissions. The national system operates within the context of international treaties and obligations agreed to by Australia.

This section broadly examines the information available on the potential impacts of manufactured chemicals on human health and the environment in NSW and the responses to these.

Status and trends

Assessing the risk from manufactured chemicals relies on comprehensive information about chemicals in the environment as well as their exposure levels and effects on living things. Assessment informs many decisions that need to be made, including for regulators about which chemicals require stricter controls or removal from use; for chemical users looking to use safer chemicals in manufacturing and production; and for consumers wishing to make more ecologically sustainable purchases. However information about the impacts of chemicals on the environment; and for living things is only available for a relatively small number of chemicals. Current understanding of the acute effects of single chemicals is well-studied, as are the chronic effects of certain types of chemicals, such as heavy metals and persistent organic pollutants.

Chemicals in the environment

There is limited data on the levels, fate and distribution of commercial chemicals and their breakdown products in the NSW environment. When exposure levels are not available, information on chemical releases or use is often used as a surrogate for exposure. However, good information is available on contaminated sites and chemical residues in food. Contaminated land and sediments, which are primarily legacies of poor waste management and past industrial practices, have been actively regulated for decades in NSW. Data on contaminated sites and chemical residues in food and produce has been reported for some time and current indicators for chemicals in the NSW environment are based on these and similar sources of data.

Chemical releases to the environment

Data on the total load of chemicals released into the environment has been estimated using the total volumes manufactured and/or imported or used. These estimates show that very large amounts are released into the environment, either directly during manufacturing or use or indirectly when products containing the chemicals degrade over time.

The Australian National Pollutant Inventory (NPI) reports on the releases of 93 chemicals across Australia from various sources, including mines, power stations and factories, as well as houses and transport. The program was designed to provide information to the community about those chemicals recognised as posing risks and typically targets pollutants released in large volumes (see Atmosphere 2.1).

Chemical release data is also reported for point sources on many premises that are licensed under the *Protection of the Environment Operations Act 1997*. In NSW, recent changes designed to strengthen this legislation will make monitoring data publicly available for the first time. The chemicals covered in this reporting, as for the NPI, primarily target those known to pose risks.

Ambient monitoring data

A relatively small number of chemical pollutants are monitored in different parts of the NSW environment, including in water, air, soil, sediments and household dust for a variety of specific purposes. This monitoring is used to evaluate compliance of licensed premises with licence conditions, determine whether the restrictions on emissions and discharges from licensed premises are appropriate, and assess the risks from a particular substance or contaminated site.

The information available shows that numerous chemicals are found throughout the NSW environment in complex mixtures (with individual chemicals mostly present at very low levels). Examples include personal care products and endocrine disruptors in biosolids (Langdon et al. 2011) and the fluorinated chemicals used in many consumer and industrial applications in Sydney Harbour (Thompson et al. 2011). Consumer products are an important source of chemical pollutants in the environment and include pharmaceuticals, personal care products and chemicals leaching from tiny pieces of plastic arising from the partial breakdown of waste plastic and the washing of synthetic textiles and clothing (ASoEC 2011).

Contaminated land data

Significantly contaminated land is regulated under the *Contaminated Land Management Act 1997* (CLM Act). Sites declared contaminated have data recorded about them, including the types and levels of contaminants and stage of remediation. However, this information cannot be used to make inferences about overall chemical levels in soils across the state. This is because these regulated sites are special cases of intensive use of hazardous chemicals typically over long periods, where known poor management practices were involved or particular sectors or activities (such as petroleum storage) operated. Contaminated sites that do not pose an unacceptable risk under the current or approved use are regulated under the planning process using the *Environmental Planning and Assessment Act 1979* and *State Environmental Planning Policy No. 55 – Remediation of Land.*

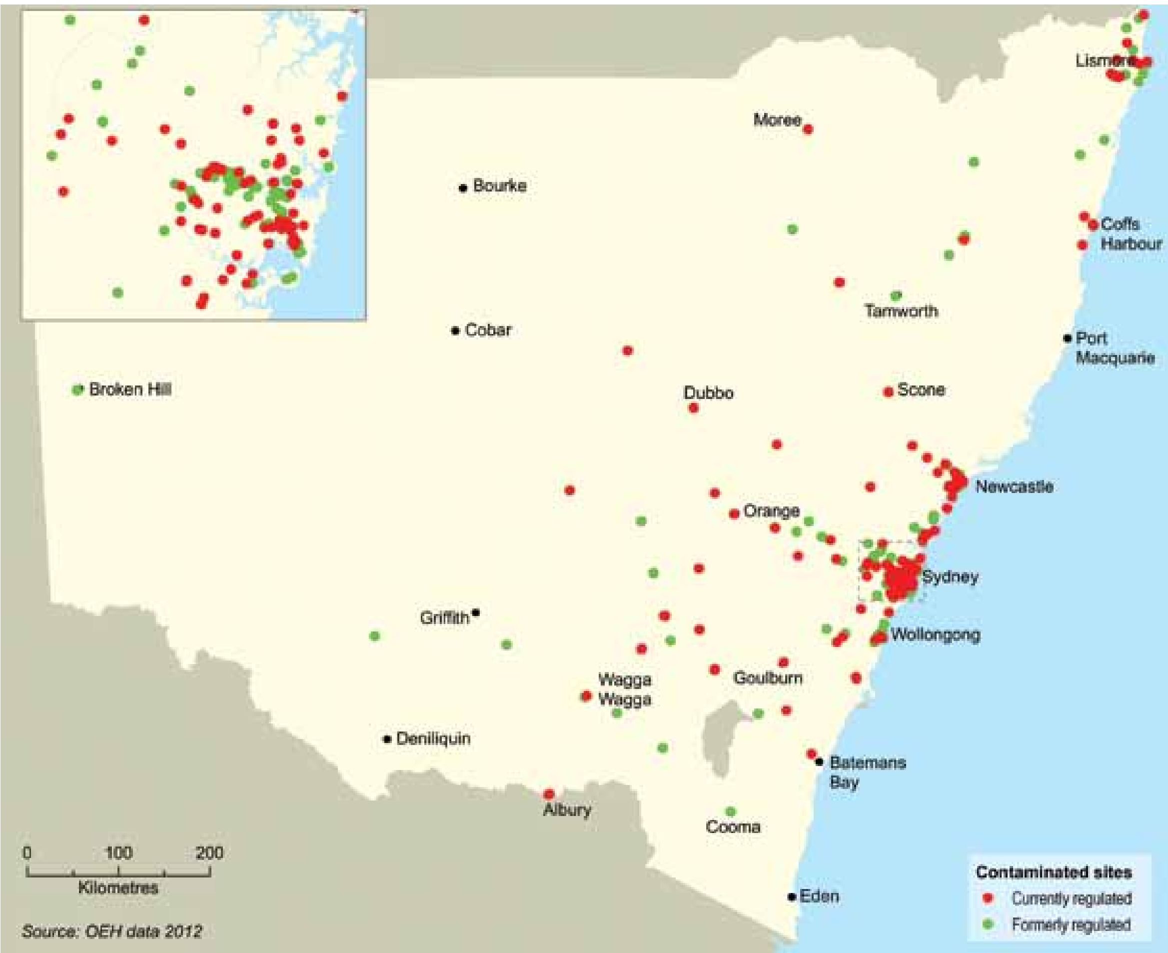
In April 2012, approximately 300 contaminated sites had been reported and were being regulated under the CLM Act (**Map 3.6**). Key contaminating activities include service stations and other petroleum industrial sites (37% of contaminated sites), chemical, metal and other industrial sites (10%, 7% and 16%, respectively) and former gasworks and landfill sites (12% and 9%, respectively).

The number of potentially contaminated sites being reported has increased due to passage of the *Contaminated Land Management Amendment Act 2008* which improved the clarity of reporting requirements under the CLM Act. Approximately 970 have been notified since December 2009, after new triggers for notification and regulatory action were based on endorsed national guideline criteria rather than the previously used concept of 'significant risk of harm'. This large increase in the number of contaminated sites being reported to the NSW Government compares with around 500 site notifications received between 1998 and 2009. Screening of the sites reported since December 2009 has identified a further 150 sites that will be regulated under the CLM Act.

By June 2011, the NSW Government had facilitated the remediation of around 100 sites since 1997. Between July 2008 and June 2011, 32 sites were remediated under the CLM Act.

A number of large remediation projects have been completed in 2012, including the Rhodes Peninsula in Sydney and BHP Billiton's Hunter River remediation. Rhodes Peninsula, which has undergone remediation since the 1980s, has resulted in productive land being turned into a populous residential area open to the community. Finalisation of the remediation at the Hunter River site in Mayfield has been deemed Australia's largest-ever sediment remediation project. Its completion marks the removal of the risks posed to the aquatic environment and enables redevelopment of a former contaminated site, with improved access to the river and better opportunity for local industries still operating there.

Map 3.6: Contaminated sites regulated and reported under the Contaminated Land Management Act 1997 in NSW



Since the commencement of the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation in 2008, more sites with leaking underground storage systems have been investigated. This has led to over 750 sites with leaking fuels being reported. Leaks from underground systems can go unnoticed for many years and cause significant environmental and financial impacts on the communities affected.

Contaminated food and produce

The inappropriate or illegal use of chemicals in farming, silviculture and horticulture, and leakage from contaminated land can leave residues and contaminants in produce intended for human or animal consumption. Information on chemical residues in food is available through national programs that test for a number of chemicals. Food Standards Australia New Zealand (FSANZ) publishes the Australian Total Diet Studies, which report comprehensive data every two years on consumers' dietary exposure to a range of food chemicals. The program recently found that dietary exposures to agricultural and veterinary chemical residues were all below the relevant reference health standards, consistent with the findings from previous studies of this kind (FSANZ 2011).

The National Residue Survey analyses samples of animal and plant food products in Australia for the presence of chemical residues and environmental contaminants, such as heavy metals. Chemical and commodity combinations for sampling are self-nominated by participating industries. During 2009–10, samples were collected from 21 grain commodities and products, pulses and oilseeds, and five horticultural commodities. The overall rate of compliance remained very high, consistent with previous surveys (DAFF 2011).

FSANZ also conducts one-off analytical surveys that target particular chemical contaminants that may be present in food, such as bisphenol A, dioxins and brominated flame retardants. In 2010, FSANZ analysed the levels of bisphenol A in food and drinks available in Australia. This chemical is used in many applications, including the lining of food and beverage packaging, to protect food from contamination. Only a limited number of products were found with detectable levels of bisphenol A, well below the levels of potential concern (FSANZ 2010).

Chemicals in living things

Effective mechanisms for detecting and mitigating acute impacts arising from exposure to chemicals are in place in NSW. However, it is not clear whether the chemicals that have been detected in the NSW environment as a result of human-related activities are causing adverse ecological or human health impacts in the long term. In order to rigorously assess this, better information is needed about chemical levels found in living things. Overseas monitoring of a selected number of chemicals has shown that, while the general public is widely exposed to mixtures of hundreds of manufactured chemicals (or their breakdown products), the levels of individual chemical components are generally present at levels well below those expected to pose risks (CDC 2009). One small study found 287 commercial chemicals, pesticides and pollutants in the umbilical cord blood of 10 newborn infants (EWG 2005).

Monitoring for the presence in NSW people and the environment of persistent organic pollutants and heavy metals (chemicals known to pose risks at relatively low levels) is mostly based on one-off activities, generally at single locations and points in time. For example, chemical residues in fish have been monitored to determine whether they should be eaten; blood-lead levels in children have been measured to determine the effectiveness of regulatory campaigns and lead management programs; and a small number of chemicals in animals killed at roadsides have been measured to determine the levels in wildlife and the effectiveness of pest abatement programs.

This monitoring, although limited, has shown that pollutants like triclosan (used in consumer products), brominated flame retardants (chemicals applied to prevent electronics, clothes and furniture from catching fire) and fluorinated chemicals are all found at low levels in NSW in humans (Toms et al. 2008; Toms et al. 2011) and flora and fauna (Thompson et al. 2011). Monitoring has also demonstrated the effectiveness of regulatory programs and health campaigns in greatly reducing chemical levels in people and other living things, such as the phasing out the use of lead in petrol (Gulson et al. 2006; Boreland et al. 2008).

Effects of chemicals on humans and the environment

There is growing evidence that chemicals in the environment may contribute to a range of adverse human health and environmental impacts (Diamanti-Kandarakis et al. 2009), including certain cancers (PCP 2010), asthma, developmental disorders (Grandjean et al. 2008), reproductive impairment, neurodegenerative conditions (such as Parkinson's disease), diabetes (Patel et al. 2010) and obesity (Holtcamp 2012). In particular, concerns have been raised about the potential impacts of manufactured chemicals, including those released from certain consumer products, on children and pregnant women (AAoP 2011).

Although the impacts posed by chemical exposures are complex and therefore attract considerable debate, some negative effects are well-documented, for example in the case of lead, asbestos and many pesticides. Toxicity varies depending on the amount an organism is exposed to (even water is harmful if ingested in very large quantities); the timing (certain stages in a life cycle, such as during early stages of development, have been shown to be particularly vulnerable); and the presence of other exacerbating factors, such as poor nutrition, stress and other chemicals.

The Organisation for Economic Cooperation and Development (OECD) is particularly concerned about those substances that may be hazardous, but which have not yet been characterised as such due to a lack of toxicity data and are therefore not listed anywhere as being priority pollutants that require controls (OECD 2001a). Possible combined effects of exposure to mixtures of numerous chemicals at low levels in the environment or in consumer goods, especially young children, are receiving particular attention by scientists, policymakers and community groups (Bonnefoi et al. 2010). Furthermore, some adult diseases are linked to early-life or even prenatal exposures (EEA 2010).

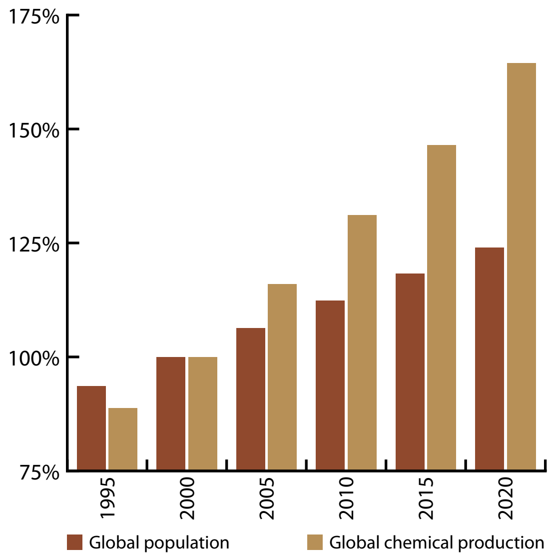
Most Australian data on chemical-related health effects relate to acute effects and high exposure levels, for example, data collected by Poisons Information Centres (NSWPIC, VPIC, QldPIC and WAPIC), rather than potential effects related to environmental exposures which are typically chronic low doses. As the chronic exposure data to chemicals is unavailable, assessments are performed to estimate the risks on a case-by-case basis.

Pressures

A number of pressures will have an impact on the regulation of chemicals. These include the growing global population and greatly increasing global production of chemicals, technological changes, climate change in relation to the fate, distribution, and even toxicity of chemicals, and finally the increased drive for sustainability.

Figure 3.2 shows projected increases in global chemical production compared with global population growth. Production is expected to grow 3% per year, while population increases 0.77%. On this trajectory, chemical production will jump 330% by 2050, compared with a 47% increase in population, relative to the year 2000 (OECD 2001b; UoC 2008). This imbalance will not necessarily lead to increased risks to human health and the environment if the toxicity and persistence of chemicals manufactured and used are significantly reduced through cleaner production approaches. There is increasing consumer demand for safer chemicals and a growing number of businesses are capitalising on this trend, simultaneously reducing their liabilities and the extra regulatory requirements associated with using more hazardous substances (Environment California 2010).

Figure 3.2: Projected increases in global population and chemical production



Source: OECD 2001b

Technological changes will bring both potential benefits and potential risks. For example, nanotechnology is being used to tackle a range of environmental issues, including purifying water, monitoring pollutants in the environment and more efficient generation of energy. However, there has been much discussion about the potential for the unique features of nanomaterials to pose new environmental, health, occupational and general safety hazards. The challenge for society is to realise the benefits of technologies but be alert to potential risks and take appropriate and timely action to avoid them.

Climate change will affect the quantity, fate and transport of chemicals released to the environment. For example, as global average temperatures rise, additional unintentional releases of chemicals to the environment are expected following accidental fires in buildings and landfills. Changes in rainfall patterns and a greater frequency and intensity of storms in some regions will increase and widen the distribution of debris containing a range of contaminants, such as asbestos and heavy metals. Landfills and contaminated sites may need better flood protection upstream and contamination barriers downstream to filter the groundwater leaching out of them (CRC CARE 2012). The melting of ice, which has previously trapped persistent organic pollutants and other contaminants, is leading to recirculation of these substances back into the environment (Ma et al. 2011). Increased ambient temperatures, such as might occur with climate change, may cause mean metabolic rates to increase in cold-blooded animals (such as reptiles, fish and invertebrates), possibly altering their susceptibility to the toxicity of some chemicals. For example, one NSW study found that exposure to a chemical at a level formerly believed to be harmless actually affected the ability of fish to tolerate higher water temperatures (Patra et al. 2007).

A key challenge for achieving a sustainable society will be to balance or otherwise address trade-offs so that environmental improvements in one area do not introduce new or increased risks elsewhere. This is particularly important with respect to resource recovery. For example, successful water saving campaigns will increase the concentration of contaminants in sewerage treatment plant discharges as the volume of discharges from plants decreases, potentially increasing risks to the aquatic environment. Similarly, NSW policy recognises that beneficial reuse of wastes must ensure that this does not cause the dispersal of hazardous substances into the environment (see People and the Environment 1.3). These considerations also apply to protecting and conserving water, air and soil resources.

Responses

In response to an increasing production of chemicals, new information about the presence of chemicals in living things and the environment, and a growing understanding of the potential associated risks, greater attention is being paid to the appropriate regulation of chemicals. This is reflected in the number of chemical-related reviews, regulations and proposals worldwide and in Australia.

Established responses

An increasing number of international agreements recognise the need for appropriate controls throughout the entire life cycle of chemicals. In the case of persistent bioaccumulative toxic substances, this has meant action early in the life cycle by preventing the use or generation of these chemicals: for example, the *Stockholm Convention on Persistent Organic Pollutants* (the Stockholm Convention) aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). In 2010, nine more pollutants were proposed to be added to the list in addition to the original 12, including certain pesticides and industrial chemicals such as DDT, PCBs and dioxin. Newly listed chemicals include lindane (a pesticide no longer used in Australia and soon to be prohibited), pentachlorophenol (an industrial by-product), certain flame retardants (no longer used in new products in Australia) and PFOS (used in a wide range of products and processes).

At the state level, the following legislation controls the use or release of chemicals into the environment:

- the *Protection of the Environment Operations Act 1997* (POEO Act), which regulates chemical pollution and wastes, establishes management and licensing requirements, and includes chemical offence provisions
- the *Environmentally Hazardous Chemicals Act 1985*, which regulates chemicals of particular concern throughout their entire life cycle, thereby minimising potential environmental impacts from hazardous chemicals and chemical waste in NSW
- the *Contaminated Land Management Act 1997*, which regulates sites that are contaminated with chemical wastes that pose a significant risk of harm to human health and/or the environment
- the *Pesticides Act 1999*, which regulates and controls the use of pesticides in NSW.

NSW has taken the following action to reduce risks arising from present and past activities involving chemicals:

- The Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation, which commenced in June 2008, focuses on a preventative approach to minimising the risk of soil and groundwater contamination from leaking underground storage tanks. In recent years, industry in NSW has adopted best recognised practices for the operation of underground systems, such as inventory control and regular monitoring of systems. These practices have helped reduce the risk of fuels leaking from the storage systems and thus the risk of serious harm to the local community and environment.
- A campaign was completed in 2011 to reduce chemical emissions from industry that caused photochemical smog in Sydney and Illawarra. Licence conditions under the POEO Act required major industries to adapt their operations to alternative, more efficient and cleaner methods and materials production. As a result of shifting to a cleaner production approach, much of major industry reaped many benefits, in particular, saving operational costs associated with raw materials and energy.
- In October 2011, a survey of NSW businesses and research organisations that work with nanotechnology or nanomaterials sought to better understand their operations, including workplace practices and knowledge gaps in the use and handling of these materials. The information from the survey will be used to inform further work by the government in relation to nanotechnology, including helping regulators to monitor safe work practices and understand the risks associated with this emerging technology.
- In 2009–10, a program of bilingual extension officer services aimed to increase the participation of farmers from diverse cultural and linguistic backgrounds in mandatory training courses on the safe use of pesticides. The ongoing courses also promote best practice methods for using chemicals that reduce the risks to human health and the environment.
- Preventative strategies are being implemented for certain high-risk industries, such as sites with underground petrol storage systems, marinas, galvanisers and timber treatment sites. Strategies include targeted environmental audits, identification of best practice measures, and revisions to licensing conditions.

Developing responses

Given the division of responsibilities for regulating chemicals between state and national governments and the desire to harmonise legislation, much of the work to develop policies and programs that promote effective controls on chemicals is coordinated at the national level. The Council of Australian Governments (COAG) has nominated chemicals and plastics as a priority for regulatory reform and reducing red tape (COAG 2009). A 2008 study by the Productivity Commission recommended a broad range of reforms, many of which have now been endorsed by COAG (Productivity Commission 2008).

NSW has been very active in these reforms covering industrial chemicals, agricultural and veterinary chemicals, waste and consumer products. NSW is working with other jurisdictions to implement reforms to achieve a national approach to managing the impact of chemicals on the environment through the National Framework for Chemicals Environmental Management (NChEM). The COAG Standing Council on Environment and Water is overseeing these reforms which are discussed below.

Industrial chemicals

The potential environmental and health risks of industrial chemicals are assessed under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). All new chemicals are assessed before being marketed in Australia, except when chemicals are eligible for an exemption. However, as in other countries, 39,000 older chemicals that were on the market prior to the establishment of the scheme may be used without assessment. NICNAS is planning to evaluate approximately 3000 chemicals within the next four years as part of the staged implementation of a new Inventory Multi-tiered Assessment and Prioritisation Framework. This is the first time that information about the risks associated with a large group of industrial chemicals will be available to regulators, chemicals users and consumers. It will help inform choices about the use of safer chemicals and the identification of appropriate controls for those still in use.

Agricultural and veterinary chemicals

In late 2011, the Australian Government announced a range of proposed enhancements to the legislation governing the operation of the Australian Pesticides and Veterinary Medicines Authority, which is responsible for the regulation of these chemicals up to, and including, their point-of-sale. The proposed reforms are expected to result in improved health and environment protection for the broader community by requiring companies to regularly demonstrate that their chemicals meet health and environmental standards and placing an upper limit on the time taken for chemical reviews. In many cases, particularly for low-risk products, the proposed amendments will reform the current system to provide more timely outcomes. The proposed reforms also introduce a time limit on the approval and registration of agricultural and veterinary chemicals, providing a periodic review of a chemical's safety.

Product stewardship and waste management

Important reforms in waste policy and product stewardship are being progressed nationally. The *National Waste Policy: Less waste, more resources* (EPHC 2009), agreed to by all Australian environment ministers in 2009, leads the way for a new, coherent, efficient and environmentally responsible approach to waste management in Australia. It establishes a comprehensive work program for national coordinated action on waste across six key areas, including reducing hazard and risk in products. This is the first time that reducing the toxicity of chemicals in products has been recognised, putting Australia in line with other countries at the forefront of ecologically sustainable approaches. National Product Stewardship legislation has been passed recently. This important development will require producers to take more responsibility for their products, including reducing the toxicity of ingredients (see People and the Environment 1.3).

A growing number of non-government initiatives are encouraging a progressive approach to chemicals management through substitution of hazardous substances with safer alternatives, including non-chemical options. For example, a new $72.8-million green chemistry and engineering project announced in 2010 is developing a Green Chemical Futures facility at Monash University in Victoria. This nationally co-funded initiative will provide opportunities for the Plastics and Chemical Industries Association, CSIRO and other partnering institutions from Australia and overseas, including the United States, India and Japan, to develop and promote environmentally safer chemicals. The project is an expansion of work undertaken at the Centre for Green Chemistry at Monash University, which currently conducts innovative research, develops and promotes green chemistry in educational materials, and provides training in sustainable chemical policy for regulators.

Future opportunities

The OECD has identified chemicals in the environment and in products, particularly persistent bioaccumulative and toxic chemicals, as a 'red light' issue (OECD 2001a). Views on how to respond effectively to these concerns have been changing. Until recently, regulatory attention worldwide focused on managing risks at the end of a chemical's life cycle through regulating emissions, discharges and wastes – the so-called end-of-pipe approach. The human and financial costs associated with legacy issues from once commonly used chemicals, such as asbestos, CFCs and DDT, are encouraging a shift toward the use of safer, greener chemicals at the outset.

The primary difficulty in chemicals management, however, is the lack of knowledge about the properties, effects and exposure patterns of the great majority of chemicals, industrial chemicals in particular. Many programs are under way worldwide, including in Australia, to address this concern, leading to much new information about chemical risks and better alternatives. Examples are the existing NICNAS chemical assessment and prioritisation program and the Monash University Green Chemical Futures program. This new information will support application of the substitution principle (choosing safer chemicals) and open up opportunities for its use in sustainability programs.

The initial focus of many sustainability initiatives has been on reducing the use of energy and water as well as the generation of waste. It is not clear how successful this has been in promoting the development and use of greener chemicals or non-chemical alternatives. This crucial aspect of sustainability, however, may be given more attention in NSW as new information about the risks of chemicals and their alternatives becomes available. For example, overseas, organisations, including retailers, manufacturing and hospitals, are developing their own chemicals policies and action plans, going well beyond current regulatory requirements (Environment California 2010). These proactive approaches include using screening tools to identify potentially hazardous substances as well as developing their own lists of priority substances to phase out of their operations and supply chains. There are opportunities to explore similar initiatives in NSW.

Current indicators focus on chemicals at the end of their life cycle, that is, chemical residues in food or chemicals in contaminated sites. As more data becomes available, indicators that provide a more comprehensive picture regarding chemical impacts on the environment may be developed.

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Water 4

4.1 Water resources

After a period of protracted drought, widespread rains across New South Wales have increased river flows and the water available in storages. As of 2011–12, most major storages stood at over 90% capacity.

River flows have generally been higher than average in the major inland river valleys over the past two years and levels of extraction have been relatively low for the flow levels experienced.

The ongoing impacts of water extraction and flow regulation, together with the residual effects of the drought, remain significant pressures on the health of river systems.

Demand for the state's water resources is high and needs to be managed through water sharing plans to balance equity of access for users, while maintaining ecosystem health. Since 2004, a total of 63 water sharing plans have been implemented across NSW, covering about 95% of water use. Plans for the remaining water sources are being developed progressively with those for the Murray–Darling Basin to be completed in 2013 and for the rest of the state by 2014.

In June 2012, cumulative holdings of environmental water by the NSW Government stood at 357,141 megalitres (ML). In each of the past two years, just over a million ML (on average) of environmental water have been delivered to environmental assets, a substantial rise compared with the 123,000 ML delivered in 2009–10.

NSW indicators

Indicator and status	Trend	Information availability
Available water supply (in storage)	Increasing	✓✓✓
Proportion of water extraction covered by water sharing plans	Increasing	✓✓✓
Environmental share of available water	Increasing	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Water resources are critical for many human needs, such as the supply of town water, and stock and domestic water, the irrigation of crops, and for mining and industry. Most of these needs are satisfied by water held in storages or extracted from rivers and groundwater. Rainfall runoff is also collected in farm dams and floodwater is harvested from river floodplains.

The need to maintain a healthy environment as well as securing water resources to enable future 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 maintain the food chains that support fish and other aquatic species. Floods and river flows enrich floodplain soils and provide connectivity between different aquatic habitats and ecosystems. The health of riverine ecosystems is discussed in Water 4.2, wetlands in Water 4.3 and estuaries and coastal lakes in Water 4.6.

Planning for water use to meet socioeconomic demands and environmental needs must be balanced and take into account the long-term variability in water availability due to the extremes of climate, such as droughts and floods. To address this, NSW is developing statutory water sharing plans under the state's *Water Management Act 2000* to provide certainty for all users as well as the environment. These plans, which are discussed later in this section, 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 in NSW

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 the State Water Corporation. The remainder comes mainly from groundwater in the major inland alluvial systems (see Water 4.4), with the balance drawn from unregulated rivers.

Figure 4.1 shows how this water was used by different sectors in three individual years (2000–01, 2004–05 and 2008–09). Total water use varies considerably from year to year. In the three years depicted it fell by 33% from an estimated 8800 GL used in 2000–01 just at the start of the drought to around 6000 GL in 2004–05 and then a further 23% to around 4500 GL in 2008–09.

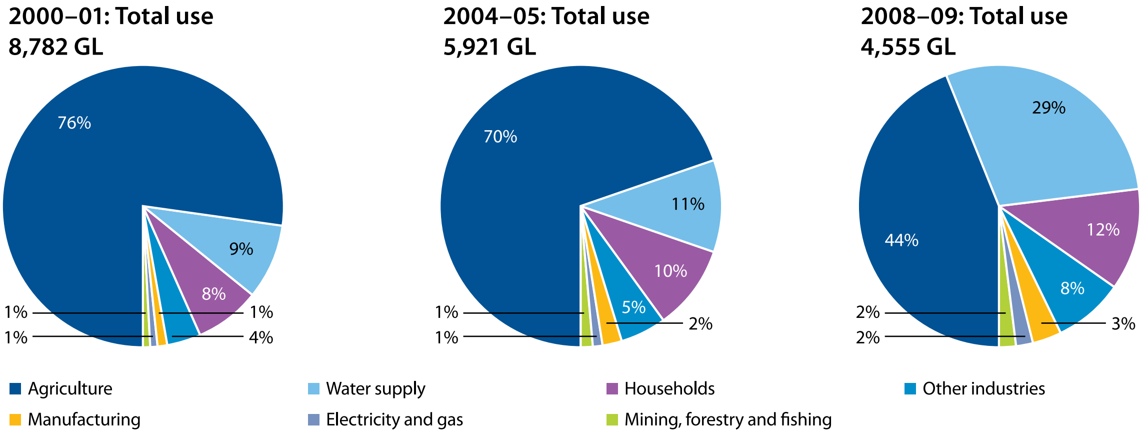
In all three years agriculture was the largest user of bulk water, ranging from just under 80% during a period of relatively good water availability in 2000–01 to 44% towards the end of the drought in 2008–09. Water supply – which includes sewerage and drainage services, as well as water lost to evaporation and leakage during water delivery – was the next largest 'user'. It accounted for almost 10% of total water use during periods of higher water availability, but increased considerably in both absolute and relative terms during the drier years of the drought. By contrast, the next highest water use – domestic household use – decreased in absolute terms as conservation measures were implemented during the drought, although its relative share increased.

Water availability

The factors that most significantly influence water availability are climate (rainfall and temperature) and storage capacity. Water supply largely depends on the regulation and storage of river flows in large dams for human consumption as well as for agriculture and industry. The dams have the effect of 'smoothing' out the natural variability in water availability by storing large volumes during periods of high river flows and releasing water to meet demand and supplement periods of low rainfall or extended drought.

By contrast, much of the extraction on unregulated rivers tends to occur at low-flow levels as irrigators access water to supplement periods of low rainfall. This is particularly the case on the coast, tablelands and slopes. During high-flow periods in these areas, water demand and thus the volume pumped from a river tend to be lower. However, on the inland plains, where unregulated river flows are less reliable, users access higher flows and often pump water into off-river storages to meet needs through dry periods.

Figure 4.1: Water consumption in NSW by sector, 2000–01, 2004–05 and 2008–09



Source: ABS 2006; ABS 2010

Notes: 'Water supply' includes sewerage and drainage, as well as the water lost through evaporation and leakage in the process of water supply.

NSW has 19 major dams and storages. The largest dams are the Eucumbene, Hume, Warragamba, Blowering, Copeton, Wyangala and Burrendong. Menindee Lakes also operates as a major water storage through an interconnected lake system. Much of the public storage capacity was built between the mid-1950s and 1980. The combined capacity of these storages is over 18 million megalitres (ML) of water.

Table 4.1 summarises water levels in major NSW water storages between 2006 and 2011. As of 2011–12, most of the major storages stood at over 90% of capacity. Early in the 2010–11 water year, an extended drought was broken by substantial and widespread rainfall across much of NSW, resulting in major flooding in many river valleys. Most of the major storages filled and spilled for the first time in about a decade. This provided substantial improvements to water availability in NSW and full water allocations in most valleys. The flooding also caused substantial inundation of floodplains and the restoration of important wetlands.

Water extraction

The major regulated river valleys in NSW are the Murray, Murrumbidgee, Lachlan, Macquarie, Border, Gwydir, Namoi and Hunter and these represent the bulk of water extraction in NSW. Significant extraction also occurs in the unregulated Barwon–Darling River. A large amount of water is also extracted from the Hawkesbury–Nepean for urban use in Sydney. Water from the Snowy River is stored and diverted inland to the Murray and Murrumbidgee rivers to supplement water extraction in those valleys.

Table 4.1: Storage levels at major public water storages managed by the State Water Corporation in NSW, 2006–11

Valley and storage	Storage volume (% of full capacity)					
	2006	2007	2008	2009	2010	2011
Selected inland water storages of the Murray–Darling Basin						
Border Rivers: Glenlyon Dam	28	13	35	24	22	99
Border Rivers: Pindari Dam	66	23	31	43	25	99
Gwydir: Copeton Dam	23	10	21	12	7	50
Namoi: Keepit Dam	17	4	21	36	28	98
Namoi: Split Rock Dam	19	3	5	5	3	21
Macquarie: Burrendong Dam	28	9	18	19	17	91
Lachlan: Wyangala Dam	21	11	10	6	7	92
Lower Darling: Menindee Lakes	16	5	31	31	91	116
Murrumbidgee: Blowering Dam	53	23	36	32	46	97
Murrumbidgee: Burrinjuck Dam	33	34	41	37	41	88
Murray: Hume Dam	21	13	16	11	27	92
Coastal water storages						
North Coast: Toonumbar Dam	100	84	100	101	101	102
Hunter: Glenbawn Dam	38	32	54	72	67	96
Hunter: Glennies Creek Dam	38	33	60	80	70	88
South Coast: Brogo Dam	68	103	99	29	101	101

Source: State Water Corporation data 2011
Notes: The total volume of water storage for NSW includes some storages not included in the table.
Storage volumes are as recorded at 1 July each year.

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' below). At the beginning of each water accounting year and sometimes 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 over all other licensed purposes. Other high security licences receive allocations in all but the driest years and are typically used for irrigation of permanent plantings, such as horticulture and vines, as well as 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 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 are based on climate and flow data for the last 120 years. They describe the variation that can be expected in river flows and water extraction over the longer term and provide 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 typical wet flows than during dry periods. By contrast, when flows are low, there is less water available in total and a greater proportion of it is allocated for consumption.

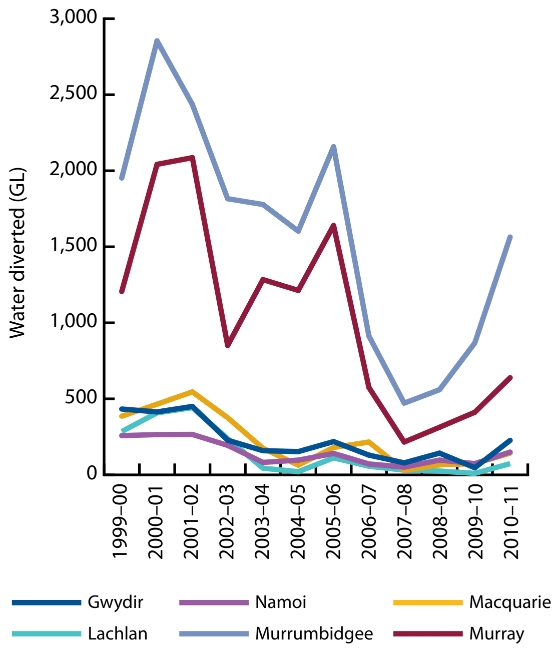
Current river flows and extractions

Up until 2010–11, water extractions over recent years have been substantially lower than average. **Figure 4.2** shows that the overall quantity of water extracted from regulated rivers fell as the severity of drought conditions intensified up until 2009–10, and then rose in 2010–11 as the heavy rains across NSW increased surface water availability.

The proportion of water extracted and that remaining for the environment in the major regulated river valleys of NSW is shown in **Figure 4.3**. In all of the river valleys depicted over the 12 years shown, river flows only exceeded median flow levels in two years, except for the Macquarie (three years). In general terms, the higher flows were at either end of the 12-year period, with dry flow levels or worse being experienced in most of the intervening years.

The period described (1999–2011) was exceptionally dry and the usual patterns of river flows and water usage did not apply, with water sharing plans being suspended in some river valleys. However, the proportion of water retained in river systems was relatively high during the isolated wet years. During most of the dry years, extraction levels fluctuated around 50% of water available, except for the Murrumbidgee, where extraction levels were consistently higher, and the Lachlan, where they were generally lower.

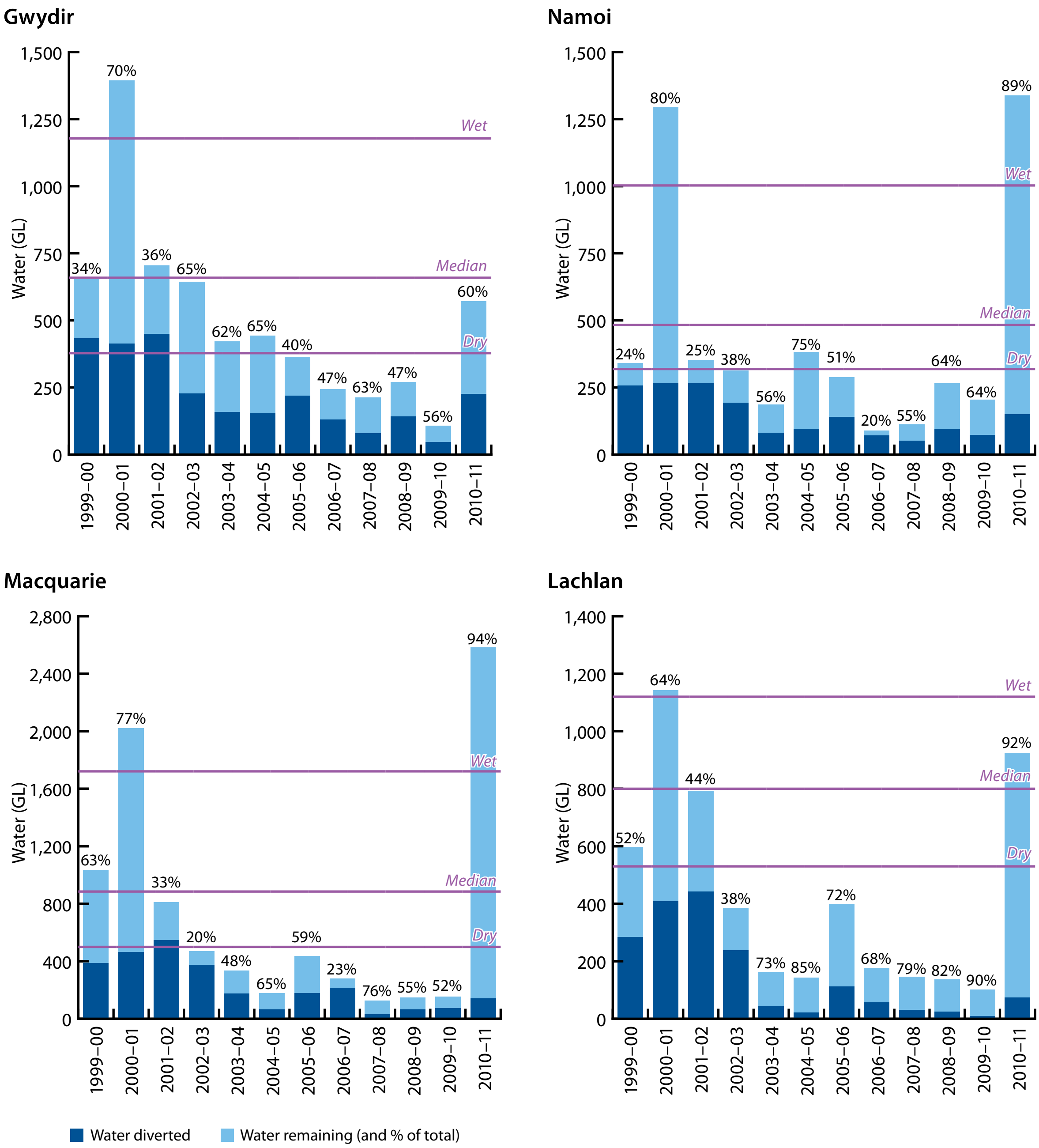
Figure 4.2: Water diverted by licensed users in major NSW regulated valleys, 1999–2000 to 2010–11



Source: NSW Office of Water (NOW) data 2011

Notes: Observed diversions are metered general security, high security and supplementary diversions.

Figure 4.3: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2010–11



Source: NOW data 2011

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.

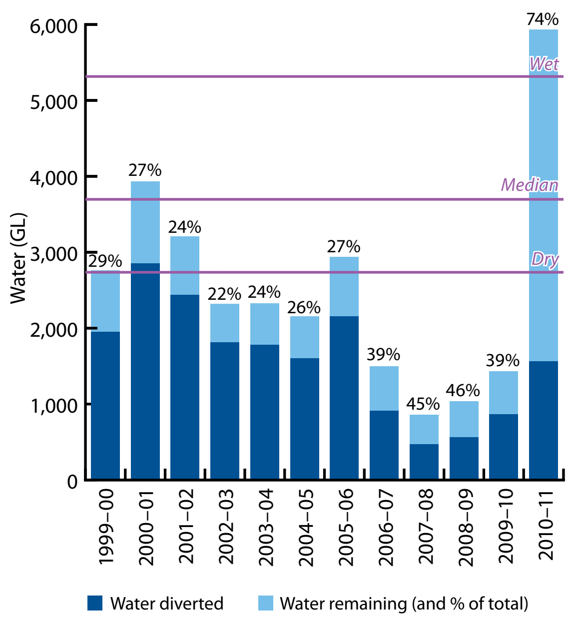
The data for each valley represents total water available and is taken from a representative gauging station downstream of major tributary inflows and upstream of major extractions.

Total flow and observed diversions in the Murrumbidgee Valley are influenced by water released from the Snowy Mountains 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.

Figure 4.3: Diversions and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2010–11 (continued)



Source: NOW data 2011
Notes: See previous page.

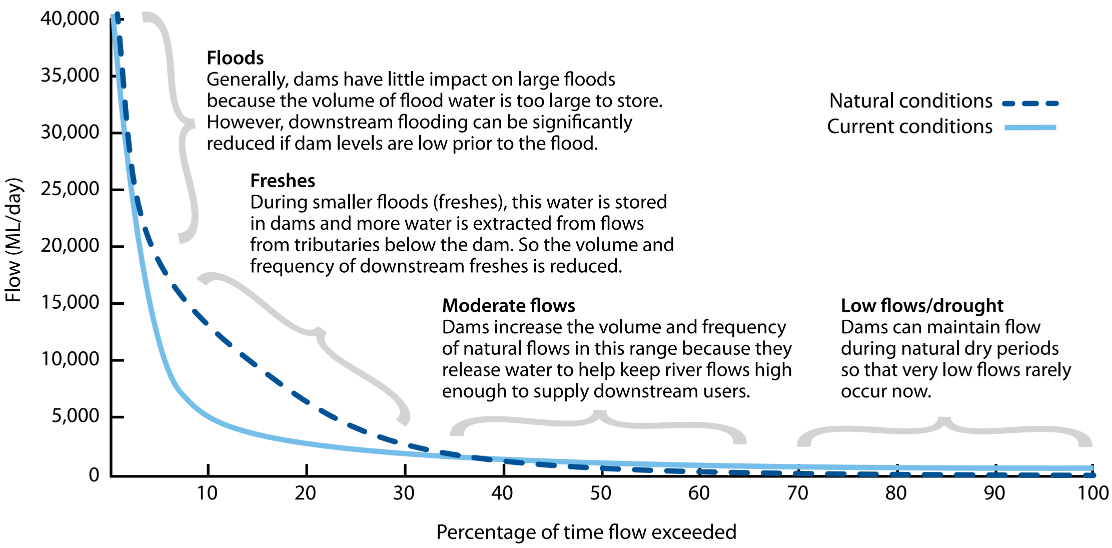
Floodplain harvesting is the collection, extraction, diversion or impoundment of water flowing across floodplains, a practice that further reduces the volume of the 'water remaining' shown in Figure 4.3. Extractions occurring through floodplain harvesting are not included in the extractions described in the figure as they have not yet been licensed. Floodplain harvesting is considered to be most significant in the valleys of the northern Murray–Darling Basin, including the Border, Gwydir and Namoi rivers.

Effects of water storage and river regulation

River flow regimes are characterised by the magnitude, timing and duration of various flow levels. How often a flow of a particular volume is likely to occur can be illustrated by a flow duration curve. A flow duration curve, such as shown in **Figure 4.4**, plots the volumes of flow (ML per day) against the percentage of days that such a flow will be equalled or exceeded. These curves can be used to illustrate the volumes of water typical for a given river for low flows, moderate flows, freshes and floods, as well as the changes to natural river flows (particularly volumes) that can occur as a consequence of building dams and regulating flows.

Dams generally have a minimal impact on large floods. During high flows or 'freshes' (flows that occur around 10% of the time), dams exert their greatest impact and flow levels can be significantly reduced. During moderate flows (median flows that occur 50% of the time), levels may be increased downstream of dams as operational releases for water supply to users lift flow levels. In regulated systems, low flows are increased artificially to maintain flows and continue providing water for users.

Figure 4.4: Hypothetical flow duration curve showing the potential effect of major dams on natural river flows



Source: DLWC 2000

Individual river systems have differently shaped flow duration curves and experience varying impacts according to their own specific flow levels and patterns of extraction. The data in Figure 4.3 provides a better indication of the actual extent of extraction in a particular river valley and its potential level of impact on river systems.

Flow regulation has two additional effects on natural ecosystems. Firstly, it causes a dampening of the seasonal fluctuations and natural flow variability of rivers that result in the boom and bust cycles in response to which many of Australia's aquatic ecosystems have evolved. Secondly, and less apparent from the flow duration curve, regulation has the effect of reversing the seasonality of flows by storing water during high winter flows and releasing it in summer when flows are naturally low.

Environmental water

To offset the impact of water extraction and flow regulation and 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 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 the environmental water described as 'held water' under Commonwealth legislation. It is generally purchased in water markets from willing sellers or 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.

Table 4.2 provides examples of some environmental water rules currently in use in the regulated river system.

Unregulated water sharing plans generally rely on rules that limit extraction of river flows to protect a share of water for the environment. In most cases, rules set out an annual extraction limit and a low-flow 'cease-to-pump' level. This threshold – when pumping stops – is intended to minimise impacts on low flows and protect water for basic ecosystem health and riparian water users.

Table 4.2: Examples of environmental flow rules under water sharing plans in NSW regulated rivers

Environmental flow rule	Purpose	Valleys where rule applies
Diversion limits	Precludes increases in the total volume of water extracted	All regulated rivers
End-of-system flows	Requires a certain minimum flow to be retained at the downstream end of the river, below the areas where major extraction occurs	Hunter, Murrumbidgee, Namoi
Transparent dam releases	Requires all reservoir inflows occurring at certain times to be passed immediately downstream, as though no dam were present	Murrumbidgee
Translucent dam releases	Requires part of a reservoir inflow to be passed immediately downstream	Lachlan, Macquarie
High flow access	Limits pumping and/or total extractions when reservoirs spill or high flows enter flow-regulated rivers from unregulated tributaries	Gwydir, Hunter, Lachlan, Namoi
Environmental allowances	Creates a 'bank' of reservoir water to be used for specific environmental purposes, such as flushing blue-green algal blooms, reducing salinity or supporting bird-breeding events	Gwydir, Hunter, Lachlan, Macquarie, Murray, Murrumbidgee

Source: Department of Environment, Climate Change and Water NSW 2009

Environmental water delivery

Water purchased under programs such as The Living Murray and NSW RiverBank is used as adaptive environmental water and is additional to the planned environmental water protected through water sharing plans.

Table 4.3 presents the volumes of water that were released from storages in different river valleys through specific environmental allowances between 2009–10 and 2011–12 or as a result of adaptive environmental licences. It does not include water made available to the environment through fixed rules, such as prescribed end-of-system flows or dam transparency.

From the first purchase of water for environmental use in 2004 until June 2012, NSW has acquired the equivalent of 357,141 megalitres (ML) in water holdings across the Gwydir, Macquarie, Murrumbidgee and the NSW portion of the Lower Murray–Darling river systems. Table 4.3 shows the result of increased water availability after the above-average rainfall in 2010 following the extended drought conditions. Around 937,000 ML of environmental water were delivered to environmental assets during 2011–12 and 1,141,000 ML in 2010–11, substantially more than the 123,000 ML delivered in 2009–10.

These environmental water deliveries included nearly 200,000 ML of environmental water to the internationally important Macquarie Marshes and 400,000 ML to wetland systems in the Murrumbidgee, including the mid-Murrumbidgee wetlands and the Lowbidgee area of the lower Murrumbidgee floodplain. Delivery of this water after a decade of managing small amounts of environmental water to maintain core ecosystem processes produced significant ecological responses, including widespread and successful bird breeding events, and enabled the watering of large areas of highly stressed river red gum woodland.

Pressures

Drought

Droughts occur naturally in Australia and aquatic ecosystems are adapted to periods of dryness. However, severe, extensive or prolonged drought can have major repercussions for all water users and the environment. The most recent drought was among the worst on record for some river valleys – the cumulative stress of reduced water availability over a number of years had severe environmental and socioeconomic impacts. In five river systems, it was necessary to suspend water sharing plans and contingency plans were implemented to meet critical water needs.

Table 4.3: Environmental water delivered, 2009–10 to 2011–12

Water source	2009–10		2010–11		2011–12	
	Environmental water allowance	Adaptive environmental water	Environmental water allowance	Adaptive environmental water	Environmental water allowance	Adaptive environmental water
Gwydir	–	70	5,000	17,783	16,500	1,798
Macquarie	16,000	4,784	139,101	60,210	88,229	65,251
Lachlan	–	–	–	10,334	–	27,551
Murrumbidgee	30,372	56,146	185,249	233,926	132,003	91,394
Murray and Lower Darling	15,606	–	219,000	270,768	283,100	231,086
Total	61,978	61,000	548,350	593,021	519,832	417,080
Total environmental water	122,978		1,141,371		936,912	

Source: NSW Office of Environment and Heritage (OEH) data 2012

Notes: All values in megalitres

'Environmental water allowance' refers to water held in storage for release to assist in environmental watering.

'Adaptive environmental water' refers to water allocated to the environment under the conditions of water access licences and includes licences held by the Commonwealth Environmental Water Holder and water sourced through The Living Murray and coordinated by the Murray–Darling Basin Authority.

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 2010a) shows the decline and/or loss of wetland communities that has resulted from water extraction, combined with the effects of river regulation and drought. This finding necessitated a formal notification by the Australian Government to the Ramsar Convention of a likely change to the ecological character of this Ramsar-listed wetland caused by human disturbance.

The Sustainable Yields Assessment Project for the Murray–Darling Basin (CSIRO 2008a) 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 and that climate change could have additional effects on the seasonal patterns and overall availability of flows.

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 contributes 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 2008a). 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 that also has no significant water extraction. These results show a strong pattern of conformity with the overall river ecosystem health outcomes described in Table 4.5 and Map 4.1 in Water 4.2.

Climate change

Over the longer term, projected changes in rainfall due to climate change are expected to create risks for water availability (Climate Commission 2011; Vaze & Teng 2011). In addition, the frequency and intensity of heavy rainfall events is likely to increase as the climate continues to warm. A pattern of more severe droughts and intense rainfall events would increase the risk of severe flooding when rain does occur, particularly in low-lying areas, such as the Illawarra region (Climate Commission 2011). The impacts of climate change on rainfall events leading to flooding are likely to be different from the impacts on seasonal or average rainfalls (DECCW 2010b).

Analyses of modelled runoff projections indicate that a shift in the seasonality of patterns is virtually certain, with significantly more summer runoff (up to about 20% increase) and significantly less in winter (up to about 25% decrease). The projections also indicate some minor increases in autumn runoff and moderate to significant decreases in spring runoff. In northern NSW, which is dominated by summer rainfall and runoff, projections indicate a slight increase in mean annual runoff (DECCW 2010b; Vaze & Teng 2011). 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 2010b; Vaze & Teng 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 Water 4.2.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Improve the environmental health of wetlands and catchments through actively managing water for the environment by 2021'. This includes the strategic recovery and management of water for the environment to improve the health of the most stressed rivers and wetlands.

Priority actions to protect waterways include:

- 'Completing the water sharing plans for surface and groundwater sources and reporting annually on environmental water use'
- 'Driving the Commonwealth to ensure it delivers a plan for the Murray–Darling Basin that protects the environment and regional, social and economic outcomes through investment in strategic water recovery, water efficiency and river health measures'.

Progress on achieving *NSW 2021* goals and targets is regularly reported on-line and through an annual report tabled in the NSW Parliament. *NSW 2021 Performance Report 2012–13* (NSW Government 2012a) sets out baseline performance data for the goals and targets which provide the foundation for future performance monitoring and public reporting and the technical context for each NSW 2021 target.

Water reforms

Significant progress has been made in water reform in NSW including:

- introduction and implementation of the *Water Management Act 2000*, which recognises the importance of transparent and controlled allocation of water to the environment and extractive uses
- implementation of the Murray–Darling Basin cap on water extractions in the basin
- establishment of environmental and water sharing rules in water sharing plans and of tradeable water property rights
- development of 63 water sharing plans (including for groundwater), with seven more covering the remaining inland water sources to be completed by 2013, and the remaining plans for coastal water sources by 2014
- implementation of the National Water Initiative and working in partnership with the Commonwealth Government to progress four State Priority Projects
- acquisition of additional water for the environment through water savings and buyback of water licences to address historical over-extraction.

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 Commonwealth *Water Act 2007*.

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. In tracking progress against the NWI, the National Water Commission has produced a report card assessing individual water sharing plans within each jurisdiction (NWC 2011).

Murray–Darling Basin Plan

A key role for the Murray–Darling Basin Authority (MDBA) is to prepare the Murray–Darling Basin Plan, a legislative instrument that will set a long-term sustainable limit on the use of both surface and groundwater in the basin. The MDBA released a draft basin plan for public comment in November 2011. NSW submitted a response to the draft (NSW Government 2012b) which outlined the state's position on the proposed plan as follows:

- the plan should balance the needs of the environment, communities and the economy
- unavoidable social and economic costs should be identified and mitigated through a Commonwealth structural adjustment package
- water recovery should be equitably shared between basin states
- water should be recovered through a combination of improved infrastructure, environmental works and measures, review of water rules, and strategic buyback.

Revised draft plans were subsequently produced by the MDBA in May and August 2012 (MDBA 2012) and provided to the Ministerial Council (which includes the NSW Minister) for a formal response by the council, both collectively and by individual members. The plan is now expected to be finalised in late 2012.

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. As a result, a limit ('cap') on surface water extractions in the basin was introduced to prevent further growth in extractions and these are monitored to ensure that the amount of water taken by licence holders remains below the cap.

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 Water 4.4) 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.

Environmental flow rules, implemented through the water sharing plans for each river valley, enable the equitable sharing of water between users and the environment.

Since 2004, a total of 63 water sharing plans have been implemented across NSW, covering about 95% of the water used. Plans for the remaining water sources are being developed progressively with those for the Murray–Darling Basin to be completed by 2013 and the rest of the state by 2014. Over the long term, the plans for regulated rivers will return on average an additional 220,000 megalitres (ML) of water per year to the environment, over and above the requirement under the Murray–Darling Basin cap.

Additional constraints or requirements may be imposed in the Murray–Darling Basin Plan being developed by the MDBA. Long-term average annual extraction limits (LTAAEL) established in water sharing plans are generally lower than the Murray–Darling Basin cap. These LTAAELs will become the Baseline Diversion Limits under the basin plan, which will set new Sustainable Diversion Limits.

Although environmental flow rules have been introduced, it may take some time before the aquatic ecosystems receiving environmental water are restored to an acceptable environmental condition. Until recently, the severity of drought conditions in some regions of NSW has meant that insufficient water has been available for some water sharing plans to operate effectively.

Water sharing plans were suspended in the Lachlan from the time the plan commenced in 2004, and in the Murray and Murrumbidgee in September 2006, the Macquarie–Cudgegong in July 2007 and the Hunter Regulated Water Source in December 2006. During 2009–10, drought conditions eased and all plans have since been reactivated. While suspended, contingency arrangements were in place with the water available being prioritised for critical human uses, such as domestic requirements and high priority industry needs.

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.

Environmental water recovery

Water has been recovered for the environment in NSW through a number of programs including NSW RiverBank, the NSW Rivers Environmental Restoration Program, The Living Murray program (see Water 4.2), the NSW Wetland Recovery Program (see Water 4.3) and Water for Rivers. The cumulative total for all adaptive environmental water at June 2012 was 357,141 ML.

Table 4.4 summarises the amount of licensed water purchased collectively by NSW from these programs by river valley. However, it does not include water purchases by the Australian Government.

Adaptive environmental licences are also being created through water savings from infrastructure efficiency projects. These licences include over 93,000 ML of entitlement through Water for Rivers projects in NSW (see Water 4.2), as well as 63,000 ML from The Living Murray (TLM) in the state. For example, about 47,000 ML per year of water will be saved and committed as an adaptive environmental licence through TLM's Darling Anabranch Pipeline project.

Table 4.4: Cumulative holdings of adaptive environmental water recovered to 30 June 2012 by program and valley (ML)

Regulated water source	NSW RiverBank				Rivers Environmental Restoration Program			NSW Wetland Recovery Program		The Living Murray	Subtotal per valley
	HS	GS	SA	UR	GS	SA	UR	GS	SA	LTCE	
Gwydir	–	7,798	–	–	7,104	441	–	2,190	–	n/a	17,533
Macquarie	–	19,926	28	–	22,602	122	2,980	5,891	1,302	n/a	52,851
Lachlan	1,000	24,097	–	–	472	–	184	–	–	n/a	25,753
Murrumbidgee	–	27,676	5,679	6,162	–	–	–	–	–	n/a	39,292
NSW Southern Murray–Darling Basin[6]	–	–	–	–	–	–	–	–	–	221,487	221,487
Subtotal per program	1,000	79,497	5,707	6,162	30,178	563	3,164	8,081	1,302	221,487	
Cumulative total											357,141

Source: OEH 2011a; OEH data 2012; Water for the environment (water purchase programs)

Notes: The Rivers Environmental Restoration Program and NSW Wetland Recovery Program were jointly funded by the NSW and Australian Governments.

HS = High security – Shares are likely to receive close to 100% of their allocation in most years.

GS = General security – Allocation varies depending on inflows and storage levels.

SA = Supplementary access – is subject to event-based announcements

UR = Unregulated entitlement – Available water is not regulated by a major storage. For many valleys, water sharing plans for unregulated water sources have not yet been completed and licences are administered under the *Water Act 1912*.

LTCE = Long-term cap equivalent – Units of measure for entitlement purchased under The Living Murray (TLM) which approximates long-term water availability and includes all entitlement categories (HS, GS, SA, Conveyance). A breakdown of TLM water purchase and recovery is available at the website.

NSW Southern Murray–Darling Basin includes water recovered from the Murray, Murrumbidgee and Lower Darling valleys for the benefit of the Murray River (The Living Murray).

Water recovery is also occurring under the following programs:

- Pipeline NSW is a joint NSW and Commonwealth Government project to improve the efficiency of delivering rural stock and domestic water by substituting channels and dams with piped systems, tanks and troughs. The project is due for completion in 2012 and will recover about 5000 ML per year of water from reduced system and operational losses.
- The Darling River Water Savings Project was established to improve the water supply and management of the entire Darling River system, in particular for the Menindee Lakes.
- Sustaining the Murray–Darling Basin is a State Priority Project focused on improving water efficiency, particularly the investment in metering works in the basin.
- Hawkesbury–Nepean River Recovery Program: The Hawkesbury–Nepean catchment is the most developed catchment for water use in coastal NSW. This program includes the following projects aimed at water efficiency: metering of water users; water-smart and nutrient-smart farms; water recycling; reducing water use from the tap; more efficient irrigation; and purchase of water licences.

Developing responses

Floodplain Harvesting Policy

Floodplain harvesting works and water extractions fall under the scope of the *Water Management Act 2000*. The NSW Office of Water (NOW) has released a draft *NSW Floodplain Harvesting Policy* for community consultation (NOW 2010). It foreshadows that all floodplain harvesting activities will require a water supply work approval and a water access licence to harvest water, both issued under the Act. Floodplain harvesting extractions will be managed within long-term average annual extraction limits under water sharing plans.

Future opportunities

Over the next few years, water sharing plans will be completed for all river valleys, floodplain management plans will be produced, and the harvesting of water from floodplains is likely to be regulated, all with the aim of enhancing the sustainable and equitable management of water resources in NSW.

The 2008 Intergovernmental Agreement on Murray–Darling Basin Reform established a framework for greater coordination and a whole-of-basin focus for the management of basin water resources. When finalised, the Murray–Darling Basin Plan will set a new sustainable diversion cap on water extractions for each valley and any water sharing plans developed after this will need to be consistent with the plan.

With the referral of powers relating to water management in the Murray–Darling Basin through the basin plan, the Commonwealth will play a more prominent role in determining water extraction levels, coordinating environmental water management and developing future initiatives to improve water resources and river health. The NSW Government will ensure that the Commonwealth delivers a plan that protects the environment as well as the social and economic wellbeing of regional communities.

Better information on the relationship between surface water and groundwater is desirable to facilitate more integrated and holistic management of all water resources.

4.2 River health

The stresses on New South Wales inland rivers have eased after a period of protracted drought as widespread rains have led to high flows and enhanced the productivity of aquatic ecosystems. Coastal river systems have also experienced good flows that have enhanced the condition of riverine ecosystems and downstream estuaries.

The condition of macroinvertebrate communities in inland rivers is moderate, though this was recorded during low flows. Native fish populations remain in poor condition and have shown little response to higher flows. Nine out of 25 native fish species found in inland rivers were not sighted at all in recent surveys and exotic species accounted for 68% of the fish biomass sampled. Recruitment rates of native fish in coastal rivers were also very low. Large algal blooms that occurred in inland river systems during drought conditions in 2008–10 have since dissipated with increased river flows.

Most major inland river systems are still affected by pressures, including the ongoing impacts of water extraction and altered river flows, degradation of the riparian zone, catchment disturbance, invasion by exotic species and changes to water quality. As a result, most inland rivers remain in poor ecosystem health. By contrast, coastal rivers are less affected by flow regulation and, with the exception of fish communities, are generally in better ecological health.

The extent of use of water resources is a major determinant of the condition of freshwater riverine systems. Areas where the flow regime has changed the most (where river regulation and water use are highest) are generally showing the greatest signs of ecosystem stress.

Water sharing plans are being implemented for all major rivers in NSW to ensure a balance between human uses of water and the environment, with all plans for the Murray–Darling Basin to be completed by the end of 2013.

NSW indicators

Indicator and status	Trend	Information availability
Health of aquatic macroinvertebrate communities	Stable	✓✓
Health of fish assemblages	Decreasing	✓✓
Hydrological condition	Increasing	✓✓
SRA overall health index of Murray–Darling Basin rivers	Stable	✓✓
Salinity levels	Stable	✓✓
Phosphorus levels	Stable	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Healthy riverine ecosystems, comprising rivers and their riparian zones, floodplains and wetlands, are vital for the maintenance of aquatic and terrestrial biodiversity. However, while aquatic ecosystems have their own intrinsic value, 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 beneficial uses of water by humans, including activities such as agriculture, aquaculture, fishing, recreation and tourism.

NSW has approximately 58,000 kilometres of rivers and major streams. These can generally be categorised as either short, high-gradient coastal streams or long, low-gradient inland rivers. The flow of these rivers is highly variable and often unpredictable. Streams and creeks may flow permanently or only intermittently after heavy rainfall and floods. About 97% of river length in NSW has been substantially modified (NLWRA 2002). Typical changes include the removal of riverine vegetation, the regulation of river flows, sedimentation from erosion of land and river banks, and the introduction of exotic species.

A river is in good health if it is resilient in the face of environmental change, including changes in climate patterns, resource exploitation and other human impacts. A primary objective is to achieve a long-term balance, whereby the integrity of natural systems is preserved while providing for a range of beneficial human uses. Factors that affect the resilience of river systems include river geomorphology, riparian vegetation, natural flow regimes, water quality and exotic species.

This section focuses on inland and coastal freshwater riverine ecosystems, including floodplains which are essential for connecting many types of freshwater wetlands and associated ecological processes to the rivers. Other ecosystem types are discussed elsewhere in this report: freshwater wetlands in Water 4.3 and estuaries in Water 4.6.

Status and trends

The health of NSW coastal and inland rivers is likely to have improved following the breaking of a prolonged drought. In 2010, NSW had its third-wettest year on record and the wettest in over 50 years. It was also the wettest year on record for the Murray–Darling Basin (BoM 2011a). In 2010, a number of major flood events occurred in inland and coastal catchments across NSW, with significant flooding in southern NSW (BoM 2011a). Another wet year in 2011 caused further widespread flooding, particularly in northern NSW, and the flushing of most NSW river systems.

Most of the sampling of macroinvertebrates outlined in this report was, however, undertaken during drought conditions so any improvements as a result of the drought breaking will not be observed or reported until the next SoE report. For fish communities, some post-drought sampling has occurred in most valleys, excluding the Gwydir, Lachlan, Macquarie and Murrumbidgee rivers.

River health

The Sustainable Rivers Audit (SRA) has developed a methodology to assess the health of rivers in the Murray–Darling Basin (MDB) based on indexes for hydrology, fish and macroinvertebrates. More recently, measures of riparian vegetation and physical form have been added. A set of rules is used to combine the indexes for fish, macroinvertebrates and riparian vegetation to determine an overall rating of ecosystem health (Davies et al. 2012). These are reported alongside index scores for hydrology and physical form, which provide additional information on some of the drivers of ecosystem health.

Overall results for the inland river systems of the Murray–Darling Basin are summarised in **Table 4.5** and described in greater detail below. Data recorded for the three years up to the end of 2010 were available for the SRA analysis, collected mainly during drought conditions. No assessment has been conducted for those rivers in far western NSW beyond the MDB.

Development of a complementary assessment process for coastal rivers in NSW has now commenced. Coastal rivers were assessed using similar, but not directly comparable methodologies, with an extra year of data recording available for the wet conditions of 2011. However, data for the condition of macroinvertebrates in coastal rivers was not available for this report. The results for the other indicators are summarised in **Table 4.6**.

Hydrology

River flow influences virtually every facet of river ecosystem health and is therefore an indicator of river condition. The SRA hydrology condition index for inland NSW compares measured flows with reference conditions for each river using modelled data based on flow variability over the longer term (110 years of recording). The index reflects the overall effects of water resource development on historical flow patterns or the naturalness of the flow regime. However, the results are less indicative of shorter term variability or current flows, and therefore do not directly reflect the effects of either the recent drought or the subsequent flooding that has occurred in much of the Murray–Darling Basin over the past two years.

The SRA hydrology component has been broadened to assess most of the river network, not just individual locations within the regulated components and now includes:

- improved hydrological modelling and broader assessment within valleys
- the hydrological effects of farm dams and historical changes to land cover
- measures of hydrological condition for both the channel and near and far floodplain environments (with four additional measures to characterise the overbank flooding regime)
- assessments of temporal changes over the previous 12 years, alongside the condition assessment based on a longer term (30-year) record.

As a result of these changes, the condition scores for hydrology presented in Table 4.5 cannot be directly compared to those presented in *SoE 2009* (DECCW 2009).

For coastal rivers, an approach consistent with that used to calculate hydrological stress for water sharing plans was used. This approach compares peak daily demand estimates with the 80th percentile flow to develop a low-flow hydrological index. It was adopted because the vast majority of licences issued for water extraction on the coast are for unregulated flows, which are generally accessed during dry conditions when river flows are low. The exceptions to this are those valleys with major storages for town water supply and river regulation, such as the Hunter, Hawkesbury–Nepean, Shoalhaven and Snowy rivers. In these valleys, dam releases are made to allow low flows to continue, but the dams capture most high-flow events.

Table 4.5: Summary of ecosystem health and condition assessments for NSW Murray–Darling Basin rivers, 2010

Valley	Hydrology	Physical form	Fish	Macro-invertebrates	Riparian vegetation	Ecosystem health rating
Border Rivers	Good	Moderate	Moderate	Moderate	Poor	Poor
Condamine-Culgoa	Poor	Moderate	Moderate	Moderate	Good	Moderate
Warrego River	Good	Good	Poor	Good	Good	Moderate
Paroo River	Good	Good	Good	Good	Good	Good
Gwydir River	Poor	Moderate	Poor	Moderate	Moderate	Poor
Namoi River	Good	Moderate	Very poor	Moderate	Poor	Poor
Castlereagh River	Good	Good	Very poor	Moderate	Good	Poor
Macquarie–Bogan Rivers	Moderate	Moderate	Extremely poor	Moderate	Moderate	Very poor
Darling River	Moderate	Moderate	Poor	Poor	Good	Poor
Lachlan River	Moderate	Good	Extremely poor	Moderate	Poor	Very poor
Murrumbidgee River	Poor	Good	Extremely poor	Good	Moderate	Poor
Upper Murray River	Poor	Good	Extremely poor	Good	Moderate	Poor
Central Murray River	Poor	Moderate	Very poor	Poor	Good	Poor
Lower Murray River	Very poor	Moderate	Poor	Moderate	Poor	Poor

Source: Davies et al. 2012

Inland rivers: The SRA found that most sites in the Murray–Darling Basin were in moderate to good hydrological condition (Table 4.5). Those valleys that fell short of reference condition were the Condamine–Culgoa, Gwydir, Murrumbidgee and Upper, Central and Lower Murray valleys. For the Condamine, Gwydir, Murrumbidgee and Upper Murray valleys, the montane and upland zones were in good condition, with the poor rating resulting from changes to the hydrology of the main river channels. The Central and Lower Murray valleys are dominated by the regulation of the Murray River which was in very poor condition. The Border Rivers, Warrego, Paroo, Namoi and Castlereagh were rated as being in good hydrological condition (Davies et al. 2012).

Table 4.6: Summary of ecosystem health and condition assessments for NSW coastal rivers, 2011

Valley	Hydrology	Physical form	Fish	Riparian vegetation
Tweed River	Moderate	Very poor	Very poor	Poor
Brunswick River	Poor	Very poor	Poor	Poor
Richmond River	Poor	Poor	Poor	Moderate
Clarence River	Good	Moderate	Poor	Moderate
Bellinger River	Good	Moderate	Poor	Good
Macleay River	Good	Moderate	Poor	Poor
Hastings River	Moderate	Moderate	Very poor	Good
Manning River	Moderate	Moderate	Very poor	Good
Karuah River	Moderate	Moderate	Poor	Good
Hunter River	Moderate*	Very poor	Very poor	Moderate
Macquarie–Tuggerah Lakes	Poor	Moderate	Poor	Good
Hawkesbury–Nepean River	Good*	Poor	Very poor	Not assessed
Sydney Coast–Georges River	Not assessed	Poor	Very poor	Poor
Illawarra Coast	Not assessed	Moderate	Very poor	Good
Shoalhaven River	Good*	Moderate	Very poor	Moderate
Clyde River–Jervis Bay	Good	Good	Poor	Good
Moruya River	Good	Good	Very poor	Good
Tuross River	Good	Good	Very poor	Good
Bega River	Moderate	Moderate	Very poor	Moderate
Towamba River	Moderate	Moderate	Very poor	Good
Genoa River (NSW)	Not assessed	Good	Very poor	Good
Snowy River (NSW)	Good*	Poor	Extremely poor	Poor

Source: NSW Office of Water (NOW), NSW Office of Environment and Heritage and NSW Department of Primary Industries data 2012

Notes: Hydrological condition uses an assessment based on hydrological stress at low flows. Entries marked * do not have low-flow stress as they receive regulated flows which are greater than natural low-flow levels, so stress mainly occurs as extractions during high levels.

Fish condition uses the same methodology as the SRA with some minor adjustments. Fish results are very low due to a new measure for recruitment, which was found to be poor in coastal rivers. The measures for 'nativeness' and 'expectedness' gave relatively better ratings.

Coastal rivers: The coastal rivers of NSW were mostly rated as being in good condition (Table 4.6). Only the condition of the Brunswick, Richmond and Macquarie–Tuggerah Lakes was rated as poor, reflecting the high peak demand during low flows in these rivers. The Tweed, Hastings, Manning, Karuah, Hunter, Bega and Towamba rivers had moderate levels of low-flow hydrological stress, reflecting a moderate impact at low flows as a result of extraction. All other valleys assessed were rated as good.

Physical form

The SRA's new physical form component has been developed and implemented since the first SRA report (MDBC 2008a). Assessment of physical form for the SRA uses remotely sensed data obtained from airborne laser altimetry (LiDAR) surveys, sediment data modelled by SedNet (a catchment-based sediment model) and empirical models of reference condition.

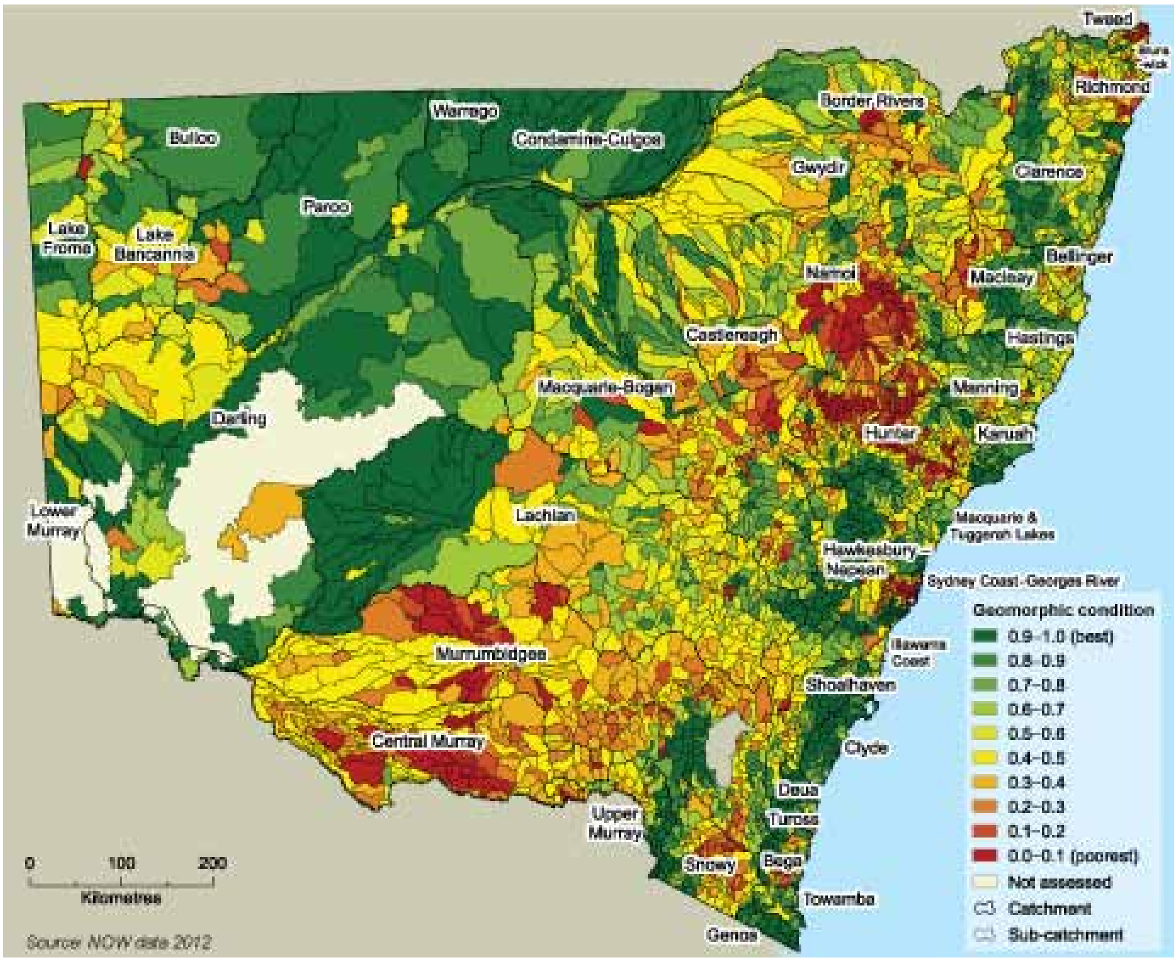
Inland rivers: Based on the SRA methodology, all inland rivers were rated as being in moderate or good physical form (Table 4.5). The Warrego, Paroo, Castlereagh, Lachlan, Murrumbidgee and Upper Murray valleys all received a good rating compared to reference. However, there are substantial areas of moderate and poor geomorphic condition in the Murray and Murrumbidgee catchments at the reach level.

A more elaborate system for assessing physical form is provided by the Riverstyles® framework, based on river type, condition and recovery potential (Brierley & Fryirs 2005).

Mapping of geomorphic condition using the Riverstyles methodology has recently been completed for most of NSW and the outcomes are shown in **Map 4.1**. The results have been used to describe physical form for coastal rivers.

Riverstyles captures data at the river reach scale and therefore provides a more detailed analysis of geomorphic condition than the SRA in inland NSW. As a result, the outputs from Riverstyles mapping may be different from those derived using the physical form component of the SRA.

Map 4.1: Statewide geomorphic condition based on Riverstyles®



Notes: Areas coloured off-white have not yet been assessed.

Riverstyles mapping also captures a stream's recovery potential, which is a measure of the capacity of a stream reach to return to a good or realistically rehabilitated condition, given the limiting factors of the reach. These factors are based on hydraulics and the ability of vegetation and sediment to facilitate geomorphic evolution (Outhet & Young 2004).

Coastal rivers: Most coastal valleys are in good to moderate condition with three – the Tweed, Brunswick and Hunter – having a condition score of very poor (Table 4.6). The Tweed and Brunswick both have large areas of coastal plains relative to the size of their catchments with significant scope for lateral channel movement across the floodplain. The likelihood for this to occur has increased following extensive changes to riparian vegetation and large woody debris which constrained this movement in the past. The Hunter River has also undergone major change since European settlement. On the south coast, the Clyde, Moruya, Tuross and Genoa rivers had ratings of good.

Fish

The fish component of the SRA has been broadened since the last report to include a measure for native fish recruitment. The recruitment indicator is weighted to have an intermediate influence on the overall fish condition score, relative to the existing 'expectedness' and 'nativeness' indicators. Data analysis also incorporates a more comprehensive quantification of native fish distributions in reference condition. As a result, the condition ratings for fish presented in this report are not directly comparable to those used in *SoE 2009* (DECCW 2009).

Ratings of expectedness and nativeness showed a slight improvement since 2009 in both inland and coastal rivers so what appears to be a decline in overall condition is mainly due to the influence of the new indicator for fish recruitment.

Inland rivers: Overall, fish condition index scores indicate that condition was poor to extremely poor in most inland valleys (Table 4.5). Only the Paroo Valley received a rating of good while the Border Rivers and Condamine–Culgoa were rated moderate. The valleys in the worst overall condition were the Macquarie–Bogan, Lachlan, Murrumbidgee and Upper Murray.

'Expectedness' (an indicator of the proportion of species historically found in each valley that are still present) was good in the Border Rivers and moderate in the Gwydir and Darling valleys. In some valleys many native fish species expected to occur were not recorded at all. Of 25 native fish species inhabiting inland rivers, nine were not recorded at any site sampled, including four that are threatened: the flat-headed galaxias, Murray hardyhead, trout cod and southern pygmy perch. Native fish recruitment was rated good in the Condamine–Culgoa and Paroo valleys and moderate in the Border Rivers, Castlereagh and Lower Murray, and was worst in the Lachlan, Murrumbidgee, and Upper and Central Murray valleys.

While data available for the SRA river health analysis and the outcomes described in this report was sampled wholly during drought conditions, an extra year of unpublished data recorded during flood conditions in 2011 has since become available, but reveals little change to the overall results described here. Fish sampling was also undertaken in the far west of NSW, outside the Murray–Darling Basin. Results for Lake Bancannia were very poor and those for Cooper Creek, Lake Frome and the Bulloo River extremely poor.

Coastal rivers: Overall, fish condition index scores indicate that condition was poor to extremely poor in all coastal valleys with none rated as being in moderate or good condition (Table 4.6). Valleys in the best condition (poor) were the Brunswick, Richmond, Clarence, Bellinger, Macleay, Karuah, Macquarie–Tuggerah Lakes and Clyde River–Jervis Bay. The only coastal valley in extremely poor condition was the Snowy.

'Nativeness' of fish assemblages was generally very good, but this is the lowest weighted indicator for fish. Expectedness scores in coastal rivers were slightly better than for inland rivers, but much of the species diversity that should be present was not detected. Five freshwater species expected to be present in coastal catchments were not sampled at all during the reporting period, including the threatened Oxleyan pygmy perch and southern purple-spotted gudgeon, as well as jungle perch, spangled perch and the Darling River hardyhead.

Recruitment was lower in coastal valleys than in inland rivers with many of the species present not recruiting or recruits not being very abundant. The exact cause for this is not known but the impacts of fish barriers on the movement upstream of estuarine species and the recent spate of flooding in coastal catchments may be contributing factors.

Macroinvertebrates

The SRA macroinvertebrate index (MDBC 2003) describes the condition of macroinvertebrate communities in rivers. The index integrates indicators for observed macroinvertebrate families (compared with reference conditions) and sensitivity to disturbance. The macroinvertebrate component of SRA has been refined by improving the assessment of reference condition for macroinvertebrate communities and the calculation of indicator values. As a result, the condition ratings for macroinvertebrates presented in this report are not directly comparable to those reported in *SoE 2009* (DECCW 2009).

Inland rivers: Overall, macroinvertebrate condition was best in the Warrego, Paroo, Murrumbidgee and Upper Murray systems which all had ratings of good (Table 4.5). This reflects relatively fewer stressors, such as water extraction or flow regulation, in these valleys. With the exception of the Darling and Central Murray valleys, which were in poor condition, all other valleys rated moderate.

Riparian vegetation

A new riparian vegetation index has been developed and implemented since the first SRA report (MDBC 2008a). Because no reference condition could be established for fringing riparian vegetation, scores for SRA analysis of inland rivers are based on the near-riparian zone, which describes vegetation occurring beyond the high river bank. For coastal rivers, riparian vegetation condition was assessed by analysing the extent of native woody vegetation that occurred within a 30-metre buffer applied to the stream line.

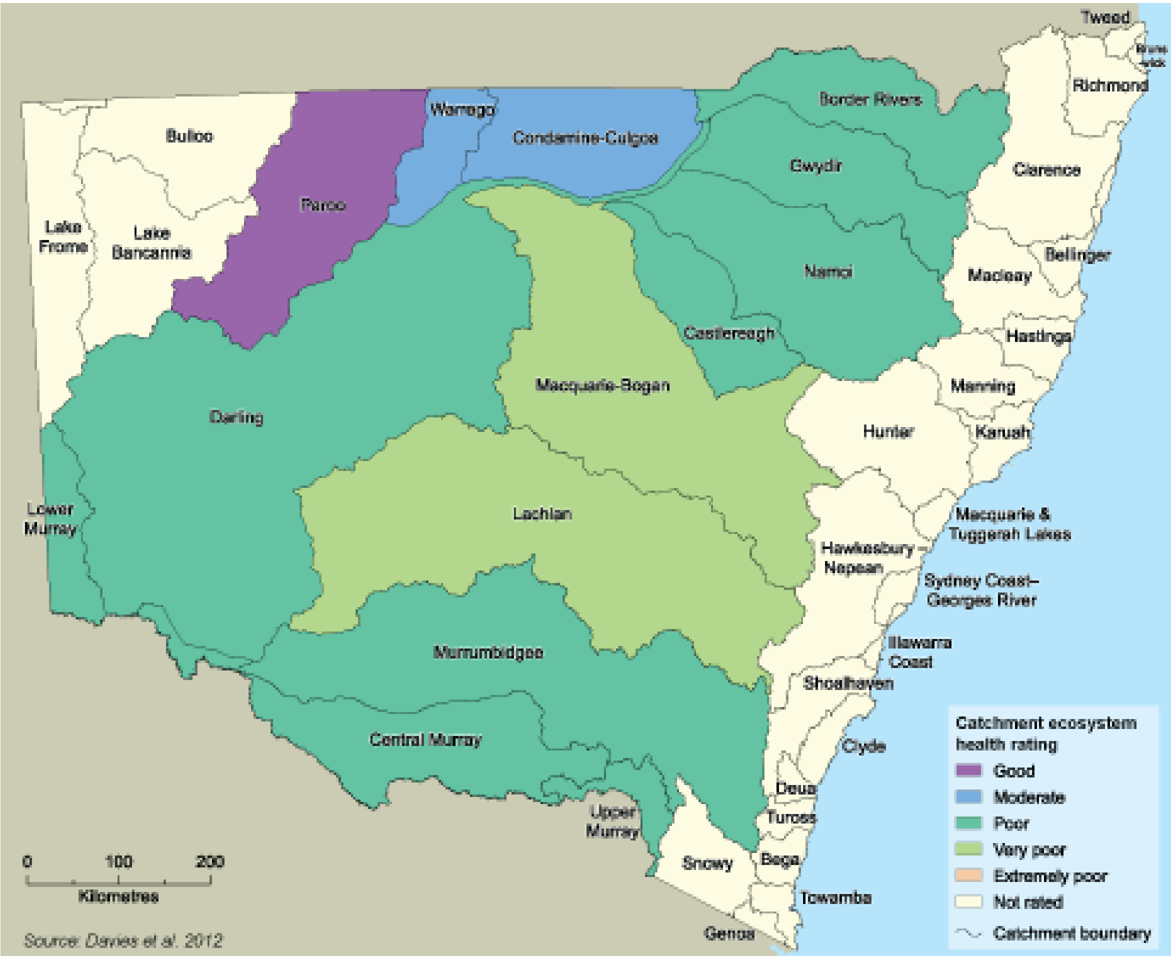
Inland rivers: For near-riparian vegetation, the Condamine–Culgoa, Warrego, Paroo, Castlereagh, Darling and Central Murray valleys had good condition ratings, while the Border Rivers, Namoi, Lachlan and Lower Murray valleys were in poor condition. The remaining valleys rated moderate.

Coastal rivers: Ratings of the condition of riparian vegetation for coastal rivers are closely related to physical form, with most valleys in moderate to good condition.

Ecosystem health

Map 4.2 shows the SRA ecosystem health ratings by river valley for the inland rivers of the Murray–Darling Basin only. The rating of river ecosystem health is a combined assessment based on the indexes for fish, macroinvertebrates and riparian vegetation shown in Table 4.5. 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.

Map 4.2: SRA assessment of ecosystem health in the Murray–Darling Basin, 2010



Notes: The SRA catchment ecosystem health rating is based on fish, macroinvertebrates and riparian vegetation.

Due to the relatively recent commencement of broadscale coastal monitoring, it is not yet possible to make an overall assessment of ecosystem health for coastal rivers.

Threatened species

Declining biodiversity and the number of threatened species in Australia is of serious environmental concern. While it may be more widely recognised that many mammals, birds and other terrestrial species are threatened, some aquatic species are also under threat.

In NSW, seven of the 25 native freshwater fish species found in inland rivers and nine in total are listed as threatened with extinction under the *Fisheries Management Act 1994*. Three freshwater invertebrates have also been listed as endangered species under the Act and the status of many other species is of concern for conservation purposes.

Three aquatic ecological communities have been listed as endangered under the Act:

- the Lowland Murray River ecological community
- the Lowland Darling River ecological community
- the Lowland Lachlan River ecological community.

Water quality

Parameters for describing water quality include:

- salinity, where the electrical conductivity (EC) of water is used as a surrogate measure for total concentration of all salts in water
- nutrients, represented by total phosphorus and nitrogen content of the water, both measured in milligrams per litre (mg/L)
- turbidity, where the light-scattering properties of water measured in nephelometric turbidity units (NTU) is a surrogate measure for the amount of suspended particles in water.

In NSW, the current water quality guidelines for ecosystem protection use the default trigger values in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000) which were prepared under the National Water Quality Management Strategy (ANZECC & ARMCANZ 1994). The extent and frequency with which water quality monitoring data exceeds these trigger values provides an indication of the potential risk that environmental disturbance is occurring.

Salinity

Geology, climate, groundwater interactions and land-use practices all affect the level of salinity in NSW streams. High salt concentrations can degrade freshwater aquatic ecosystems while irrigation water with high salt loads can increase soil salinity.

Electrical conductivity is used as a measure of the level of salts in water. Continuous monitoring of electrical conductivity has been established at a number of sites across NSW. **Table 4.7** shows mean daily salinity levels for a three-year period (2008–2011) and a 10-year period (2001–11). The table also shows the maximum salinity level measured during the latest three-year period of record at each stream measuring point. Mean daily salinity levels are well below the World Health Organization desirable upper limit for drinking water of 800 EC units. However the maximum spot readings in Table 4.7 indicate that the limits for drinking water have been exceeded in many systems for short periods.

Compared with the 10-year mean, the latest three-year reporting period shows a relatively stable or slightly lower mean daily electrical conductivity in the streams surveyed. Only the Hunter River at Greta showed a substantial increase (over 70 EC units) while five sites showed a decrease of the same magnitude or greater. This is likely to be due to major flooding that occurred in the latter part of 2010 and into 2011 as drought conditions broke across large areas of NSW.

Nutrients

Nutrients, especially nitrogen and phosphorus, can have a significant effect on water quality when present in excess of ecosystem needs. The current guidelines for water quality (ANZECC & ARMCANZ 2000), along with NSW River Flow Objectives, provide default trigger values for water quality parameters designed to protect potential uses of water. Trigger values are conservative and where they are exceeded indicate the need to investigate possible causes, but they do not necessarily signify poor river health.

Table 4.7: Electrical conductivity in selected NSW rivers

Stream measuring point	Daily river salinity levels (EC units) for specified period: Period of record	July 2001–June 2011 mean	July 2008–June 2011 mean	Maximum spot readings: July 2008–June 2011
Macintyre at Holdfast	2002–2012	281.1	255.0	475.5
Mehi at Bronte*	2001–2012	436.0	331.2	167.8
Barwon–Darling at Collarenebri	2002–2012	283.7	214.6	330.7
Namoi at Goangara*	1995–2012	415.7	383.9	783.0
Namoi at Gunnedah	1995–2012	454.4	463.0	932.0
Castlereagh at Gungalman Bridge*	2001–2012	600.9	574.4	1,527.3
Macquarie at Carinda*	1999–2012	577.2	480.1	734.2
Macquarie at Baroona	1999–2012	450.1	425.5	1,057.9
Bogan at Gongolgon*	2000–2012	377.4	281.3	843.6
Hunter at Greta	1992–2012	713.5	784.9	1,447.0
Lachlan at Booligal*	1999–2012	593.6	520.7	858.8
Lachlan at Forbes	1999–2012	497.8	490.0	1,017.1
Murrumbidgee at Wagga Wagga	1993–2012	139.2	149.5	318.0
Murrumbidgee at Balranald*	1992–2012	149.1	158.3	329.0

Source: NOW data 2012
Notes: 'Maximum spot readings' (not means) cover the latest three-year period of record
* End-of-valley site

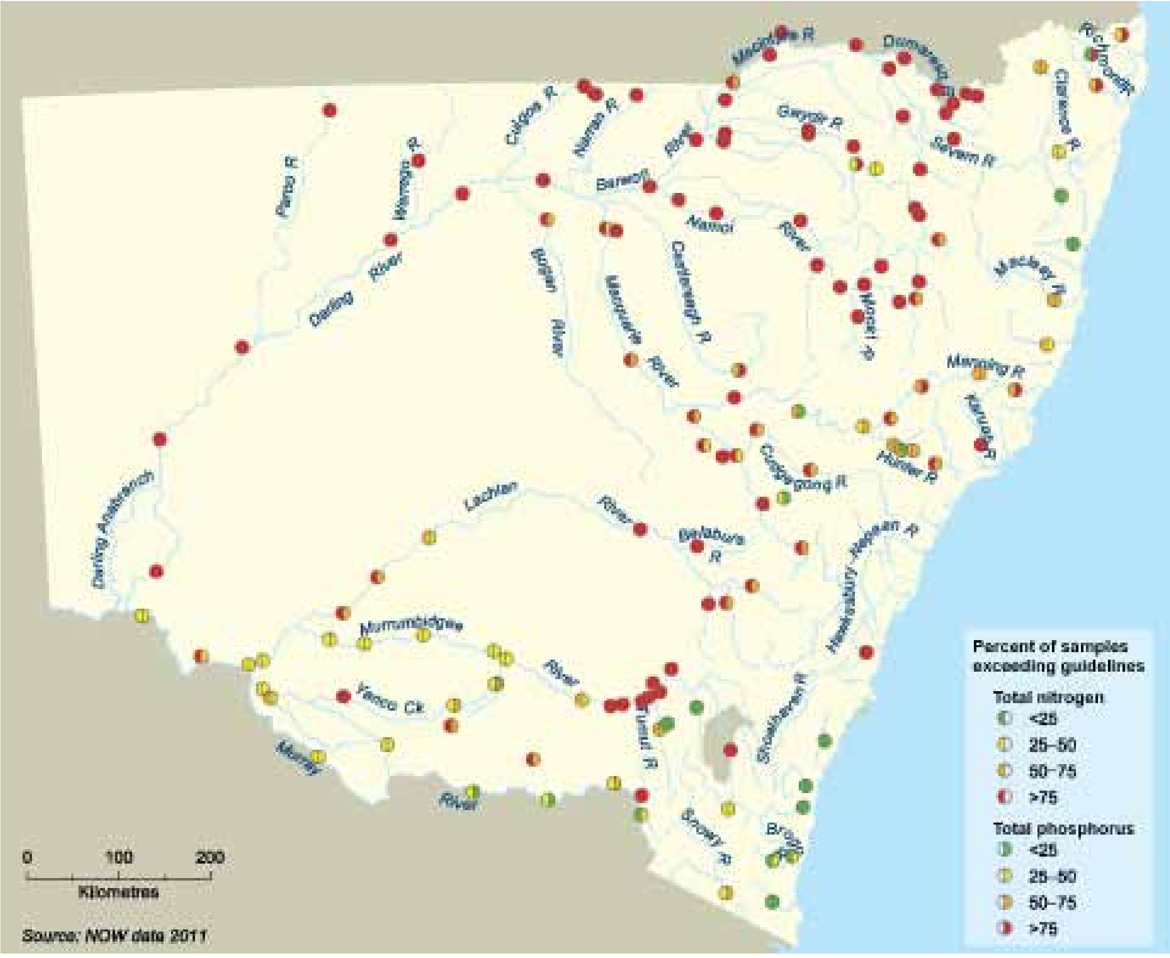
Map 4.3 shows the percentage of water samples from streams across NSW that had nitrogen and phosphorus concentrations above the ecosystem protection trigger values (ANZECC & ARMCANZ 2000). The results show that the northern inland and western drainages of NSW – the Border Rivers, Gwydir, Namoi, Macquarie, Darling and intersecting streams – regularly exceed trigger values for nutrients. In the central and southern inland drainages of NSW (the Lachlan and Murrumbidgee valleys), nitrogen and phosphorus levels are also elevated in mid-catchment locations, but trigger values are exceeded less frequently in the lower reaches of these drainages and in the Murray. In the coastal regions of NSW, trigger values are generally exceeded less frequently than in inland regions, with some exceptions around the Hunter Valley and north coast.

Turbidity

Water clarity decreases – or becomes more turbid – as the amount of sediment and other particles in the water column increases. Turbidity levels vary according to the geology, soil type and cover, climate and intensity of disturbance to the landscape through land clearing and the erosion of agricultural land, stream banks and channels. High turbidity can decrease the amount of light that sustains plant growth, suppress the growth of aquatic organisms and choke habitat. It can also carry with it pesticides and other chemicals.

In NSW there is generally a pattern of low turbidity in upland areas and higher turbidity in lowland areas, reflecting the progression of rivers through the landscape and the effects of geology and topography. However there is also a tendency for higher levels of turbidity in river basins in the north-west of the state, such as the Paroo and Warrego, due to the naturally occurring dispersive soils found there.

Map 4.3: Exceedences of ecological trigger levels for total nitrogen and total phosphorus, 2009–11



Water quality by river valley

Nationally, an assessment of the water quality of river valleys (SKM 2011) was prepared for the Australian *State of the Environment 2011* (ASoEC 2011). The NSW component of this assessment consisted of site and overall ratings for the inland river valleys of NSW, evaluated against the ANZECC default trigger values. The overall results for rivers are presented in **Table 4.8**.

The results show that the low-gradient, far western streams have a tendency to poor water quality, particularly turbidity but also nitrogen and phosphorus, with only the Mallee and Murray–Riverina recording good ratings. These results for water quality display some inconsistency with the outcomes of the SRA ecosystem health assessments shown in Table 4.5, most markedly for the Paroo River, but also the Warrego and Condamine–Culgoa. While these rivers have high levels of natural turbidity and therefore lower ratings for water quality, their ecosystems are adapted to these conditions and, being relatively undisturbed, they remain in better ecosystem health than the other rivers assessed.

These outcomes demonstrate the need for regional guidelines which better reflect natural variability in water quality and the influence of soil types and flow patterns on water quality at the regional level. Work is now progressing on the development of regional water quality guidelines for NSW. This involves modelling reference (natural) water quality and currently observed water quality, based on the characteristics of individual catchments and their levels of disturbance to develop more appropriate guidelines for water quality that are not uniform across the state.

Algal blooms

Most freshwater algal blooms in NSW are caused by blue-green algae (or 'cyanobacteria'), some of which produce toxins that are harmful to humans, livestock and aquatic fauna. However, non-toxic blooms can also have significant impacts on the health of aquatic ecosystems by depleting dissolved oxygen (which can cause fish kills), changing pH levels, reducing light penetration, and smothering habitat.

Drought conditions in 2008–09 and 2009–10 led to major blue-green algal blooms in many inland waters across NSW. In particular, warm conditions and low water availability caused major blooms in the Murray River in the autumns of both 2009 and 2010 that extended for over 1000 kilometres downstream of Lake Hume. In contrast, the 2010–11 period was much wetter with higher water levels and good flows in many NSW rivers and significantly fewer blooms reported.

Pressures

Water extraction and altered flow regimes

The drought in NSW, which lasted for over eight years in many river valleys, was replaced by wetter than average rainfall in 2010 and 2011. Water availability to the environment has improved in most inland rivers and wetlands following flooding events that have flushed river systems. However, natural flows continue to be modified by the effects of water extraction and flow regulation and control, through the dams built on most large river systems (see Water 4.1). Altered flow regimes also affect the seasonality and variability of flows, dampening both the peaks and troughs in water levels. This has an impact on the critical ecological processes that trigger breeding cues for bird and fish species, and has been a significant factor in the loss of biodiversity and decline of aquatic ecosystems over the longer term.

'Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands' has been listed as a Key Threatening Process (KTP) under the *Threatened Species Conservation Act 1995*. A related process, 'the installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams' is also listed as a KTP under the *Fisheries Management Act 1994*. Alteration to natural flows has impacts on the habitat of native species, their dispersal and breeding, and encourages the establishment of introduced pest species.

Table 4.8: Water quality assessment for NSW river basins from the National Water Quality Assessment, 2007–11

River basin	Sites	Salinity	Total nitrogen	Total phosphorus	Turbidity	pH
Border Rivers	33	Fair	Very poor	Very poor	Fair	Fair
Moonie River	1	Good	Very poor	Very poor	Very poor	Good
Condamine–Culgoa Rivers	7	Good	Very poor	Very poor	Very poor	Good
Warrego River	1	Good	Very poor	Very poor	Very poor	Good
Paroo River	1	Good	Very poor	Very poor	Very poor	Good
Gwydir Lakes	24	Poor	Very poor	Very poor	Fair	Poor
Namoi River	38	Poor	Very poor	Very poor	Fair	Poor
Castlereagh River	1	Very poor	Poor	Very poor	Good	Good
Macquarie–Bogan Rivers	17	Poor	Very poor	Very poor	Good	Fair
Darling River	26	Fair	Very poor	Very poor	Poor	Poor
Lachlan River	15	Fair	Very poor	Poor	Fair	Good
Benanee River	4	Good	No data	No data	Good	Good
Murrumbidgee River	70	Good	Poor	Fair	Good	Good
Upper Murray River	16	Good	Poor	Poor	Good	Good
Murray-Riverina	20	Good	Good	Good	Good	Good
Lower Murray River	2	Good	Good	Good	Good	Good

Source: SKM 2011

The alteration to natural flow regimes encompasses a range of changes or disturbances within rivers and associated floodplains, including to the frequency, duration, magnitude, timing and variability of flow events, altered surface water levels and seasonality of flows, and changes to the rates at which water levels rise and fall. Water resource development, while necessary to provide resource security and access, is the main cause of alterations to natural flows through the building of dams and weirs, diversion or extraction of in-stream flows, and the alteration of flows on floodplains by levees and other structures.

Drought

Australia is a land prone to drought and many of its native plants and animals, as well as most inland aquatic ecosystems, are adapted to drought conditions and recover quickly when rain falls and flows increase. Many species depend on the natural variability in river flows to complete critical stages in their life cycles. However prolonged drought is a major disturbance to riverine systems and can place severe stress on aquatic ecosystems.

Where the cumulative effects of drought conditions and water extraction continue over an extended period, critical thresholds in life cycles may be exceeded, placing prospects for recovery at risk. Due to long-term changes in river condition, many native fish populations are now much reduced in numbers and hence less resilient to change, such as the additional stress placed on them during the recent decade-long drought.

Following the end of the drought, several major rivers experienced new threats from 'blackwater events'. These occur after a dry spell when accumulated debris is washed into the river during a flood, lowering levels of dissolved oxygen as microbes in the water break down the organic matter. While blackwater events have occurred naturally in the past, changes to river hydrology have decreased their frequency but increased their intensity in lowland river floodplains. Blackwater events are now more likely to lead to complete oxygen starvation in rivers, resulting in more devastating fish kills and further ecosystem deterioration (Hardwick 2011).

Floodplain fragmentation and harvesting

Floodplains are the areas of land that would naturally receive waters during floods, while floodplain harvesting is the collection, extraction, diversion or impoundment of water flowing across a floodplain. Historic settlement on floodplains has changed natural flow patterns and the behaviour of floods through associated structures, such as levee banks built to harvest water or protect property, as well as bridges, roads and railway lines. The redirection of floodwaters and reduction in flow levels have significant impacts on the health of riverine and wetland ecosystems.

Catchment disturbance

Activities in river catchments can have a significant impact on riverine ecosystems, primarily through a reduction in water quality and changes to river geomorphology. Agriculture, urban stormwater and effluent can introduce nutrients, pollutants, suspended sediments and other contaminants into rivers and streams, reducing water quality during both high- and low-flow events. Changes in the land cover of catchments, such as the clearing of riparian and terrestrial vegetation and drainage of wetlands, have altered river geomorphology, including the widening of channels, headcut incisions in headwater streams, and increased sediment loads that smother aquatic habitats (Brierley & Fryirs 2005).

Pollution from a variety of sources has impacts on water quality and riverine ecosystem health. Point-source pollution has largely been addressed through regulatory processes, but pollution from diffuse sources is still an issue that affects water quality in some catchments (DECC 2009). The most significant pollutants from diffuse sources are sediments and nutrients, which are washed into streams by runoff from surrounding catchments. The quality and quantity of water pollution within a catchment largely depends on the extent of vegetation cover and local land management practices including agriculture and urban development. Generally, the more intensive the development, the greater the impact on riverine ecosystems.

Riparian vegetation provides habitat and food for aquatic communities so its disturbance is of particular significance for river health. Riverbank integrity is also critical because many species use overhanging banks and vegetation for habitat. Healthy fringing riparian vegetation is valuable for maintaining healthy aquatic ecosystems. It provides structural integrity for river banks to protect against erosion, as well as being a complex habitat and source of food and nutrients. The loss or degradation of the riparian zone through vegetation clearing and trampling by stock causes significant impacts.

Other forms of catchment disturbance that can influence river health include bushfires, roads, large dams and industrial activities such as mining.

Water temperature

Cold water pollution is caused by low-temperature water being released into rivers from the bottom of large thermally stratified dams during summer. Cold water releases can prevent the natural seasonal changes in river temperature and reduce the range of temperature variation, both seasonally and diurnally, sometimes for hundreds of kilometres downstream. These variations may affect fragile ecosystems, fish breeding, the hatching of fish eggs and ecosystem productivity (Astles et al. 2004).

Discharge of cold water from dams is believed to be one of the main factors behind severe declines in native warm-water fish species in the Murray–Darling Basin (Phillips 2001). Nine dams in NSW are likely to cause severe cold water impacts: the Blowering, Burrendong, Burrinjuck, Copeton, Hume, Keepit, Khancoban, Pindari and Wyangala storages (Preece 2003). Over 3000 kilometres of NSW rivers are estimated to be affected by cold water pollution.

Invasive species

Alien fish compete for food and space with native fish and frogs. They also prey on fish and frog eggs, tadpoles and juvenile fish, fundamentally altering food webs and habitats. Surveys of freshwater fish species by the NSW Department of Primary Industries (DPI) over the past three years found only 31% of the sites sampled were free from introduced fish, mainly in coastal rivers. A small number of sites – 6.7% – contained only introduced fish.

Averaged across all sites, introduced taxa accounted for 33% of the fish species collected at each site, 34% of the total fish abundance and 45% of the total fish biomass (DPI data 2011). The impact of introduced species is much greater in the inland rivers of the Murray–Darling Basin, with introduced fish present at 90% of all sites, and accounting for 40% of all species collected, 44% of total fish abundance and 68% of total fish biomass (see Biodiversity 5.4).

Climate change

According to the findings of the CSIRO Sustainable Yields Assessment (CSIRO 2008a), the impacts of climate change on environmentally beneficial flooding in most regions of the Murray–Darling Basin, especially the highly developed regions, will be smaller than the impacts already brought about by water resource development. However, when the incremental impacts of climate change are superimposed on the existing pressures on water availability, the ecological consequences could be substantial as important ecological thresholds may be crossed (CSIRO 2008a).

Under a median climate change scenario, impacts by 2030 are expected to include:

- extended dry periods between important flood events and reduced flood volumes for the Murray icon sites identified in The Living Murray program (CSIRO 2008a)
- a 10% increase in the interval between beneficial flood events in the Macquarie River (CSIRO 2008b)
- a 24% increase in the flood interval in the Lachlan River (CSIRO 2008c).

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Improve the environmental health of wetlands and catchments through actively managing water for the environment by 2021'. This includes the strategic recovery and management of water for the environment to improve the health of the most stressed rivers and wetlands. Further details on Goal 22 are provided in Water 4.1.

Water sharing plans

Water sharing plans are a significant tool in water management for addressing river health in NSW, by improving the management of river flows and water extraction practices to protect a proportion of flows for the environment. They are described in greater detail in Water 4.1.

Water recovery

Improving the condition of aquatic ecosystems is a high priority for NSW. The Australian and NSW Governments have recovered water through the purchase of water entitlements and infrastructure works under a number of programs, including NSW RiverBank, The Living Murray program, Water for Rivers and the NSW Wetland Recovery Program. Further information on water recovery is available in Water 4.1.

The Living Murray program: This program is a major investment by the NSW, Victorian, South Australian, ACT and Commonwealth Governments to recover water and improve the environmental health of the Murray River at six significant ecological sites along the river. In NSW, these include the Millewa Forest, Koondrook–Perricoota Forest, Chowilla Floodplain, and the river channel itself.

The NSW target is to recover 249,000 megalitres (ML) of water for the environment. By June 2012, the program had recovered 221,000 ML of water.

Projects completed in NSW include:

- the Great Darling Anabranch Pipeline scheme, which saw the removal or modification of water regulation structures that previously created a series of pools, and replacing them with pumps, a pipeline and a filtration system to restore more natural flows to the Great Darling Anabranch, saving 47,000 ML of water per year
- the purchase of 12,000 ML of irrigation entitlement from the Poon Boon Irrigation Trust
- wetland rehabilitation works on the Edward River through construction of 18 regulators to stop the unwanted flooding of the Millewa Forest, saving 7100 ML of water a year
- construction of a regulator to better manage flows and prevent unnatural flooding of Croppers Lagoon, providing an annual saving 8000 ML of water.

NSW Rivers Environmental Restoration Program: This program was completed in 2011. It targeted important wetlands in the Macquarie Marshes and the Gwydir, Lachlan and Murrumbidgee river systems to arrest their decline by purchasing water for the environment and improving the management and delivery of environmental flows. The achievements of this program are described in greater detail in Water 4.3.

NSW Weir Review

The 2006 Weir Review identified more than 3300 dams and weirs on NSW rivers. A central issue for water sharing plans is the degree to which any management recommendation to remove or modify weirs affects water resource availability and water sharing arrangements. While weirs create impediments to fish passage and cause impacts on water quality, they can provide valuable 'compensatory' refuge areas for fauna during drought times. These factors need to be carefully weighed when considering management intervention.

Rural floodplain management plans

Rural floodplain management plans have been adopted for 17 floodplains covering approximately 20,800 square kilometres. Completion of another four plans currently being developed will bring the total coverage to more than 24,300 square kilometres. Plans have been adopted or are being prepared for floodplains associated with rural sections 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 through control of development that is likely to block or redistribute flows during floods. This is achieved by mapping floodway networks based on historical flood information to allow for the unimpeded passage of floodwaters. 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.

Water releases for the Snowy River

Water for Rivers was established to achieve significant improvements in environmental flows into the Snowy and Murray river systems. Targets include returning 212,000 ML or 21% of average annual natural flows to the Snowy River and 70,000 ML to the Murray River in a staged approach over 10 years. In the 2010–11 water year, a total of 24,200 ML of water was committed for additional environmental flows by the NSW, Victorian and Commonwealth Governments. The first release of 16,600 ML occurred in 2010 and was the largest environmental release to the Snowy River since the Jindabyne Dam was built in 1967. This was followed by an additional 7600 ML in April 2011 and 84,000 ML during October 2011.

Pipeline NSW

Under Pipeline NSW, old and wasteful open channels that deliver stock and domestic water from NSW rivers are being replaced with piped systems modelled on the successful Cap and Pipe the Bores program in the Great Artesian Basin. New pipelines will pump water from rivers or groundwater sources and deliver it directly to farm storage tanks and stock troughs via a network of underground pipes in three locations:

- the Barwon Channel Association stock and domestic pipeline, saving 1488 ML per year
- the Lower Gwydir domestic pipeline, saving 2544 ML per year
- the Lower Lachlan Noonamah Water Authority stock and domestic pipeline, saving 795 ML per year.

The water saved by Pipeline NSW will be reallocated and managed through environmental water licences held by the NSW and Commonwealth Governments to benefit the rivers.

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 groundwaters. The strategy's primary focus is 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 Strategy

The Cold Water Pollution Strategy adopted in 2004 aims to reduce the significant effect that major dams have on the ecology of many of the large rivers across NSW. The strategy is being implemented in five-year stages: outcomes achieved in the first stage included major infrastructure works at Jindabyne and Tallowa Dam, investigations at Keepit and Burrendong dams, integration of cold water pollution conditions in State Water works approvals and identification of high priority dams for possible action in Stage 2. *Guidelines for Managing Cold Water Releases* became available in April 2011 (NOW 2011) and a *Report on the implementation of Stage 1* of the strategy was released in July (NOW 2012).

Native Fish Strategy for the Murray–Darling Basin 2003–2013

The *Native Fish Strategy for the Murray–Darling Basin 2003–2013* (MDBMC 2003) has the long-term goal of rehabilitating native fish communities back to 60% of estimated pre-European fish populations by the year 2050 (MDBC 2006). It covers a range of initiatives designed to reduce the threats to native fish and engage the local community in improving river health across the basin. Actions taken so far have included placement of over 5100 snags in rivers and improving the condition of over 90 km of riparian vegetation. In addition, over 14,800 people across the state have attended community engagement events promoting activities and an understanding of native fish issues.

Fishways

Remediation of fish passage at weirs, dams and road crossings by constructing fishways or fish ladders and redesigning existing barriers plays an important role in improving the health of fish communities.

Improvements have been delivered through three major projects. The Sea to Hume Dam Fishway Program involves the construction of 19 fishways on the Murray and adjacent waterways, improving fish access to over 2000 km of waterway. The program is nearing completion, with 14 fishways now completed.

The Fish Superhighways Program is a strategic initiative to improve fish passage at State Water Corporation assets across NSW. Fishways have been completed at 15 weirs, allowing improved passage to over 1700 km of river, while a further 17 fishways in the planning and design phase will improve connectivity to another 1600 km. Six weirs have been removed since 2002 and the removal of another 18 is being investigated.

The Bringing Back the Fish Project concluded in 2009, improving migratory fish access to over 1200 km of waterways in coastal NSW.

Developing responses

Water shepherding project

The NSW and Commonwealth Governments signed a Memorandum of Understanding (MoU) on shepherding environmental water in July 2010. The MoU sets out the principles for how water purchased for environmental purposes in one location will be protected from extraction or 'shepherded' to a downstream location. Submissions on proposed arrangements for shepherding environmental water in NSW were received until July 2012.

Draft Floodplain Harvesting Policy

A draft *NSW Floodplain Harvesting Policy* (NOW 2010) to provide a framework for managing licensing and approvals for the harvesting of water from floodplains has been released for public consultation. More detail is available in Water 4.1.

Future opportunities

The monitoring of habitat and ecosystem responses to environmental flows will allow knowledge to be refined so that adaptive management can optimise the benefits of flows and better target high-value ecosystems.

Many native fish species have been under severe stress during the extensive drought that broke in 2010. The recovery of species as more typical flow patterns resume will be monitored and supplementary measures, such as selective restocking considered, where appropriate.

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.

Further research is desirable to determine the likely effects on the health of aquatic ecosystems of changes in water availability and possible shifts in community composition due to the altered seasonality of flows.

4.3 Wetlands

The condition of wetlands in inland New South Wales has improved markedly since 2009, mainly due to increased rainfall and river flows following a prolonged drought. Despite their resilience, wetland systems require careful management of water inflows to maintain or improve their condition.

The majority of inland floodplain wetlands are presently undergoing a cycle of enhanced productivity with increases in extent and vegetation, and more waterbird breeding than has been experienced in over 10 years. The highest level of breeding activity and the second largest area of wetlands in 30 years of monitoring were recorded in 2010, followed by the second highest number of waterbirds in 2011.

Long-term surveys demonstrate a general pattern of decline in the extent and productivity of inland wetlands over the longer term due to the effects of water extraction and altered flow regimes.

Reduced water availability and changed patterns of river flows remain the principal causes of wetland decline. Habitat degradation as the result of changes in catchment land use, clearing and modified drainage patterns are other significant pressures.

Many important wetlands occur within regulated catchments and are dependent on careful management of environmental water and river flows to maintain ecosystem health. Around 7% of inland wetlands and 19% of coastal wetlands are now protected within the terrestrial reserve system of NSW.

NSW indicators

Indicator and status	Trend	Information availability
Wetland extent	Stable	✓
Wetland condition	Increasing	✓✓
Waterbird abundance and diversity	Increasing	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Wetlands are dynamic by nature and an important part of the natural environment. They are 'hot spots' for plant and animal biodiversity and integral to landscape processes at regional and larger scales. Wetlands moderate the impacts of floods and contribute to regional economies by providing nurseries for estuarine commercial fisheries and also supporting grazing, apiary and tourism. They provide a regional focus for many communities, including ones based on Aboriginal culture.

NSW has 12 'Ramsar' wetlands recognised as internationally important for their biodiversity and ecosystem values under the Ramsar Convention. Wetlands provide vital habitat for the migratory bird species protected under various bilateral international agreements, such as the Japan–Australia Migratory Bird Agreement (JAMBA), China–Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA).

Status and trends

Wetland extent and condition

Little new statewide or systematic mapping of the extent and condition of wetlands in NSW has become available recently. However, catchment-specific studies clearly demonstrate that, despite significant declines in extent over the long term (**Table 4.9**), wetlands are resilient to climatic variability and have responded to recent drought-breaking rains.

The first statewide map of wetland extent in NSW was published in 2004 (Kingsford et al. 2004). It found that wetlands then covered 4.3 million hectares or 5.6% of the state. The map used satellite imagery from 1984 to 1993 to delineate inland wetlands and satellite imagery from 1994 to 1995 to delineate coastal wetlands.

While no update of the statewide extent of wetlands is available, inundation frequency and extent have recently been mapped for the Macquarie Marshes, Gwydir wetlands and Lowbidgee floodplain using satellite imagery (Landsat MSS and TM data). This mapping shows that the frequency of inundation of these key wetlands has declined over the past 30 years and the areas that are frequently inundated have also declined over this time (Thomas et al. 2012)

The condition of wetland vegetation has also been assessed in the Macquarie Marshes, Gwydir wetlands and Lowbidgee, in relation to the frequency, duration and extent of inundation. *SoE 2009* (DECCW 2009) noted that between 2001 and 2009 reduced flooding in the Macquarie Marshes resulted in a decline in condition and extent of characteristic wetland vegetation communities there (Bowen & Simpson 2010b). The condition of river red gum forests and woodlands and semi-permanent wetland vegetation in the marshes improved in response to floods in 2010–11, which inundated more than 80% of all wetland vegetation communities (Spencer et al. 2011). A substantial waterbird breeding event was also stimulated by the floods.

In 2010, it was estimated that only 25% of the original extent of the Gwydir wetlands still remained (Bowen & Simpson 2010a), with much of the wetland area converted to cropping. In 2008, the remaining area of wetland was mostly in poor condition (Bowen & Simpson 2010a). However, in response to prolonged natural flows of about 117,000 megalitres (ML) and environmental releases of 20,000 ML into the Gwydir wetlands from mid-2010 to March 2011, the health of wetland vegetation in areas receiving this inundation improved markedly and an increase in waterbird abundance, species diversity and breeding occurred (GECAOAC 2011).

Extensive flooding in the Lowbidgee wetlands in 2010–11 significantly increased the extent of wetland habitat and created breeding opportunities for waterbird species when compared with 2008 and 2009 (Spencer et al. 2011). Scientific studies found that, during the flood, wetlands that had previously been intermittently flooded (in at least 5–6 years of the last 10) supported the greatest abundance and diversity of waterbirds. This large-scale flood event also facilitated the re-colonisation of wetlands formerly occupied by threatened frog species, including the vulnerable southern bell frog (*Litoria raniformis*) (Spencer et al. 2011).

Mapping of the extent and condition of river red gum communities in the Millewa Forest in June 2010 found that 78% of those reserved were in intermediate condition and 17% in good condition. This provides a benchmark for adaptive management within the new Murray Valley National Park and State Conservation Area (Bowen et al. 2011).

Table 4.9: Declines in significant NSW wetlands

Significant wetlands	Long-term changes	Causes	Source
Murray River wetlands	72% of river red gum forests and woodlands in the Living Murray icon sites in stressed condition in 2009	Drought Flow regulation	Cunningham et al. 2009
Sydney region	50% of freshwater wetlands lost	Land clearing Locally changed hydrologic regimes	Adam & Stricker 1993
Gwydir River wetlands	75% decline in area	River regulation Clearing Changed flow regimes Water extraction	Keyte 1994 Mawhinney 2003 Bowen & Simpson 2010a
Macquarie Marshes	40–50% decline in area Sharp decline in bird and fish populations Sharp decline in area of reed, cumbungi and water couch Invasion of wetland communities by chenopod shrubland during drought	River regulation Clearing Changed flow regimes Water extraction	Kingsford & Thomas 1995 Kingsford & Johnson 1998 Kingsford & Auld 2005 Bowen & Simpson 2010b
Mid-Murrumbidgee River	Impacts on 62% of the total area of open water wetlands	Locally changed hydrologic regimes	Finlayson & Rea 1999
Border Rivers region	Probably substantially altered by water resource development	Water resource development	Kingsford 1999 Thoms & Sheldon 2000
New England Tablelands	80% of freshwater wetlands destroyed Remaining 20% nearly all drained or dammed	Land clearing Locally changed hydrologic regimes	Brock et al. 1999
Narran Lakes Ramsar site	75% reduction in median natural flows Wetland vegetation highly stressed with 54% of river red gums classified as dead in 2007	Water extraction in the Condamine–Balonne catchment	DNR 2000 Sheldon et al. 2000 Thoms 2003 MDBC 2008b MDBA 2010
Lower Murrumbidgee floodplain	76% of floodplain lost or degraded 80% decline in waterbird populations	Water resource development	Kingsford & Thomas 2001 Kingsford 2003 Kingsford & Thomas 2004
Wingecarribee Swamp	Collapse after peat mining caused sedimentation of a downstream water reservoir with resulting long-term changes to soil and vegetation	Remaining swamp stable but under severe threat from further invasion of weeds and inappropriate fire episodes	SCA 2001
Lachlan River wetlands	Decline in the condition of river red gums in Booligal wetlands and Cumbung Swamp Decreased river flows to Booligal wetlands by at least 50% from 1894–2007 levels Increase in maximum period between winter–spring flood events in Cumbung Swamp from 7 years to 16 years	River regulation	Capon et al. 2008 CSIRO 2008c Armstrong et al. 2009
Thirlmere Lakes	Major drop in lake levels in recent years	Drought from 2000–10	Jankowski & Knights 2010 Russell et al. 2010

Waterbird surveys

The best long-term data on changes in wetland extent in NSW is provided by the annual aerial waterbird surveys conducted since 1983 (Porter & Kingsford 2011). These estimate the area of available wetland habitat and also the abundance and diversity of waterbirds, which are useful indicators of wetland condition because waterbirds are sensitive to environmental changes (Kingsford 1999; Baldwin et al. 2005).

Following a prolonged drought over the past decade, widespread and extensive rains occurred across most areas of inland NSW during 2010 and 2011. The long-term aerial monitoring program found that the area of wetlands rose sharply in response to the inundation, exceeding the long-term average for the first time in 10 years. Wetland habitat was widely available with many large areas in the Murray–Darling Basin, including the Paroo overflow lakes, Cuttaburra channels, Macquarie Marshes, Lowbidgee wetlands and Menindee Lakes all holding water.

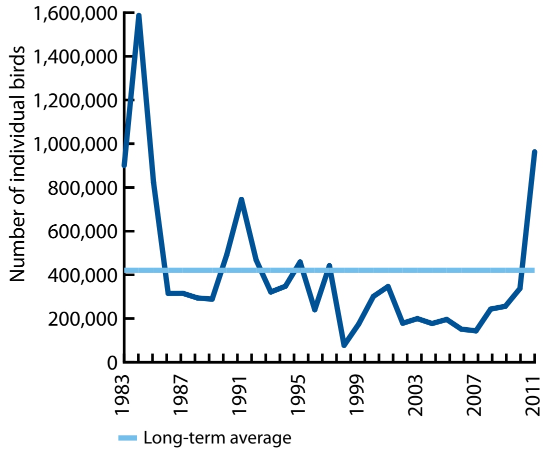
Total breeding for all waterbird species, based on the number of nest sites, was the highest on record in 2010, but then declined in 2011 to below the long-term average (**Figure 4.5**). However, following the successful breeding season in 2010, total waterbird numbers in eastern Australia during 2011 were the second-highest on record and the highest recorded since 1984 (Figure 4.5).

Breeding in 2011 was concentrated in the Lowbidgee and Murray River wetlands. Three species of ibis (glossy, straw-necked and white) accounted for more than 80% of total breeding abundance in the Lowbidgee wetlands during the 2011 survey.

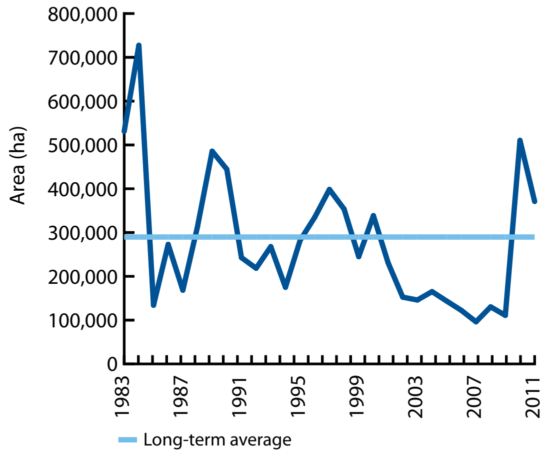
Although total waterbird abundance and wetland area were above the long-term average in 2011, these increases have not reversed long-term declines. Trend analyses indicate long-term declines in waterbird abundance, wetland area and breeding species richness remain significant (Porter & Kingsford 2011).

Figure 4.5: Estimated number of waterbirds, wetland area and breeding in eastern Australia, 1983–2011

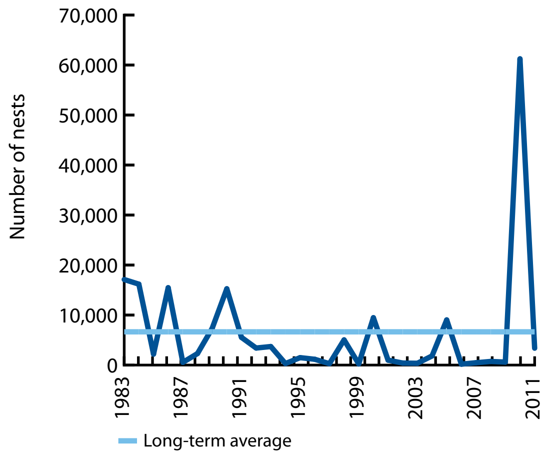
Number of waterbirds



Wetland area



Breeding index (number of nests)



Source: Porter & Kingsford 2011

Notes: Aerial survey along 10 aerial survey bands, 1983–2011

Reservation of wetlands

Protection of wetlands under the *National Parks and Wildlife Act 1974* or through Ramsar listing or other means is desirable to achieve effective conservation of these areas over the longer term. Studies suggest that the size of the protected area and the management of the surrounding catchment are critical for effectively protecting aquatic biodiversity (Nevill 2004; Kingsford et al. 2005). However, the sustainability of wetlands within the reserve system still depends heavily on the provision of adequate environmental flows, as well as sympathetic management of land and water resources by government agencies and surrounding landowners (see Water 4.1).

Table 4.10 shows that, at December 2011, 7% of the area of inland wetlands in NSW was managed within the national parks estate, an increase in area of 4% over the preceding three years. Coastal wetlands are better represented, with nearly 19% of their area in the formal reserve system, a 1% increase since 2008. This analysis is based on a wetlands compilation map drawn from satellite imagery for the period 1986–95 which is presently the best available statewide representation of wetland distribution in NSW (Kingsford et al. 2004).

Table 4.10: Extent of wetland types and their inclusion in the NSW national parks estate, 2011

Wetland type	Total area in NSW (ha)	Total area in NSW parks estate (ha) (% of total)	Additions to NSW parks estate in 2009–11 (ha)	Examples of new areas declared or added to NSW parks estate in 2009–11
Coastal wetlands				
Floodplain wetlands	11,890	2,476 (21%)	27	Curracabundi National Park Oxley Wild Rivers National Park
Freshwater wetlands	1,926	221 (11%)	–	
Estuarine wetlands	110,791	14,735 (13%)	826	Hunter Valley National Park Gaagal Wanggaan (South Beach) National Park Limeburners Creek National Park
Coastal lakes and lagoons	66,103	18,480 (28%)	766	Limeburners Creek National Park Clybucca Aboriginal Area Meroo National Park
Total	**190,710**	**35,912 (19%)**	**1,619**	
Inland wetlands				
Floodplain wetlands	4,008,834	267,505 (7%)	168,231	Gwydir Wetlands State Conservation Area Lachlan Valley National Park and Nature Reserve Lachlan Valley State Conservation Area Macquarie Marshes State Conservation Area Murrumbidgee Valley National Park and State Conservation Area Murray Valley National Park Murray Valley Regional Park Toorale National Park and State Conservation Area
Freshwater lakes	296,071	21,034 (7%)	2,247	Murrumbidgee Valley National Park Murray Valley National Park
Saline lakes	18,542	–	–	
Total	**4,323,447**	**288,539 (7%)**	**170,479**	

Source: NSW Office of Environment and Heritage data 2012

Significant wetlands have been added to the NSW parks estate with the creation in July 2010 of the Murray Valley and Murrumbidgee Valley national parks by combining a number of former state forests. The Murray Valley National Park protects most of the largest remaining river red gum forest in Australia (with the section located in Victoria also being protected). The reserve also includes freshwater wetlands in the former Millewa State Forest that are Ramsar-listed. In July 2010, responsibility for the Ramsar-listed Werai Forests wetlands was vested in the Minister for the Environment and will be transferred to traditional owners for conservation purposes.

In 2010, the Gwydir Wetlands State Conservation Area became the first wetland reserve to be created in the Gwydir Valley. Part of this reserve is also Ramsar-listed.

Pressures

Flow modification (and drought)

Water availability is the most significant pressure on the health of wetland ecosystems. In NSW, the stresses caused by altered flow regimes due to water resource development over the longer term were most prevalent during the drought of 2000–10. Current conditions have improved as a result of flooding rains in 2010 and 2011.

Scientific studies of the response of water-dependent ecosystems to changes in the flow regime show that variability in stream flow and flooding is critical for maintaining and improving ecological health (Roberts & Marston 2000; Rogers & Ralph 2010). Essentially, different characteristics of a river's flow regime support specific flora, fauna, ecological functions and processes in the river channel and across its floodplains. Major dams modify flow patterns by storing inflows then releasing stored water when downstream water needs exceed downstream flows or on the few occasions when they overflow during flood periods. The overall effect of this is to smooth out flow variability and remove the 'boom and bust' patterns that many wetland plants and animals require to reproduce.

The impacts of water extraction, altered flow regimes and drought on water availability are discussed in greater detail in Water 4.1, while Water 4.2 outlines the implications of flow modification and drought for aquatic ecosystems.

Habitat degradation

A number of processes are responsible for habitat degradation. Clearing of wetlands for development and/or cropping may result in irreparable damage to wetland ecosystems and the loss of biodiversity. Modifications to natural patterns of drainage are often difficult to detect or monitor, particularly during dry spells when the changes are less visible. Over-draining of coastal landscapes is a particular threat to freshwater wetlands that may create acid discharges to rivers.

More diffuse impacts to wetland habitats can be caused by surrounding land uses, pests and weeds. Increased nutrient and sediment loads and turbidity are particular threats to submerged aquatic vegetation in wetlands. Subsidence and cracking of watercourses and upland swamps resulting from long-wall mining can also pose problems for water quality and aquatic ecosystems.

In rural and semi-rural areas, grazing of wetland plants by livestock and pest species, such as rabbits and goats, can have a serious impact on the diversity, distribution and health of wetland plants. Grazing of stock may also lead to the compaction of soils, increased nutrient levels, the introduction of weed species, trampling of native plants, and the ringbarking of mature trees.

Invasive species

Introduced plants, which can change wetland structure and function, are favoured by disturbances such as altered flow regimes, clearing or draining of wetlands, and increased nutrient loads. Significant weed species in NSW wetlands include lippia, salvinia, alligator weed and water hyacinth, which can all rapidly clog waterways when conditions are favourable for recruitment and spread (see Biodiversity 5.4).

Lippia has taken over thousands of hectares of the state's inland watercourse country and has had a major impact on the condition of the Gwydir wetlands. Lippia can out-compete all native vegetation, including tree seedlings, and it poses a severe threat to watercourses and adjacent grazing lands.

Introduced aquatic species, such as European carp and gambusia (commonly known as mosquito fish or plague minnow), can decimate native fish populations in wetlands and affect water quality. Introduced herbivores, such as pigs and goats, have caused extensive damage to the condition of wetland vegetation and soils through grazing, trampling and digging and are also capable of altering the channel and bank structure of watercourses (see Biodiversity 5.4).

Water quality

Water quality plays an important role in wetland health. Runoff from towns, cities and farms may contain toxic substances or high levels of nutrients and sediments. Where excessive levels of nutrients enter wetlands, they can cause problems, such as eutrophication (the severe depletion of dissolved oxygen levels), fish kills or excessive plant growth. Increased turbidity affects the productivity of submerged vegetation and leads to siltation, which may have an impact on the composition and habitat of many dependent species. Increased salinity can affect other characteristics of water quality, contribute to the development of acid sulfate sediments, and adversely affect biodiversity.

Acid sulfate soils

Acid sulfate soils are generally regarded as an issue for coastal waterways. If left undisturbed and covered with water, sulfidic material poses little or no threat of acidification. However, when it is exposed to oxygen in the air, the sulfides react to form sulfuric acid which can contaminate waterways. See Land 3.1 for more detail.

River regulation has seen some wetlands used as water storages, causing the loss of their dry phase. Where these wetlands are associated with saline groundwater that is high in sulfur, sulfidic sediments may accumulate in the inundated wetland. The drought conditions (2000–10) led to the drying of many otherwise permanently inundated wetlands in the Murray–Darling Basin, exposing sulfidic material with the potential to cause the acidification of some inland wetlands, as occurred at Bottle Bend on the Murray River. While some investigations have been conducted (Hall et al. 2006), the full extent of the threat posed by acid sulfate soils to inland wetlands is still unclear. The Murray–Darling Basin Commission has done a rapid assessment of the acid sulfate soil risk across the basin and identified key areas along the Murray and Murrumbidgee in NSW for detailed assessment.

Climate change

Climate change is likely to affect wetlands through changes in water availability and higher temperatures and rates of evaporation. These are expected to affect wetland condition and productivity and potentially lead to shifts in wetland distribution or ecosystem types (CSIRO 2008c). For further consideration of this issue, see Water 4.1 and Water 4.2.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Improve the environmental health of wetlands and catchments through actively managing water for the environment by 2021'. This includes the strategic recovery and management of water for the environment to improve the health of the most stressed rivers and wetlands. Further details on Goal 22 are provided in Water 4.1.

NSW Wetlands Policy

The NSW Wetlands Policy (DECCW 2010c) updates the 1996 NSW Wetlands Management Policy to reflect developments in natural resource management and planning that affect wetlands. It 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.

Water sharing plans

Water sharing plans provide for flows of environmental water to inland and coastal wetlands to improve wetland health. The amount of water received by the environment depends on the share specified in the water sharing plan and water availability. For example, with the end of the drought, the 2010–11 water year was the first time that the Macquarie Marshes received 100% of its environmental water allowance since the introduction of the water sharing plan in 2004–05. Water sharing plans are discussed in Water 4.1.

For inland water sources, the proposed Murray–Darling Basin Plan requires the development of long-term environmental watering plans that identify assets within each valley, their water requirements and targets for their management. Once developed, these long-term plans will be taken into account when water sharing plans are reviewed.

Purchase of water licences

The purchase of water licences has increased the share of water available for the environment and its active management under programs such as NSW RiverBank has enhanced the levels and patterns of flows to wetlands. Water 4.1 describes water purchases for the environment.

Adaptive environmental water plans

These plans facilitate the delivery of available environmental water to key wetlands. Adaptive environmental water plans have been approved for the Lachlan, Macquarie and Gwydir valleys and a draft plan prepared for the Murrumbidgee.

NSW Wetland Recovery Program

The NSW Wetland Recovery Program was completed in 2010. Management plans were developed for environmental watering of the Gwydir wetlands and Macquarie Marshes. In addition, infrastructure projects were delivered, including the Gingham pipeline project, providing water savings of 958 megalitres (ML) to water ecological assets in the Gwydir wetlands, and the upgrade of Gradgery Lane, upstream of the Macquarie Marshes, to remove a system choke and allow the passage of increased volumes of environmental water.

NSW Rivers Environmental Restoration Program

The NSW Rivers Environmental Restoration Program was completed in 2011. This program to arrest the decline in iconic rivers and wetlands in NSW delivered the following outcomes:

- the purchase of 108,000 ML of water entitlement across the Lowbidgee floodplain, Lachlan wetlands, Macquarie Marshes, Gwydir wetlands and Narran Lakes
- preparation of decision support systems and hydrologic and hydrodynamic models for the Gwydir Valley, Macquarie Marshes, Lowbidgee floodplain and Narran Lakes to assist in managing environmental flows
- completion of major infrastructure works, including 10 regulating structures, 10 floodways and the breaching of 40 pre-existing embankments in Yanga National Park to improve environmental flows
- engagement of Aboriginal communities to reconnect to culturally significant wetlands on private land and the identification of over 1200 new sites of cultural significance
- negotiation of 15 land management agreements with landholders to improve management of over 3200 hectares of wetlands of high conservation value
- acquisition of 14,000 hectares of significant wetlands for inclusion in the National Reserve System, including Booligal Station (Lachlan), Old Dromana (Gwydir), and parts of Pillicawarrina (Macquarie) and Geramy (Lachlan).

Change in ecological character: Macquarie Marshes

The notification of a 'likely change in ecological character' under the Ramsar Convention was made in August 2009 for the Macquarie Marshes Ramsar site. The key driver of change was identified as water management. The NSW Office of Environment and Heritage is currently taking action and preparing a response strategy consistent with the *Adaptive Environmental Management Plan for the Macquarie Marshes* (DECCW 2010a).

Coastal wetland rehabilitation

In 2012, four major coastal wetland areas were restored at Darawakh Swamp (929 hectares – Great Lakes region), Yarrahapinni (600 ha – Macleay River), Ash Island (500 ha – Hunter River) and Hexham Swamp (2000 ha – Hunter River). These large-scale rehabilitation projects will benefit fish and other species that were lost due to drainage changes associated with flood mitigation schemes, improving the breeding of fish targeted by commercial and recreational fishers.

Future opportunities

Assets such as priority wetlands will be identified for each Water Resource Plan area within the Murray–Darling Basin so that environmental water can be directed to them.

The monitoring of environmental flows will facilitate adaptive management so that these flows better replicate natural conditions and optimise the benefits to the health of wetland ecosystems.

Inland rivers and wetlands are not well represented within the national parks estate. The *NSW National Parks Establishment Plan 2008* (DECC 2008) identified wetlands as a key priority for building the reserve system over the 10 years to 2018.

Better scientific information on the location and types of wetlands found in NSW is desirable, particularly the conservation values of the smaller and less well-studied wetland types that may have unique values and inadequate protection.

A better understanding of the processes and factors affecting the health and resilience of floodplain wetlands will enhance their management, given the intermittent and unpredictable nature of inundation patterns which vary substantially over longer time frames.

4.4 Groundwater

Demand for assigned groundwater resources in New South Wales has eased significantly in recent years as more surface water has become available following high rainfall. Water sharing plans continue to be implemented for groundwater aquifers, with 34 now completed and all NSW sources in the Murray–Darling Basin to be covered by the end of 2012.

Overall groundwater use fell considerably during the 2010–11 water year, with extraction from most groundwater sources well below the long-term sustainable extraction limit. Groundwater levels have risen in most areas in response to the higher rainfall, enabling aquifers to recharge and usage levels to drop.

During 2010–11, the Lower Gwydir and parts of the Upper Namoi groundwater sources experienced the highest levels of groundwater demand, due to the relatively drier conditions being experienced in northern inland NSW.

The most significant fall in groundwater use occurred in the Lower Murrumbidgee and Lower Murray Groundwater sources due to the flooding experienced in southern NSW in late 2010–early 2011.

Water sharing plans set annual extraction limits for groundwater use. Extraction from some groundwater sources has been above the long-term sustainable yield in the recent past, but use is now being managed to align with the sustainable yield through the implementation of water sharing plans.

NSW indicators

Indicator and status	Trend	Information availability
Extent and condition of groundwater-dependent ecosystems	Unknown	✓
Long-term extraction limit: use	Decreasing	✓✓
Long-term extraction limit: entitlement	Decreasing	✓✓✓
Aquifer integrity	Stable	✓✓
Groundwater quality	Stable	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Where surface water is available, groundwater is generally seen 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 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 bodies (wetlands, rivers and lakes) that are connected to groundwater and some terrestrial ecosystems.

Significant changes in the quality and quantity of groundwater available have the potential to degrade ecosystems and affect human uses of water. Because of the hidden nature of many groundwater-dependent ecosystems, the impacts on these systems are likely to be less obvious and understood.

Status and trends

Extent and major uses of groundwater in NSW

Approximately 11% of all water used in NSW comes from groundwater sources. It is used for drinking water, irrigation, watering stock, and domestic and industrial purposes. For more than 200 towns in NSW, groundwater is the principal source of water supply. An estimated 13% of the groundwater used in NSW goes to domestic and stock purposes.

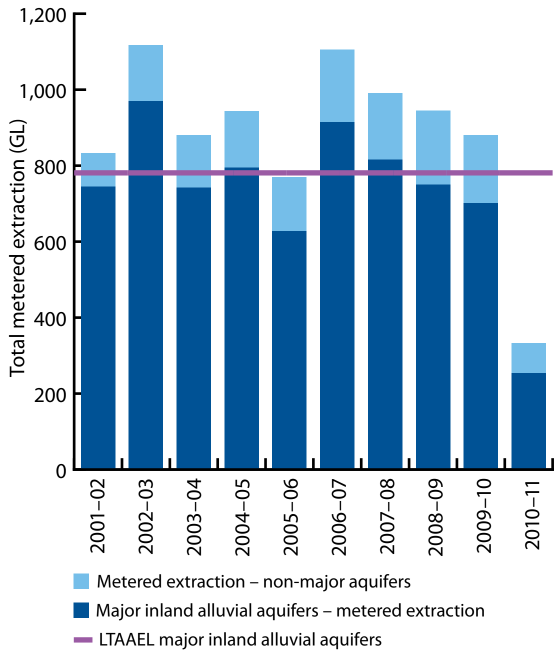
However, agriculture is the largest user of groundwater in NSW with the greatest volume of use being for irrigation in the areas of the main inland alluvial aquifers. This is followed by mining, with groundwater being the only available source of water for some inland mining operations, although it can also be an obstruction or hazard that must be removed for mining to proceed.

Levels of extraction and recharge

Variability in climatic conditions affects the amount of groundwater used. Extraction may increase substantially in times of drought to offset the lack of surface water, while in periods of high rainfall and associated recharge less groundwater is used. Due to high rainfall and an increase in surface water availability, demand for groundwater resources has decreased over the past three years, following an extended period of high demand.

Figure 4.6 shows groundwater extraction from all metered aquifers in NSW and the major inland alluvial aquifers over the 10 years to 2010–11. Two peaks in extraction occurred in 2002–03 and 2006–07 when drought conditions were particularly acute. A gradual decline in extraction has occurred since 2006–07 as the effects of the drought eased, but also due to the introduction of water sharing plans in several of the large inland alluvial groundwater sources since 2006. A further substantial reduction occurred in the 2010–11 water year, due to very high rainfall and flooding in many areas. Overall only 350 gigalitres (GL) was extracted in 2010–11, around a third of the volume used when demand was at its peak.

Figure 4.6: Annual levels of groundwater extraction from metered aquifers in NSW and the major inland alluvial aquifers, 2001–02 to 2010–11



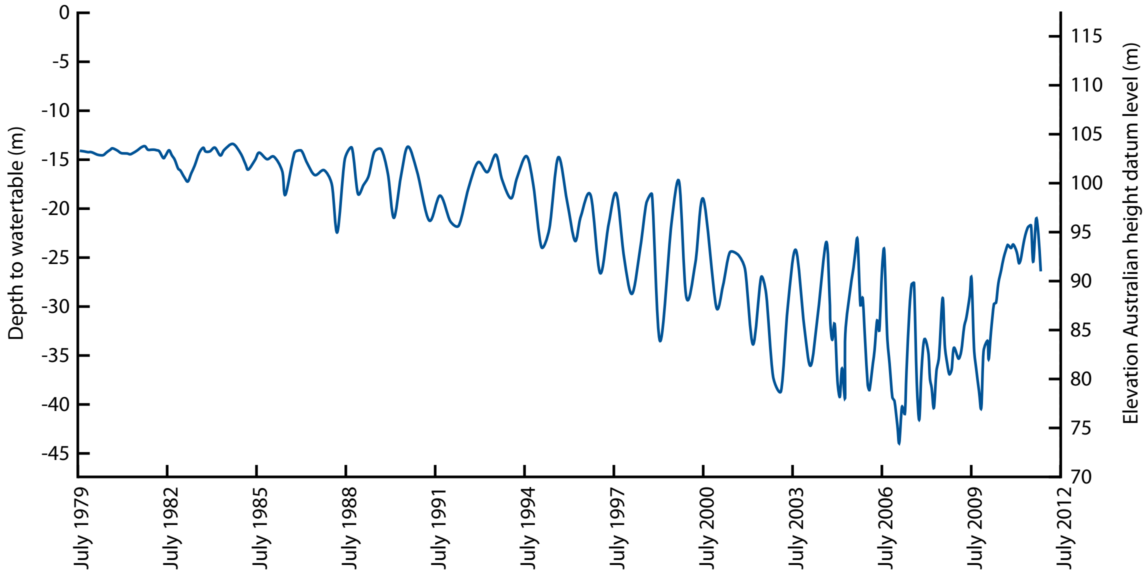
Source: NSW Office of Water (NOW) data 2011

Notes: The major inland alluvial aquifers are the basins of the Gwydir, Namoi, Macquarie, Lachlan, Murrumbidgee and Murray rivers.

The purple 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 LTAAEL does not apply to 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, so extraction levels for the major inland alluvial aquifers are permitted to exceed the LTAAEL until then.

Figure 4.7: Groundwater hydrograph for a monitoring bore in the Lower Murrumbidgee deep groundwater source (GW036358)



Source: NOW data 2011

Around 80% of metered groundwater use in NSW occurs in the six major inland alluvial aquifers of the Gwydir, Namoi, Macquarie, Lachlan, Murrumbidgee and Murray River valleys as shown in Figure 4.6. The overall volume of groundwater extracted in NSW is higher as extraction is not metered in many areas of NSW where groundwater demand is low, particularly on the coastal side of the Great Dividing Range.

A groundwater hydrograph from a monitoring bore located in the largest groundwater source in NSW – the Lower Murrumbidgee deep aquifer – illustrates the general pattern of groundwater response to climatic conditions and variations in groundwater demand (**Figure 4.7**).

Groundwater use in this area began in the late 1970s and early 1980s, with an annual pattern of drawdown over the spring and summer, followed by recovery during autumn and winter, restoring previous levels by late winter. However, as demand grew and water pumping increased, drawdowns became deeper and seasonal recovery incomplete. As drier conditions set in, very deep drawdowns occurred, with the most acute in the summer of 2006–07 when it became clear that such levels of extraction could not be sustained in the longer term. In the years that followed, a reduction in use coincident with higher rainfall resulted in some recovery of levels, until 2010–11 when groundwater levels rose significantly. However, levels have not returned to pre-development levels and are not expected to do so.

Long-term average annual extraction limits

The intent of water sharing plans for groundwater (see 'Responses' below) is to manage the resource sustainably so that groundwater levels do not decline excessively, causing unacceptable impacts on the aquifer or groundwater-dependent ecosystems, and extraction remains in balance with recharge over the longer term. This means that extraction above sustainable levels in times of drought, for one or several years, will result in a decline in groundwater levels with recovery occurring during wetter periods when recharge is much greater than extraction. This natural variability of groundwater systems provides for a reliable and secure water resource.

The long-term average annual extraction limit (LTAAEL) is the average level of groundwater that can be extracted sustainably on an annual 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 which relate rainfall and river leakage to recharge over a period of 20 to 30 years. Where insufficient data is available, it is based on a percentage of the annual average rainfall being captured as recharge. The final extraction limit is then set after a portion of groundwater is allocated to the environment, based on the environmental assets identified as requiring protection.

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. At the state scale, therefore, the overall level of entitlement compared with the LTAAEL is quite low, at around 25%.

The inland alluvium geological provinces lie in the flat lands of north-western and south-western NSW and provide high-yielding, good quality water supplies which are able to be used extensively for irrigation. About 98% of all metered groundwater extraction in NSW is from these aquifers, including the six major aquifers referred to in Figure 4.6, which provide 80% of extraction. As a consequence, it is mainly in the inland alluvium that there is pressure to manage groundwater sustainably as extraction is close to the LTAAEL.

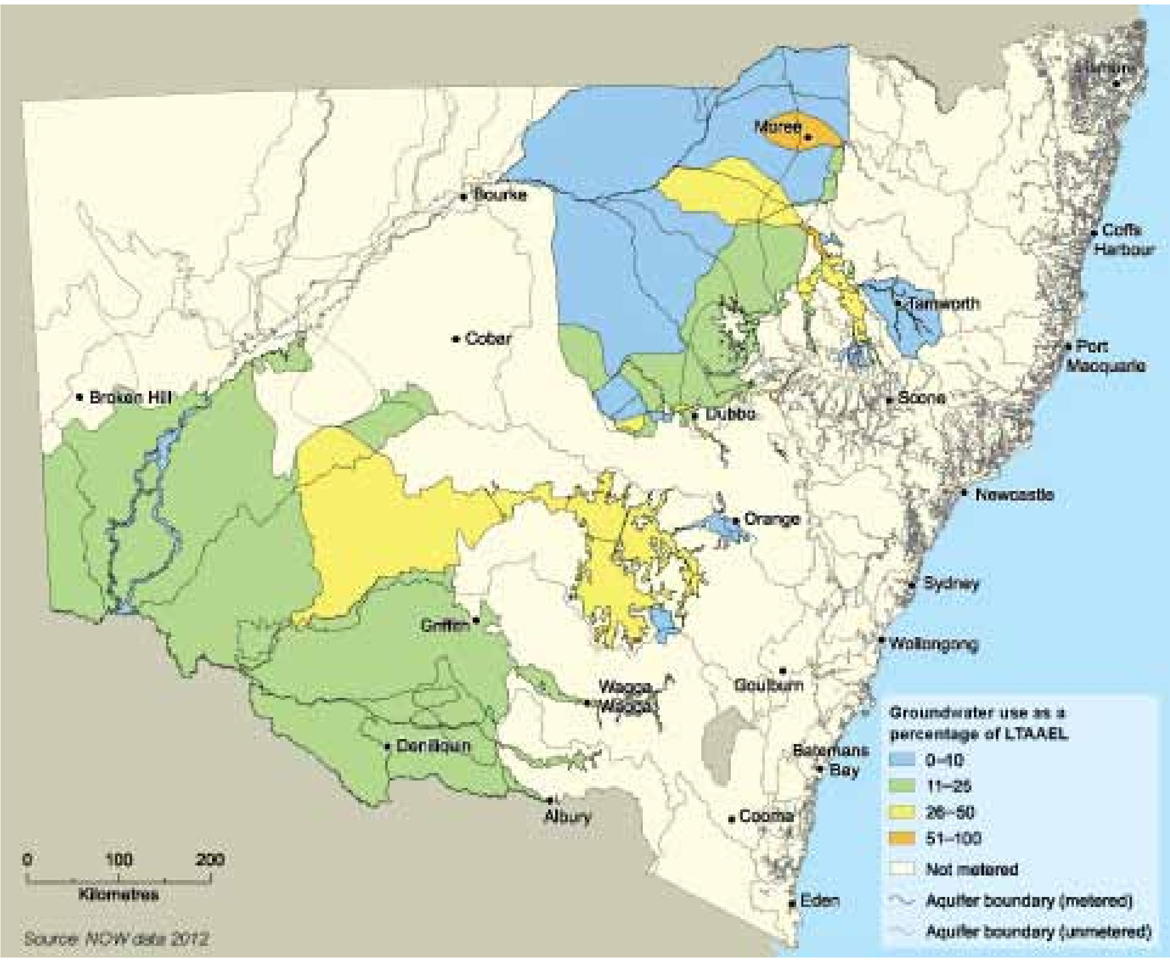
From the early 1980s, embargos have been imposed on the issue of further licences in the inland alluvial aquifers and annual limits have been placed on extractions. Since 2006, water sharing plans have placed a formal limit on extraction enforced through regulation. The implementation of these plans has expanded to areas beyond the six major inland alluvial aquifers, with all inland NSW groundwater sources to be covered by the end of 2012 (see below under 'Responses').

Extraction compared to extraction limits

Groundwater use can be quite variable, both within and between groundwater sources. In some years and some groundwater sources, extraction can exceed the LTAAELs that are set in water sharing plans. To address historical over-allocation, water sharing plans provide for a progressive reduction in water allocations over their 10-year term. At the end of their terms, water sharing plans will ensure that average annual groundwater use will be within the LTAAEL.

Map 4.4 shows groundwater use during the 2010–11 water year as a percentage of the LTAAEL, which provides an indication of sustainable use in areas where groundwater use is metered and monitored. The very wet water year caused groundwater demand to fall significantly with use at, or well below, the LTAAEL in most areas. The highest levels of extraction were from the Lower Gwydir groundwater source around Moree at 102% of LTAAEL. This level is within the acceptable buffer allowed in the water sharing

Map 4.4: Extraction from NSW groundwater aquifers as a percentage of the long-term average annual extraction limit, 2010–11



Notes: Only those areas of NSW where groundwater use is metered are shown on the map.
LTAAELs for the six major inland alluvial water sources are being reduced during the life of their respective water sharing plans. Usage is compared with the LTAAEL applicable for the 2010–11 water year, not the LTAAEL specified for the end of the plan (at year 10).

plan and does not exceed the interim extraction limit set annually while long-term levels of use are adjusted to align with the LTAAEL. The only other area where use was greater than 50% of the LTAAEL was in some groundwater sources of the Upper Namoi around Narrabri. Usage was highest in these areas due to the relatively lower rainfall in northern inland NSW during 2010–11. The greatest falls in demand were in the groundwater sources of the Lower Murrumbidgee (around Hay) and Lower Murray (around Deniliquin) because of very high rainfall and flooding which occurred in southern NSW.

Some areas outside the six major alluvial groundwater sources have entitlements higher than the extraction limit, but use is currently at or below the limit. Where use approaches the extraction limit due to the activation of previously unused entitlements, the water sharing plan allows for usage to be moderated by determining the water levels available for extraction.

Groundwater-dependent ecosystems

Groundwater-dependent ecosystems (GDEs) are described in water sharing plans for groundwater as those where species composition or natural functions depend on the availability of groundwater. Dependence may be complete or partial, such as during periods of drought. The degree and nature of 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. GDEs were first identified and classified in Australia in the late 1990s (Hatton & Evans 1998) and were subsequently recognised in NSW by the *NSW State Groundwater Dependent Ecosystems Policy* (DLWC 2002). Since the release of this policy, the number of GDE types has grown as knowledge has improved.

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, as described below.

Subsurface ecosystems

The most significant, diverse and potentially sensitive groundwater-dependent organisms are those found underground within aquifers and cave ecosystems. These organisms are totally reliant on groundwater and are adapted to these environments (Gibert et al. 1994).

Karsts and caves are defined as 'natural cavities in rock which act as a conduit for water flow between input points, such as stream sinks, and output points, such as springs or seeps' (White 1984). Karsts are a specific form of cave terrain with distinct landforms and drainage characteristics. The aquatic ecosystems within these subterranean environments consist of communities of organisms, mainly microorganisms and invertebrates that are adapted to live in perpetual darkness and are totally dependent on groundwater (Ward et al. 2000). Life forms that exist in caves and aquifers are considered to be highly endemic.

Subsurface phreatic aquifer ecosystems: The free water within the pore spaces and cracks of unconsolidated sand and gravel and fractured rock aquifers can also support communities of diverse, endemic, highly specialised, and often relict life forms. These can include microorganisms, invertebrates and, occasionally, vertebrate species. Due to their adaptation to a relatively narrow natural range of water chemistry, these communities may be of interest as indicators of groundwater health and water quality.

Subsurface baseflow streams: Many river reaches have a baseflow component derived from groundwater discharge which is vital to the character and composition of in-stream and near-stream ecosystems. By providing a permanent water source, baseflow streams support ecosystems that are able to live in subsurface sediments (Evans 2007).

Surface ecosystems

Surface baseflow streams also support surface ecosystems through surface flows or permanent pools that provide refuges in times of low flows.

Wetland ecosystems may depend on groundwater to maintain seasonal patterns of waterlogging or flooding. Wetlands provide the most extensive and diverse set of potential GDEs in Australia (Hatton & Evans 1998). Examples include paperbark swamp forests and woodlands, swamp sclerophyll forests and woodlands, swamp scrubs and heaths, swamp shrublands, sedgelands and mound spring ecosystems.

Estuarine and near-shore marine ecosystems: Many of these systems depend on groundwater discharges to provide suitable habitats for a diverse group of flora and fauna. These include coastal lakes, mangroves, saltmarshes and seagrass beds (Hatton & Evans 1998; SKM 2001; Burnett et al. 2003). Groundwater discharges may be in the form of direct off-shore discharge zones called 'wonky holes', diffuse discharges through sandbeds, or baseflow streams that discharge to the ocean.

Groundwater-dependent or phreatophytic vegetation: This is terrestrial vegetation that depends on the subsurface presence of groundwater, often accessed via the capillary fringe – the subsurface layer just above the watertable that is not completely saturated (SKM 2001; Eamus et al. 2006). This vegetation may be dependent on groundwater to sustain transpiration and growth through a dry season or maintain perennially lush ecosystems in otherwise arid environments.

Although not a specific GDE type, terrestrial fauna may also depend on groundwater as a source of drinking water.

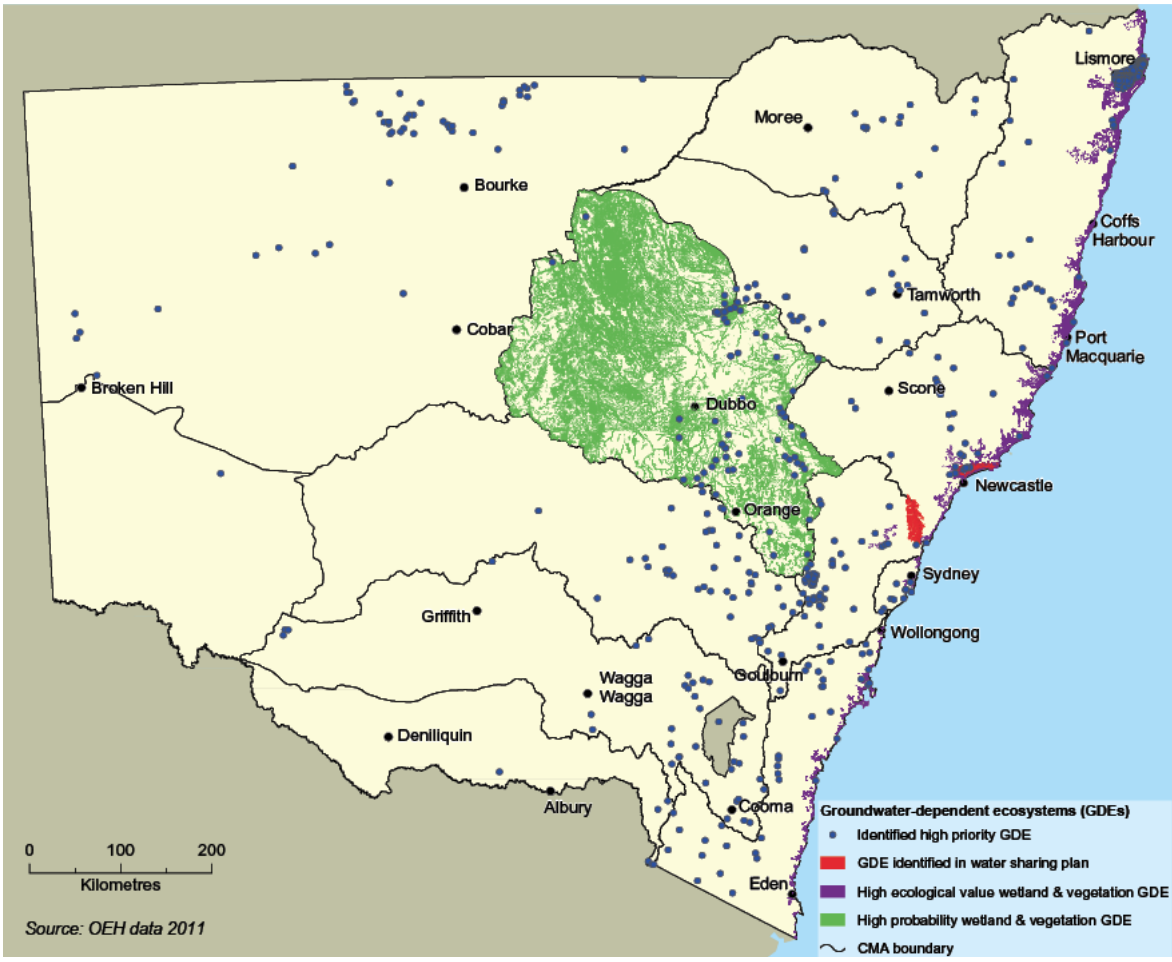
Identification of groundwater-dependent ecosystems

Interest in GDEs and their sustainability is relatively recent and little is known about their location or condition (Eamus & Froend 2006). However, the NSW Government has been actively engaged in identifying GDEs across the state in recent years. A preliminary desktop study identified a range of GDEs and sites where they could potentially occur. Areas of terrestrial vegetation that are potentially groundwater-dependent are being mapped using satellite imagery (MODIS). Follow-up field survey work will establish the extent of their natural values and the condition of these sites, as well as their level of dependence on groundwater.

Risk assessment guidelines to provide methods for identifying and valuing GDEs and their associated aquifers (Serov et al. 2012) have now been developed during assessment of the coastal sands and floodplain alluvium on the NSW coast. The guidelines enable the development of management strategies for aquifers and GDEs and assessment of the potential and actual impacts of proposed activities on GDEs.

High priority GDEs shown in **Map 4.5** have high ecological value and are mostly associated with springs and karsts, but may include other GDEs identified as high priority in water sharing plans. At this stage, mapping of GDEs with high ecological value has only occurred along the coast. Map 4.5 also displays high probability GDEs within the Central West Catchment Management Authority area but the ecological value of many of these communities is yet to be determined. Current mapping is still limited and will be expanded in future.

Map 4.5: Mapped NSW groundwater-dependent ecosystems at December 2011



Source: OEH data 2011

Pressures

Excessive demand and extraction

Over the longer term, reducing the storage levels of an aquifer or permanent mining of the resource will affect its stability and integrity, as well as having permanent consequences for all dependent ecosystems and beneficial uses. Competition for groundwater resources can place the long-term security of these resources at risk.

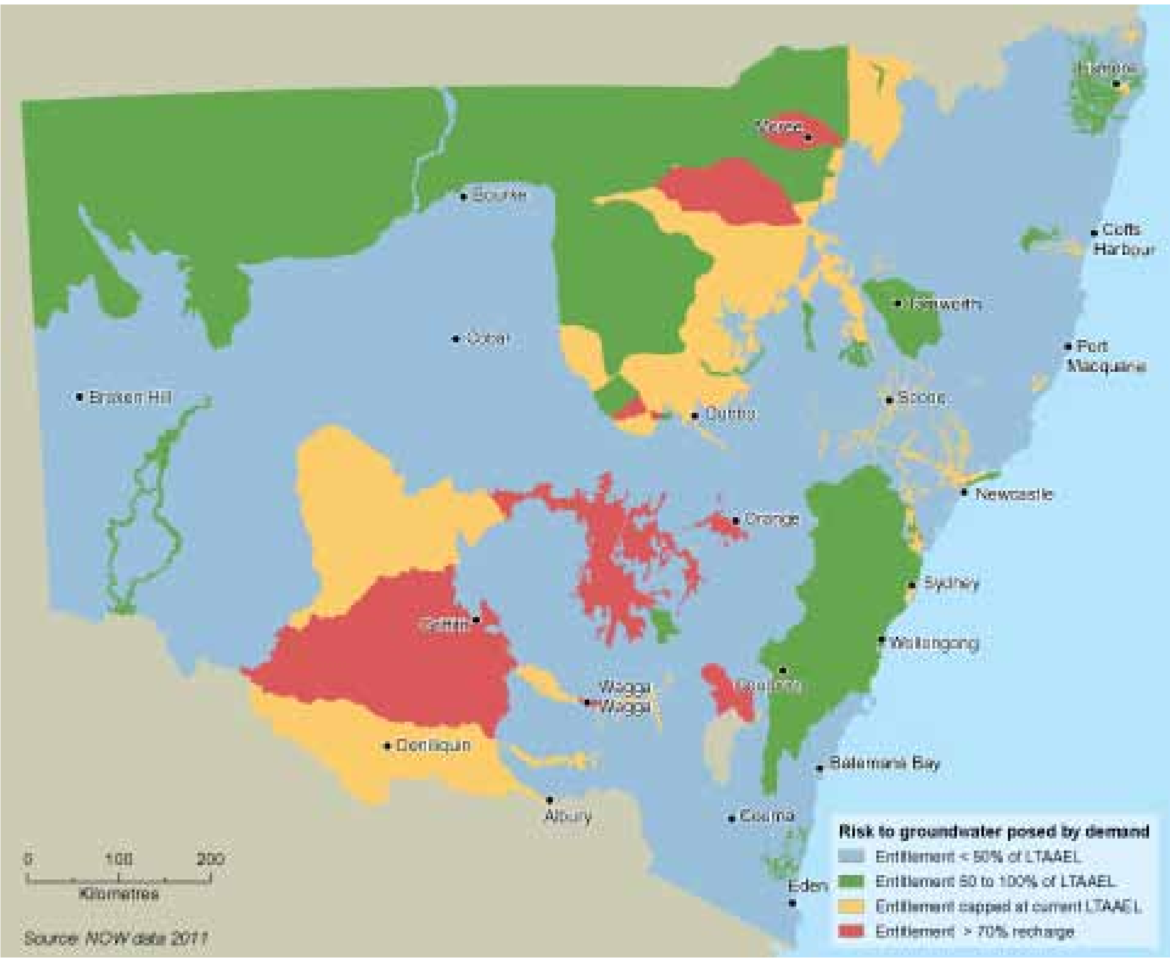
NSW groundwater sources have been assessed for risk due to groundwater demand using a standard developed under the National Framework for Compliance and Enforcement Systems for Water Resource Management, agreed to by COAG in December 2009. The areas at highest risk are characterised by high consumption with entitlements close to or above extraction limits and actively protected water rights. The areas of lower risk are those where demand is low and entitlements are significantly below sustainable levels.

The outcome of the risk assessment is shown in **Map 4.6**. The areas at highest risk are:

- Lower Murrumbidgee around Hay
- Mid-Murrumbidgee around Wagga Wagga
- Lower Namoi, west of Narrabri
- Lower Gwydir around Moree
- parts of the Lower Macquarie, west of Dubbo
- Orange basalt
- alluvial valleys of the Hunter catchment
- coastal sand beds north of Newcastle.

Although the risk assessment was intended to guide the prioritisation of water compliance resourcing, it has also highlighted the most important and sensitive areas for broader decision-making on groundwater management. The aim of water sharing plans is to ensure that water is managed sustainably and plans will shortly be in place in all these areas to protect the long-term security of groundwater supplies.

Map 4.6: Risk posed to groundwater due to groundwater demand



Saline intrusion

Where the level of extraction of groundwater is high and the aquifer is overlain by saline aquifers or 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. The water sharing plans contain provisions to ensure groundwater quality does not change to a less beneficial risk class.

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 2008a) identified that the current and probable future levels of groundwater extraction will have a greater impact on inland aquifer systems than a 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

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Improve the environmental health of wetlands and catchments through actively managing water for the environment by 2021'. Further details on Goal 22 are provided in Water 4.1.

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.

Groundwater-dependent Ecosystems Policy

The *NSW State Groundwater Dependent Ecosystems Policy* (DLWC 2002) provides guidelines on how to protect and manage groundwater-dependent ecosystems. Further work will help to establish the location of these ecosystems and how heavily they rely on groundwater.

Water sharing plans for groundwater

The intent of water sharing plans for groundwater is to manage the resource so that extraction remains in balance with the capacity to replenish them 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 is greater than the sustainable yield of the aquifer. 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 six major inland alluvial groundwater sources over the 10-year period of the water sharing plans. **Figure 4.8** shows the effect of these reductions in the early years of the plans.

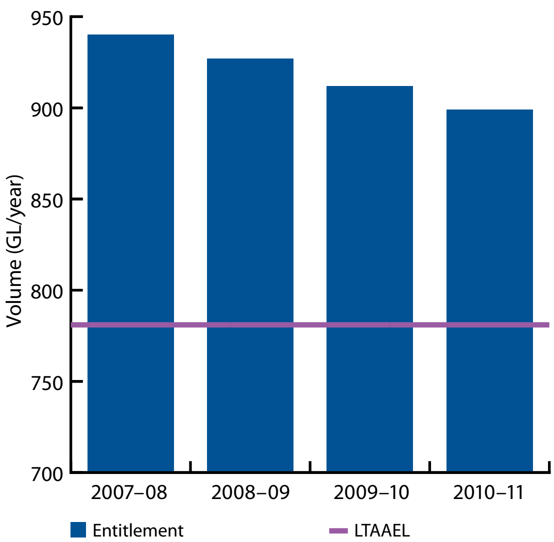
There were 34 gazetted water sharing plans which covered groundwater sources as of July 2012, with another six for the remaining inland aquifers to be completed by the end of 2012 and a further 12 plans for coastal aquifers expected to be completed by 2014. In time, all groundwater in NSW will be regulated by water sharing plans made under the *Water Management Act 2000* and the *Water Act 1912* will no longer apply to groundwater use. The making of these plans will ensure that water entitlements are brought into equilibrium with the sustainable yields of all aquifers throughout NSW.

In the interim, the issue of further entitlements has been embargoed in many areas not covered by a water sharing plan. This is to minimise the risk of resource over-allocation and lessen potential impacts on surface water resources ahead of the making of water sharing plans.

Achieving Sustainable Groundwater Entitlements program

Under this program the Australian and NSW Governments are providing financial assistance to groundwater licence holders and regional communities to help them adjust to reduced groundwater entitlements.

Figure 4.8: Entitlements to groundwater under water sharing plans



Source: NOW 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 63,000 megalitres (ML) per year and there has now been an increase in water pressure across the basin.

Aquifer protection and research

Great care needs to be taken to ensure that the rapid expansion of mining and coal seam gas developments does not result in permanent damage to aquifers. A new interim aquifer interference regulation took effect on 30 June 2011, which requires new mining and petroleum exploration activities that extract more than 3 ML per year from groundwater sources to hold a water access licence. The *NSW Aquifer Interference Policy* (DPI 2012) has been developed by the NSW Office of Water 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 coal seam gas activities, should be assessed and licensed to strike a balance between the water requirements of towns, farmers, industry and the environment.

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, their hydraulic interaction with rivers, and learn more about groundwater-dependent ecosystems. Some of these studies have been completed and are already influencing decision-making for groundwater management.

This research has been supported by an expansion of groundwater monitoring and improved data management. Monitoring of groundwater levels has increased in sophistication with the roll-out of instruments which measure water levels and transfer the data continuously making it available on the internet.

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. There is a risk that more stringent limits on the use of surface water will place greater pressure on groundwater as a substitute source of water.

In making new water sharing plans, the sustainable extraction limit for each water source has been determined for the first time. However, many water sources that are deep or contain brackish groundwater have water that is unassigned. A process is being formulated for the controlled allocation of a proportion of this water where its use would not adversely affect surface water flows, other groundwater users or the environment.

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.

4.5 Marine waters and ecosystems

The overall health of the New South Wales marine environment and ecosystems is considered to be good, as is recreational water quality.

While instances of contamination from stormwater runoff, sewage overflows and outfall emissions do occur, their impacts tend to be localised and of limited effect. Beach suitability, based on levels of stormwater and sewage contamination, is rated as good or very good at 83% of all beaches in NSW and at over 99% of ocean beaches. It is lower at around 60% of beaches in the enclosed waters of coastal lakes, estuaries and rivers.

Forty-one species found in NSW coastal waters are listed as threatened or extinct, around half of them ocean birds and most of the rest higher order species, such as marine mammals and large fish.

The listing of some marine species as threatened indicates that external pressures are having an impact on some species and, by implication, on ecosystems.

The main pressures on marine species include destruction of vital habitats, chemical contamination, overfishing, and entanglement in disused fishing gear and refuse, such as plastic bags and ring pulls.

NSW indicators

Indicator and status	Trend	Information availability
Percentage of beaches with beach suitability grades for swimming of good or better	Stable	✓✓✓
Frequency of algal blooms	Stable	✓✓
Distribution of rocky reef-covering biota	Unknown	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

NSW marine waters contain high levels of biodiversity because of their wide range of oceanic, shoreline and estuarine habitats and the strong influence of both subtropical and temperate currents. These varied environments provide many important ecosystem services, including 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 state's marine jurisdiction extends three nautical miles (5.6 kilometres) off the 1900-kilometre NSW coast. Marine waters and ecosystems adjacent to urban and industrial areas are more susceptible to the effects of pollution from urban runoff, stormwater and sewage discharge.

Status and trends

To meet the requirements of the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d), indicators have been developed to assess the status of the marine environment but information is still quite limited. Information on marine protected areas is addressed in more detail in Biodiversity 5.3.

Water quality

Marine waters are generally considered to be in good condition as currents, wave action and tides are usually able to dilute pollution, making marine systems less vulnerable to degradation. Nonetheless, even in well-flushed systems, pollutants can bind to organic material and sediments and accumulate in filter feeders and higher order predators with adverse effects on ecosystems and human health.

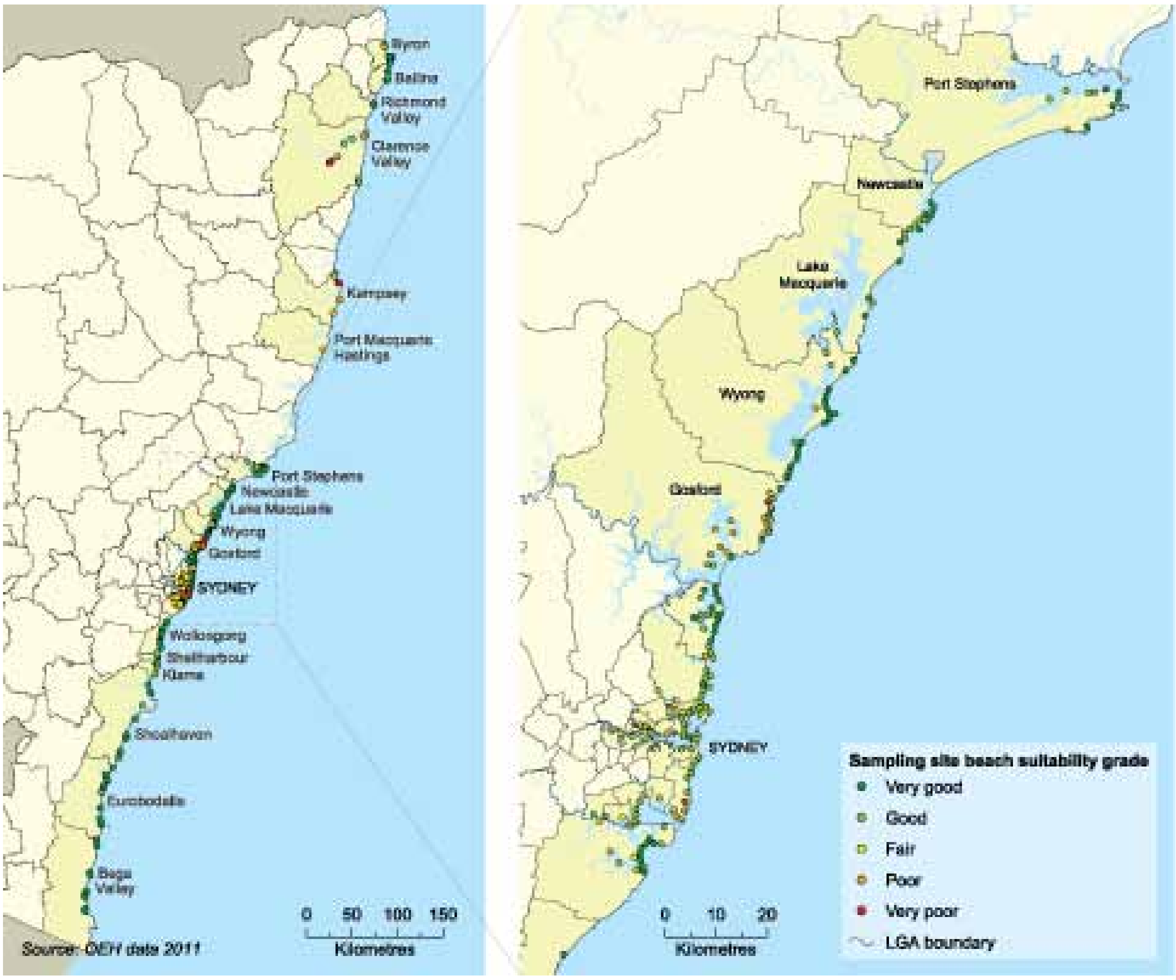
Sedimentation and local pollution from sewage and stormwater overflows associated with urban development can have an impact on water quality. *Marine Water Quality Objectives for NSW Ocean Waters* (DEC 2005) simplify and streamline the consideration of water quality in coastal planning and management. These objectives reflect the environmental values the community places on marine waters and their uses. Together with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000), the objectives identify the steps required to protect these values and uses, now and in the future.

Recreational water quality

Information on the recreational water quality in marine and estuarine waters is provided by the Beachwatch programs. The Beachwatch program conducted by the NSW Office of Environment and Heritage (OEH) monitors 127 swimming sites in the Sydney, Hunter and Illawarra regions, while coastal councils also monitor beaches in their areas under the Beachwatch Partnership Program. In the 2010–11 swimming season, 14 local councils participated in this program, monitoring 132 swimming sites, including beaches, coastal lagoons, tidal pools, estuaries and rivers.

Both programs provide information on the risks of sewage and stormwater pollution at beaches. Swimming sites are assigned a beach suitability grade ranging from 'very good' to 'very poor' based on a risk assessment of pollution sources affecting the beach and the level of the bacterial indicator enterococci, in accordance with the *Guidelines for Managing Risks in Recreational Water* (NHMRC 2008). **Map 4.7** shows the beach sustainability grades at NSW sites in 2010–11.

Map 4.7: Beach suitability grades at swimming sites in NSW, 2010–11



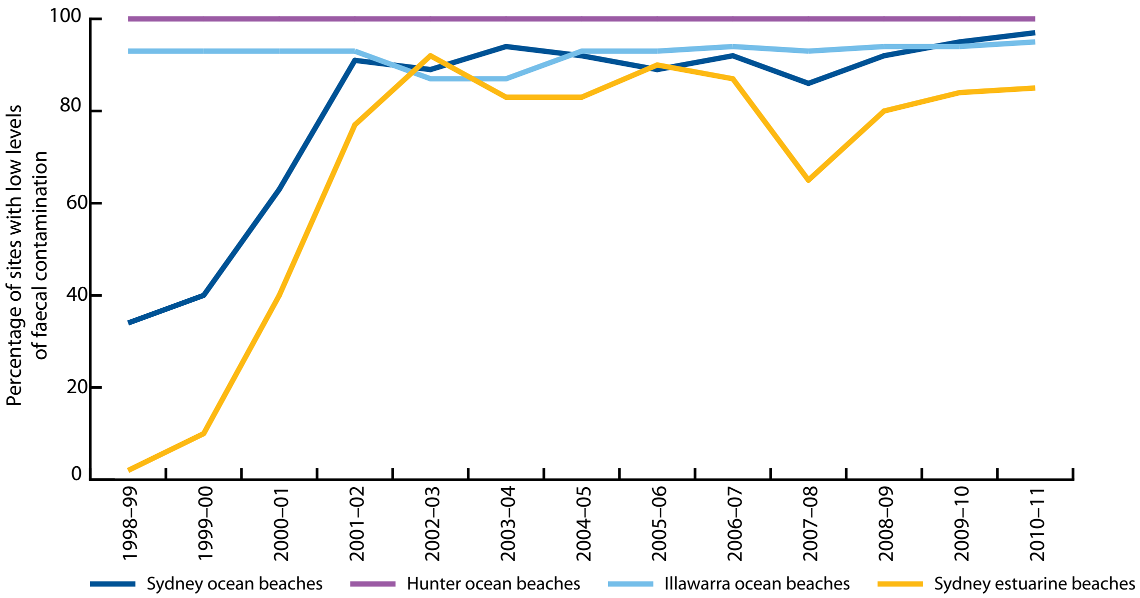
This system for grading beaches is based on new guidelines that were adopted in NSW in May 2009, replacing the earlier 1990 guidelines. Although monitoring water for recreational use does not provide an assessment of overall water quality and waterway health, changes over time enable the effectiveness of stormwater and wastewater management to be assessed.

In 2010–11, 83% of the 259 swimming locations monitored were graded as 'very good' or 'good'. However, there are differences between swimming sites with over 99% of all ocean beaches achieving ratings of very good or good, compared with around 60% of sites in coastal lagoons, estuaries and rivers due to the lower dilution and tidal flushing capacities of these waterways (Map 4.7). Overall, this is a strong result which was achieved despite the NSW coast experiencing its wettest spring and fifth-wettest summer on record. High rainfall causing stormwater discharges and sewerage overflows is recognised as the principal factor in the contamination of water at NSW beaches. Detailed results for all swimming sites monitored in NSW can be found in the *State of the Beaches* reports (OEH 2011b).

Figure 4.9 shows the proportion of sites with low levels of faecal contamination over the past 13 years at ocean and estuarine beaches in the greater Sydney area. Less than a decade ago wet weather had a much greater impact on swimming locations in Sydney. During 1998–99, when almost as much rain fell as in 2007–08 and 2010–11, only 35% of Sydney's ocean beaches and 2% of Sydney's estuarine swimming areas recorded low levels of faecal contamination (Microbial Assessment Categories A and B defined by NHMRC 2008). These results are based on the measure used prior to 2009 and they are therefore not directly comparable to the outcomes displayed in Map 4.7. Improvements in stormwater and wastewater management over the past decade have resulted in significant reductions in bacterial levels at swimming locations in the Sydney region.

While significant progress has been achieved in controlling point sources of pollution and some diffuse sources, such as stormwater, diffuse source water pollution remains one of the biggest challenges in improving water quality for government, industry and the community (DECC 2009).

Figure 4.9: Sydney, Hunter and Illawarra beach and estuary monitoring sites graded as having low levels of faecal contamination, 1998–99 to 2010–11



Source: OEH data 2011

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.

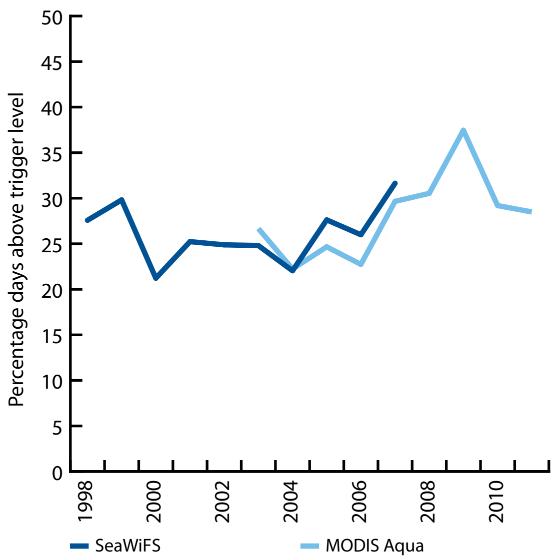
Data from the Beachwatch Partnership Program is not included.

Algal blooms

While algal blooms occur naturally in the marine environment, some species such as dinoflagellates can be harmful to aquatic organisms (DEH 2005). Less harmful blooms can cause odours or discolouration, such as the red tides that affect visual amenity. The nutrients which promote the growth of algal blooms come from ocean upwellings, which have a close association with El Niño weather cycles, and from the outflows of estuaries. Ocean outfalls, rainfall runoff and stormwater discharges may also boost local nutrient levels in waters close to urban areas.

Satellite data from 1998 onwards is being used to derive information on the occurrence of marine algal blooms in NSW waters. This data allows for a broad and systematic assessment of the frequency and type of blooms and improves on the largely reactive reporting of the past which relied on testing of water quality in affected areas after algal blooms were sighted. Following the failure of the SeaWiFS satellite initially used, it has been necessary to transition to the MODIS Aqua satellite to monitor blooms. As there are some differences between the characteristics of the two sensors, the results recorded are similar but not directly equivalent as shown in **Figure 4.10**.

Figure 4.10: Sampling days when chlorophyll-a levels indicate an algal bloom, 1998–2011



Source: OEH data 2012

Notes: An algal bloom is indicated when the water concentration of chlorophyll-a is greater than or equal to the ANZECC trigger value of 1 µg/L.

Figure 4.10 shows the frequency of algal blooms at 17 sites covering the length of the NSW coast between 1998 and 2011. An algal bloom is considered to have occurred when the concentration of chlorophyll-a in the water is equal to or exceeds a trigger value of 1 microgram per litre (1 µg/L) (ANZECC & ARMCANZ 2000). Overall, the frequency of algal blooms appears to be relatively stable, allowing for some differences in the characteristics of the two satellite sensors. Trigger levels were generally reached on fewer days in the southern part of the state. Higher rates of exceedence at some sites may be caused by natural upwellings, while others may be influenced by river discharges. Further analysis is probably needed to identify algal blooms outside their natural range with confidence.

Ecosystem health

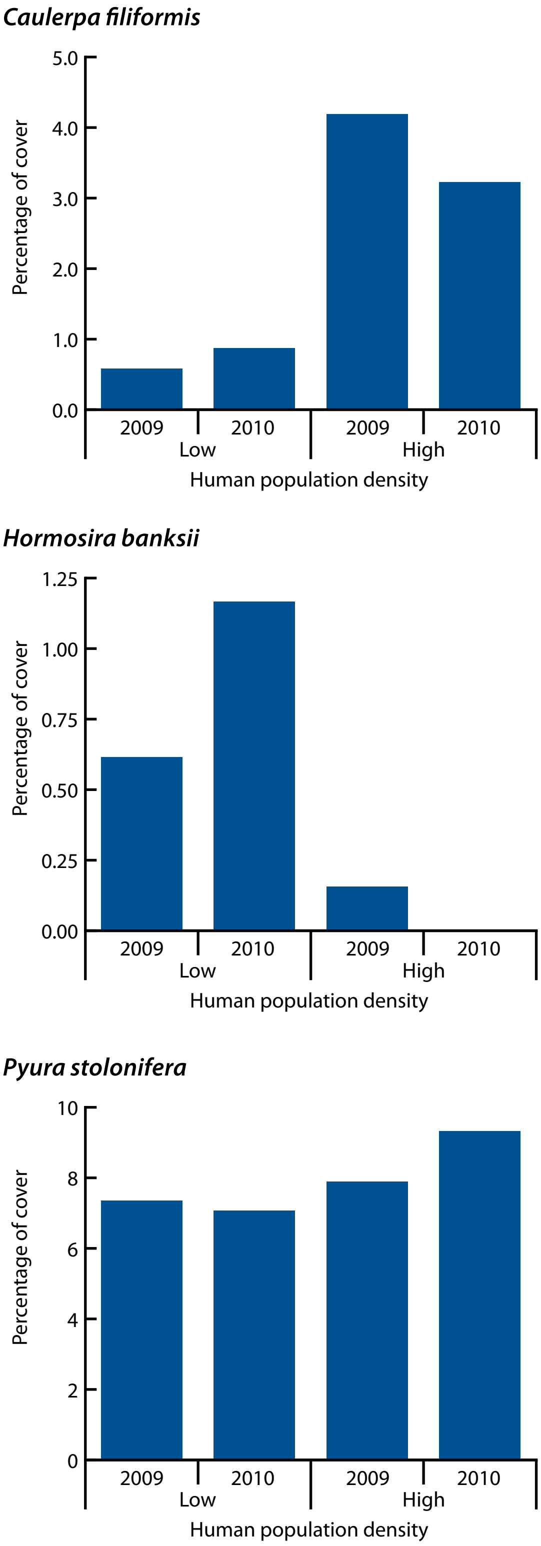
Rocky reef biota

Previous SoE reports relied on commercial harvest data to report on the condition of rocky reef biota. Since 2009, a statewide program has been sampling the dominant biota covering near-shore rocky reefs. Each year, approximately 40 sites associated with a range of nearby human population levels are sampled. Over time, it will be possible to assess the impact of anthropogenic (human-derived) disturbances on rocky reef biota, as an indicator of marine condition. With only two years of monitoring, the data collected so far only allows an estimate of condition and not trend.

The sampling of near-shore rocky reefs indicates that there is considerable variation in covering biota in permanently submerged (subtidal) habitats along the NSW coast. However, there appears to be no significant association between human population level and either condition or patterns of change in condition. The indicators suggest that subtidal habitats are in similar condition throughout NSW.

Similar surveys of periodically exposed (intertidal) rocky shore habitats where specific habitat categories can be distinguished indicate that various species may be responding in different ways to human disturbances. For example, the green seaweed, *Caulerpa filiformis*, is significantly more abundant when located near large human populations than smaller ones. This pattern was consistent in 2009 and 2010 (Figure 4.11). For the smaller brown seaweed, *Hormosira banksii*, this pattern appears to be reversed (**Figure 4.11**). Increased disturbance (such as elevated levels of nutrients) could favour the growth of this green seaweed, while more human activity (such as an increase in trampling) could adversely affect the brown variety. Other species show no clear patterns associated with population level.

Figure 4.11: Changes in biota covering rocky reefs



Source: NSW Department of Trade and Investment, Regional Infrastructure and Services data 2012

It had also been predicted that fewer cunjevoi (*Pyura stolonifera*) would be associated with large human populations, since fishers use cunjevoi for bait, but this pattern was not observed in the surveys undertaken (Figure 4.11).

While there are some indications that certain intertidal species may be affected by human activities, at this stage there is no strong overall association between the rocky reef biota sampled and human population levels.

Threatened species

Information on the status of marine species is not generally as good as that for terrestrial species. However 41 marine species and one population are currently listed as extinct or under threat by the *Fisheries Management Act 1994* (FM Act) and *Threatened Species Conservation Act 1995* (TSC Act).

Around half of the listings are marine seabirds (19 species), the majority of which are classed as vulnerable. Marine mammals (7 species), fish (6), reptiles (3), marine invertebrates (4), macroalgae (2) and one marine vegetation population make up the remaining listings. The four invertebrates were added over the past three years and two – Haswell's caprellid (*Metaprotella haswelliana*) and the marine worm, *Hadrachaeta aspeta* – are presumed extinct.

As information improves, more species may be recognised as being extinct or under threat than are currently known and the number of species listed may also grow as pressures on the marine environment increase. Higher order species, such as sharks, tuna and whales, remain the most vulnerable to external pressures.

Eight key threatening processes are listed under the FM Act. Four relate to the marine environment:

- Introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW
- The current shark meshing program in NSW waters
- Hook and line fishing in areas important for the survival of threatened fish species
- Human-caused climate change.

Climate change and shark meshing are also listed as threats under the TSC Act along with 'Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments' (see Biodiversity 5.1).

The Fisheries Management (General) Regulation 2010 lists seven protected marine or estuarine species, the entire zoological families of seahorses and pipefish (Syngnathidae), ghostpipefish (Solenostomidae) and seamoths (Pegasidae), and four marine or estuarine species protected from commercial fishing, including southern bluefin tuna.

Marine protected areas

Marine protected areas, which include six marine parks and 12 aquatic reserves, aim to conserve biodiversity by protecting representative habitats and reducing pressures on the marine environment, particularly from certain fishing activities. Marine parks and aquatic reserves cover approximately 347,000 hectares or around 34% of the state's waters.

Multiple-use zoning within marine parks restricts activities in line with conservation and management priorities while permitting reasonable use and providing protection for the diverse marine ecosystems found within park boundaries (NSW Government 2001). There are four types of zones: sanctuary, habitat protection, special purpose and general use. The role of marine protected areas and the areas under each zoning category are discussed further in Biodiversity 5.3.

The report from an independent scientific audit of marine parks in NSW, undertaken at the request of the NSW Government, was released in February 2012 (Beeton et al. 2012) with the public invited to comment until 30 June 2012.

Pressures

Pollution

Pollutants have a range of impacts on biodiversity in the marine environment (NBSRTG 2009) including:

- degrading habitats
- changing the distribution and density of species
- increasing the levels of contaminants in some species (which can accumulate up the food chain)
- reducing the relative abundance of top-order predators.

Most of the pollution in coastal and marine waters comes from land-based activities. The main pressures arise from human settlement, population growth and urbanisation in the coastal zones adjacent to marine waters and include sewage and stormwater discharges, diffuse sources of pollution (such as runoff from agricultural land), outflows from estuaries and marine debris.

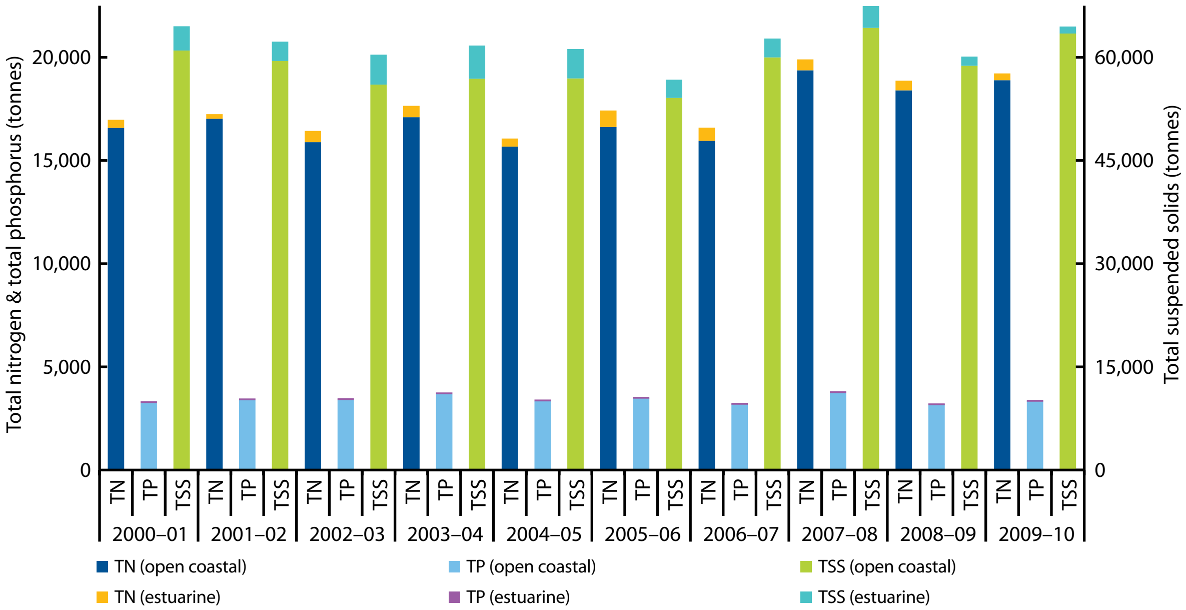
Sediments, nutrients and other pollutants in freshwater from rivers, creeks and coastal lagoons are discharged into the ocean through estuaries. Modelling indicates that each year 135 NSW estuaries discharge an average 23,000 tonnes of nitrogen, 2400 tonnes of phosphorus and around 835,000 tonnes of sediment into marine waters (Roper et al. 2011). Excess sediments, phosphorus and nitrogen in the marine environment, usually delivered by flooding, can have significant impacts on marine water quality and habitats, including seagrass beds and reefs.

Figure 4.12 shows licensed discharges of total nitrogen, total phosphorus and total suspended solids to open marine waters and estuaries. Nitrogen and phosphorus discharges to the marine environment have been relatively stable over the period shown. These are largely the outputs of sewage treatment plants. Discharges of suspended solids into marine waters increased in 2006–07 and 2007–08 primarily due to the increase in average yearly rainfall in coastal areas in those years following a dry period (SWC 2008). High levels of iron, steel and coke production also contribute to discharges of suspended solids into marine waters.

On average, licensed discharges of suspended solids to the marine environment represent less than 7% of the overall load of total suspended solids to the marine environment. Licensed discharges of nitrogen and phosphorus are predominantly restricted to waters off Sydney and Wollongong. Diffuse source discharges to the marine environment are more significant than point source discharges in most coastal waters, excluding the waters off Sydney, where ocean outfalls contribute the majority of nutrients to marine waters.

Some marine pollution is not from land-based sources. This generally includes material from shipping-related incidents, such as oil or chemical spills, ballast water discharges and sewage released from vessels. Many of these incidents are minor and usually occur around ports and harbours. No major pollution incidents have been recorded in NSW marine waters over the last three years.

Figure 4.12: Licensed discharges to NSW open marine waters and estuaries, 2000–01 to 2009–10



Source: Environment Protection Authority data 2012

Notes: Data covers all licensees discharging into the marine environment under the Load-based Licensing Scheme.

Refuse and habitat disturbance

The Commonwealth *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. Harmful marine debris consists of garbage washed or blown from land into the sea, fishing gear abandoned by recreational and commercial fishers, and solid non-biodegradable floating materials (such as plastics) disposed of by ships at sea (DEH 2003). Entanglement and ingestion of debris, such as plastic bags, cigarette butts, lolly wrappers and discarded fishing gear, can be fatal to marine species, particularly listed threatened species, such as seabirds, turtles and whales. Grey nurse sharks in NSW waters have also been found to have fishing hooks snared in both their mouths and stomachs, with the potential to cause death. Recovery in the populations of threatened species, such as humpback whales, is likely to result in a greater number of accidental entanglements.

Demersal trawl nets used in the NSW Ocean Trawl Fishery are dragged along the seabed in suitable fishing areas (DPI 2004). Gear restrictions, area closures and a reduction in licence holders in the fishery have helped reduce the impacts of trawling on marine habitats. The mapping of habitat and trawl grounds presently under way should provide for improved management of trawling into the future.

Fishing

Commercial and recreational fishing occurs in the marine waters of NSW. Commercial fish landings and overall numbers of recreational anglers are currently relatively stable in NSW, although the number of commercial catch returns, which can be used as an indicator of fishing effort, has been steadily decreasing over the last 10 years. The decrease in the number of submitted catch returns indicates an increase in the average catch per return.

The number of commercial fishing licences has decreased over recent years. This is the result of licence buybacks for marine parks or to restructure fisheries, the introduction of 'recreational fishing havens', commercial closures in Sydney Harbour and other areas, as well as a reduction of effort in Commonwealth fisheries that would have had an impact on dual Commonwealth and NSW licence holders. High fuel prices and low product prices have also affected fishing effort in NSW commercial fisheries.

Invasive species

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 Biodiversity 5.4).

Climate change

The potential impacts of climate change on the marine environment are not well understood but predicted increases in sea surface temperature and ocean acidification (Guinotte & Fabry 2008) are likely to have the most significant impacts.

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 2011c). The temperature in the Tasman Sea off the east coast of NSW has risen markedly. Climate change predictions for NSW include higher sea surface temperatures (by possibly up to 4°C), stronger currents and more frequent storms (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 kilometres 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 1750, the pH of the world's oceans has decreased by an average of 0.1 (McNeil & Matear 2007; Riebesell et al. 2009).

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). These effects are now being observed in the Southern Ocean where it was predicted they would first become evident. 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.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Protect rivers, wetlands and coastal environments'. Further details on Goal 22 are provided in Water 4.1.

Legislation

The *Fisheries Management Act 1994* and supporting regulations provides for conservation of fish stocks, key fish habitats, threatened species, populations and ecological communities of fish and marine vegetation. This includes the regulation and management of recreational and commercial fisheries, including licence, gear and species restrictions, application of commercial catch quotas for some species, recreational bag limits and habitat protection through the establishment of aquatic reserves and closures.

The *Protection of the Environment Operations Act 1997* aims to protect the sea and certain waters from pollution by oil and other noxious substances discharged from ships through such mechanisms as protection of the environment policies and licensing, including the regulation of point source discharges into the marine environment.

The *Marine Parks Act 1997* aims to conserve marine biological diversity, habitats and ecological processes in marine parks (see also Biodiversity 5.3). All six NSW marine parks have their own zoning plan, which specifies the activities that are allowed in each zone (such as where fishing is allowed).

Water quality objectives

Marine Water Quality Objectives for NSW Ocean Waters (DEC 2005) describe the water quality needed to protect the community's values for, and uses of, the marine environment. The objectives simplify and streamline the consideration of water quality in coastal planning and management.

Policy and programs

The *NSW Diffuse Source Water Pollution Strategy* (DECC 2009) provides a framework for coordinating efforts to reduce diffuse source water pollution across NSW. The strategy promotes partnerships and provides a guide for investment and an avenue to share information on projects and their outcomes across the state. Reducing diffuse sources of pollution in upstream catchments will help to improve the quality of the marine waters into which they discharge.

Future opportunities

NSW marine waters and ecosystems are currently considered to be in good condition. However, pressures from urban, industrial and recreational development are growing. NSW will need to continue to implement suitable management and adaptation strategies to prevent a decline in the quality of the marine environment.

Apart from commercial fishing and sea surface temperature records, little ongoing monitoring has occurred to determine the impacts of the key pressures on the marine environment. Improved information on marine water quality, species diversity and abundance, and marine habitats through remote sensing and aerial helicopter and underwater video surveys will improve our understanding of the marine environment and enable it to be managed more effectively.

A mix of pollution control, fishing management and conservation measures will continue to be required to maintain the condition of marine waters and ecosystems. This mix of approaches is likely to evolve in response to our understanding of how best to adapt to the changing marine environment.

4.6 Estuaries and coastal lakes

New South Wales estuaries and coastal lakes continue to come under increasing pressure from coastal development. While many estuaries are resilient to some level of change and remain in reasonably good condition, the condition of more vulnerable estuaries or those subject to greater pressures is poorer.

The condition of NSW estuaries is highly variable. Many remain in good condition but a small number are considered to be in poor condition. The overall condition of individual estuaries generally reflects their level of resilience to change caused by disturbances to their waterways and catchments.

The pressures facing NSW estuaries are also highly variable. Most have been modified to some extent, but around 20% have experienced little or no clearing of their immediate catchments, especially those along the south coast. However a significant proportion are considered to be under high pressure due to a range of intensive catchment and waterway activities, particularly in more settled areas.

Catchment and waterway disturbance results in habitat modification, including changes in runoff characteristics which increase the loads of sediments and nutrients that affect estuarine water quality and ecosystem health.

Continuing population growth and urban development along the NSW coast are expected to intensify pressures on estuaries and coastal lakes.

NSW indicators

Indicator and status	Trend	Information availability
Chlorophyll-a levels in seawater	Stable	✓
Turbidity levels in seawater	Stable	✓
Percentage of estuaries with beach suitability grades for swimming of good or better	Stable	✓✓✓
Distribution of estuarine macrophytes	Stable	✓
Levels of catchment disturbance	Increasing	✓✓
Levels of riparian disturbance	Increasing	✓✓
Rate of sea level rise	Increasing	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Estuaries are semi-enclosed bodies of water with an open or intermittently open connection with the ocean, where water levels vary in a predictable and periodic way in response to the ocean tide at the entrance. Coastal lakes are a relatively common estuary type in NSW; many have only intermittent connections to the ocean often referred to as 'intermittently closed and open lakes and lagoons'.

Estuaries occupy the transition zone between the freshwater and marine environments. They are highly productive natural systems that form the basis of complex food webs and underpin life in near-shore waters and marine environments.

The desirability of coastal lifestyles and increasing settlement along the coast are placing estuaries and coastal lakes under ever greater levels of stress. The attendant pressures of development and urbanisation, and disturbance of the natural values of surrounding catchments need to be carefully managed in order 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 estuaries and the important ecosystems they support. However in implementing the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d), relevant data from a range of stakeholders was collected, consolidated and analysed for the *State of the Catchments Reports* series (DECCW 2010e). Data is still not available on the condition of all NSW estuaries but data collection and analysis is ongoing and reporting coverage is improving over time.

Status and trends

Estuary types

The types of estuaries found along the NSW coast vary according to their geophysical setting. 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 that cut through a sandstone plateau. Much of the south coast is less developed and characterised by many coastal lakes and lagoons with relatively small catchments and often intermittent connections to the ocean.

Water quality

The health of estuarine 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, the loss of biodiversity, and reduced recreational value and amenity.

Turbidity and chlorophyll-a are monitored in NSW to assess estuary condition as part of the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (MER Strategy) (DECCW 2010d). Two datasets are available for comparison: the first a baseline dataset compiled from a variety of sources for the period July 2005–June 2008, the second containing monitoring data from July 2008 to June 2011. Both datasets include estuaries from the three regions (north, central and south) and the range of estuary types, but the specific estuaries monitored vary. However, the same estuaries were used to monitor both turbidity and chlorophyll-a in the second dataset.

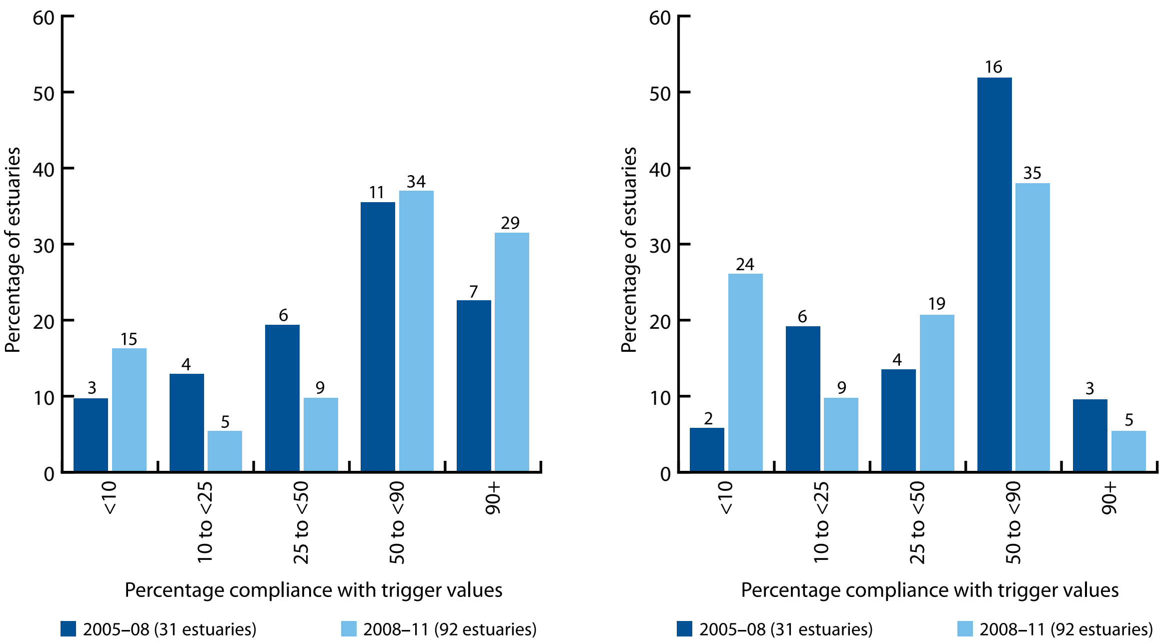
Trigger values and compliance intervals for turbidity and chlorophyll-a have been derived for the MER Strategy program using an approach consistent with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000). Exceeding the guidelines' trigger levels does not automatically indicate that estuarine conditions are poor, but any pattern of exceedences is regarded as a cue for further investigation to determine whether water quality issues exist. Further details on site selection, monitoring procedures and data analysis are available in the MER Strategy technical report for estuaries (Roper et al. 2011).

Turbidity

Water clarity is an indication of the amount of particulate matter in the water, which may consist of clay and silt particles, phytoplankton or natural tannins. Measuring turbidity provides an indication of the amount of light available for aquatic plants and other benthic organisms that inhabit the water column and substrate of estuaries.

Turbidity data is available for 92 estuaries for the period July 2008–June 2011 and 31 estuaries between July 2005 and June 2008. Results were generally similar for the two periods of monitoring (**Figure 4.13**). During 2008–11, compliance with trigger values was very good (over 90% of sampling occasions) in 29 estuaries (32% of those monitored) and good (50–90% compliance) in 34 (37%); for 2005–08, compliance was very good in seven estuaries (23% of those monitored) and good in 11 estuaries (35%) (Figure 4.13).

Figure 4.13: Water quality sampling from selected NSW estuaries, 2005–08 and 2008–11



Source: Department of Environment, Climate Change and Water data 2010 and NSW Office of Environment and Heritage (OEH) data 2012

Notes: The values shown above the bars in the graphs are the number of estuaries in each compliance category.

These estuaries are generally under relatively little pressure with low to moderate sediment inputs (Roper at al. 2011). However, it appears that some estuaries may receive larger sediment inputs from catchment disturbance than are reflected in this turbidity data possibly because the sediment is delivered by rainfall outside the summer sampling period.

Fifteen estuaries (16%) had very poor compliance with trigger levels, complying on less than 10% of sampling occasions during 2008–11 and three estuaries (10%) in 2005–08. Many of these estuaries receive relatively large sediment inputs because of the scale and nature of disturbance in their catchments (Roper et al. 2011).

Chlorophyll-a

Abnormally high levels of chlorophyll-a indicate high phytoplankton levels or algal blooms and are a symptom of eutrophication, the over-enrichment of a water body with nutrients. High levels of algae may lead to reduced levels of dissolved oxygen in the water column and some algal species may produce toxins which have serious implications for fish, shellfish and humans coming into contact with the water.

Increased levels of chlorophyll-a are generally recorded in the warmer months when higher temperatures and more light provide better growing conditions. The generally higher rainfall over the warmer months is also when nutrient inflows to an estuary are greatest. This combination of conditions gives a better indication of the potential for eutrophication to occur.

Chlorophyll-a data is available from 92 estuaries for the period 2008–11 and 31 estuaries during the period 2005–08. For 2008–11, compliance with trigger values was very good (more than 90% of sampling occasions) in five estuaries (5% of those monitored) and good in 35 (38%); for 2005–08, it was very good in three estuaries (10% of those monitored) and good in 16 estuaries (52%) (Figure 4.13). These estuaries are generally under low to moderate pressure (Roper et al. 2011).

While there are generally similarities in monitoring results for chlorophyll-a across the compliance categories, the largest difference between 2005–08 and 2008–11 was the increase in the proportion of estuaries with very poor ratings (<10% compliance with the trigger values) in the second sampling period. The majority of these estuaries receive relatively high loads of nutrients from catchment disturbance which probably explains the findings (Roper et al. 2011), although two exceptions on the south coast – Baragoot Lake and Tuross River – receive relatively low nutrient loads and require further investigation.

Recreational water quality

Beachwatch programs monitor recreational water quality at swimming beaches in NSW. While not an assessment of overall water quality, the results provide an indication of sewage and stormwater pollution which affects the fitness of water bodies for human recreational use as well as the effectiveness of stormwater management.

In the Sydney region, 55 estuarine beaches are monitored for the bacterial indicator enterococci, in accordance with the *Guidelines for Managing Risks in Recreational Water* issued by the National Health and Medical Research Council (NHMRC 2008). Sites are located in Pittwater, Sydney Harbour, Botany Bay, Lower Georges River and Port Hacking. **Map 4.8** shows the outcomes of this monitoring.

Rainfall during 2010–11 was extremely high and only 38 of the 55 swimming locations (69%) received a beach suitability grading of 'very good' or 'good' (Map 4.8). The poorest performing swimming sites were generally those located in the upper reaches of tributaries. These sites have less capacity to dilute pollution sources and lower levels of tidal flushing.

While the results for 2010–11 indicate that there is still a need to improve the management of stormwater inflows to estuaries in urban catchments, they are a significant improvement compared with a similarly wet period in 1998–99 (assessed under an older measurement system). When the data for 1998–99 is converted to the assessment system currently used, only 2% of estuarine swimming sites in that year recorded low levels of enterococci (Microbial Assessment Category A or B) compared with 85% of sites in 2010–11.

Water 4.5 has further information on Beachwatch monitoring programs.

Map 4.8: Beach suitability grades at estuary swimming sites in the Sydney area, 2010–11

Estuarine macrophytes

Estuarine macrophytes include seagrass, mangroves and saltmarsh communities. The distribution of macrophytes in NSW estuaries has been systematically mapped several times, firstly in the 1980s (West et al. 1985), then as part of the Comprehensive Coastal Assessment (CCA) (Williams et al. 2006) and the Seabed Mapping Project which filled in some gaps not mapped in the CCA. This data was compiled in Creese et al. 2009.

Estuarine macrophyte mapping continues under the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d) with 26 estuaries now remapped. These represent a range of estuary types from large river systems, such as the Clarence and Shoalhaven, to small coastal lake systems, such as Dalhousie Creek and Dee Why Lagoon.

Distribution of seagrass

Seagrasses occur in the subtidal zones of estuaries. They are particularly important because of their role in maintaining sediment stability and water quality, and providing shelter and food to a wide variety of aquatic biota. Causes of seagrass decline include:

- impaired water quality due to increased sediment and nutrient levels, which reduces the light that enables their growth
- physical disturbance through such activities as dredging and reclamation
- changes to hydrologic flows
- natural phenomena such as storms.

Four estuaries account for more than 60% of the total area of seagrass in NSW. However the distribution and area of seagrass and of the species represented is highly variable. Three of the four main species of seagrass found in NSW often display substantial variations in distribution over time with cyclical patterns of loss followed by slower periods of regeneration and regrowth. The fourth, *Posidonia australis*, is the exception.

The natural variability of seagrass communities and lack of consistent mapping prior to the 1970s makes it difficult to assess their overall status or trends in distribution over the longer term. It is believed that there has been an overall decline in the extent of seagrasses since European settlement, but this is difficult to quantify. Based on the historic evidence available, the total loss has been estimated at less than 30% (Keith 2004). However, many major estuaries in NSW lost as much as 85% of their seagrass beds in the 30–40 years prior to the commencement of systematic mapping in the 1970s (DPI 1997).

Reference to the most recent seagrass mapping indicates a slight overall decline (<4%) in the total area of seagrass since 2009 (**Figure 4.14**), with significant to total loss of seagrass in several of the smaller estuaries in the northern part of NSW. The distribution of seagrass increased in four estuaries, where the dominant species is *Zostera capricorni*, which has highly dynamic distribution patterns that may relate to localised climatic events, such as high rainfall and flooding, rather than direct human impacts. The cause of specific declines requires further investigation.

Distribution of mangroves

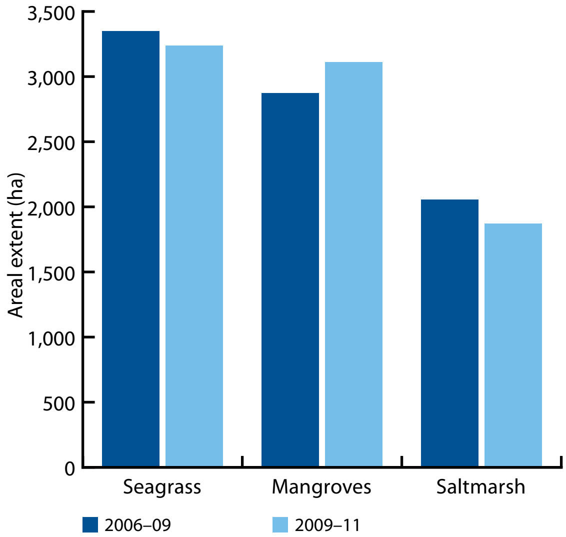
Mangroves grow along the intertidal shores of many NSW estuaries, in some places forming extensive forests. They are absent from many intermittently closed and open lakes and lagoons, particularly those where entrances are frequently closed.

Although five mangrove species occur in NSW, only the grey mangrove and river mangrove are found extensively. The diversity of mangroves decreases southwards along the coast with only grey mangroves found beyond Merimbula Lake on the far south coast. Three major estuaries – Port Stephens and the Hunter and Hawkesbury rivers – account for approximately 50% of the total distribution of mangroves in NSW.

Mangroves are quite resilient and are able to rapidly colonise favourable areas. Expansion may be due to a range of factors, including:

- regrowth in areas of past clearing
- expansion into areas of saltmarsh

Figure 4.14: Change in macrophyte distribution



Source: Department of Primary Industries data 2012

- colonisation of areas where sedimentation has occurred and altered hydrology and tidal regimes favour them, such as coastal lakes where artificial entrance regimes have increased tidal inundation.

A lack of consistent mapping over the longer term has made it difficult to assess overall trends in the status and extent of mangroves. It is believed that there has been an overall decline in their extent since European settlement, but this is difficult to quantify. Based on the historic evidence available, Keith 2004 has estimated the loss of mangroves at between 30 and 70%.

The most recent surveys indicate that the total area of mangroves across 26 estuaries has increased by about 8% since 2009 (Figure 4.14). The distribution of mangroves in the majority of estuaries expanded or remained similar. The largest expansion was recorded in the Clarence River, while two estuaries – Darkum Creek and Lake Macquarie – registered a slight decline. Given the relatively small area of mangroves around Darkum Creek, these changes may relate to the resolution of mapping, whereas the losses around Lake Macquarie occur in a number of areas and require further investigation.

The overall distribution of mangroves, however, is still greater than that mapped in the 1980s (West et al. 1985).

Distribution of saltmarsh

Saltmarsh communities grow to the highest tide levels, meaning that they are only inundated by larger tides or extremes in water levels. Where saltmarsh occurs in conjunction with mangroves, it occupies the landward area. Saltmarsh can also occur around coastal lakes where conditions do not favour mangroves. Typically vegetated by low shrubs, herbs and grasses, they can range from narrow fringes on steep shorelines to nearly flat expanses.

There has been a substantial decline in the extent of saltmarsh since European settlement, but this is difficult to quantify. However, based on the historic evidence available, the loss has been estimated at 30–70% (Keith 2004). Losses of saltmarsh have been particularly severe in the Sydney region and on the central coast (Wilton 2002; Williams & Meehan 2004; Kelleway et al. 2007). Saltmarsh has been listed as an endangered ecological community in NSW due to the nature of ongoing losses. The processes threatening saltmarsh include infilling, modified tidal flows, weed invasion, human disturbance and climate change (Adam 2002).

An overall loss of saltmarsh of around 9% was found across the 26 estuaries recently remapped (Figure 4.14). An increase in saltmarsh distribution was mapped in 13 estuaries: 10 had distributions similar to the previous mapping and three had reduced saltmarsh distributions.

The largest area of change was in Cathie Creek where saltmarsh species have been replaced by freshwater wetland species (a reduction of 412 hectares or 22% of the saltmarsh distribution mapped by Williams et al. 2006). This change is likely to be in response to varying hydrologic conditions as the entrance to the creek has become constricted over recent years and water levels have increased, submerging saltmarshes and favouring freshwater species.

Excluding Cathie Creek from the analysis, the overall trend for NSW is an increase in saltmarsh distribution of about 230 ha or 16%.

Pressures

Pressures influencing the condition of NSW estuaries originate in the surrounding catchment, in the area immediately adjacent to the estuary known as the foreshore or riparian zone, and within the estuarine waterway itself.

Many of the pressures on estuaries are associated with the growth in population along the coast and the land clearing and development this entails. These activities increase the volume and change the nature of rainfall runoff and stormwater which carries sediment and other pollutants to coastal environments with impacts on water quality. Areas of mangroves, saltmarsh and coastal wetland have been cleared or reclaimed for port infrastructure, recreation, housing and rubbish disposal. Aquatic communities, such as seagrasses, have been disturbed by waterway activities and infrastructure, including boat ramps, jetties and moorings, and affected by changes in water quality.

Catchment disturbance

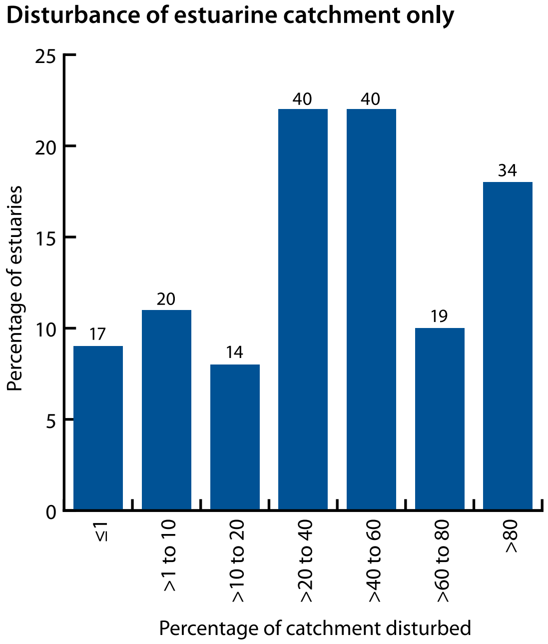
Changes in land use and the removal of vegetation in coastal catchments are good indicators of the pressures affecting water bodies from increased loads of diffuse source nutrients and sediments. Where vegetation has been cleared, the nature of the subsequent land use will determine the extent of the increase in runoff transporting nutrients and sediment from the catchment to estuaries. For example, increasing urbanisation leads to greater runoff from the hard non-porous surfaces found in built-up areas.

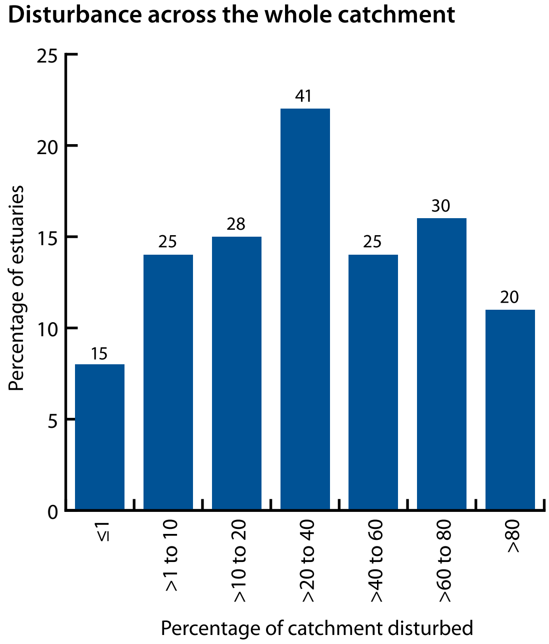
The level of disturbance affecting the catchments of NSW estuaries has been mapped as part of the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d). The area of the catchment can be divided into the ‘estuary catchment’ where runoff drains directly to the estuary below the tidal limit and the ‘fluvial catchment’ where drainage is to areas above the tidal limit, including freshwater tributaries. The largest fluvial catchments tend to be associated with larger estuaries which have significant tributaries. The catchments of 30 NSW estuaries have no mapped fluvial component due to their small size and absence of major freshwater tributaries draining to the estuary.

The average rate of vegetation clearance in the catchments of NSW estuaries is approximately 38%. For that part of the catchment that drains directly to the estuary, the average rate of disturbance increases to 44%. It is possible that pressures originating nearer to waterways have a greater influence on condition.

Thirty-seven estuaries (about 20%) have experienced little or no clearing of their direct catchments (less than 10% of vegetation cover), while for the total catchment the figure is 40 estuaries (22%) (**Figure 4.15**). The majority of these are within the public reserve system of national parks or other public lands.

Figure 4.15: Level of catchment disturbance (vegetation clearing) in NSW estuaries





Source: OEH data 2012

Notes: The data covers 184 estuaries and the values shown above the bars in the graphs are the number of estuaries in each disturbance category.

Thirty-four estuaries (around 18%) have experienced extensive clearing of 80% or more of their immediate catchment areas, while 20 estuaries (11%) have experienced this level of disturbance throughout the whole catchment (Figure 4.15). Many of these estuaries are considered to be in a fair to poor state, particularly the smaller systems with intermittent connections to the ocean. The smaller number of larger, well-flushed estuaries that have been extensively cleared are generally considered to be in better condition.

Population and demographic change

The majority of the NSW population lives close to the coast and this places considerable pressure on coastal and estuarine ecosystems through increased development and disturbance of the catchments.

Population density data has been calculated from data collected by the Australian Bureau of Statistics in the 1996, 2001 and 2006 Censuses. The population density of estuary catchments ranges from nil for estuaries with catchments located wholly within national parks to very high densities for estuaries in metropolitan Sydney, where Port Jackson and Dee Why catchments support over 5000 people per square kilometre (km^2). The average population density for NSW estuary catchments is 211 people/km^2.

An ongoing shift of population to the coast occurred across the three Censuses. The proportion of the NSW population living in estuary and coastal catchments increased from 80.6% of the total NSW population in 1996 to 82.1% in 2006. Population density across all coastal catchments has increased from 38.3 to 42.2 people/km^2 or an increase of 9.2% for the period (Roper et al. 2011). A continuation of this trend is likely to increase the pressures on NSW estuaries and coastlines that are adjacent to population centres.

Nutrient and sediment loads

Many NSW estuaries face the threats of eutrophication (excessive nutrient enrichment) and sedimentation.

Increases in nutrient loads to estuaries are associated with a range of land uses and activities, such as urban development, agricultural land-use practices and effluent discharges. Increases in nutrient loads may lead to excessive production of algae and aquatic plants, with flow-on effects up the food chain. System productivity may increase temporarily but, because excessive levels of nutrients tend to favour a smaller number of species, overall biodiversity and ecosystem health is reduced.

Sediment loads entering estuaries can increase as a result of disturbance to soils, erosion in catchments, and riverbank, shoreline and in-stream erosion. Following its transport by rainfall, coarse sediment settles out, smothering sensitive species, while finer sediment may remain suspended and limit primary production by reducing water clarity.

Direct measurement of the sediment and nutrient loadings to coastal lakes and estuaries from a range of diffuse sources in a catchment is difficult and costly. Therefore sediment and nutrient loads are estimated using models of the surface flows across catchments associated with a range of land uses.

Point source discharges from sewage treatment plants (STPs) directly into estuaries or their tributaries are another source of sediment and nutrient inputs. Discharges from STPs and sewage overflow points are licensed by the NSW Environment Protection Authority. Combining the annual discharge loads with the diffuse source loads from modelling provides an estimate of the annual loads for total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP).

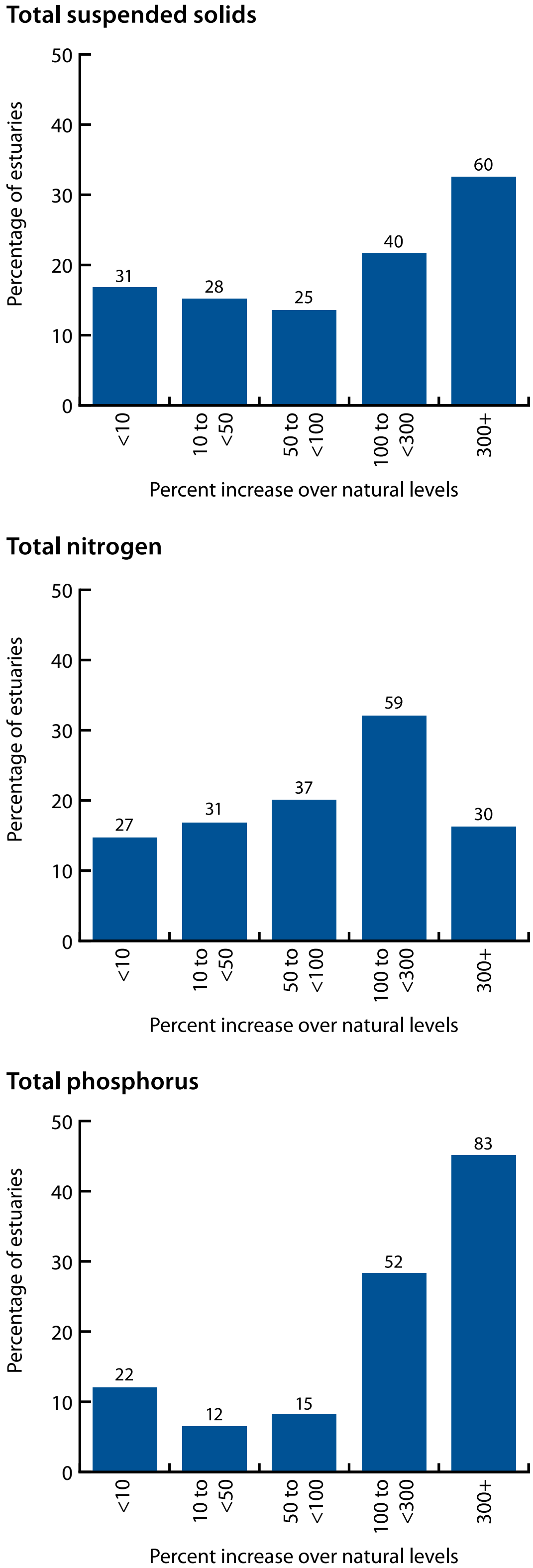
The percentage increase above natural levels of TSS, TN and TP in NSW estuaries has been estimated using this approach. **Figure 4.16** shows the combined results for TSS and demonstrates that while some estuaries still have nearly natural loads, in many others the loads are well above natural, undisturbed levels. An estimated 54% of NSW estuaries have undergone a doubling (or greater) of loads of TSS.

The modelled results for nutrients are similar with an estimated 48% of NSW estuaries experiencing a doubling (or greater) of TN levels, while TP levels in 73% of estuaries have at least doubled (Figure 4.16). With a small number of exceptions, estuaries determined to be in a fair to very poor condition (DECCW 2010e) are generally within this group of estuaries.

Riparian disturbance

Riparian zones are the areas directly adjacent to a waterway, often referred to as 'foreshores' in estuaries. Disturbance within this zone is of particular interest as riparian vegetation acts as a barrier or filter to protect the water body and minimise erosion. Pressures originating in this area are likely to have a more direct impact on estuary condition than the same pressure acting further away.

Figure 4.16: Modelled loads of total suspended solids and nutrients to NSW estuaries



Source: Roper et al. 2011

Notes: The data covers 184 estuaries and the values shown above the bars in the graphs are the number of estuaries in each increase category.

The riparian zones around each of the 184 estuaries in NSW have been mapped. These cover the area that is within 100 metres of the waterway and less than 0.6 m above mean sea level, an area that generally defines the outer edge of seagrass, mangrove or saltmarsh communities. Within this zone, land-use mapping identifies the areas of disturbance based on the same land-use classes used to determine catchment disturbance and diffuse nutrient and sediment loads (Roper et al. 2011).

Similar to the patterns of disturbance within the estuary catchments, 11% of estuaries have riparian zones with little or no disturbance and a further 9% have disturbance levels of less than 10% (**Figure 4.17**). Around 11% of estuaries have experienced disturbance to 80% or more of their riparian zone, a similar proportion to estuaries with the same level of disturbance throughout the whole catchment.

Waterway disturbance

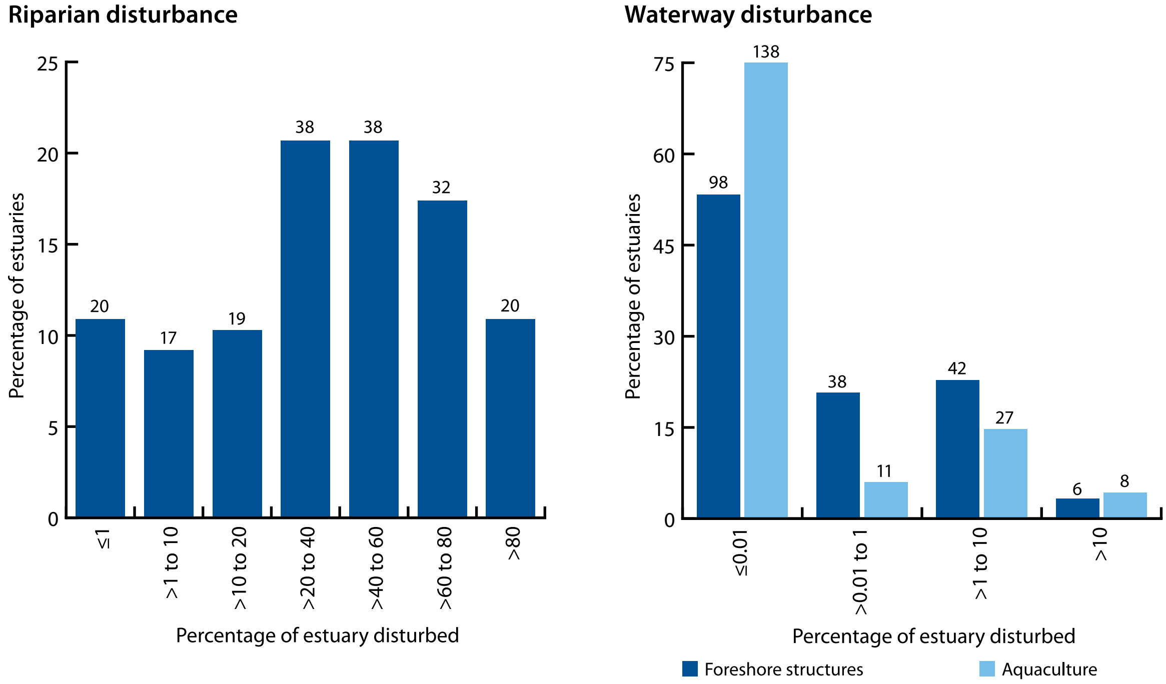
Change in estuarine habitats, water quality and estuarine processes can also occur as the result of disturbance directly to the waterway itself, including:

- the removal of vegetation
- competition from introduced species
- the building of structures, such as marinas, boat ramps, foreshore reclamation, hard erosion control structures, weirs, training walls and artificial entrance openings
- activities such as fishing, trawling and aquaculture.

One measure of direct waterway disturbance is the percentage of the estuary perimeter that is occupied by foreshore structures on Crown land above or below the mean high water mark. Structures include buildings, jetties and wharves, boat ramps, foreshore reclamation and seawalls. Another measure is the percentage of estuary area leased for waterway-based aquaculture, such as oyster and mussel farming. The levels of these disturbances in NSW estuaries are shown in Figure 4.17.

Just over 50% of estuaries have few, if any, foreshore structures and 75% of estuaries contain no aquaculture leases. Estuaries in the metropolitan area with higher percentages of their perimeters occupied by foreshore leases tend to be waterways with a proliferation of boating infrastructure associated with urban development. As such, these estuaries are generally subject to catchment, riparian and waterway pressures and determining the dominant pressures influencing their condition can be difficult.

Figure 4.17: Levels of disturbance to riparian vegetation and waterways in NSW estuaries



Source: OEH data 2012

Notes: The data covers 184 estuaries and the values shown above the bars in the graphs are the number of estuaries in each disturbance category.

Estuaries with over 10% of their waterway area occupied by aquaculture leases are all located on the south coast of NSW in waterways that are generally in good condition, have moderate to low levels of catchment development and consistent patterns of tidal variation, all conditions that favour a productive aquaculture industry.

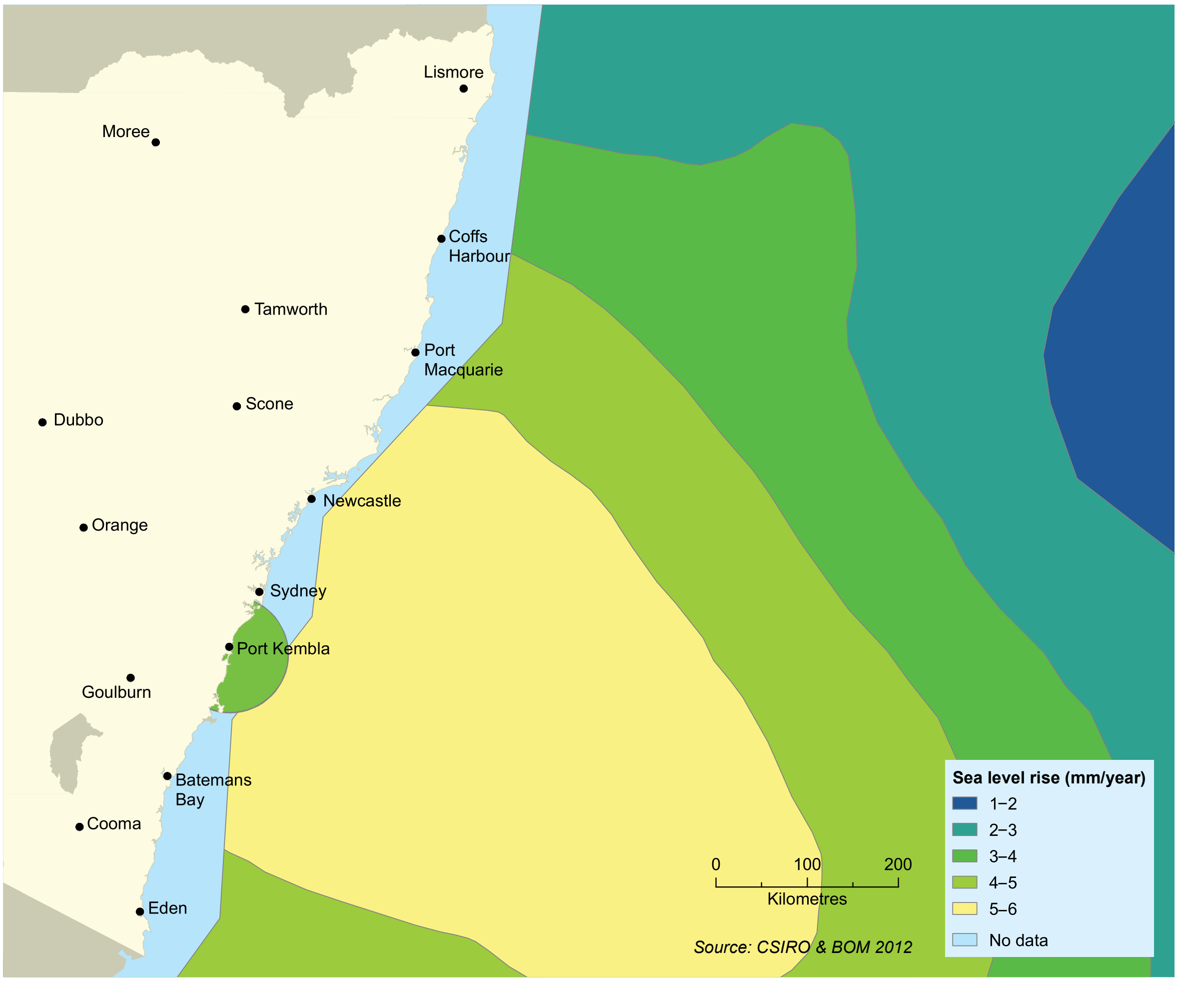
Climate change

Variations in climate and sea level are inextricably linked (BoM 2011b). Warming temperatures lead to sea level rise for two main reasons: water expands as it warms and, as average temperatures rise, the polar ice sheets begin to melt (IPCC 2007). Sea level rise is not uniform around the world or in Australia as climatic cycles such as El Niño-Southern Oscillation and the Indian Ocean Dipole create further variations that can mask or enhance changes due to global warming.

Such variations will only become evident over the longer term and it is not possible to identify changes over a relatively short time frame such as the three-year cycle of SoE reporting. Since 1993, sea levels around Australia have risen 7–10 millimetres per year in the north and west and about 4 mm per year in the south and east. Off the east coast of NSW, warm water currents have elevated sea levels by about 6 mm per year as demonstrated by tidal gauge readings from Port Kembla shown in **Map 4.9** (CSIRO & BoM 2012).

Sea level rise is virtually certain to increase tidal levels, enlarging the areas of low-lying land near coastal waterways that are exposed to more frequent tidal inundation (DECCW 2010b). 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 2010b). With 63% of the NSW population living in Sydney – a coastal city – and a further 20% living in the non-metropolitan coastal strip (ABS 2012), rising sea levels are likely to have a significant effect on human settlements in coastal NSW.

Map 4.9: Sea level rise between 1993 and 2011 at Port Kembla, 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 heightened coastal erosion (DECCW 2010b).

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 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).

Other pressures

A range of other pressures also affect waterway health, but their cumulative impact is more difficult to measure or assess. Tidal flows may be affected by rock training walls designed to keep estuary entrances open, the artificial opening of lagoon entrances to alleviate flooding, and other flood mitigation structures. Changes to hydrology and flows can have a significant impact on water and salinity levels and the distribution and composition of estuarine ecosystems.

Changes in the volume of freshwater flows entering estuaries can arise from upstream water storages, extraction of water for agriculture, and barriers such as weirs. A reduction in freshwater flows to estuaries can influence the location of the tidal limit and the salinity profile, as well as affect the distribution and composition of ecosystems.

Commercial and recreational fishing place pressures on the fisheries they target as well as the broader estuarine environment. Impacts from fishing and trawling can include damage to habitat, bycatch, waste and infrastructure pressures.

Responses

Established responses

Management of the NSW coastal zone is the responsibility of all levels of government. The expected growth in population in coastal areas is likely to increase the importance of integrated coastal zone management and strategies that enable communities to adapt to changing environmental conditions.

Local government plays a key role in protecting the health of estuarine ecosystems through a variety of mechanisms including land-use and strategic planning, development controls and a range of policies affecting water utilities and water quality management, including sewage and stormwater management strategies and estuary management plans.

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Protect rivers, wetlands and coastal environments'. Further details on Goal 22 are provided in Water 4.1.

Legislation

The NSW *Environmental Planning and Assessment Act 1979* sets the framework for land-use planning decisions. The *Coastal Protection Act 1979* and *NSW Coastal Policy 1997* (NSW Government 1997) provide the strategic direction and legislative framework for managing the NSW coastal zone, including the requirement for coastal zone management plans and the matters these plans should consider. Mangroves and seagrass habitats are protected under the *Fisheries Management Act 1994*.

State environmental planning policies

State environmental planning policies (SEPPs) address specific planning issues in NSW.

State Environmental Planning Policy No. 71 – Coastal Protection 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.

State Environmental Planning Policy No. 14 – Coastal Wetlands ensures that coastal wetlands are preserved and protected for environmental and economic reasons. The policy applies to coastal local government areas outside the Sydney metropolitan area and identifies over 1300 wetlands of high natural value from Tweed Heads to Broken Bay and Wollongong to Cape Howe. All land clearing, construction of levees, and drainage work or filling within wetland boundaries requires consent and the preparation of an environmental impact statement.

Other SEPPs relevant to coastal development include:

- *State Environmental Planning Policy No. 26 – Littoral Rainforests*
- *State Environmental Planning Policy No. 50 – Canal Estate Development*
- *State Environmental Planning Policy No. 62 – Sustainable Aquaculture.*

Review of coastal protection and NSW Sea Level Rise Policy

A Coastal Ministerial Taskforce has been established to review coastal protection arrangements. Stage 1 coastal reforms were announced in October 2012. These included the removal of sea level rise benchmarks, which will no longer apply to coastal zone planning in NSW. Further developments will be announced in stage 2 of the reforms.

Coastal zone and estuary management plans

The *Guidelines for Preparing Coastal Zone Management Plans* (DECCW 2010f) 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 consistent with the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d).

Coastal zone and estuary management plans are being prepared and implemented by local councils for over 90 estuaries in order to achieve integrated, balanced and ecologically sustainable management.

Regional strategies

Regional strategies are in place for six coastal areas of regional NSW: Central Coast, Lower Hunter, Far North Coast, Mid North Coast, Illawarra and South Coast.

The strategies set a strategic direction for these rapidly growing coastal regions on issues including management of the high rates of population growth in a sustainable manner, while protecting valuable natural and cultural assets. The strategies require local environmental plans to protect and zone lands with aquatic, riparian and wetland conservation values.

Catchment action plans

Catchment action plans are developed by catchment management authorities and represent the key process that coordinates and drives natural resource management at the regional level. The plans describe the approaches to be adopted for addressing statewide targets at the regional scale and also specify the regional targets and the programs of investments and works that are needed to deliver outcomes at the regional and local levels.

Management of water quality

The main responses aimed specifically at improving estuarine water quality by reducing pollution include:

- planning strategies covering land use and catchment management, which set water quality objectives
- licensing or management of pollution from major point sources
- works to manage stormwater and diffuse runoff
- programs to prevent and manage pollution incidents
- tools to assist in managing estuaries.

The Coastal Catchments Initiative is the Australian Government's primary vehicle to deliver significant reductions in the discharge of pollutants to 'hot spots' identified through agreement with relevant state jurisdictions. The Great Lakes (Wallis, Smiths and Myall Lakes) and Botany Bay have been identified as hot spots in NSW. Implementation of the initiative included the preparation of water quality improvement plans for hot spots to guide investment in water quality projects.

NSW Water Quality Objectives set out the agreed environmental values and long-term goals for NSW surface waters. The objectives are consistent with the agreed national framework for assessing water quality described in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000). They set out a range of water quality indicators and criteria to determine whether water quality in estuaries and coastal lakes is able to support healthy ecosystems and a range of beneficial uses, including recreational activities. Consistent with the Water Quality Objectives and the process recommended in the ANZECC Water Quality Guidelines, the NSW Natural Resources Monitoring, Evaluation and Reporting Strategy (DECCW 2010d) provides further advice on estuarine water quality indicators and monitoring and has derived a number of water quality trigger values that can be used in lieu of the default values provided.

The *NSW Diffuse Source Water Pollution Strategy* (DECC 2009) recognises that diffuse source pollution accounts for the majority of the pollution load in NSW waterways. The strategy aims to coordinate the NSW Government's approach to the management of diffuse water pollution and identifies a list of actions to be implemented.

Future opportunities

The strong preference of many Australians to live near the coast means that it is likely that pressures on the NSW coastal zone will continue to grow, due to expanding population and development.

The poor condition of water quality in some highly urbanised estuaries suggests that stormwater runoff and new urban development can be managed better in order to maintain the health of estuaries and coastal lakes and the desirability of coastal lifestyles.

Due to a lack of consistent and reliable data, there are still many uncertainties in assessing the status of estuaries and coastal lakes and any related trends.

Susceptibility 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.

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Biodiversity

5

5.1 Native fauna and threatened species

The overall diversity and richness of native species in New South Wales remain under threat of further decline. Thirty-five additional species have been listed as threatened under NSW legislation since 2009, including 11 terrestrial vertebrate species. The conservation status of 66% of terrestrial vertebrate species still remains non-threatened.

A general pattern of decline in biodiversity over the longer term is evident in changes to the extent and abundance of many native vertebrate species. At the same time, many species less susceptible to existing pressures have maintained their distributions, while a small number of adaptable species have flourished.

In terms of declines detected over historical time frames of around 200 years, birds have been more resistant to change than other vertebrate groups, whereas there have been substantial declines in mammals, especially small- to medium-sized ground-dwelling species.

Currently, 989 species of plants and animals, 49 populations and 107 ecological communities are listed as threatened in NSW legislation, and 45 key threatening processes have been identified. These numbers continue to rise.

Overall outcomes for native species represent the cumulative impact of many diverse pressures and threats. The main threats to native species are vegetation clearing, habitat degradation and invasive species, with vertebrate fauna in particular impacted by foxes and cats on the mainland and introduced rodents on islands.

NSW indicators

Indicator and status	Trend	Information availability
Terrestrial mammals: long-term (~200 year) loss of distribution	Stable	✓
Birds: long-term (~200 year) loss of distribution	Stable	✓
Proportion of vertebrate fauna species that is non-threatened	Decreasing	✓✓
Number of threatened species, communities and populations	Increasing	✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Biodiversity is the diversity of ecosystems, the species and populations they support and the genes they contain. It also encompasses the complex interactions between living organisms and the environment which provide the basis for a range of ecosystem services and maintain the health and productivity of the land.

NSW has a rich biodiversity, much of which is recognised as being internationally significant.

It is seldom possible to monitor or report on biodiversity across its breadth (Saunders et al. 1998). Because of the paucity of data for other groups, this section is largely restricted to dealing with the status of native fauna, particularly terrestrial vertebrates, and native plant and animal species listed as threatened under the *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act).

A shrinking distribution is often the first and only evidence that a species is declining in numbers. Declines in many species have been under way for decades or longer, but have largely gone unrecorded. Heightened awareness of the plight of native flora and fauna over the past two decades has revealed the extent of many of these declines and the threats that cause them. For example, the eastern quoll once ranged over most of eastern NSW, but is now found only in Tasmania, representing a 100% decline in distribution in NSW which occurred before any estimates had been undertaken. In western NSW, 24 species of mammal became locally extinct between European settlement in 1841 and Federation in 1901 (Morton 1990; Lunney et al. 2000).

Much effort has gone into arresting declines that were largely incurred before the NSW Government recognised the need to formally protect native species. Growing knowledge about the extent of declines in species has the potential to mask recent achievements in stabilising declines and recovering some species.

Status and trends

Native fauna

The status of species under threat varies regionally and across Australia. Some species lost from NSW, such as the pig-footed bandicoot, are extinct throughout Australia, while others, such as the numbat, are still found elsewhere in Australia. A number of species no longer exist on the NSW mainland, but survive on predator-free islands. The brush-tailed rock-wallaby is listed under both the TSC Act and *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth), but is under greater threat in Victoria than NSW. Conversely, the koala is threatened in NSW but not in Victoria, where is it regarded as being over-abundant.

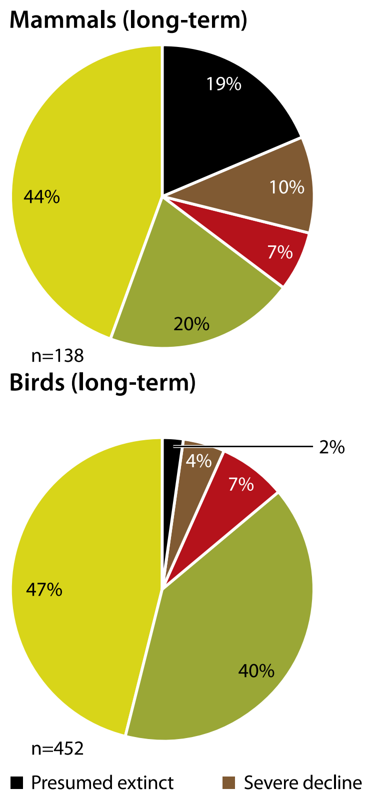
Declines in distribution and abundance

The lack of data makes it difficult to assess the distribution and abundance or conservation status of many species of native fauna, particularly those that are rare. The first comprehensive assessment of vertebrate fauna in NSW was undertaken in 1992 (Lunney et al. 2000) to determine which vertebrate species should be listed as threatened under the TSC Act and which did not require listing. *SoE 2009* (DECCW 2009a) provided clear evidence that the decline of NSW species was ongoing and concluded that the long-term sustainability of many species was poor.

An estimated 897 species of native terrestrial vertebrates were found in NSW at the time of European settlement. Long-term changes in distribution since settlement have been estimated for all species for which there is adequate and reliable data (Mahon et al. 2011), using a methodology that relies on data collected at low intensity but rigorously and continuously over 200 years. The cumulative record can be used to build up and describe overall patterns of distribution over longer time frames.

The outcomes of this analysis were presented for mammals, birds, amphibians and reptiles in Figure 7.2 of *SoE 2009* (DECCW 2009a). As the outcomes described by this data are only expected to change slowly, over much longer time frames than the present reporting cycle of three years, the results of the 2009 analysis still apply.

Figure 5.1: Long-term loss of distribution for native mammals and birds



Source: Mahon et al. 2011; DECCW 2009a

Notes: Presumed extinct – 100% change (contraction) in distribution

Severe decline – 50–<100% change in distribution

Moderate decline – 25–<50% change in distribution

No significant decline – less than 25% change in distribution

n = the total number of species recorded as inhabiting NSW at the time of European settlement, but not including species regarded as 'vagrants' (occasional or accidental sightings of species well outside their normal range)

The results for birds and mammals shown in **Figure 5.1** illustrate the best and worst outcomes for the different vertebrate groups.

Over the longer term, outcomes for birds have been much better than for mammals, with only 2% of bird species (12 species of 452) becoming extinct compared with 19% of mammals (26 of 138 species). Losses of distribution of 50% or greater (including extinctions) involved only 6% of birds (31 species) compared with 29% of mammals (40 species).

The data reveals that, historically, birds have been significantly less susceptible to the pressures that have affected other terrestrial vertebrates, particularly mammals. Nine of the 12 bird extinctions occurred on Lord Howe Island which is a localised hotspot for bird extinctions. If these figures are disregarded, the persistence and survival of bird species on mainland NSW is even more pronounced.

However, shorter term data on bird populations produced over the past 10 years indicates that their numbers and range have recently declined significantly (Garnett et al. 2010; Mahon et al. 2011). This suggests that the relatively good outcomes for birds recorded over longer time frames may not be sustainable. Populations of woodland birds have declined the most (MacNally et al. 2009; Paton & O'Connor 2010), due to the extensive clearing of woodlands described in Biodiversity 5.2 and the effects of extended drought over much of the past decade.

Patterns of decline in vertebrate fauna groups

Most extinctions of native fauna in NSW have been in small- to medium-sized species of ground-dwelling mammals, including small wallabies, native mice, bandicoots and bettongs (Dickman et al. 1993; Lunney et al. 2000). Many of these species inhabited arid shrublands and grasslands in the west of the state and most of them had become extinct by the end of the nineteenth century. Predation by foxes and cats and overgrazing by stock have been attributed as the main causes. Other factors that may also have contributed to the decline include competition with invasive species, such as rabbits and goats, and the habitat degradation they cause, as well as changed fire regimes.

Historically, species that were habitat or dietary specialists have been the most vulnerable to extinction. Species that survived occupied a broader range of habitats and had broader dietary requirements. A similar pattern is also evident in surviving mammal species, with non-threatened species generally occupying a greater range of habitats than those under threat. Ground-dwelling mammals that occupy a broad range of habitats, such as woodlands and forests, as well as grasslands and shrublands, have better prospects for survival than those that occupy a narrower habitat range. The prospects for survival of arboreal or tree-dwelling species are significantly greater than those of ground-dwelling species (Lunney et al. 2000).

Regional patterns are also evident in the extinction or persistence of species. For example, nine of the 12 species of birds that are extinct in NSW were found only on Lord Howe Island, with human settlement and introduced rodents being the major pressures. The other three species were found in central or western NSW.

The largest number of mammal species, both threatened and non-threatened, are found in north-eastern NSW, where open forest habitats contain 38 non-threatened and 33 threatened mammal species. However, the habitat where the highest levels of mammal extinctions have occurred, by number and proportion, is the semi-arid shrubland in the west of the state, with 18 extinct species (Lunney et al. 2000).

An example of decline – koalas

As part of the process of preparing the approved Recovery Plan for the Koala (DECC 2008a), a major statewide survey of koalas was undertaken. This showed that koalas are concentrated along the north coast and in the north-east of the state within the eastern edge of the Murray–Darling Basin, particularly on the Liverpool Plains around Gunnedah. Comparison with a similar survey in 1986–87 showed that in contrast to general declines elsewhere in NSW, the koala population on the Liverpool Plains had expanded in the intervening two decades, where it was using trees planted in the 1990s to combat soil degradation and erosion as habitat (Lunney et al. 2009). However, intense heatwaves during the drought in 2009 killed about a quarter of this population, showing that short-term fluctuations in numbers also need to be considered when assessing the status of fauna populations.

Species with stable populations

Assessment of change in species distribution and abundance tends to focus on declines because this is the most common change. However, Figure 5.1 shows that the distributions of most bird species (for which there is sufficient data) have not declined over the long term. Disregarding the figures for extinctions, even in the case of terrestrial mammals, slightly more species have stable distributions than declining ones. Therefore, while many populations of species are declining in numbers and range due to human-caused habitat disturbance, many other species have been less susceptible to the effects of these pressures and maintained relatively stable populations.

Some species are more adaptable and can take advantage of human disturbances, even becoming nuisances which affect or interfere with human activities. The nuisance may be local – such as brush-tailed possums in the roofs of houses, ibises near airport runways or at waste disposal sites, and flying-foxes in orchards or near houses and schools – or regional – such as kangaroos on rural lands.

There is also some limited evidence that a few native species may be expanding in numbers or range, but such outcomes are rarely studied and difficult to demonstrate conclusively. However, some native species have become invasive after being translocated from their natural habitats, particularly native freshwater fish (see Table 5.12 and Table 5.17).

Threatened species

Species considered to be threatened can be listed as 'extinct', 'critically endangered', 'endangered' or 'vulnerable' in the schedules to the TSC Act or FM Act. Threatened populations and ecological communities are also listed in these Acts. Scientific committees established under both Acts evaluate all submissions for adding or removing species from the lists.

The conservation status of a species is based on its prospects for survival, its numbers and patterns of reproduction, and the pressures and risks that threaten it. This assessment is distinct from the analyses of species distributions and abundance described above, but population data would contribute to assessing a species' conservation status when it is available. Despite evidence of a decline in its abundance and range, a species may not be listed as threatened if its survival is not considered to be at risk.

Listed threatened species, populations and ecological communities

At 31 December 2011, 989 species in NSW were listed as threatened in the TSC and FM Acts. Over the past three years, 35 additional species have been added to the listings, including 11 terrestrial vertebrate species – an increase in listing of 3.7%. The number of extinct species has increased by three.

Table 5.1: Number of listed threatened species, populations and ecological communities in NSW

Taxa	No. of native NSW species	Extinct	Critically endangered	Endangered	Vulnerable	No. 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	90	136	30%	7
Amphibians	83	0	5	12	11	28	34%	1
Reptiles	230	1	0	18	23	42	18%	1
Plants	4,677	33	44	335	231	643	14%	25
Aquatic plants and algae	?	1	1	0	0	2	?	1
Freshwater fish	55	0	2	6	1	9	16%	3
Marine fish, sharks and rays	?	1	1	1	3	6	?	0
Terrestrial invertebrates	?	1	2	14	0	17	?	1
Aquatic invertebrates	?	2	1	3	2	8	?	0
Fungi	?	0	0	5	4	9	?	0
Total	**?**	**76**	**69**	**436**	**408**	**989**	**?**	**49**

Source: Office of Environment and Heritage (OEH) and Department of Primary Industries (DPI) data 2012
Notes: Based on listings at 31 December 2011

Table 5.1 displays numbers of listings for various plant and animal groups.

Terrestrial mammals are particularly at risk, with 59% of all species in NSW now identified as threatened. Other fauna groups to be severely affected include amphibians (34%), birds (30%), reptiles (18%), marine mammals (18%) and freshwater fish (16%). A total of 643 plants (14%) have also been identified as threatened.

The number of endangered populations is now 49, an increase of five (12%) since 2008, with populations of plants, mammals and birds being most represented. There are now 107 threatened ecological communities, an increase of 16 (18%) over the past three years.

Figure 5.2 shows the growth in the total number of listings of threatened species and ecological communities since 1995. Over the same period, the conservation status of some listed species and communities has continued to deteriorate, with many moving into higher risk categories and closer to the risk of extinction. There are now 505 endangered or critically endangered species, compared with 471 in 2009 and 251 in 1995.

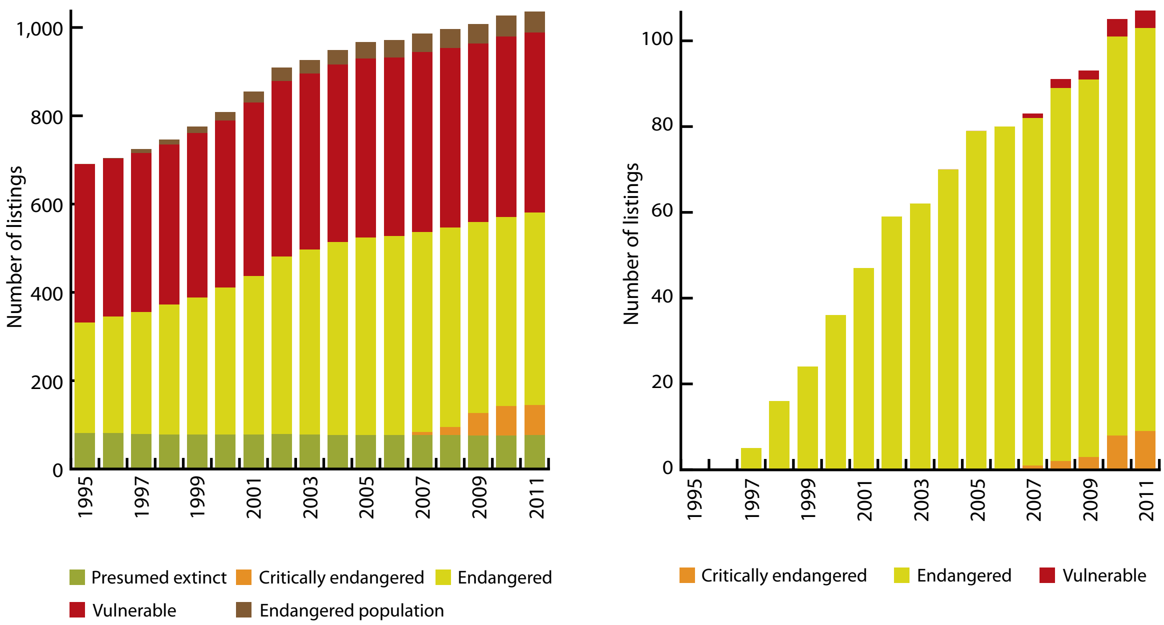
Interpretation of threatened species listings

The significance of changes in the number of listings of threatened species between reporting cycles and their interpretation is the subject of ongoing scientific investigation and debate. Some changes in conservation status may reflect improvements in the availability of information and knowledge rather than recent changes in species' prospects for survival (Keith & Burgman 2004). This is possible for most flora and fauna groups, such as invertebrates, where the full number of species is still not known with any certainty.

However, terrestrial vertebrates are relatively well-studied and the conservation status of all species in these groups was assessed soon after the TSC Act was introduced (Lunney et al. 2000). Any subsequent changes in status in these groups are more likely to reflect actual changes in their prospects for survival than recently filled gaps in information.

Figure 5.2: Changes in total listings of threatened species and ecological communities, 1995–2011

Threatened species | **Threatened ecological communities**



Source: OEH data 2012

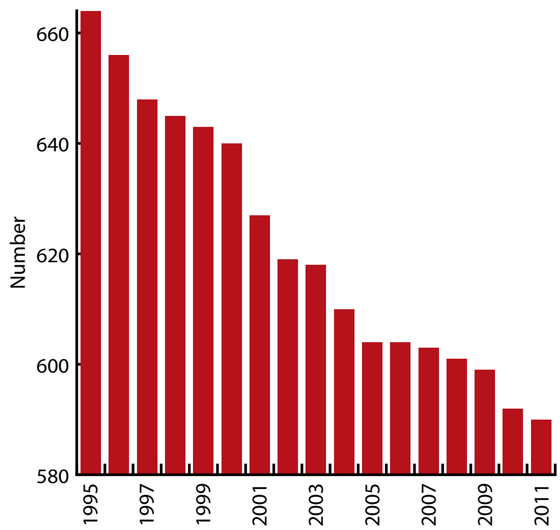
In the case of populations and ecological communities, their description or classification is open-ended so any changes reflect a pattern of new listings that had not previously been assessed. It is not possible to interpret these patterns as it is not clear when the actual declines that resulted in listing occurred.

Species that are not threatened

Where the total number of species in a group is known and there is sufficient information to systematically assess their conservation status , their overall prospects for survival can be described by looking at changes in the proportion of species that are listed as threatened over time. This information is available for terrestrial vertebrates (mammals, birds, reptiles and amphibians) and is shown in **Figure 5.3**.

Of the 903 terrestrial vertebrate species that inhabited NSW, 662 or 73% were not listed as threatened in the first assessment of conservation status, completed in 1995. This number has declined to 590 or 65% in 2011. Terrestrial vertebrates are the most well-known and best-studied group and the deteriorating conservation status of these species reflects the increasing number and intensity of pressures affecting the biodiversity of NSW. There is no reason to doubt that other, less well-studied groups are declining similarly.

Figure 5.3: Changes in the number of vertebrate species not listed as threatened under the TSC Act, 1995–2011



Source: OEH data 2012

Notes: For the purposes of this analysis, 'vertebrate species' refers to mammals, birds, reptiles and amphibians. It does not include fish, which are listed separately under the FM Act or marine mammals about which less is known due to their cryptic lifestyle and habits.

Pressures

The most important threats to ecosystems around the world have been identified (Millennium Ecosystem Assessment 2005) as:

- habitat change (land-use change, physical modification of rivers or withdrawal of water from rivers)
- over-exploitation
- invasive species
- pollution
- climate change.

The threats to biodiversity in NSW are varied and are described in greater detail in other sections of this report, including:

- clearing, fragmentation and disturbance of native vegetation (Biodiversity 5.2)
- land degradation (Land 3.1)
- the introduction of invasive species of pests, weeds and diseases and pathogens (Biodiversity 5.4)
- overgrazing by cattle, sheep and invasive herbivores (Biodiversity 5.2)
- changes to fire regimes (Biodiversity 5.5)
- changes to water flows (Water 4.1).

Over-exploitation and pollution are less substantial threats in the NSW context.

Main threats to threatened species

When a species, population or ecological community is listed as being threatened under the TSC Act or FM Act, the main pressures and threats affecting its conservation status are also described. These threats have been analysed for all threatened species listed in the TSC Act to identify the threats that have the greatest impact on biodiversity and the environment in NSW (Coutts-Smith & Downey 2006). The pressure affecting the largest number of threatened species in NSW (87%) is the clearing and disturbance of native vegetation, followed by invasive pest and weed species (70%).

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). Based on the evidence above, the clearing of native vegetation and impacts of introduced species are therefore the most significant threats to biodiversity in NSW. However, many threats operate together to hasten the decline of species and communities and species often face multiple threats, requiring an integrated set of targeted actions to ensure their survival.

Listed key threatening processes

The biodiversity of NSW is subject to an increasing number and range of threats. The TSC Act and FM Act both list the key threatening processes (KTPs) that impact on native plants and animals. At 31 December 2011, there were 45 KTPs listed for NSW, an increase of five over the preceding three years. Thirty-seven were listed in the TSC Act and eight listed in the FM Act. There is, however, some overlap in the threats listed, with climate change, shark meshing and changes to river flow regimes listed in both Acts in some form.

Table 5.2 summarises the types of KTPs listed. Over 50% of all KTPs relate to invasive species, with 23 associated with pests and weeds and a further five pertaining to pathogens and diseases.

Table 5.2: Summary of the key threatening processes listed in NSW, 2011

Issue	Number of KTPs
Invasive species	23
Habitat change	10
Disease	5
Over-exploitation	3
Climate change	2
Altered fire regimes	1
Pollution	1
Total	**45**

Source: OEH and DPI data 2011
Notes: At 31 December 2011

Climate change

As many Australian species are adapted to highly variable climates, they are likely to have some capacity to cope with expected changes in climate. However, their resilience may have been eroded by existing pressures on biodiversity which have resulted in documented declines. Climate change is expected to exacerbate the effects of existing threats and introduce additional pressures (Steffen et al. 2009; DECCW 2010a; Hughes 2011).

Studies suggest that climate change could surpass habitat destruction as the greatest global threat to biodiversity over the next few decades (Leadley et al. 2010). Its likely effects include changes to species' distributions and the timing of their life cycles, and disruptions to food chains (Bellard et al. 2012). Species with broader geographic and habitat ranges, dietary requirements and environmental tolerances are expected to cope better and some will benefit from a warming climate (Chessman 2011).

The composition and function of ecosystems will be affected by changes in fire regimes and hydrological flows, as well as in the distribution and abundance of species. Many of the most vulnerable ecosystems in Australia are found in NSW and are sensitive to changes in climate. These include ecosystems that only exist at certain elevations, coastal floodplains and wetlands, the wetlands and floodplains of the Murray–Darling Basin, temperate eucalypt forests, and saltmarshes and mangroves. The main threats to these ecosystems are extreme weather events and changes in water balance and hydrology (Laurence et al. 2011).

There is evidence that recent climatic and atmospheric changes are already having wide-ranging effects on species (OEH 2011a). Long-term studies of 24 species of birds migrating to south-eastern Australia each year indicate that 12 species are arriving earlier by 3.5 days each decade and leaving earlier by 5.1 days each decade (Beaumont et al. 2006). Birds of the same species tend to have larger body sizes in cooler climates, so in NSW larger birds are usually found further south in their range. For eight species, birds with smaller body sizes are now being found further south in NSW, consistent with the effects of a warming climate (Gardner et al. 2009).

Rising temperatures have caused bold-striped cool skinks in south-eastern Australia to change the depth of their nests and the time at which they lay their eggs. Nest temperature affects the sex of their offspring, so more females are now being born (Telemeco et al. 2009).

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

Lack of Information

Knowledge of the conservation status of species has improved markedly over the past 20 years. There is now much more information available on the distribution and abundance of terrestrial vertebrates, but less is known about other groups. Patterns of decline likely to have been present for many years are still being discovered in the less well-studied groups of species, together with declines that have occurred more recently. For invertebrates, microorganisms and many plant groups, information is more likely to exist for only a few isolated species and this provides little insight into the broader status of, and prospects for, those groups.

It is unrealistic to expect that a full range of biodiversity could ever be monitored systematically with available resources. It is therefore an ongoing challenge to optimise the monitoring information that is collected so it can inform effective decision-making for managing biodiversity. Long-term monitoring projects are essential for detecting changes in patterns of distribution and abundance and the dynamics affecting them, so these can be managed appropriately while there is still scope for beneficial outcomes.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Protect and conserve land, biodiversity and native vegetation'. Strategies for achieving this target are:

- 'Identify and seek to acquire land of high conservation and strategic conservation value, for permanent conservation measures'
- 'Establish voluntary arrangements with landowners over the next decade to bring an average 20,000 hectares per year of private land under conservation management and an average 300,000 hectares per year of private land being improved for sustainable management'.

NSW 2021 identifies actions to reduce 'red tape' (Goal 4), which includes reducing barriers associated with biodiversity controls. It specifically seeks to remove the need for dual approvals from the NSW and Australian governments for protecting threatened species and developing a common set of principles and practices to apply to offsetting disturbances to biodiversity.

Legislation

Legislation for protecting threatened species in NSW includes the:

- *Threatened Species Conservation Act 1995* (TSC Act), which provides a range of strategies for protecting threatened species, populations, communities and their habitats, and addressing threats to their survival
- *Fisheries Management Act 1994* (FM Act) which provides protection similar to the TSC Act for threatened fish, aquatic invertebrates and marine vegetation.

In accordance with section 157 of the TSC Act, a review is being undertaken to determine whether its policy objectives remain valid and the terms of the legislation are still appropriate for securing those objectives. A similar review of the FM Act was completed and tabled in Parliament in 2011 with no changes to the objectives of the Act proposed. A number of recommendations relating to aquatic habitat protection and threatened species conservation were made, and public consultation papers are being developed outlining options to improve the legislation in these areas.

Strategic policy framework

Over the past 10 years, there has been a shift in focus from recovering individual threatened species, an approach which is largely reactive, to a more strategic focus on conservation across the whole landscape and the protection of communities and habitats. Consistent with this approach, there has been more emphasis on benefiting as many species as possible by addressing general threats to biodiversity and the processes that lead to decline. Nevertheless, for many threatened species, their prospects for survival can only be improved through undertaking a specific set of management actions at identified priority sites.

A biodiversity strategy is under development and the *Draft New South Wales Biodiversity Strategy 2010–2015* (DECCW 2010b) was released for public consultation from November 2010 to February 2011.

Priorities action statements

Priorities action statements (PAS) provide a strategic framework for coordinating conservation and management actions across the more than 1000 entities (threatened species, populations and communities) that are listed as threatened in NSW. One PAS is in place for entities listed in the TSC Act and one for entities listed in the FM Act.

With the implementation of the PAS for both Acts, NSW became one of the first jurisdictions in the world to formally document the management requirements of its threatened species, populations and communities. Following its first three years of operation (2007–10), the performance of the PAS for the TSC Act is being reviewed to revitalise threatened species management in NSW.

Threat abatement plans

Threat abatement plans (TAPs) have been developed to manage some listed key threatening processes (KTPs). These include TAPs for the red fox, bitou bush and boneseed, and gambusia under the TSC Act, and a TAP for the removal of woody debris from rivers and streams under the FM Act.

Each TAP:

- outlines actions to manage the relevant key threatening process
- provides a program and timetable for carrying out the actions
- explains how the success of these actions will be measured.

BioBanking

The Biodiversity Banking and Offsets Scheme (BioBanking) is a market-based scheme designed to reduce the impacts of development on biodiversity, particularly threatened species and ecological communities. BioBanking enables developers to offset the impacts of development on biodiversity at one site by improving its management at other sites, provided that overall biodiversity values are improved or maintained. Offset (biobank) sites are expected to contain the same threatened species or ecological communities as those affected by the development and must be managed for conservation in perpetuity.

BioBanking is currently being reviewed to identify its strengths and challenges, ensure it achieves effective environmental outcomes and is practical to use.

Planning and biocertification

The *Biodiversity Certification Assessment Methodology* (DECCW 2011) was introduced in February 2011. Biodiversity certification provides a streamlined process for assessing the biodiversity of areas proposed for development during strategic planning and a range of enduring options for offsetting impacts on biodiversity. After biodiversity certification is conferred on an area, development may proceed without the usual requirement for site-by-site assessments of threatened species listed in the TSC Act.

On-ground programs and management

The strategic framework described above provides direction for a range of conservation programs and activities that are delivered locally and regionally. These programs protect native species, reduce threatening processes and provide effective conservation outcomes.

Reservation

A dedicated system of national parks and reserves is the cornerstone of conservation efforts to preserve and protect biodiversity and ecosystems in NSW. Approximately 8.8% of land and 34% of NSW marine waters have been incorporated into the terrestrial and marine reserve systems. Conservation in reserves is being supplemented by conservation measures on other public and private lands, which are described in Biodiversity 5.3. Under *NSW 2021*, the NSW Government has committed to establishing more national parks, including the new Dharawal National Park.

Recovery plans for threatened species

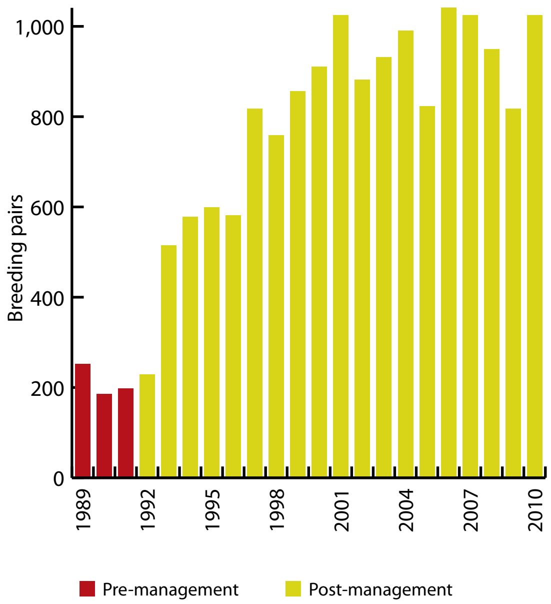
Both the TSC and FM Acts provide for the development of recovery plans for threatened species. Targeted recovery plans set out management actions to ensure the survival of high-profile, complex or critically endangered species. However, around 90% of species listed as threatened under the TSC Act are not covered by a recovery plan and are managed under the PAS system. Nineteen per cent of species listed under the FM Act have recovery plans in place, with recovery and threat abatement strategies for the remainder incorporated into the PAS for the FM Act.

Recovery of species

The status of some threatened species such as the Lord Howe woodhen, little tern and Gould's petrel has improved through direct conservation action. Recovery actions for Gould's petrel have increased numbers from fewer than 250 breeding pairs in the early 1990s to about 1000 pairs, as shown in **Figure 5.4** (Priddel & Carlile 2009). In addition, a second colony of this island-nesting seabird has now been established through the translocation of nestlings (Priddel et al. 2006). Accordingly, the listing of this species has changed from endangered to vulnerable. To date, this is the only instance of a threatened species in NSW having improved its conservation status as a direct result of such actions.

Management actions have significantly reduced the impact of invasive species on some NSW offshore islands. Exotic rodents and rabbits have been eradicated from several islands (Priddel et al. 2011), which has reduced predation on, and competition with, seabirds and other native species, and facilitated the return of some species previously eliminated by these pests, such as the white-faced storm-petrel. The removal of the highly invasive weed Kikuyu grass from Montague Island has stopped little penguins becoming entangled in the grass, improving their survival rate.

Figure 5.4: Number of breeding pairs of Gould's petrel, 1989–2010



Source: OEH data 2012

Table 5.3: Combined performance outputs of programs delivered regionally for natural resource management in NSW during 2010

Natural resource management actions	Area (ha)
Total area of native vegetation protected and actively managed under new conservation covenants on public and private land, including:	**859,500**
– Area of land added to the national parks system	378,600
– Area of native vegetation protected by property vegetation plans on public or private land	3,000
Total area of native vegetation where vegetation condition was improved, including:	**1,360,000**
– Area of terrestrial vegetation where vegetation condition was improved	730,000
– Area of riparian vegetation where vegetation condition was improved	20,400
– Area of wetland and aquatic vegetation where vegetation condition was improved	127,000
Total area of land managed to control or eradicate new, widespread or invasive weeds	**3,500,000**
Total area of land managed to reduce the impact of feral pest animals, including:	**5,300,000**
– Area where specific pest control activities were carried out (baiting, trapping, shooting)	984,000

Source: OEH data 2011

The critically endangered Lord Howe phasmid (or giant stick insect) has been successfully bred in captivity, for reintroduction to Lord Howe Island once rats and mice have been eradicated. The phasmid was once common on Lord Howe Island, but disappeared soon after rats arrived in 1918 after a cargo ship ran aground. It was thought to be extinct until a tiny population was rediscovered in 2001 (Priddel et al. 2003).

Natural resource management

NSW natural resource management programs are primarily delivered regionally through the state's 13 catchment management authorities (CMAs). The CMAs reflect regional priorities and sensitivities in their catchment action plans. These plans provide the direction and framework for delivering programs regionally while incorporating statewide targets and objectives. CMAs engage with their local communities, and support private and public land managers and community volunteers in maintaining and restoring the natural environment.

For the first time, the collective actions of the CMAs and government agencies can now be compiled and reported on in a common framework for describing program performance, and this reporting will be improved and refined in the future. It is recognised that in natural resource management it can take a long time for the outputs of programs to be fully effective, and reach the critical levels needed to translate into measurable outcomes and environmental change. Actions benefiting biodiversity throughout 2010 are summarised in **Table 5.3**.

Under the *NSW 2021* target to protect and conserve land, biodiversity and native vegetation, the NSW Government is committed to working with CMAs and local community groups to deliver programs that will:

- regenerate degraded natural bushland, including riverbanks and degraded waterways, through a $10-million fund
- purchase and protect strategic areas of high conservation value and ensure more green spaces across Sydney and NSW through the $40-million Green Corridors Program
- increase Aboriginal participation in natural resource management by supporting Aboriginal Green Teams and other Aboriginal groups working to protect and conserve natural environments
- better protect threatened and iconic species, such as koalas, and review the PAS for the TSC Act to enable community groups and businesses to get involved in threatened species conservation.

Regulation of clearing

The clearing of native vegetation and harvesting of non-plantation native forest timber on rural lands are regulated under the *Native Vegetation Act 2003* and enhanced systems for enforcing and monitoring compliance are now in place. Approvals to clear native vegetation have fallen significantly since the introduction of the Act. At the same time, measures to promote revegetation and improve the condition and management of native vegetation are being delivered regionally through property vegetation plans established by the CMAs and implemented by landowners (Biodiversity 5.2). Corridors and buffers are being established through urban planning processes.

Management and control of invasive species

Eradication of widespread invasive species is seldom feasible. Therefore, control of some high-priority invasive species, such as foxes and bitou bush, is specifically targeted at sites of high conservation value. Control is delivered through TAPs which facilitate whole-of-government coordination across agencies and local authorities. Broadscale rabbit control is being provided through the release of rabbit haemorrhagic disease, while rats, mice and rabbits have been eradicated from some NSW islands. CMAs are responsible for identifying priority weeds regionally and developing programs to manage them (Biodiversity 5.4).

Management of native species

Plans are needed for the management of some native fauna in NSW. Licences have been issued to manage 50 species of native fauna in NSW at least once in recent decades. Licensing is also required to conduct research to better understand and conserve native fauna and to look after animals that are taken into care for rehabilitation and subsequent release. Up to 70,000 native animals are taken into care each year.

The Kangaroo Management Program monitors numbers of the four large kangaroo species in NSW to ensure that populations do not expand at the expense of other native fauna. Changes to benefit stock, such as clearing of woodlands, removing dingos and providing watering points, have all contributed to increasing the populations of kangaroos, which are regarded as pests and culled on agricultural and pastoral lands.

Adaptation to climate change

Priorities for Biodiversity Adaptation to Climate Change (DECCW 2010c) was produced in response to the listing of anthropogenic climate change as a key threatening process under the TSC Act.

The report outlines priority measures for dealing with the effects of climate change over the next five years, which focus on four key areas:

- enhancing understanding of the likely responses of biodiversity to climate change and readjusting management programs where necessary
- protecting a diverse range of habitats by building a comprehensive, adequate and representative public reserve system in NSW, with a focus on under-represented bioregions
- increasing opportunities for species to move across the landscape by working with partners and the community to protect habitat and increase connectivity by consolidating areas of vegetation in good condition
- assessing adaptation options for ecosystems most at risk from climate change in NSW.

Management of other threats

The extraction and use of water from rivers and groundwater sources is now largely regulated and specific allocations are made for environmental flows (see Water 4.1 and Water 4.2).

Management of fire has focused mostly on reducing risks to people. However, research on the relationships between fire and the population dynamics of a range of Australian flora and fauna is now enabling fire regimes to be developed that maintain biodiversity and can be incorporated into fire management practices (Biodiversity 5.5).

Future opportunities

A combination of integrated conservation management across landscapes and actions targeted to specific species will be needed to prevent further biodiversity declines. Programs that deliver targeted on-ground actions regionally within a strategic framework are likely to achieve the most effective outcomes.

Measures to improve connectivity across landscapes and build the health and resilience of the land will enhance the capacity of species and ecosystems to adapt to, and cope with, disturbance.

More information about the factors contributing to the resilience or success of some native species and processes, in contrast to the declines of many others, may assist in efforts to maintain sustainable populations of flora and fauna species.

5.2 Native vegetation

Sixty-one per cent of New South Wales is covered by native vegetation. Of this, only 9% of NSW has vegetation considered to be in close to natural condition, whereas condition has deteriorated in the remaining 52%. Land use and land management have had an impact on the condition and function of native vegetation. Levels of vegetation clearing have stabilised over the past six years.

Land clearing has been recognised as the main threat to the extent and condition of native vegetation in NSW. While some vegetation classes, particularly woodlands and grasslands, have been substantially depleted since European settlement, others remain largely intact.

The clearing of native vegetation has been greatest in areas preferred for urban development (the coastal plain) or agricultural development (the wheat–sheep belt of central NSW).

Over the past nine years, the overall area of woody vegetation has remained relatively stable, but in the longer term positive gains in the overall extent and condition of native vegetation are expected as current programs take effect.

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.

NSW indicators

Indicator and status	Trend	Information availability
Extent of native vegetation	Stable	✓✓✓
Condition of native vegetation	Stable	✓
Levels of pressures on native vegetation condition	Stable	✓
Clearing rate for woody native vegetation	Decreasing	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

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). While 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, it is less descriptive of ecosystems. More detailed vegetation mapping based on information about species composition provides a better practical indicator of the location and status of ecosystems. However, the description in this section is largely based on generalised mapping as more detailed mapping is not consistently available across the state.

Status and trends

Vegetation extent

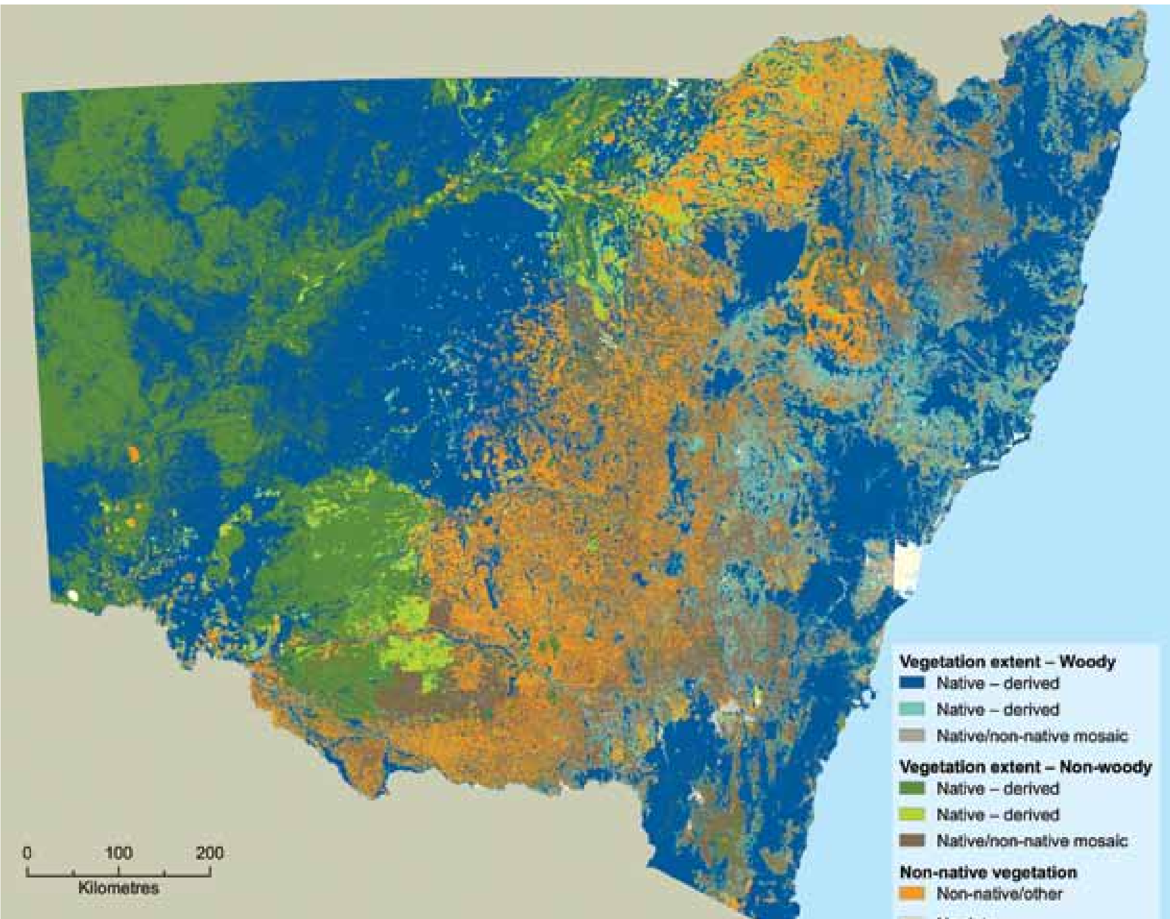
A dataset on the extent of NSW native vegetation was prepared under the NSW Natural Resources Monitoring Evaluation and Reporting Strategy 2010–2015 (DECCW 2010d) using a compilation of vegetation mapping and remote sensing analysis (Dillon et al. 2011). This described the extent of native vegetation in four 'extent modification categories' which represented various levels or degrees of modification and was presented as Map 7.1 in *SoE 2009* (DECCW 2009a). The four extent modification categories shown were:

- **native – intact:** native vegetation in which the structure has not been substantially altered
- **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
- **native/non-native mosaic:** vegetation that cannot be classified as native or non-native using current remote sensing technologies
- **non-native/other vegetation types:** non-native vegetation (crops, plantations, pasture) or other non-vegetative land cover.

This earlier map has now been combined with the latest map of change in woody vegetation. 'Woody' vegetation is vegetation that is over two metres tall with a canopy cover of more than 20%. All other vegetation is described as 'non-woody'. Whether native vegetation is woody or non-woody affects how it is monitored and hence the quality of the information available on vegetation clearing in different areas and the change in its extent (see 'Pressures'). Information is generally more reliable for woody vegetation as it is easier to monitor by satellite.

Map 5.1 depicts the location and extent of native vegetation that is woody or non-woody in each of the extent modification categories.

Map 5.1: Extent of woody and non-woody native vegetation in NSW in various states of modification



Source: OEH data 2012

Table 5.4: Proportion of extent modification categories that is woody or non-woody

Extent modification category	Area of extent modification category (sq km)	Percentage of total area analysed*	Area of woody vegetation (sq km)	Area of non-woody vegetation (sq km)	Percentage of category that is woody vegetation
Native – intact	489,670	61%	267,960	221,710	55%
Native – derived	60,090	8%	29,970	30,120	49.9%
Native/non-native mosaic	161,780	20%	23,950	137,830	15%
Total – all categories containing native vegetation	711,540	89%	321,880	389,660	45%
Non-native/other	86,660	11%			
Total*	**798,200**	**100%**			

Notes: * This is not the total area of NSW: the analysis excluded an area of metropolitan Sydney which was not assessed.

Extent of woody and non-woody vegetation by extent modification category

The data extracted from Map 5.1 indicates the changes affecting native vegetation modified to various levels in NSW and the confidence in this information, which is greater for woody vegetation. The results are shown in **Table 5.4**.

Table 5.4 shows that 45% of all native vegetation in NSW is woody and 55% non-woody. However, this pattern is reversed for intact native vegetation, where the proportion of woody vegetation is greater (55%). Most derived and mosaic vegetation is therefore non-woody, reflecting the significant changes that have occurred to native vegetation in NSW.

The most extensive changes have been to native grasslands, most of which no longer exist as natural grasslands, and to grassy woodlands, where removal of the tree layer has created non-natural (not naturally occurring) grasslands. While the overall area of grasslands has probably now increased, most are not naturally occurring and do not consist of vegetation that can be categorised as intact native vegetation.

Extent of intact native vegetation

'Native – intact' vegetation covers 61% of NSW. As native vegetation in this category retains its structural integrity, naturally occurring vegetation communities can still be identified (Keith & Simpson 2006; Keith & Simpson 2008), but these communities are not necessarily in good condition. Much of the vegetation in this category faces a range of impacts on its condition from a variety of land uses, including changes to species composition and ecological function, reduced vigour or regeneration, and diminished habitat values. 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 and is therefore not subject to land-use pressures.

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. **Table 5.5** summarises the status of a range of intact native vegetation formations.

Table 5.5: Extent of clearing of native vegetation formations in NSW since 1750

Vegetation formation	Status
Native grasslands	Extensively cleared or modified with only small fragments remaining outside the semi-arid zone, although some grazing lands retain important remnants
Grassy woodlands	Substantially depleted with less than 10% of some classes remaining
Rainforests	Littoral rainforests and those on coastal lowlands have been substantially reduced. Other classes of rainforests occurring in more rugged terrain are less depleted, although changes in structure and species composition have occurred in areas with a history of timber harvesting.
Dry sclerophyll forests	Less cleared, because of constraints imposed by terrain and less fertile soils, although levels of depletion are still substantial in some classes
Wet sclerophyll forests	Less cleared, because of constraints imposed by terrain and less fertile soils, although levels of depletion are still substantial in some classes
Semi-arid woodlands	Have undergone low to moderate levels of clearing (10–60%), although this has increased in recent decades
Arid shrublands	Still largely intact as they are generally less suitable for development
Heathlands	Still largely intact as they are generally less suitable for development
Alpine complex	Still largely intact as they are generally less suitable for development

Source: Keith 2004

Extent of modified native vegetation

Modified or 'derived' native vegetation covers 8% of NSW. Although the structure of derived native vegetation has been deliberately modified, more than 50% of the vegetation cover is composed of native species, so it still makes some contribution to overall native habitat values in NSW (DECC 2008b).

Vegetation described as 'native/non-native mosaic' (see Map 5.1) covers 20% of NSW and contains a mixture of native and non-native vegetation which cannot be distinguished, so this category could be regarded as indeterminate (DECC 2008b). Much of this vegetation is grassland used for grazing and the inability to categorise it reflects the less advanced state of monitoring of non-woody vegetation.

Vegetation condition

Where native vegetation has not been cleared, its condition ranges from pristine when undisturbed to heavily degraded. Between these two extremes, the condition of native vegetation may be 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
- the prevalence of parasites and diseases
- the 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 visible than clearing and occurs over a longer time frame. It is therefore more difficult to detect and assess.

A broad assessment of vegetation condition, largely based on generalised land use where vegetation condition declines with an increase in land-use intensity, was presented in Map 7.2 of *SoE 2009* (DECCW 2009a). 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 a further major land-use change occurs.

A more detailed analysis which incorporates site survey data on the condition of vegetation and relates it to land use and present land management practices is being developed, but this is not yet available statewide. This analysis will better reflect ongoing changes to vegetation condition that are produced by improved land management practices than the static map of land use described above.

Pressures

Vegetation extent

Land clearing

Native vegetation has been extensively cleared in NSW for settlement, industry and agriculture. Clearing facilitates land-use change and is generally irreversible due to the ongoing nature of the subsequent uses of cleared land. The process of clearing actively displaces many native animals and plants and has a negative impact on biodiversity. Over time, through the effects of fragmentation and disturbance, it leads to weed invasion and further deterioration in the condition and habitat values of the vegetation that remains.

Clearing is therefore accepted as being the main cause of vegetation change and decline. Clearing of native vegetation, and 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 both the *Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

However, not all clearing occurs through the direct removal of vegetation. 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 also been cleared, in effect, by prolonged overgrazing.

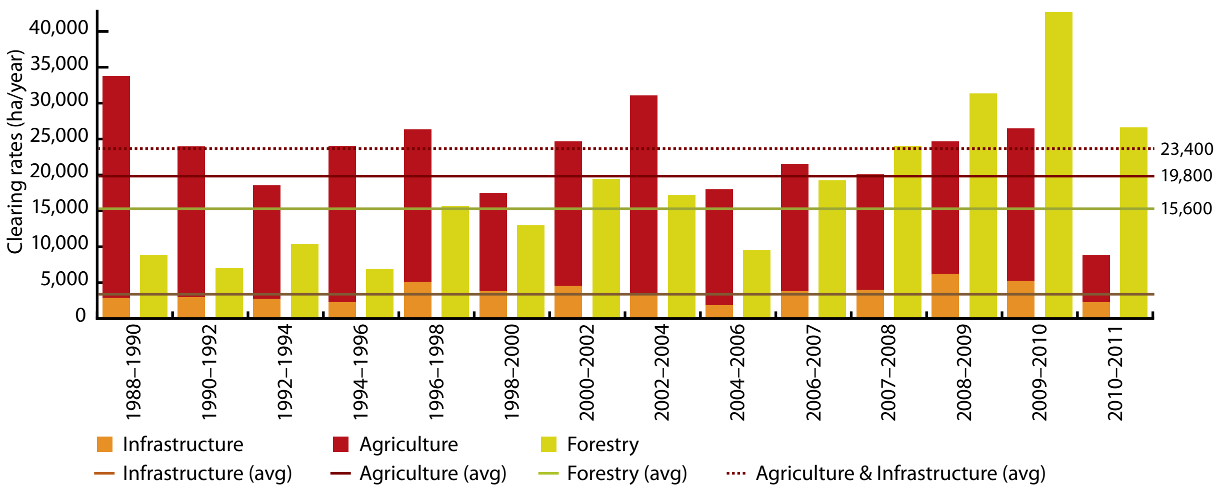
Clearing of woody vegetation

The annual record of woody vegetation change is produced by analysing Landsat remote sensing data using the SLATS methodology, developed in Queensland (DNRW 2007). This record provides an indication of the rate of clearing of woody vegetation, which is vegetation that is over two metres in height with a canopy cover of 20% or more. Generally, woody vegetation is found in forests and woodlands.

The SLATS methodology identifies changes in the extent and structure of woody vegetation that are due to agriculture, infrastructure development and forestry. **Figure 5.5** presents data on these changes.

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. Since 2005, the clearing of woody vegetation has been relatively stable, fluctuating around the long-term combined average for agriculture and infrastructure of about 23,400 hectares per annum. However, in the last period of monitoring for which data is available (2010–2011) it dropped sharply to around 9000 hectares. Most of the recent clearing has been in the wheat–sheep belt, along the eastern fringe of the semi-arid zone (DLWC 2002; Keith et al. 2009; OEH 2011a).

Figure 5.5: Woody vegetation change in NSW, 1988–1990 to 2010–2011



Source: Office of Environment and Heritage (OEH) data 2011

Notes: Until 2006–2007, the annual rate of clearing was derived from change detected over a two-year period (for example, 1988–1990 represents two years from around the end of 1988 to around the end of 1990) with the value averaged over the two years. From 2006–2007 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.

Forestry operations have not been included as clearing because they do not lead to land-use change. Most of the areas where change is detected due to logging are expected to be regenerated as regrowth forest. A spike in forestry activity is evident in the data since 2006–2007, with levels in subsequent years above the long-term average of about 15,600 hectares per annum. However, this trend had begun to decline in 2010–2011, the final year for which data is available.

Monitoring of revegetation is inherently more complex than monitoring of clearing. A preliminary analysis in 2009 appeared to show that the overall level of woody vegetation has been stable since 2003, with clearing being balanced by regrowth, revegetation and restoration. However, further work is needed before a detailed interpretation of this result is possible.

Clearing of non-woody vegetation

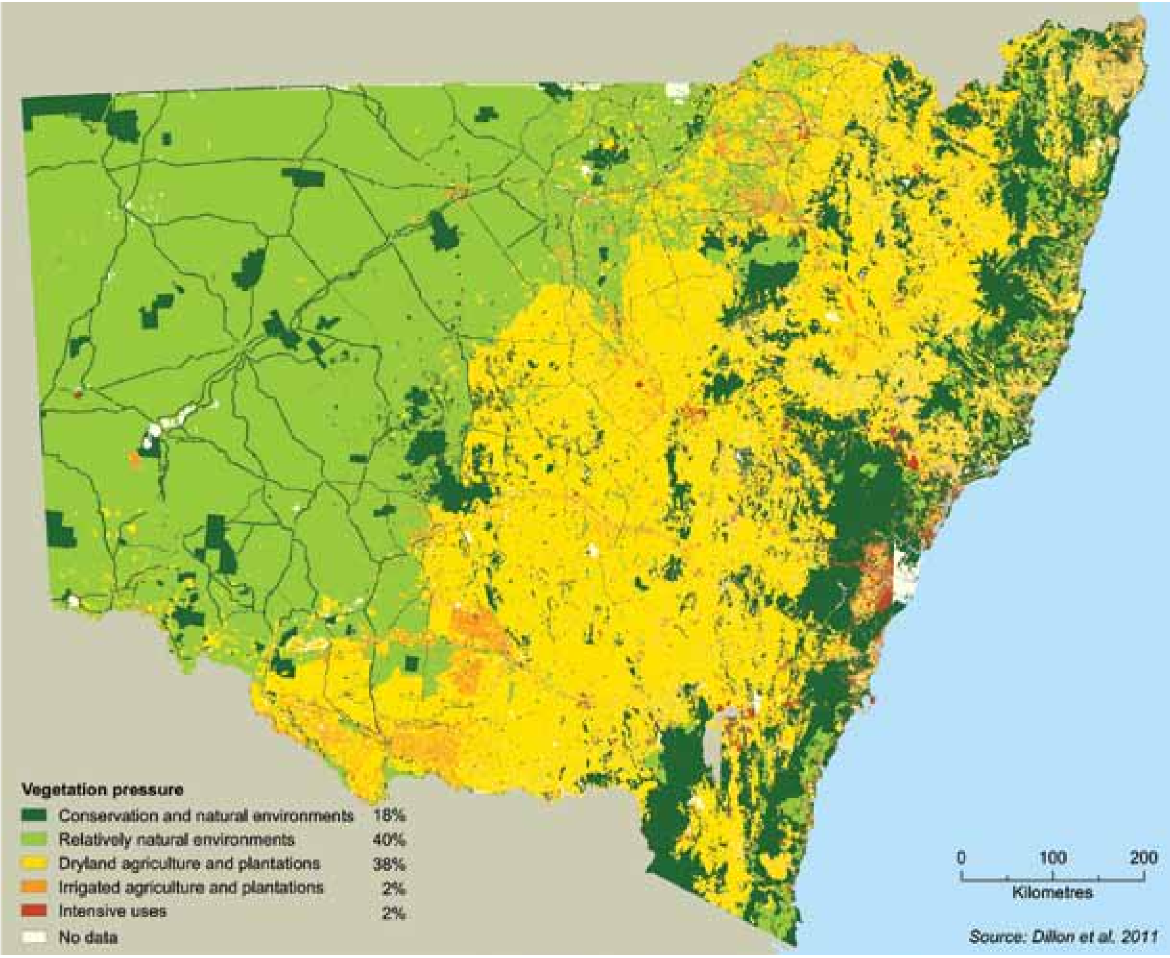
Non-woody vegetation is generally all vegetation that does not meet the criteria to be classified as woody vegetation. It refers to all grasslands and large areas of open woodlands and arid shrublands characteristic of western NSW, where densities of trees and shrubs are below the threshold of reliable detectability by the SLATS methodology. As discussed previously, 55% of all vegetation is non-woody, but it is difficult to detect change in this type of vegetation or monitor clearing of it. The processes and dynamics that affect change in non-woody vegetation are different from those affecting woody vegetation so it is not possible to use woody vegetation data to draw conclusions about the clearing of non-woody vegetation. All that is known about the overall level of clearing of all vegetation in NSW is that it is likely to be somewhat greater than the annual level of clearing detected for woody vegetation.

Vegetation condition

Land use

Map 5.2 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). They have been reclassified

Map 5.2: Land-use pressure on the extent and condition of NSW native vegetation



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 a primary land use increases.

The five land-use pressure categories are:

- **conservation and natural environments** – land set aside primarily for conservation, where natural ecosystems are maintained
- **relatively natural environments** – land used primarily for agriculture, with limited changes to native vegetation
- **dryland agriculture and plantations** – land used mainly for agriculture, based on dryland farming
- **irrigated agriculture and plantations** – land used mostly for agriculture, based on irrigated farming
- **intensive uses** – land subject to extensive modification, generally in association with residential settlement, or commercial or industrial uses.

General pressures

Not all the pressure on vegetation is due to land use. **Table 5.6** summarises the main pressures affecting vegetation condition, the number of vegetation classes affected and the general changes to condition that have occurred over the past decade.

Assessment of the pressures is based on how many of the 99 NSW vegetation classes defined by Keith 2004 are affected. This assessment broadly indicates the extent of the pressure but not necessarily its intensity or significance. For instance, land clearing and the fragmentation that results is the most severe pressure but it affects only 60 vegetation classes, whereas climate change affects all 99 classes, invasive species 95, altered fire regimes 84 and soil degradation 86.

Table 5.6 demonstrates that over the past 10 years most pressures have been ongoing with little sign of abatement. There are relatively few instances where pressures are easing and most are either intensifying or stable. The main reasons for intensifying pressures are:

- changes in flows due to river regulation, compounded by a severe drought cycle during most of the past decade (2002–2010)
- climate change
- the appearance in 2010 of myrtle rust, a new fungal pathogen that threatens forests on the east coast.

The impacts of land clearing on habitat have been discussed in 'Vegetation extent'. 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.

Changes to water regimes, combined with a particularly severe drought until 2010 (see Water 4.1 and Water 4.2) resulted in extensive dieback in floodplain forests and woodlands and this was compounded by the impacts of salinisation in the lower Murray–Darling Basin.

Climate change is pervasive and is expected to have increasing effects on all classes of 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).

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 have been compounded by the drought cycle from 2002–2010, which reduced the cover of ephemeral plants. Overgrazing simplifies fauna habitat and promotes an overabundance of species which are less palatable to grazing animals.

Other significant and pervasive pressures affecting vegetation condition are discussed as separate issues in this report. These include soil degradation (Land 3.1), invasive species (Biodiversity 5.4) and fire (Biodiversity 5.5).

Table 5.6: Changes to pressures on NSW native vegetation, 2002–12

Pressure	No. of affected vegetation classes: Intensifying	No. of affected vegetation classes: No change	No. of affected vegetation classes: Abating	Comments on the main dynamics and trends from 2002–12
Land clearing and resulting fragmentation	9	50	1	This is the most severe* pressure, affecting about 60% of classes. Intensification is due to coastal and urban development and expansion of plantations and cropping. Some abatement has occurred following introduction of the *Native Vegetation Act 2003* and an increase in reservation of significant areas.
Climate change	99	0	0	The most pervasive threat – climate change – continues to intensify with an increasing impact across all classes. Alpine, coastal, rainforest, wetland and arid classes are the most sensitive.
Invasive species (weeds, feral animals and pathogens)	25	70	0	This is the second most pervasive threat which affects around 90% of all classes, an increase from 75% in 2006. The threat has intensified due to invasion and establishment of weeds and diseases in riparian areas and the introduction of a new pathogen, myrtle rust.
Altered fire regimes	4	78	2	This pressure is a continuing threat to more than 80% of classes, including fragmented landscapes where fire exclusion limits regeneration. Alpine and subalpine classes have experienced increased pressures due to extensive fires.
Overgrazing	24	34	3	Overgrazing affects around 66% of vegetation classes. Increased pressures to overgraze have come from the drought, especially in the south of the state.
Soil degradation	60	26	0	Erosion has continued or intensified where there are long-term effects from reduced perennial plant cover. Salinisation has intensified in lowlands due to long-term effects from less deep-rooted vegetation in recharge zones. Acidification has intensified where drying wetlands release acid sulfates.
Changes to water regimes	5	7	0	In wetlands and riparian and floodplain areas, the long-term effects of over-extraction of water during the 1970s and 1980s continue. Pressures on other vegetation classes are partially compensated for by reduced drought stress and increased environmental flow allocations since 2009.
Harvesting of native species for firewood and timber	0	8	11	Firewood collection has accelerated in woodland, while timber harvesting abated in some wet and dry sclerophyll forests due to the expansion of reserves, although this was offset to some extent by increased harvesting on private land.

Source: OEH data 2012

Notes: Totals across columns may not add up to 99 (the total number of vegetation classes) as not all vegetation classes are affected by all pressures.

* Severity refers to the intensity of the pressure and is not necessarily related to the number of classes affected. For example, the effects of land clearing are more severe but affect fewer classes than invasive species, which are more pervasive.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Protect and conserve land, biodiversity and native vegetation' which will be achieved through the following strategies:

- 'Identify and seek to acquire land of high conservation and strategic conservation value for permanent conservation measures'
- 'Establish voluntary arrangements with landowners over the next decade to bring an average 20,000 hectares per year of private land under conservation management and an average 300,000 hectares per year of private land being improved for sustainable management'.

The priority actions associated with this target are to 'work with catchment management authorities and local community groups to protect and improve habitats on private lands'. Actions to conserve biodiversity and native vegetation include:

- 'Regenerate degraded natural bushland, including riverbanks, and degraded waterways through a $10-million fund'
- 'Purchase and protect strategic areas of high conservation value and ensure more green spaces across Sydney and NSW through the $40-million Green Corridors Program'.

These targets and activities are described in greater detail under 'Responses' in Biodiversity 5.1.

Native Vegetation Act

The *Native Vegetation Act 2003* (NV Act) is 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.

The Government is presently reviewing the Native Vegetation Regulation 2005 and various other provisions under the NV Act, including the Environmental Outcomes Assessment Methodology (EOAM) and *Private Native Forestry Code of Practice*. The review is intended to cut red tape and simplify requirements, while still protecting native vegetation, soil, land and water.

Catchment action plans

Catchment management authorities (CMAs) play a central role in delivering programs to protect, maintain or improve native vegetation. They are responsible for developing catchment action plans (CAPs) which establish regional priorities for natural resource management and coordinate the delivery of programs at the regional level. More information on the role of CMAs is provided in Biodiversity 5.1.

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 EOAM: biodiversity, soil health, water quality and soil salinity. CMAs 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 'Restoration or revegetation of native vegetation' and 'New management of native vegetation' in **Table 5.7**.

Management of native vegetation

Since 2006, the NSW Government has been collecting data on native vegetation programs from various agencies to produce a native vegetation 'report card' for publication in the *NSW Annual Report on Native Vegetation* (OEH 2011a). Table 5.7 shows the extent of activity in the following categories:

- New conservation areas
- Restoration or revegetation of native vegetation
- New management of native vegetation
- New clearing of native vegetation.

The first three categories affect the extent or condition, or both, of native vegetation positively, while the last category describes approved losses in the extent of vegetation. Table 5.7 reports on the most recent three-year period and also provides cumulative totals since data was first collected in 2006.

Table 5.7: Native vegetation report card – area of land where actions to protect or manage native vegetation in NSW have occurred

	Total (2006–08)	2009	2010	2011	Total (2009–11)*	Total (2006–11)*
New conservation areas						
Public reserve system: national parks and reserves	253,770	45,360	228,120	107,570	381,050	634,820
Public reserve system: flora reserves	2,730	0	0	0	0	2,730
Private conservation areas: voluntary conservation agreements	9,200	29,810	78,840	3,550	112,200	121,400
Private conservation areas: conservation covenants	64,150	193,190	420,390	322,660	936,240	1,000,390
Private conservation areas: Nature Conservation Trust covenants	2,320	4,810	6,120	9,810	20,740	23,060
Private conservation areas: Nature Conservation Trust revolving fund properties	7,320	9,370	540	3,350	13,260	20,580
Private conservation areas: wildlife refuges	70,370	310	110	40	460	70,830
Private conservation areas: PVPs in perpetuity	3,240	6,480	63,390	7,710	77,580	80,820
Private conservation areas: BioBanking agreements	0	0	80	330	410	410
Total area	413,100	289,330	797,590	455,020	1,541,940	1,955,040
Restoration or revegetation of native vegetation						
Incentive PVPs	252,560	126,620	144,250	63,180	334,050	586,610
PVP offsets	14,520	7,360	19,970	4,040	31,370	45,890
Native plantations	60,500	4,360	10,470	4,690	19,520	80,020
Revegetation through other incentives (non-PVPs)	662,940	42,120	50,680	25,900	118,700	781,640
Retained as a condition of approval to clear: *Plantation and Reafforestation Act 1999* and *Native Vegetation Conservation Act 1997*	24,980	650	170	20	840	25,820
Wildlife refuges: habitat restored	131,940	550	7,970	280	8,800	140,740
Natural regeneration excluding invasive native scrub	22,930	0	0	0	0	22,930
Total area	1,170,370	181,660	233,510	98,110	513,280	1,683,650

Table 5.7: Native vegetation report card – area of land where actions to protect or manage native vegetation in NSW have occurred (continued)

	Total (2006–08)	2009	2010	2011	Total (2009–11)*	Total (2006–11)*
New management of native vegetation						
Invasive native scrub PVPs	1,329,260	562,410	589,920	459,430	1,611,760	2,941,020
Thinning to benchmark PVPs	1,330	910	350	280	1,540	2,870
Public forest estate	–20,540	2,570	–106,460	–39,640	–143,530	–164,070
Private native forestry on state protected land	29,720	0	0	0	0	29,720
Private native forestry PVPs	156,210	108,870	68,600	73,120	250,590	406,800
Improved rangeland management	515,680	312,750	231,430	145,940	690,120	1,205,800
Weed removal programs	474,660	70,100	169,620	30,330	270,050	744,710
Total area	2,486,320	1,057,610	953,460	669,460	2,680,530	5,166,850
New clearing of native vegetation						
Clearing PVPs approved where environmental outcomes maintained or improved	4,650	1,820	3,500	990	6,310	10,960
Clearing under *Native Vegetation Conservation Act 1997*	2,520	0	0	0	0	2,520
Clearing under *Plantation and Reafforestation Act 1999*	1,090	30	<10	<10	50	1,140
Clearing under local government routine agricultural management activities (RAMAs)	10	0	<10	<10	20	30
Clearing for increased infrastructure – RAMA buffers	10	<10	0	<10	20	30
Total area	8,280	1,860	3,520	1,020	6,400	14,680

Source: OEH and Department of Primary Industries data 2011

Notes: All areas are shown in hectares.
There may be some differences between individual figures and overall totals due to rounding.
* Cumulative totals for the previous years of reporting shown.

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 most of the measures listed in Table 5.7 to be detectable as changes in vegetation extent or condition.

Reservation

Figures for new conservation areas (Table 5.7) represent additions to the public and private reserve system. A dedicated public system of parks and reserves is the cornerstone of conservation programs to preserve biodiversity and protect native vegetation (see Biodiversity 5.3). These areas are protected from clearing and will be managed for conservation in perpetuity. About 8.8% of all land in NSW has been incorporated into the reserve system, including the newly proclaimed Dharawal National Park in March 2012. Sufficient representation of all vegetation formations and classes is a key consideration in planning the future development of the reserve system (see Table 5.9 in Biodiversity 5.3).

Greater importance is now being placed on conservation across whole landscapes and protection in the reserve system is increasingly being supplemented by measures promoting conservation on private land (see Biodiversity 5.3). The NSW Government is implementing the Great Eastern Ranges Initiative and Green Corridors Program to further advance these objectives.

Restoration and revegetation

'Restoration or revegetation of native vegetation' in Table 5.7 refers to measures to improve the condition of native vegetation or increase its extent in NSW. These include incentive PVPs and PVP offsets, CMA-funded programs and other initiatives. Restoration of native vegetation is undertaken to improve the condition and habitat values of existing vegetation, while revegetation aims to increase the extent of native vegetation. Undertaken strategically, revegetation can buffer existing reserves, provide wildlife corridors and reduce fragmentation of the landscape. There has been a major and sustained increase in revegetation since the implementation of the NV Act and PVP framework in 2005.

New management of native vegetation

'New management of native vegetation' in Table 5.7 describes activities undertaken to enhance the condition of vegetation, such as the clearing of invasive native scrub, removing weeds and regulating private native forestry. *NSW 2021* has a strong focus on regenerating bushland by improving the management of private land to enhance and maximise its environmental values and by supporting CMAs in involving local communities and landholders. Actions include protecting areas that are sensitive or have high conservation value by fencing, weeding, and other measures that address specific ecosystem, habitat or species needs.

Regulating clearing of native vegetation

Under the NV Act, clearing is not permitted on properties unless it improves or maintains environmental values. A system of offsets has been introduced which allows landowners to clear native vegetation, provided they agree to plant, improve, or better manage other vegetation on their own property or elsewhere. The offsets required are described under 'Restoration or revegetation of native vegetation' in Table 5.7, while the areas permitted to be cleared are reported on in the 'New clearing of native vegetation' category.

Compliance and enforcement

The *Native Vegetation Compliance and Enforcement Strategy* (DECCW 2009b) has been developed by the NSW Government to promote compliance with the NV Act and assist with community understanding of its provisions and requirements. Remote sensing technologies have been used extensively to enable statewide monitoring and reporting. There have been a number of successful prosecutions for breaches of the NV Act through illegal clearing.

Future opportunities

Regional programs involving local communities should provide more opportunities to improve vegetation condition, enhance habitat connectivity and reduce fragmentation which will, over time, lead to the increasing resilience, health and productivity of all native vegetation types on public and private land.

A framework to record natural resource management activities and works delivered regionally has been established. This will provide better alignment between program objectives and overall outcomes, enhancing the capacity for adaptive management and providing better information and support to guide local community involvement.

Although clearing may be slowed and fragmentation reduced, the pressures that affect vegetation condition are likely to continue in future, due to further weed invasion and new weed incursions, the effects of plant diseases and pathogens, and the effects of climate change and related changes to fire regimes.

5.3 Reserves and conservation

The area of the reserve system has grown by 5.7% since 2009, with significant additions to under-represented areas.

At January 2012, the New South Wales terrestrial reserve system covered almost 7.1 million hectares or 8.8% of the state. Since the beginning of 2009, the reserve system has grown by 380,247 hectares, an increase of 5.7%.

The representativeness of the protected area system is improving, but some bioregions and vegetation classes are still under-represented, particularly in the central and western regions.

In regions where remnant vegetation is scarce, opportunities for additions to the public reserve network are limited and measures to promote conservation on private land and other tenures are being pursued.

Conservation on both private and public land provides greater connectivity across landscapes. Conservation measures beyond the public reserve system expand the range of natural values that are protected and provide buffers and corridors to enhance the network of reserves.

The system of marine protected areas covers 345,100 hectares or approximately 34% of NSW waters and most NSW marine bioregions are well-represented.

NSW indicators

Indicator and status	Trend	Information availability
Area of terrestrial reserve system	Increasing	✓✓✓
Area of the marine protected areas system	Stable	✓✓✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Addressing the decline of biodiversity is one of the greatest environmental challenges in NSW. Conservation in public and private reserves plays an important part in the strategy to deal with this challenge.

Protected areas are the cornerstone of conservation efforts in NSW. The state's public reserve system comprises a substantial network of protected areas which:

- conserves 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.

However, more than 90% of land in NSW is not in the public reserve system. To provide effective conservation across the whole landscape and conserve all natural values, measures are increasingly being focused on public and privately owned areas outside the reserve system.

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 beneficial uses. Twelve aquatic reserves protect important marine habitats and nursery areas.

Status and trends

Terrestrial reserve system

Extent of public reserve system

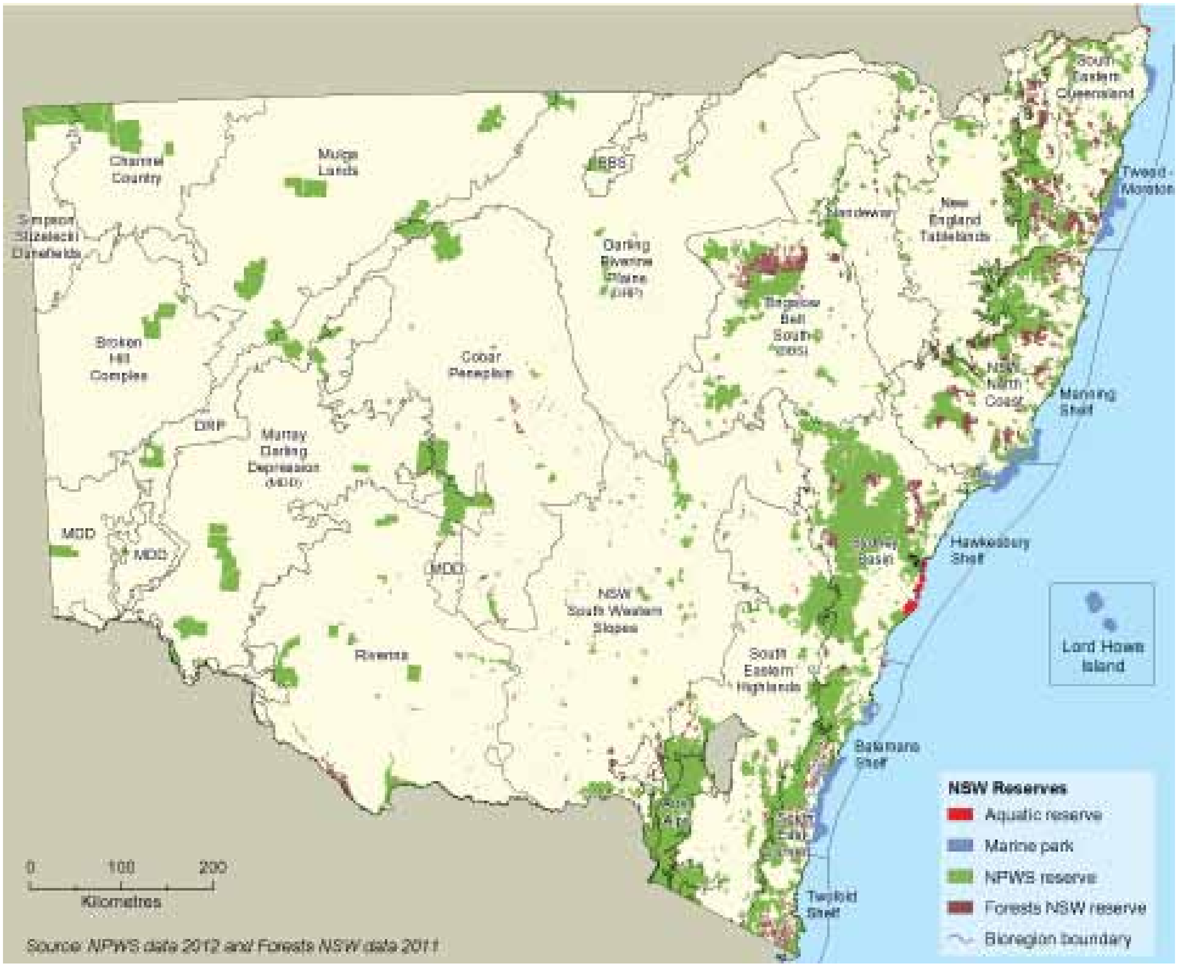
At 1 January 2012, the area of the NSW public reserve system protected under the *National Parks and Wildlife Act 1974* and *Brigalow and Nandewar Community Conservation Area Act 2005* had grown to 861 parks, a total of 7,080,934 hectares, or approximately 8.83% of NSW.

Since 1 January 2009, the area protected under both these Acts has increased by 380,247 hectares, an additional 5.7% of the total area reserved. Significant additions to the reserve system since January 2009 include Toorale National Park and State Conservation Area (85,251 hectares), the Riverina Red Gum Reserves (106,364 ha), South-Western Cypress Reserves (54,387 ha) and further additions to the Brigalow and Nandewar Community Conservation Areas (22,277 ha).

Map 5.3 shows the location of national parks and reserves managed by the NSW National Parks and Wildlife Service (NPWS) and reserves managed by Forests NSW, as well as the marine parks and aquatic reserves.

Table 5.8 describes the main types of protected area in the terrestrial reserve system and the additions between 2009 and 2012. There have been significant additions to most types of protected area and these have largely focused on addressing gaps in the system and enhancing the representation of poorly conserved ecosystems and natural values.

Map 5.3: National parks and forest reserves, marine parks and aquatic reserves in NSW



Source: NPWS data 2012 and Forests NSW data 2011

Table 5.8: Extent and types of terrestrial protected areas in NSW and changes since 2009

Type of protected area	Description	Number of areas (size in hectares)	Change since January 2009
NSW national parks and reserves			
National parks	Large areas encompassing a range of ecosystems, allowing for recreation that is compatible with the area's natural features	199 (5,188,434 ha)	14 new national parks (increase of 171,223 ha)
Nature reserves	Areas with significant biodiversity values, generally smaller than national parks	417 (942,761 ha)	21 new nature reserves (increase of 54,985 ha)
Aboriginal areas	Places of significance to Aboriginal people or sites containing relics of Aboriginal culture	19 (14,171 ha)	5 new areas (increase of 2,454 ha)
Historic sites	Areas of national importance, including buildings, objects, monuments and landscapes	16 (3,023 ha)	1 new area (overall decrease of 43 ha)
State conservation areas	Areas managed for conservation while providing opportunities for sustainable visitor use and permitting mining	125 (554,370 ha)	16 new areas (increase of 113,679 ha)
Regional parks	Conserved areas in a natural or modified landscape which provide opportunities for recreation	19 (22,354 ha)	5 new parks (increase of 15,065 ha)
Karst conservation reserves	Areas of limestone or dolomite characterised by landforms, such as caves and their decorative features, produced by solution, abrasion or collapse, or by underground drainage	4 (5,172 ha)	No new reserves, but an increase of 607 ha to existing reserves
Community conservation areas: Zone 1	As for national parks	34 (132,464 ha)	7 new parks (increase of 11,162 ha)
Community conservation areas: Zone 2	As for Aboriginal areas	5 (21,661 ha)	No new areas, but an increase of 43 ha to existing areas
Community conservation areas: Zone 3	As for state conservation areas	23 (196,524 ha)	4 new areas (increase of 11,072 ha)
Total		861 (7,080,934 ha) 8.83% of NSW	380,247 ha
Wilderness declarations			
Wilderness areas	Remote and undisturbed areas of sufficient size to enable long-term preservation of their natural systems and biological diversity, currently gazetted over existing national parks and nature reserves	51 contiguous areas (2,091,318 ha)	2 new wilderness areas and additions to 15 existing areas (increase of 207,314 ha)

Type of protected area	Description	Number of areas (size in hectares)	Change since January 2009
NSW national parks and reserves			
Wild rivers	Waterways in near-pristine condition in terms of animal and plant life and water flow, which are free of unnatural rates of siltation or bank erosion, currently gazetted over existing national parks and nature reserves	7 rivers and associated tributaries	No new rivers and associated tributaries
Reserved areas in state forests			
State forest dedicated reserve: special protection	Dedicated reserve managed to maximise protection of very high natural and cultural conservation values and not available for timber harvesting (Zones FMZ1 and PMP1.3)	29,177 ha (1.33% of total native forest estate)	4,773 ha reduction with transfer of estate to NPWS for addition to national parks
State forest informal reserve: special management	Informal reserve (special management): allowing specific management and protection of natural and cultural conservation values where it is not possible or practical to include them in Zone 1. Not available for timber harvesting (Zones FMZ2 and PMP1.2.)	167,177 ha (7.59% of total forest estate)	Reduction of 57,428 ha
State forest informal reserve: harvest exclusion	Informal reserve (harvest exclusion): managed for conservation of identified values and ecosystems and their natural processes. In these areas, timber harvesting is excluded but other management and production activities not permitted in Zone 1 or 2 may be appropriate, such as grazing or mineral exploration (Zone FMZ3a).	229,544 ha (10.43% of total forest estate)	Decrease of 52,230 ha Transfer of tenure to NPWS as part of the Western Regional Assessment

Source: NPWS and Forests NSW data 2012
Note: Data is as at the beginning of 2012

Progress towards a comprehensive, adequate and representative reserve system

The NSW Government is committed to building a comprehensive, adequate and representative (CAR) system of reserves and has adopted national targets for reserving ecosystems which are set out in *Australia's Strategy for the National Reserve System 2009–2030* (NRMMC 2009) and the *NSW National Parks Establishment Plan 2008* (DECC 2008c). The targets are based on bioregions and subregions defined in the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell 1995).

'Comprehensiveness' requires that each recognised ecosystem is represented in protected areas. The broad national target is for at least 80% of regional ecosystems to be included in the national reserve system (NRS) in each IBRA bioregion by 2015 (NRMMC 2009).

'Representativeness' means that the full variability of biodiversity within each ecosystem is protected. The broad national target is for at least 80% of regional ecosystems to be included in the NRS in each IBRA subregion by 2025 (NRMMC 2005).

'Adequacy' is the long-term capacity of protected areas to sustain the biodiversity within their boundaries. The viability of reserves in achieving their conservation objectives depends on their size, shape, configuration and location, as well as the land uses and management regimes on adjacent land. No specific targets have been established for the adequacy of the NRS, but wherever possible, reserves are located in areas where there is still relatively good habitat connectivity. In this way, reserves form the foundation of efforts to retain and reconnect habitat and establish corridors to facilitate species' migration in a changing climate.

Map 5.4 shows the proportion of land in public reserves in each of the 18 bioregions of NSW. The National Land and Water Resources Audit landscape health assessment recommended that 15% of the area in each bioregion should be protected in public reserves (CoA 2002).

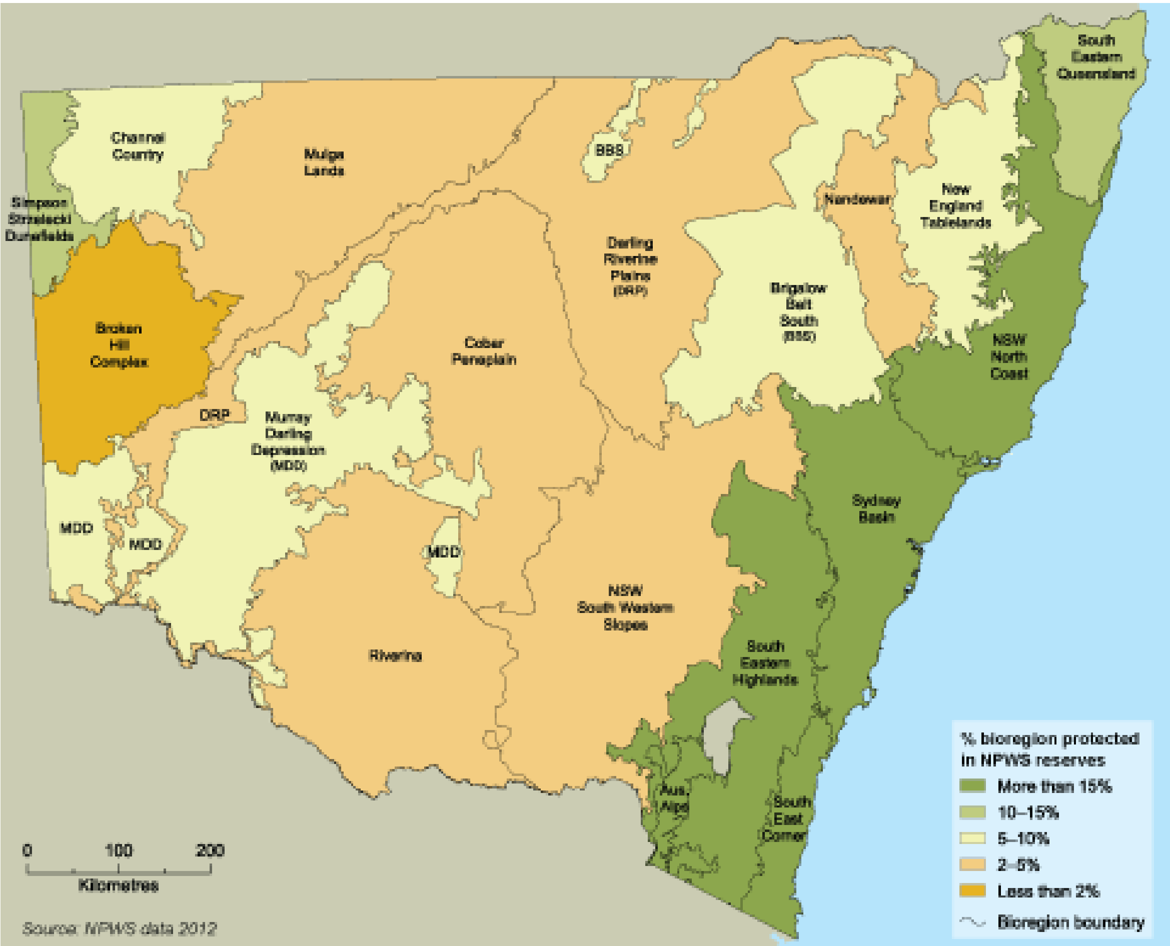
The bioregions of eastern NSW are generally well-represented in the reserve system compared with bioregions in the centre and far west of the state which are mostly under-represented. However, significant progress has been made recently in adding under-represented areas to the reserve system. The same map in *SoE 2009* showed four bioregions (NSW South Western Slopes, Darling Riverine Plains, Riverina and the Broken Hill Complex) with less than 2% of their area reserved. Now, only the Broken Hill Complex has this level of representation and coverage has improved in all four bioregions. These figures demonstrate that the new additions to the reserve system have been targeted effectively to under-represented areas.

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, 29 of the 129 subregions in NSW still have fewer than half of their regional ecosystems represented in the reserve system.

Despite the relatively high levels of comprehensiveness and representativeness of ecosystems in the eastern and alpine bioregions (Map 5.4; Table 5.9), the adequacy of the reserves in these bioregions could still be improved.

The goals in the *NSW National Parks Establishment Plan 2008* are based on the principle that existing and future opportunities for building a full CAR system will vary greatly across the state (DECC 2008c). In regions where over 70% of native vegetation remains relatively intact, the objective of building a full CAR

Map 5.4: Reservation of bioregions in NSW



Source: NPWS data 2012

system remains achievable. In areas with less than 70% of native vegetation remaining, realistic long-term reservation goals have been adjusted, depending on the proportion of native vegetation intact. However, in areas where less than 30% of native vegetation remains, a full CAR reserve system is not practically achievable. **Table 5.9** describes progress in meeting CAR objectives across the state.

Table 5.9: 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 comprehensiveness (%)	Progress towards representativeness (%)
Regions where over 70% of native vegetation remains relatively intact						
Mulga Lands	6,592,311	286,929	4.4	100	59	56
Channel Country	2,340,556	219,140	9.4	100	41	43
Simpson–Strzelecki Dunefields	1,069,837	119,090	11.1	100	43	35
Broken Hill Complex	3,795,093	75,526	2.0	100	36	27
Australian Alps	460,321	376,403	81.8	96	100	100
Murray–Darling Depression	7,929,235	461,262	5.8	93	72	55
South East Corner	1,162,086	496,694	42.7	82	97	97
Riverina	7,019,310	240,705	3.4	72	78	48
Regions where 30–70% of native vegetation remains relatively intact						
Cobar Peneplain	7,377,200	192,564	2.6	69	50	52
NSW North Coast	3,996,115	992,839	24.9	66	92	88
Sydney Basin	3,795,733	1,460,733	38.5	66	96	89
Darling Riverine Plains	9,409,645	233,471	2.5	65	48	42
South Eastern Queensland	1,662,539	226,652	13.6	53	95	86
South Eastern Highlands	4,718,158	719,905	15.3	42	86	74
New England Tableland	2,860,044	274,402	9.6	42	86	71
Brigalow Belt South	5,636,565	490,879	8.7	42	65	48
Nandewar	2,073,150	80,520	3.9	34	68	68
Regions where less than 30% of native vegetation remains relatively intact						
NSW South Western Slopes	8,198,413	174,529	2.1	16	53	40

Source: Adapted from DECC 2008c; NPWS data 2012

Notes: The NRS target for comprehensiveness is for at least 80% of extant regional ecosystems in each IBRA bioregion 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.

Private land conservation

To maintain productivity and healthy ecosystems across whole landscapes, areas need to be conserved beyond the borders of the public reserve system. Many reserves are relatively small and isolated, rather than being the large, continuous areas needed to optimally maintain biodiversity. As more than 90% of the land in NSW lies outside the reserve system, private land conservation can play a key role in enhancing landscape connectivity and resilience, and protecting threatened species, populations and ecological communities.

Where native vegetation types are substantially under-represented in the public reserve system, complementary conservation measures on private land are important. In many regions that have been highly cleared, all remaining native vegetation has significant conservation value. Some native vegetation formations are now found almost entirely on private land, with only 1% of grasslands, 3% of grassy woodlands, 3% of semi-arid woodlands and 4% of arid shrublands contained in the public reserve system.

Table 5.10 shows the area of private land subject to the various conservation programs in NSW discussed below. To date, this area amounts to around 3,215,750 hectares or about 3.9% of NSW.

Private land conservation programs

The NSW Government has developed a range of measures under its Conservation Partners Program to encourage and support conservation on private land. The options available provide flexibility for property owners wishing to conserve biodiversity and natural heritage on their land. Differing levels of government assistance are available, depending on the level of commitment preferred.

The level of involvement of private landholders in biodiversity and natural heritage conservation has grown substantially over recent years in response to the various options now available, which are described below.

Conservation agreements are legally binding covenants that are entered into voluntarily to protect biodiversity and natural and cultural heritage values in perpetuity on private and other public lands. The area under the agreement is registered on the land title, ensuring that if the land is sold the agreement and management requirements remain in place. Rate relief and tax concessions are available to landholders for land subject to a conservation agreement. There are currently 344 conservation agreements protecting 135,855 hectares of high conservation value land in NSW.

Table 5.10: Areas of land subject to a private land conservation agreement in NSW at 30 June 2012

Conservation measure	Number	Area (hectares)
Conservation agreements	344	135,855 ha
Wildlife refuges	670	1,936,198 ha*
Property registration	845	62,487 ha**
Conservation covenants	Not available	1,000,390 ha
PVPs in perpetuity	Not available	80,820 ha
Total	**1,859**	**3,215,750 ha**

Notes: * 10–20% is dedicated to conservation; 80–90 % is managed with compatible land uses.
** Includes around 30,000 ha of natural bushland and 4000 ha of rehabilitated bushland.

Wildlife refuges are legal declarations that enable landholders to voluntarily nominate all or part of a property where land will be managed to retain wildlife and habitat values. A property report and management plan are prepared outlining actions needed to maintain natural values, while ensuring that other compatible property management objectives will still be achieved. A wildlife refuge declaration is free and provides landholders with the flexibility to change the status of the refuge if required. There are currently 670 wildlife refuges providing protection for all or part of properties covering a total area of 1,936,198 hectares in NSW.

Property registration: This arrangement suits landholders wishing to conserve wildlife on private land who prefer not to enter into a legal agreement. Applicants can voluntarily register all or part of a property under the Land for Wildlife scheme. This scheme provides information and support to assist landholders in managing wildlife and habitats, as well as opportunities to share experiences with other landholders. There are currently 845 private landholders registered in Land for Wildlife committing more than 62,487 hectares of land to wildlife conservation in NSW.

Conservation covenants: perpetual lease conversion program

The conversion of Crown leases to freehold under the *Crown Lands (Continued Tenures) Act 1989* has enabled conservation covenants to be placed on property titles during the conversion process. Over a million hectares of private land are subject to conservation covenants in NSW.

Property vegetation plans

A property vegetation plan (PVP) is a voluntary but legally binding agreement between a landholder and the local catchment management authority (CMA). While PVPs were introduced to approve native vegetation clearing by offsetting other areas for conservation, a range of PVPs are now available covering various aspects of habitat improvement, such as revegetation or restoration of vegetation and better management of land and habitat. Some PVPs are agreed to in perpetuity for the permanent protection of native vegetation. More information on PVPs can be found in Biodiversity 5.2.

Nature Conservation Trust

The Nature Conservation Trust of NSW (NCT) is an independent organisation promoting nature conservation on private land. The NCT operates a revolving fund scheme that buys properties with high conservation value, registers an in-perpetuity trust agreement on their title, and then resells the properties with the agreement on the title. Private landowners entering into covenants may access a range of benefits, including technical advice and assistance with management costs. The NCT has purchased 21 properties under this scheme, protecting 21,865 hectares of high conservation value land.

Privately-owned conservation reserves

Some high conservation value properties in NSW are owned and managed by non-government organisations, such as Bush Heritage Australia and the Australian Wildlife Conservancy. Most properties are legally protected in perpetuity under conservation agreements. Bush Heritage Australia has five properties in NSW: Scottsdale (1328 hectares), Burren-Burren (411 ha), Brogo (120 ha), Tarcutta Hills (432 ha) and Sylvan Reserve (54 ha). The Australian Wildlife Conservancy owns and manages Scotia Sanctuary in NSW (65,000 ha).

Conservation on other tenures

Forests NSW conservation zones

Forests NSW uses a land classification system in state forests that sets out management intent and identifies areas set aside for conservation (SFNSW 1999). Through this zoning system, about 426,000 hectares of state forest (19%) are excluded from harvesting for conservation reasons. A similar amount of land is also excluded from harvesting for silvicultural reasons. These areas 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 is usual, so the stock can eat the vegetation.

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. In many of these areas, TSRs remain in relatively good condition and provide the best or only opportunity for improved conservation of threatened species or communities. They form a fundamental network of corridors connecting fragmented landscapes, particularly in the sheep–wheat belt and the tablelands. 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

Marine protected areas are coastal, estuarine or oceanic areas that are managed to conserve marine biodiversity. Some are small, highly protected areas that focus on species or community protection. Others are large multiple-use areas that contain complex ecosystems and habitats which are managed within a multiple-use framework to provide various levels of protection while permitting recreational and commercial uses (NSW Government 2001).

The establishment of a representative system of marine protected areas is widely regarded, both nationally and internationally, as one of the most effective mechanisms for protecting biodiversity (ANZECC TFMPA 1998).

The National Representative System of Marine Protected Areas is being established by the Australian and state governments throughout Australia's marine jurisdictions. The primary goal in NSW is to establish a comprehensive, adequate and representative (CAR) system of marine protected areas that includes the full range of biodiversity, ecosystems, habitats and species (NSW Government 2001).

The integrated marine and coastal bioregionalisation of Australia (IMCRA) describes a series of bioregions for oceanic, near-shore marine and coastal waters (EA 1998; CoA 2006). The NSW Government has adopted this framework for establishing and managing a representative system of marine protected areas in NSW (EA 1998; CoA 2006). There are six bioregions in NSW waters (Map 5.3).

Types of marine protected areas

There are three types of marine protected area in NSW: marine parks, aquatic reserves and the marine components of national parks and nature reserves (NSW Government 2001).

Marine parks are zoned to conserve marine biodiversity, maintain ecological processes and provide for a range of sustainable uses such as recreational and commercial fishing, diving, boating, snorkelling and tourism. There are four types of zone: sanctuary, habitat protection, general use and special purpose.

Aquatic reserves are declared primarily to conserve the biodiversity of fish and marine vegetation and protect important habitat or nursery areas. The type of protection and the activities permitted vary among reserves.

National parks and nature reserves: Many national parks and nature reserves contain significant and extensive marine ecosystems and habitats.

Extent of marine protected areas

An integrated system of marine protected areas is being developed in NSW to conserve marine biodiversity, recover threatened species, and allow for the sustainable use of resources (NSW Government 2001). Marine protected areas are located in all marine and coastal bioregions along the coast of NSW, from the Tweed estuary in northern NSW to Nadgee Lake in southern NSW.

The state's marine parks are managed by the Marine Parks Authority. Six marine parks have been declared and zoned for multiple uses: Cape Byron, Solitary Islands, Lord Howe Island, Port Stephens–Great Lakes, Jervis Bay and Batemans marine parks. This system of marine parks covers approximately 345,100 hectares (around 34%) of NSW state waters (Map 5.3). No additional marine parks have been declared since 2006 but the zoning plans for Batemans and Port Stephens–Great Lakes marine parks began operating in 2007.

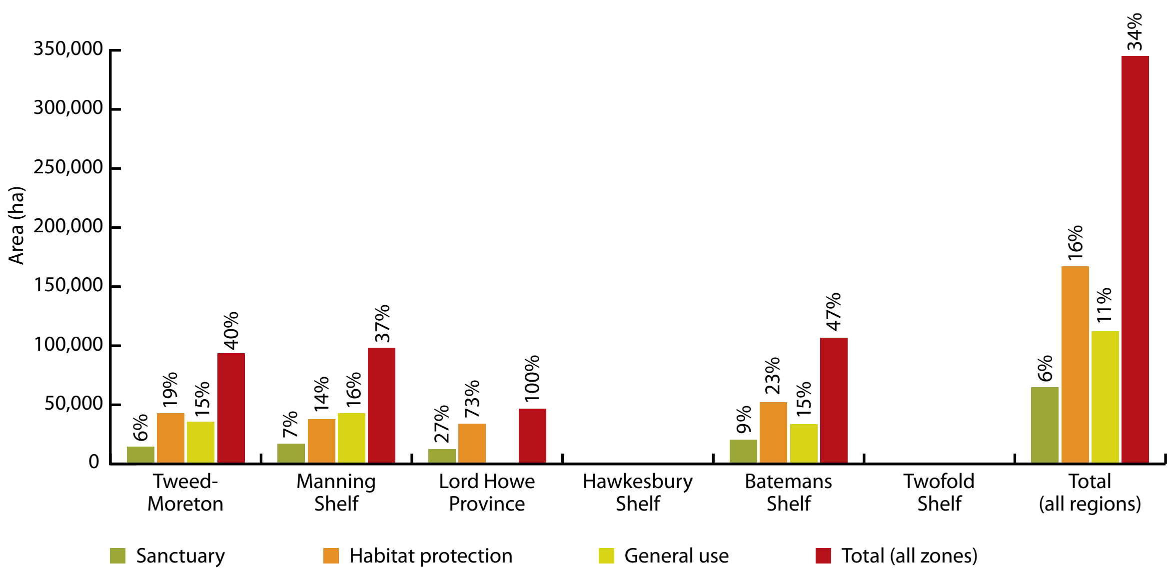
Twelve aquatic reserves cover around 2000 hectares of NSW waters. Ten of these are located in the Hawkesbury Shelf bioregion around Sydney, and there is one on the north coast and one on the south coast.

Marine and coastal areas are protected in 62 national parks and nature reserves within the terrestrial reserve system (2004 data), covering more than 10% of NSW estuary waters and incorporating about 46% of the NSW coastline. These areas include ocean coastlines, estuaries, coastal lakes, wetlands, intertidal areas, ocean beaches and rocky shores, and islands.

Some national parks and nature reserves adjoin marine parks, such as in the Myall Lakes region, or aquatic reserves, such as at Barrenjoey Head and Towra Point.

Figure 5.6 shows the area of NSW waters included in marine parks in each bioregion.

Figure 5.6: Area and percentage of each marine park zone in force in NSW bioregions



Source: Marine Parks Authority data 2009

Notes: 'Total (all zones)' refers to the percentage of each bioregion in NSW waters incorporated into marine parks (not the total % of zones within parks).

Special purpose zones are very small and are therefore not shown in the figure. They cover 0.05% of the Tweed–Moreton bioregion, 0.1% of Manning Shelf and 0.2% of Batemans Shelf.

Zoning plans

Zoning plans provide various levels of biodiversity protection in marine parks by regulating activities according to zones, regulating specific activities to manage environmental impacts, and protecting particular species. The purpose and characteristics of the different zones (shown in Figure 5.6) are described below.

Sanctuary zones comprise between 6 and 27.5% of each marine park and provide the highest level of protection by prohibiting all forms of fishing and collecting. Activities that do not harm plants, animals and habitats are permitted, including boating and diving.

Habitat protection zones comprise 14–73% of each marine park and conserve marine biodiversity by protecting habitats and reducing high-impact activities. Recreational fishing and some forms of commercial fishing are permitted.

General use zones comprise up to 16% of each marine park. A wide range of activities is permitted, including commercial and recreational fishing provided they are ecologically sustainable.

Special purpose zones are very small and apply to up to 0.2% of each marine park and are used when there are special management needs, including protection of Aboriginal and other cultural features, or for marine facilities.

Zoning plans regulate some specific activities: for example, there are restrictions on anchoring and the use of vehicles and personal watercraft in some areas. They may also provide additional protection for species of particular significance. Only some species can be taken from habitat protection zones while some species are protected throughout marine parks.

Protection under other legislation, such as controls on fisheries operations under the *Fisheries Management Act 1994*, or protection of threatened species under the *Threatened Species Conservation Act 1995*, also applies.

Pressures

Threats to values in terrestrial reserves

Park managers have identified the five major threats to national parks and reserves as weeds, pest animals, fire, illegal activities, and habitat and species isolation (**Table 5.11**). Weeds are a threat in the most parks due to localised or scattered infestations, but the area affected is less than that affected by pest animals. Weeds mainly threaten biodiversity, particularly threatened species, native flora and ecological communities. Many pest animal species are widely distributed and can travel long distances and damage large areas. For more information on the impacts of pest animals and weeds, see Biodiversity 5.4.

Table 5.11: Extent and severity of the threats to park values most commonly reported by NSW park managers

Type of threat	No. of parks identifying this threat as a concern	Estimated severity of impact (proportion of park area affected)				Total area of all parks affected
		Mild	Moderate	High	Severe	
Weeds	634	1.0%	11.2%	8.2%	1.7%	**22%**
Pest animals	546	0.9%	15.2%	14.5%	6.5%	**37%**
Fire	347	0.6%	6.5%	14.8%	3.1%	**25%**
Illegal activities	485	0.5%	6.1%	4.7%	0.2%	**11.5%**
Habitat isolation	194	0.6%	1.2%	5.2%	0.1%	**7%**

Source: NPWS State of the Parks data 2010

Notes: The estimated severity of impact is calculated by taking the median point from data for the following categories: mild threats – localised (<5% of area); moderate threats – scattered (5–15%); high threats – widespread (15–50%); and severe threats – throughout a park (>50%). A severe threat is defined as being likely to lead to a loss of natural values in the foreseeable future if it continues at current levels.

Bushfires occur sporadically and vary greatly in their impact due to the intensity, frequency and season of occurence as well as the recent fire history of the area affected. Their severity has been moderated since the last survey due to above-average rainfall and improved management. When fire does occur, however, the potential severity of the threat is greater than the threat posed by either pest animals or weeds. For more information on the impacts of bushfires, see Biodiversity 5.5.

Illegal activities such as trail biking, vandalism, dumping, stock encroachment and pig dogging are increasing but the impacts tend to be localised. These activities affect biodiversity, particularly threatened species and native flora, and Aboriginal cultural values, and have a negative effect on the experience of visitors to parks.

Parks where habitat or species isolation are a concern typically lack connectivity with other natural areas as they:

- consist of remnant vegetation within a cleared landscape
- are internally fragmented in design with a series of parcels of land separated by other land tenures
- contain internal physical barriers, such as major roads, that limit opportunities for recruitment or migration of some native fauna.

Climate change

Climate change is likely to:

- exacerbate the impacts on biodiversity caused by fragmented landscapes, introduced species and altered fire regimes
- alter the representativeness of reserves due to losses and gains of native and exotic species and ecosystems.

To manage the impacts of climate change, the objectives of future reserve management should shift from preventing ecological change to managing change to minimise the loss of biodiversity (Dunlop & Brown 2008).

The most important strategies for managing the effects of climate change in NSW reserves are building ecological resilience, improving landscape connectivity, ensuring effective fire management, and identifying priorities for pest and weed control.

Threats to conservation on private land

The pressures that affect protected areas on private land are much the same as those affecting public reserves. These include weeds and pest animals, fire regimes, climate variability such as drought and flood, activities such as firewood and bushrock collection, stock encroachment, and different 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 agricultural land uses that threaten conservation values. Unpredictable events, such as bushfires or sustained drought, may periodically exacerbate these threats and highlight the pressures arising from incompatible management objectives on private land.

To enable private landholders to successfully manage their land for conservation in the long term, it is critical to maintain monitoring and support services. Support includes continuing to recognise that private landholders' legal commitments to protect and conserve biodiversity and natural heritage are in the public interest through rate and tax concessions.

Threats to values in 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).

Resource use

Resource use includes fishing, aquaculture, mariculture, shipping and tourism, dredging and spoil dumping, and exploration and extraction of minerals, oil and gas. Marine protected areas conserve marine biodiversity and maintain ecological processes while providing for the sustainable use of resources. They work in concert with other programs that manage resource use. Activities conducted in marine protected areas are managed to ensure they are sustainable and do not threaten protected area values. Some activities are restricted to particular zones or may be prohibited throughout marine protected areas.

Invasive species

Invasive species are mainly associated with the shipping industry and ballast water exchange, but can also be associated with the aquarium industry and recreational boating (MBDWG 2008).

Invasive species are managed in marine protected areas by:

- restricting ballast water exchange
- ordering the removal of boats with heavily-fouled hulls from marine parks
- conducting monitoring programs to detect invasive species
- on-site management to enable a rapid response to threats
- maintaining or improving the health and resilience of the marine environment.

Marine pollution

Marine pollution includes debris from boating and shipping activities, nutrients from aquaculture, and spills or leakage of oil and toxic substances from the mining of oil, gas and minerals from the seafloor (MBDWG 2008).

In marine parks, zoning and operational plans aim to reduce the overall threats by eliminating, regulating or reducing the activities with the highest risk to marine park values. Many activities that may cause pollution are managed by agencies other than the Marine Parks Authority, but close relationships exist with these agencies to manage the risks.

Land-based impacts

Land-based sources of pollution that can impact on marine biodiversity include pesticides, heavy metals, nutrients, sediment and litter (Hobday et al. 2006; MBDWG 2008). The land-based activities most likely to affect the marine environment are foreshore development, sewage outfalls, and stormwater or catchment runoff.

Land-based threats are managed by locating marine protected areas where the threats are relatively small or through land-use planning, management of catchments and pollution reduction programs.

Climate change

Marine life in south-eastern Australian waters is increasingly being affected by the combined effects of changes to weather patterns and oceanographic factors such as currents. The effects of climate change on the marine environment (Hobday et al. 2006) are expected to include:

- changes in the distribution and abundance of species such as the southward movement of species along the NSW coast in response to higher temperatures
- changes in the timing of life cycle events, such as earlier spawning migrations
- changes in physiology, morphology and behaviour, such as the rates of reproduction and development
- impacts on biological communities due to different effects on individual species.

Comprehensive, adequate and representative systems of protected areas are an effective response to the threat of climate change (Hobday et al. 2006; Dunlop & Brown 2008). They can build resilience by returning areas to a more natural condition and will be important in assessing the impacts of climate change by providing benchmark areas for monitoring.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Protect and conserve land, biodiversity and native vegetation' to be achieved through the following strategies:

- 'Identify and seek to acquire land of high conservation and strategic conservation value, for permanent conservation measures'
- 'Establish voluntary arrangements with landowners over the next decade to bring an average 20,000 hectares per year of private land under conservation management and an average 300,000 hectares per year of private land improved for sustainable management'.

The priority actions associated with this target are to 'work with catchment management authorities (CMAs) and local community groups to protect and improve habitats on private lands'. Actions to conserve biodiversity and native vegetation include:

- 'Purchase and protect strategic areas of high conservation value and ensure more green spaces across Sydney and NSW through the $40-million Green Corridors Program'
- 'Establish more national parks including a new national park to protect the sensitive Dharawal State Conservation Area and continue the reserve establishment program'.

These targets and activities are described in greater detail under Responses in Biodiversity 5.1.

Additions to the terrestrial reserve system

Since 1 January 2009, over 260 additions were made to the reserve system across 15 NSW bioregions. These included 60 additions to parks in the Great Eastern Ranges and additions to over 40 areas protecting lowland coastal ecosystems. There have also been significant additions to:

- semi-arid grasslands and woodlands in the Murray–Darling Depression, Cobar Peneplain, Riverina and Mulga Lands bioregions
- river red gum forests mainly in the Riverina bioregion
- the creeks and upland swamps in the south of Sydney in Dharawal National Park
- the blue gum high forests and associated biodiversity in the Berowra Valley National Park north of Sydney.

Plans of management for the terrestrial reserve system

Under the National Parks and Wildlife Act 1974, a plan of management must be prepared for each terrestrial park and reserve. These plans identify the natural and cultural features that must be protected and specify ways to best manage them. By 1 January 2012, a total of 331 plans had been adopted, covering 472 parks and reserves. In total, more than 5.5 million hectares are now covered by a plan of management, representing around 79% of the reserve system.

Managing threats in the terrestrial reserve system

Pest and weed management: The management of pests and weeds in reserves focuses on areas where native animals and plants are the most threatened or where pests are likely to affect neighbouring land. Key strategies in managing these threats include:

- regional pest strategies – by June 2012, updated strategies for 2012–15 had been developed for all reserves
- identifying and prioritising sites where biodiversity is at greatest risk from widespread pests and weeds
- threat abatement plans such as those for the fox and bitou bush
- the *Management Plan for Myrtle Rust on the National Parks Estate* (OEH 2011b).

Fire management: Fire is managed in national parks and reserves by reserve fire management strategies (FMSs) which are map-based plans for managing fire. At 30 June 2009, all parks and reserves were covered by an adopted FMS. Around 580 separate strategies cover more than 6.6 million hectares across 793 reserves or reserve areas. Since June 2009, NPWS has acquired about 70 new reserves for which strategies are being prepared.

The FMSs feed into the NPWS annual program of hazard reduction burns. In 2009–10, favourable conditions allowed a record 93,000 hectares to be burnt in 269 operations to reduce fuel loads, particularly on the urban edge of parks.

Following the 2009 Victorian Bushfires Royal Commission, a $106.9-million bushfire protection package was announced by the NSW Government, resulting in the development of the Enhanced Bushfire Management Program. This program has enabled the annual hazard reduction program for NSW parks to be doubled and provided further resources for remote area fire suppression.

Sustainable tourism and visitation

The NSW Government provides a range of recreational opportunities in its parks and reserves that allow residents and visitors to appreciate and learn about the state's natural environment and cultural heritage. A *Sustainable Tourism Action Plan* was developed in 2010 which aims to encourage more people to visit parks and stay longer, while conserving the natural values of parks.

Private land conservation

Outside the public reserve system, the NSW Government is working with landholders, CMAs and other government agencies and non-government organisations, such as the Nature Conservation Trust, Bush Heritage Australia and Australian Wildlife Conservancy, to establish a range of conservation arrangements over private and other public lands which contain important natural and cultural heritage values (DECC 2008c).

Audit of marine protected areas

The NSW Government is committed to implementing an evidence-based marine parks policy that balances conservation and sustainable use of the marine environment and delivers tangible results. The Government commissioned an independent scientific audit of NSW marine parks to help deliver on this commitment. The audit has now been completed and the *Report of the Independent Scientific Audit of Marine Parks in NSW* (Beeton et al. 2012) released.

Zoning plans for marine protected areas

Zoning plans are used to deliver effective multiple-use management of marine parks. Under the provisions of the *Marine Parks Act 1997*, zoning plans must be reviewed after their first five years of operation and every 10 years thereafter. Since *SoE 2009*, reviews of zoning plans for Jervis Bay, Solitary Islands and Lord Howe Island marine parks have been conducted.

Amendments to the Jervis Bay and Solitary Islands zoning plans commenced on 1 March 2011 but were repealed on 26 May 2011 by the newly elected NSW Government pending its written response to the *Report of the Independent Scientific Audit of Marine Parks in NSW* (Beeton et al. 2012). The existing zoning plan for Lord Howe Island Marine Park remains in place, with options to address key issues to be developed with the local advisory committee.

The *Marine Parks Amendment (Moratorium) Act 2011* commenced on 16 September 2011 and introduced a five-year moratorium on declaring marine parks, altering the area of existing sanctuary zones, classifying new sanctuary zones, and conducting zoning plan reviews.

Operational plans for marine protected areas

An operational plan is required for each marine park, which details the strategies and actions needed to meet the key objectives of the park and provides a basis for assessing the performance of marine park management in meeting these objectives. New operational plans for Batemans Bay, Port Stephens–Great Lakes and Cape Byron marine parks commenced in 2010.

Strategic research framework for marine protected areas

The Marine Parks Strategic Research Framework 2010–2015 (MPA 2010) provides guidance to marine researchers on the principal research and monitoring needs of marine parks in NSW for the next five years.

Developing responses

Private Land Conservation Working Group

In March 2012, the Private Land Conservation Working Group was established to advise the NSW Government about how it could better support the conservation efforts of private landholders and non-government organisations. The working group reviewed existing private land conservation programs in NSW and those operating in other states, nationally and internationally and identified some emerging trends in private land conservation.

Great Eastern Ranges Initiative

The Great Eastern Ranges Initiative aims to maintain, improve and reconnect natural areas along a 3200-kilometre corridor stretching from the Grampians in Victoria, through the ACT and NSW, to the Atherton Tablelands in north-eastern Queensland. The objective is to provide healthy, functioning landscapes that will enable species to survive and adapt to environmental threats. Communities, agencies and governments are all involved in this project. The NSW Government is providing more than $4.4 million up to 2015, through the NSW Environmental Trust, to implement the initiative in NSW.

Ecological risk assessment for marine biodiversity in NSW

An ecological risk assessment of NSW marine biodiversity commenced in June 2011. The results of the assessment will reveal how effective marine parks are in conserving biodiversity and provide a guide for managing threats and stressors in future.

Future opportunities

The main priorities for further development of the terrestrial reserve system are to continue to incorporate under-represented ecosystems and habitats, rivers and wetlands into reserves and establish landscape corridors and buffers to enhance the resilience and flexibility of reserves.

Conservation on private and other public land will play an increasingly important role in supplementing the public reserve system by expanding the range and extent of the natural values that are protected. Measures that encourage further conservation on private land will be actively supported and new initiatives that facilitate conservation will continue to be explored and refined.

Efforts to promote greater use and increased public awareness and appreciation of parks, reserves and protected areas will play an important role in maintaining support for reserves and conservation. An important objective in future park management will be to improve public accessibility to parks.

The NSW Government is preparing a response to the *Report of the Independent Scientific Audit of Marine Parks in NSW* (Beeton et al. 2012). This response will help to determine the future management arrangements for marine protected areas.

5.4 Invasive species

Invasive species (including pest animals, weeds and diseases) are widespread across New South Wales. They are difficult to manage effectively and remain one of the biggest threats to biodiversity. Many are listed as key threatening processes in NSW legislation, with pest animals and, in particular, weeds identified as a threat to over 70% of all threatened species.

Most pest animals have been well established in NSW for many years, with foxes and cats found across virtually the whole state. The decline or extinction of numerous small- to medium-sized native animals has been attributed to their predation.

Introduced herbivores, particularly rabbits and feral goats, have adverse impacts on native species and ecosystems through overgrazing of native vegetation, land degradation and competition with native herbivores. Deer continue to expand their range with increasing impacts while new sightings of individual cane toads continue to occur intermittently.

To date, over 1650 exotic plant species have become established in NSW and more than 300 of these have been described as significant environmental weeds. New invasive species, particularly weeds, continue to be discovered from time to time at scattered sites in NSW and, when identified, are subject to eradication measures.

Introduced pathogens and diseases have emerged as increasingly significant threats to biodiversity, particularly the plant diseases root-rot fungus (*Phytophthora*) and myrtle rust, and the amphibian chytrid fungus.

NSW indicators

Indicator and status	Trend	Information availability
Number of new invasive species detected	Unknown	✓
Spread of emerging invasive species	Stable	✓
Impact of widespread invasive species	Stable	✓

Notes: Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Invasive species have been broadly established across NSW for many years and most areas now contain a range of weeds and pest animals. Historically, introduced species have contributed significantly to the decline and extinction of native species in NSW. In particular, foxes and cats have been implicated in the extinction of numerous small- to medium-sized ground-dwelling mammals (OEH 2011d). Human disturbance has greatly accelerated the invasion of introduced species (Coutts-Smith & Downey 2006; Coutts-Smith et al. 2007).

The collective impacts of invasive species are still poorly understood, whether on biodiversity or on the health of the environment as a whole. However, some recent advances have been made in understanding the impacts of invasive species on threatened species (Coutts-Smith & Downey 2006; Coutts-Smith et al. 2007; NLMG 2009). Statewide monitoring programs are also being established, which will enable reporting on the distribution of new and emerging pests and weeds and the extent of widespread pest species.

Status and trends

Extent of invasive species

Around 3000 introduced weed species have established self-sustaining populations in Australia since 1788. More than 1650 of these are recorded in NSW, with over 300 recognised as significant environmental weeds (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 biodiversity. Introduced fish species make up around a quarter of all freshwater fish species in NSW rivers (DPI 2008a).

Australian waters host over 200 species of introduced marine organisms (DPI 2008a). However it is not known how many insects and other invertebrates have been introduced into Australia (Coutts-Smith et al. 2007).

Invasive species place a substantial burden on the Australian economy. Invasive weeds have been estimated to cost about $4 billion per year in lost production, control costs and dealing with the impacts (McLeod 2004; Sinden et al. 2004); in NSW alone, weeds account for $1.2 billion per annum in lost production and control costs (LGSA 2011).

The cost to the Australian economy of dealing with the impacts of pest animals is over $1 billion annually (DPI 2008a), while pest animal control alone exceeds $60 million per year (Bomford & Hart 2002).

Categories of invasive species

Invasive species are generally categorised as widespread, emerging or new species, depending on their current extent and ability to persist and spread as described below:

Widespread species: any invasive species that has been present for some time and has now established a broad and relatively stable range across a region or the whole state, close to the limits of their likely distribution

Emerging species: any invasive species that has established a self-sustaining population and is actively expanding its range or has the potential to spread further

New species: any invasive 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.

Assessment of the threat posed by species that are not yet present is based on their potential to spread and significantly impact on the environment or production.

Distribution of pest animals in NSW

Thirty pest animal species have been identified as posing a threat to at least one endangered or vulnerable species in NSW (Coutts-Smith et al. 2007). Foxes, feral cats and wild dogs are the carnivores with the greatest impact on biodiversity. The herbivores or omnivores of greatest concern are rabbits, feral goats and feral pigs, while in aquatic environments European carp and gambusia are the most significant pests. **Table 5.12** lists the state's main pest animals.

Table 5.12: Main introduced animal species in NSW with an impact on listed threatened species

Carnivores	Herbivores/omnivores	Fish	Other
Feral cats	Feral goats	Gambusia	Honey bees
Red foxes	Rabbits	European carp	Grass skinks*
Wild dogs	Feral pigs	Redfin perch	Feral pigeons
Cane toads	Feral deer	Goldfish	Buff banded rail*
Masked owls*	Wild horses	Tench**	Introduced worms
Blackbirds	Black rats	Weatherloach	Black ants*
Songthrushes	Brown rats	Rainbow trout	
	House mice	Brown trout	
		Banded grunter***	

Source: Coutts-Smith et al. 2007

Notes: Introduced species are species found outside their normal range and include both exotic species and translocated native species (those moved from their natural habitat to other locations in NSW).

* Native species translocated from mainland NSW to Lord Howe Island where they are a threat to endemic native species

** Tench was identified as a threat in this study, but has not been recorded in NSW for over a decade and is no longer considered to be a significant threat.

*** Native species translocated to other rivers in NSW

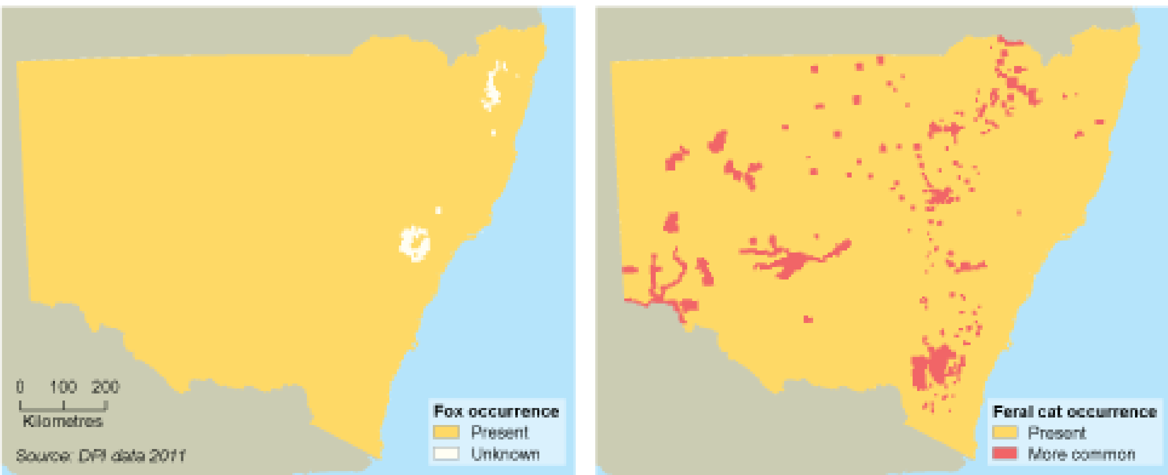
Widespread species

Widespread species have generally been present for a relatively long time, are broadly distributed and are close to the limits of their likely distribution, based on the availability of suitable habitat. The collective distribution and abundance of seven major widespread pest animals – foxes, cats, feral goats, rabbits, feral pigs, wild dogs and carp – was shown in Map 7.5 of *SoE 2009* (DECCW 2009a).

As is evident from **Map 5.5**, foxes and cats are considered to be distributed throughout the state while the other five major pests also have wide distributions across NSW, with some limited potential for further expansion.

One of the greatest threats to biodiversity is predation by foxes and cats. These animals are thought to be responsible for the decline of many small- to medium-sized native animals as well as most of the extinctions that have occurred in mainland NSW.

Map 5.5: Occurrence of foxes and feral cats in NSW in 2009 as reported in surveys of land managers



Introduced herbivores, particularly rabbits, feral goats and feral pigs, have an impact on environmental values through land degradation, competition with native species for food and increasing grazing pressure. Agricultural systems also feel their impacts.

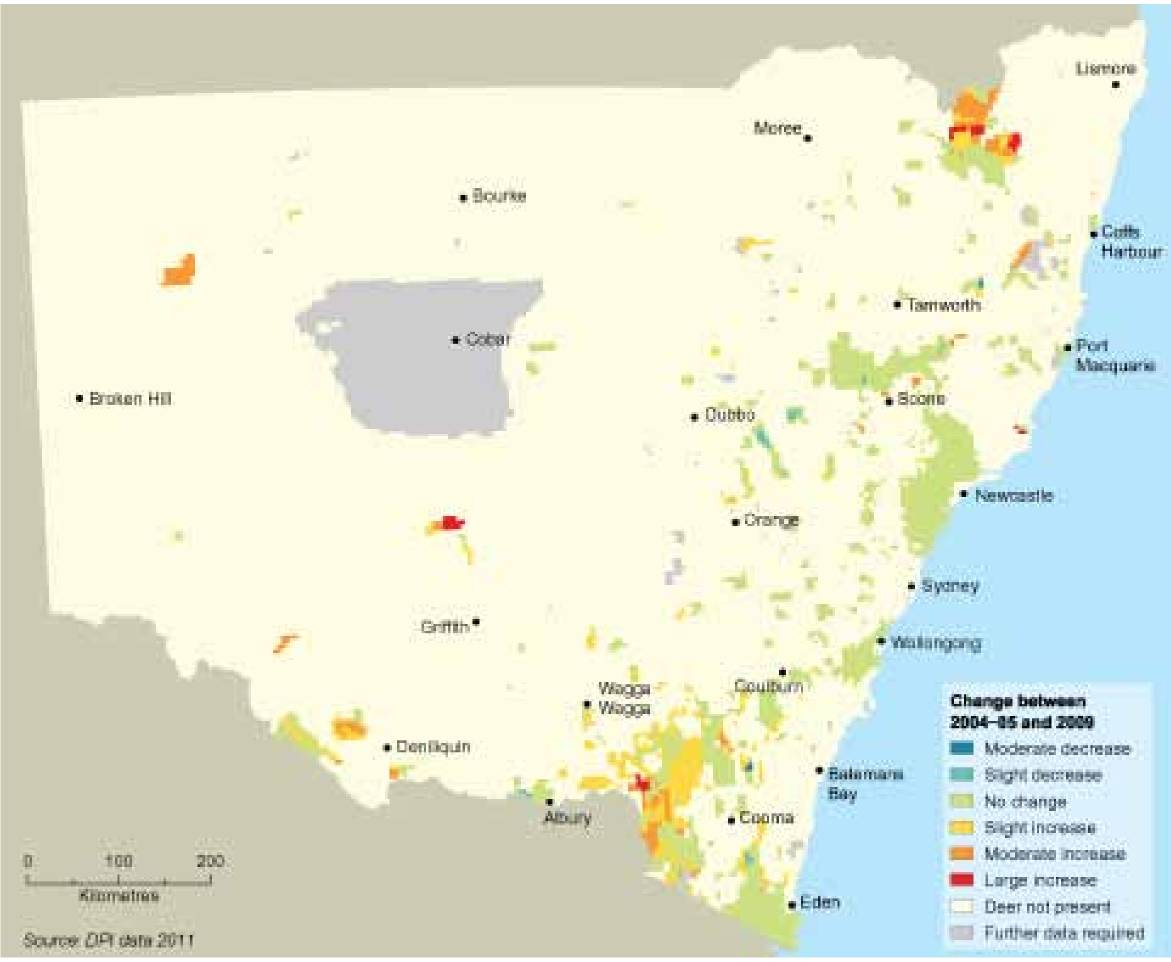
New and emerging species

New species are recent arrivals or species with a limited distribution that have not yet established self-sustaining populations. Emerging species are those that have become established and spread but have not yet reached their natural limits of distribution. Some emerging species are already having severe impacts on biodiversity or the environment, including deer and cane toads which are listed as key threatening processes under the *Threatened Species Conservation Act 1995*.

Monitoring and management of new and emerging species are generally more intensive than that for widespread species as the prospects for achieving control through eradication or containment are better, giving a greater return on the resources expended.

Deer are the main group of pest species that are expanding their range. **Map 5.6** shows the distribution of deer species between surveys in 2004–05 and 2009. Deer expanded their range from about 5% of NSW in 2002–03 (41,000 square kilometres) to about 6% in 2004–05 and then to about 8% of the state (64,000 km^2) at the time of the 2009 survey. Their spread is continuing. While also found on the coastal slopes and plains, deer appear to be moving into forested areas that have remained relatively free of other pest species. The highly scattered nature of their distribution is unusual, as is that it involves more than one species.

Map 5.6: Change in reported distribution of deer in NSW from 2004–05 to 2009



Cane toads are also an emerging species of concern. While sporadic sightings of individual toads have been confirmed at various locations along the NSW coast, they have only established viable populations on the far north coast and an isolated population at Taren Point in southern Sydney. A small population established at Port Macquarie but now appears to have been eradicated.

Distribution of environmental weeds in NSW

Environmental weeds may be either exotic species or translocated native species, but those with the greatest environmental impact are predominantly introduced from overseas. Weeds threaten biodiversity both directly by competing with native species and indirectly through their impacts on ecosystem structure and function.

Under the *Australian Weeds Strategy* (NRMMC 2006), 20 plants were identified as weeds of national significance because of their invasiveness, potential for spread, and economic and environmental impacts. Those widespread within NSW include alligator weed, bitou bush, blackberry, bridal creeper, Chilean needle grass, lantana, salvinia, serrated tussock and some species of willow. Several others have a restricted distribution, including Athel pine, boneseed, cabomba, hymenachne, mesquite and parkinsonia. Parthenium weed has also made occasional incursions into NSW from Queensland but on each occasion has been eradicated.

Additional weeds of national significance were announced in 2012. Species found in NSW include African boxthorn, asparagus weeds (six species in addition to bridal creeper), brooms (three species), cat's claw creeper, fireweed, Madeira vine, Opuntoid cacti (several species), Sagittaria, silver leaf nightshade and water hyacinth.

Over 1650 species of weeds have become established in NSW and more than 340 have significant impacts on biodiversity (DPI & OEH 2011). **Table 5.13** lists the top 20 weeds based on their potential impact on NSW biodiversity (Downey et. al. 2010).

Table 5.13: The 20 weed species posing the greatest threat to biodiversity in NSW

Common name	Scientific name	Common name	Scientific name
Madeira vine	*Anredera cordifolia*	Cat's claw creeper	*Macfadyena unguis-cati*
Lantana	*Lantana camara*	Salvinia	*Salvinia molesta*
Bitou bush	*Chrysanthemoides monilifera* subsp. *rotundata*	Gorse	*Ulex europaeus*
Ground asparagus	*Asparagus aethiopicus*	Boneseed	*Chrysanthemoides monilifera* subsp. *monilifera*
Blackberry	*Rubus fruticosus agg.*	Serrated tussock	*Nassella trichotoma*
Scotch broom	*Cytisus scoparius*	Cape ivy	*Delairea odorata*
Japanese honeysuckle	*Lonicera japonica*	Blue morning glory	*Ipomoea indica*
Large-leaved privet	*Ligustrum lucidum*	Balloon vine	*Cardiospermum grandiflorum*
Small-leaved privet	*Ligustrum sinense*	Lippia	*Phyla canescens*
Alligator weed	*Alternanthera philoxeroides*	Bridal creeper	*Asparagus asparagoides*

Source: Downey et al. 2010

Widespread species

There are too many widespread weeds in NSW to map their distribution and abundance. A broad pattern of distribution is available by looking at the total number of weeds and the number identified as having an impact on threatened species, aggregated by catchment management authority (CMA) region (**Table 5.14**).

The widespread weeds with the greatest impact on NSW biodiversity and the biodiversity values most at risk have been determined and documented in *Biodiversity Priorities for Widespread Weeds* (DPI & OEH 2011). Priorities for each CMA region are listed in individual reports.

All parts of NSW are affected by weeds that threaten biodiversity. Weeds now make up 21% of the state's total flora. The numbers of weed species are highest near the coast, particularly around major towns and cities, and in regions with high rainfall, and tend to decline from east to west (Coutts-Smith & Downey 2006).

New and emerging species

Map 7.7 of *SoE 2009* (DECCW 2009a) showed the spatial distribution of new and emerging invasive weed species, based on their listing as noxious weeds Classes 1, 2, 3 or 5. The map displayed patterns of spread similar to those described for widespread species above.

The listing of noxious weeds is a means of preventing their further spread and these listings correspond well with the categories of new and emerging weeds. Noxious weeds have the potential to cause significant environmental or economic impacts, but can still be controlled through reasonable means. Most importantly, they are likely to spread further within an area or to other areas. Most listings apply regionally to local government areas, although some apply to the whole state.

Table 5.15 describes the five classes of noxious weed listed in NSW and the number of species currently listed in each class.

Table 5.14: Number of weeds in each CMA region in NSW

CMA region	Number of weed species present	Total number of flora species	Contribution of weeds to total flora (%)	Number of weed species with an impact on threatened species
Sydney Metropolitan	758	2,356	32	101
Hawkesbury–Nepean	733	3,012	24	98
Northern Rivers	627	3,282	19	100
Hunter/Central Rivers	580	2,893	20	96
Southern Rivers	577	2,907	20	98
Murrumbidgee	531	2,159	25	67
Central West	502	2,197	23	59
Namoi	475	1,917	25	72
Lachlan	447	1,781	25	54
Murray	439	1,641	27	55
Border Rivers–Gwydir	427	2,029	21	63
Western	242	1,463	17	29
Lower Murray–Darling	187	896	21	25
NSW total	**1,386**	**6,634**	**21**	**127**

Source: Coutts-Smith & Downey 2006

When a weed becomes so widespread that eradication or containment is no longer feasible, its declaration as a noxious weed may be repealed on the basis that it no longer meets the criteria for listing. Some widespread weeds are not listed in regions where they are abundant, but may be listed in neighbouring areas where their distribution is limited, they can still be controlled, and there is the potential for further spread.

Table 5.16 summarises outbreaks of new and newly emerging weed species that have occurred in NSW from 2008 to 2012. Predominantly, these are weeds that are listed as noxious weeds Class 1 or 2, but several are yet to be considered for listing. Eradication of these weeds to prevent their establishment and further spread has the highest priority in regional weed control strategies.

Table 5.15: Numbers and classes of noxious weeds listed in NSW

Control class	Definition	Objectives of management	Number listed 2008	Number listed at 30 Sept 2011
Class 1: State prohibited weeds	Plants that pose a potentially serious threat to primary production or the environment, and are not currently in the state, or are present only to a limited extent	Prevent introduction and establishment	27	30
Class 2: Regionally prohibited weeds	Plants that pose a potentially serious threat to primary production or the environment of a region, and are not currently in the region, or are present only to a limited extent	Prevent introduction and establishment	11	13
Class 3: Regionally controlled weeds	Plants that pose a serious threat to primary production or the environment of an area, are not widely distributed in the area and are likely to spread in the area or to another area	Reduce extent and impact	43	44
Class 4: Locally controlled weeds	Plants that pose a threat to primary production, the environment or human health, are widely distributed in an area and are likely to spread in the area or to another area	Minimise negative impact on community, economy or environment	96	95
Class 5: Restricted plants	Plants that are likely, by their sale or the sale of their seeds or movement within the state or an area of the state, to spread in the state or outside the state	Prevent introduction into NSW, spread within NSW or spread from NSW to another jurisdiction	36	28

Source: DPI data 2011

Notes: Apart from Class 1 which is statewide, weeds are counted in a class if they are listed in that class in any region or local area in the state. Some species will appear in more than one class as they may be listed under different classes in different regions. The numbers given reflect the minimum value as sometimes an entire genus containing a number of unspecified species is listed.

Orange hawkweed (*Hieracium aurantiacum*) is an example of a weed in the early stages of establishment. It is one of 28 weeds on the National Environmental Alert List for environmental weeds because it is a major weed overseas and is considered to be a serious threat to biodiversity in south-eastern Australia. It also has the potential to cause serious losses to the grazing industry, which in 2002 were predicted to be around $48 million per year.

In NSW, orange hawkweed is currently only recorded in Kosciuszko National Park, where it was first detected in 2003. During 2010–11, the weed was discovered at 63 new locations in the park, bringing the total area detected since 2003 to 7.43 hectares. All known infestations have been managed, but ongoing surveillance is required to monitor known locations and search for new populations across a large remote and rugged area.

Table 5.16: Outbreaks of new and newly emerging weeds in NSW, 2008–09 to 2011–12

Weed	Noxious weed class	Number of new infestations	Number of repeat infestations
Aleman grass	2	11	0
Alligator weed	2	39	4
Asparagus falcatus	Not listed	2	0
Boneseed	2	12	0
Cape broom	2	1	0
Cecropia peltata	Not listed	1	0
Chinese violet	1	8	2
Gorse	2	2	0
Heteranthera	1	12	0
Horsetail	1	2	0
Hygrophila	2	1	0
Hymenachne	1	11	0
Mahonia (Berberis) lomariifolia	Not listed	3	0
Mesquite	2	5	12
Mexican feather grass	1	1	0
Miconia	1	21	0
Mimosa	1	0	2
Orange hawkweed	1	4	3
Orbea variegata	Not listed	1	0
Parkinsonia	2	7	2
Parthenium weed	1	15	6
Salvinia	2	4	0
Senegal tea plant	1	2	0
Tropical soda apple	2	42	0
Water hyacinth	2	12	1
Water lettuce	1	25	0

Source: DPI and OEH data 2012

Introduced aquatic species

Data on introduced freshwater fish species was collected from 669 sampling sites in NSW rivers in the three years up to the end of 2011. Across NSW, only 31% of the sites sampled – mostly coastal rivers – were free of introduced fish while 6.7% of sites contained only introduced fish. Averaged across all sites, 33% of the fish species at each site were introduced taxa, making up 34% of total fish abundance and 45% of total fish biomass.

The inland rivers of the Murray–Darling Basin were most heavily affected, with introduced fish present at 90% of all sites sampled. Introduced species made up 40% of all fish species, representing 44% of total fish abundance and 68% of total fish biomass.

Coastal rivers were less affected by exotic fish species. Introduced fish were present at 39% of sites, making up 10% or less of species collected, total fish abundance and total fish biomass.

Table 5.17 provides information on the abundance of individual introduced fish species. Since 2009, the pearl cichlid (*Geophagus brasiliensis*), a fish species native to Central America, is the only newly established species with a population detected in the Tweed catchment.

It is estimated that over 400 exotic species have been introduced into Australia's marine environment, but most of these are not considered pests. Relatively few of the exotic marine species found in NSW, including several species of toxic dinoflagellates and several species of invertebrates, are considered to be a serious threat to biodiversity.

The European shore crab (*Carcinus maenas*) has been recorded in 22 estuaries and coastal lakes from Burrill Lake south to Nadgee Lake (DPI 2008b). Its distribution has not changed greatly since the last SoE report or indeed since the 1980s, despite many more estuaries and lakes being searched in recent years. Monitoring is in place to detect any future changes in its distribution. As yet, there is no evidence that the European shore crab causes severe environmental impacts, but some oyster farmers consider it a nuisance as it can eat juvenile oysters.

Table 5.17: Introduced fish at sampling sites

Fish species	% of sites where present: 2008	% of sites where present: 2011
European carp	56.5	38.8
Gambusia	47.9	41
Goldfish	33.7	29.2
Rainbow trout	10.8	5.2
Redfin perch	9.4	7.5
Brown trout	8.3	4.9
Eel-tailed catfish (translocated native species)	3.3	2.4
Oriental weatherloach	1.5	0.4
Climbing galaxias (translocated native species)	0.3	0.1
Platy	0.2	0.0
Silver perch (translocated native species)	*	0.3
Macquarie perch (translocated native species)	*	0.3
Swordtail	*	0.1
Pearl cichlid		0.1
Golden perch (translocated native species)	*	0.1
Murray cod (translocated native species)	*	0.1
Trout cod (translocated native species)	*	0.1
Rainbow fish (translocated native species)	*	0.1

Source: DPI data 2012
Notes: * Species present in very low numbers.

The marine weed caulerpa (*Caulerpa taxifolia*) is possibly the most significant threat to the marine environment of NSW as it spreads easily from small fragments and can quickly colonise large areas of subtidal soft sediment, including seagrass beds. Introduced initially as an aquarium plant, caulerpa's impact is mainly on soft-sediment invertebrates and sediment chemistry with no direct impacts on seagrasses, although investigatory work is ongoing.

Caulerpa was first recorded in NSW coastal waters in April 2000. It initially spread to 14 estuaries and coastal lakes, ranging from Lake Macquarie to Wallagoot Lake. After considerable control work, caulerpa has not been found in Lake Macquarie since 2006 or in Wallagoot Lake and St Georges Basin since 2009. It was not detected in underwater surveys in Narawallee Inlet and Durras Lake in late 2011, nor in Burrill Lake or Lake Conjola in surveys during 2012. It is believed that increased salinity due to drought conditions and closed entrances has caused the decline in caulerpa in some lakes, whereas greatly reduced salinity due to more recent flooding killed much (or possibly all) of the caulerpa in Burrill Lake and Lake Conjola.

The European fanworm and New Zealand screw shell are both still restricted to Twofold Bay on the NSW far south coast (DPI 2008b).

Pathogens and diseases

Pathogens and diseases are an emerging threat to biodiversity and are becoming more prevalent, both internationally and in Australia. The impacts of exotic and translocated native microorganisms on biodiversity are still poorly understood. However, four diseases are listed as key threatening processes (KTPs) under the *Threatened Species Conservation Act 1995* (TSC Act), with all four having potentially serious consequences for the health of the environment. The KTPs are:

- infection by psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations
- infection of native plants by *Phytophthora cinnamomi*
- infection of frogs by the amphibian chytrid fungus causing the disease chytridiomycosis
- introduction and establishment of exotic rust fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae.

Psittacine beak and feather disease appears to have been present naturally in the environment and affects a number of species of parrots. Phytophthora root rot fungus is thought to have been introduced with European settlement. It is a soil-borne fungus that infects, and causes dieback in, a large range of mainly woody perennial plant species and some crops, particularly in higher rainfall areas.

The remaining diseases appear to have been introduced relatively recently. Chytrid fungus causes skin infections and death in native amphibians and is responsible for rapid declines in the populations of many native frog species.

Myrtle rust (*Uredo rangelii*) is a fungus which is a serious plant pathogen infecting species of the Myrtaceae family. This family includes many Australian native species such as eucalypts, paperbarks, teatrees and a range of understorey shrubs. Myrtle rust was first detected in April 2010 on the central coast of NSW and despite containment efforts it has now spread widely in NSW, Queensland and Victoria. There is serious concern about the threat it poses to the survival of many native plants in bushland areas, particularly those which are either highly susceptible to the fungus or are naturally rare or threatened (OEH 2011b).

Environmental impacts of invasive species

Impacts on threatened species

Collectively, weeds and pest animals have been identified as a threat to approximately 70% of the threatened species listed under the TSC Act and *Fisheries Management Act 1994* (FM Act). Invasion by exotic species has an impact on the second highest number of threatened species, after land clearing (Coutts-Smith & Downey 2006).

Individual widespread animal pests such as feral cats and foxes have a far greater impact than individual weeds. However, the number of weeds is much greater and their combined impact is broader than the impact of pest animals. Weeds have a negative impact on 45% of threatened species, populations and ecological communities in NSW, while pest animals threaten 40% (Coutts-Smith & Downey 2006; Coutts-Smith et al. 2007).

Listings of invasive species as key threatening processes

The magnitude of the impacts of pest and weed species is reflected in the listing of many invasive species as KTPs in both state and federal legislation. Twenty-three of the 45 KTPs listed in NSW under the TSC Act or FM Act relate to the impacts of weeds and pest animal species and a further four to pathogens. Pest animals listed as KTPs include foxes, feral cats, rabbits, feral pigs, feral goats, black rats, deer, cane toads, gambusia and four invertebrates (feral honey bees, fire ants, yellow crazy ants and large earth bumblebees). Weed species listed as KTPs include lantana, bitou bush, Scotch broom and African olive, while vines and scramblers are listed collectively, as are exotic perennial grasses.

Broader environmental impacts

It is difficult to quantify the total impact of introduced species on biodiversity and the environment as a whole. Most of the information available is specifically about impacts on threatened species, not on all native flora and fauna (Coutts-Smith & Downey 2006) and generally only describes the extent of these impacts, not their intensity or magnitude.

The broader impacts of invasive species on the environment and ecosystem health are substantial, but largely unassessed. These broader impacts include soil degradation, landscape and habitat disturbance, structural change and decline in vegetation condition, and changes to watercourses and water quality.

Pressures

Invasive species are not present in naturally functioning ecosystems and are recognised as a threat to them. Therefore the discussion of pressures in this section relates specifically to risk factors that exacerbate the impacts of invasive species or that facilitate their spread.

Habitat disturbance

Systems that are suffering from disturbance are at the greatest risk of incursion by invasive species as the balance in the dynamic processes that maintain natural systems in equilibrium has been upset. The disturbance may be physical or caused by an imbalance in the natural biota (Lake & Leishman 2004; DPI 2008a). Invasive species are generally less affected by the constraints and balances that operate in natural systems, so they can rapidly exploit suitable habitat where natural systems are disturbed or under stress and tend to have a lower impact on healthy ecosystems.

Greater mobility and trade

Greater mobility and the globalisation of international trade are significantly increasing the movement of people and goods across Australia's borders. The risk of accidental introductions, particularly of diseases, insects and other invertebrate pests, has therefore increased.

The nursery trade is responsible for introducing many new plant species into Australia with a significant number escaping from gardens to become weeds (Groves & Hosking 1998). Sixty-five per cent of the weed species that pose a risk to threatened species in NSW were introduced as ornamental plants (Coutts-Smith & Downey 2006) and some are still available for sale in NSW. The nursery trade may also have played a role in introducing new diseases, such as myrtle rust, as most early detections of this disease were found in nurseries.

The aquarium industry is also responsible for introducing a number of fish and aquatic plant species that have been released into the wild and flourished. Illegal international trade in a variety of exotic species is a further pathway for unplanned introductions. The ballast water of cargo ships and hull biofouling are well-known pathways for the incursion and spread of pests into the marine environment.

Expansions of range

Many invasive species are yet to reach the limits of their potential distribution. For example, weed species, such as orange hawkweed, boneseed, olive, cabomba and some exotic vines, occupy only a small part of their potential range. Even some widespread species, such as lantana, bitou bush, blackberry and Coolatai grass, have the potential to spread further. Emerging pest animal species, such as deer and cane toads, are also continuing to spread.

A national program is under way to eradicate red fire ants before they spread into NSW.

Climate change

Limited information is available on how climate change might affect invasive species, but it is likely that the impact of invasive species will increase (DPI 2008a). Invasive species are generally well-adapted as colonisers of disturbed ecosystems and are likely to cope better than native species with expected changes in environmental conditions, such as increased temperatures and changes in rainfall and fire regimes. Expansions and contractions in the range of both native and invasive species due to climate change are likely to differentially favour invasive species.

Lack of information

Information on the distribution and abundance of invasive species is patchy and largely subjective. A management framework has been established through the *NSW Invasive Species Plan 2008–2105* (DPI 2008a) and a monitoring program has been set up following the mid-term review of the Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015 (DECCW 2010d) to provide high level information. A pest and weed information system has been established for NSW parks, but there are few standardised procedures and databases for collecting and maintaining consistent information on invasive species statewide.

As most of the information available concerns threatened species, further work is needed to estimate the impacts of invasive species on the environment as a whole. This information would assist in identifying priorities for control, and managing both the impacts of invasive species on biodiversity and the adaptation of invasive species to the effects of climate change.

Responses

Established responses

NSW 2021

NSW 2021: A plan to make NSW number one (NSW Government 2011) is the Government's 10-year plan for NSW. Under Goal 22 – 'Protect our natural environment', the plan contains the following target: 'Manage weeds and pests'. One of the strategies for achieving this target is to 'Reduce the impact of invasive species at priority sites on National Parks and Wildlife Service (NPWS) parks and reserves, leading to a positive response of native biodiversity at 50% of these sites by October 2015'.

The priority actions associated with this target are to:

- '… use the knowledge and experience of local communities to target our resources to protect and restore natural ecosystems'
- 'address core pest control in national parks through the delivery of NPWS regional pest management strategies …'

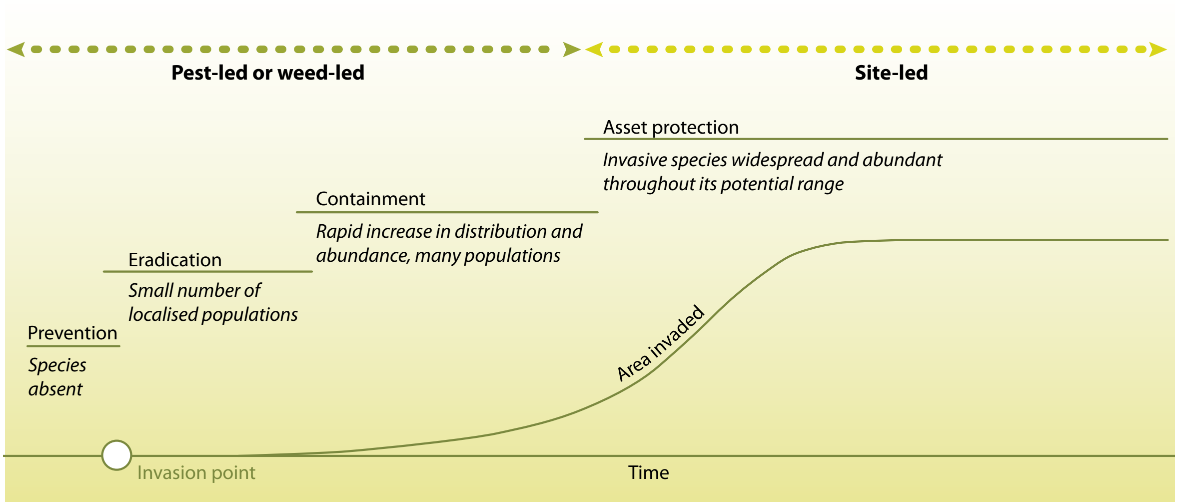
Legislation

The most important legislation relating to invasive species management is the *Noxious Weeds Act 1993*, *Rural Lands Protection Act 1998*, TSC Act, FM Act, *Game and Feral Animal Control Act 2002* and *Quarantine Act 1908* (Cwlth).

Invasive Species Plan

The response of the NSW Government to invasive species impacts is set out in the *NSW Invasive Species Plan 2008–2015* (DPI 2008a). The plan describes the control strategies that are most effective at different stages in the cycle of incursion and establishment of invasive species (**Figure 5.7**).

Figure 5.7: Strategies for managing new, emerging and widespread pests and weeds in NSW



Source: DPI 2009a

The four main strategies for managing invasive species in NSW (shown in Figure 5.7) are:

- **prevention** – precautionary measures which prevent the arrival of any new species that is likely to become invasive and have a significant impact on native species and ecosystems or agricultural production
- **eradication** – the detection and permanent removal of any newly arrived invasive species that is likely to have a significant impact on native species and ecosystems before it can establish self-sustaining populations
- **containment** – restricting the spread of recently established or emerging invasive species which cannot realistically be eradicated
- **asset protection** – targeting control at the most severe impacts of widespread invasive species in areas of high conservation value and where the prospects for successful control are greatest.

Programs that aim to prevent, eradicate or contain weeds or pests during the earlier stages of incursion are considered to be 'weed-led' or 'pest-led'. The focus of such programs is on individual weed or pest species and priorities are determined by the characteristics of each species and its potential impacts (Figure 5.7).

When invasive species are well established, programs for their control are considered to be 'site-led'. Rather than managing a specific weed or pest affecting the site, the focus is on protecting the native species or ecosystems (assets) that are most affected by the invasive species. Strategies target sites where the benefits of protection or control will be greatest.

Management of new invasive species: prevention and eradication

The most cost-effective means of managing invasive species are to:

- prevent their incursion, or
- if they occur, to rapidly detect and eradicate them.

Eradication is seldom feasible once an invasive species becomes established.

Preventing incursions is the primary focus of the Australian Biosecurity System for Primary Production and the Environment. This whole-of-government initiative brings together biosecurity activities undertaken by federal, state and territory governments, together with industry, landholders and key stakeholders in the fields of primary production and the environment within a national framework.

The *NSW New Weed Incursion Plan 2009–2015* (DPI 2009b) was developed to address the prevention and eradication objectives of the *NSW Invasive Species Plan 2008–2015* (DPI 2008a) for weeds. The incursion plan:

- coordinates surveillance in NSW
- identifies new weeds and weed incursions
- provides for risk assessments of species
- facilitates the implementation of effective barriers to prevent the establishment of weeds
- specifies ways in which responses to weed incursions are coordinated, implemented, monitored and reported.

Few management programs target invertebrates (including insects), apart from those which deal with regular outbreaks of plague locusts. However, one of the most successful programs has been the apparent eradication of an incursion of yellow crazy ants detected in 2004 at Goodwood Island, near the mouth of the Clarence River. Following a collaborative campaign of regular treatment and surveillance of the infested area during 2004 and 2005, no yellow crazy ants have been observed on the island since 2005.

Management of emerging invasive species: containment

Containment is the main focus of strategies for managing emerging invasive species. Once an invasive species becomes established and starts to expand in range, the main objective shifts from eradication to limiting its spread (see Figure 5.7). Containment zones have been established for several weeds of national significance including bitou bush on the south and far north coasts of NSW and lantana on the south coast. The objective is to completely eradicate the weeds from these zones.

As discussed earlier in this section, the listing of noxious weeds in the schedules of the *Noxious Weeds Act 1993* aims to prevent the establishment of significant new weeds and restrict the spread or limit the impact of existing significant weeds (see 'Distribution of environmental weeds in NSW').

Management of widespread invasive species: asset protection

Many invasive species are already widely established in NSW and these have the greatest impact of all invasive species on the environment. It is usually impossible to eradicate an invasive species that has become widespread or to achieve lasting control, regardless of the resources deployed. The rare exception is where a suitable biological control is identified and remains effective as is the case for prickly pear and water hyacinth, and was for rabbits for a time.

The control of widespread species must therefore be strategically targeted to reduce their impact on native species and populations, regional ecosystems and ecological communities. This targeting requires prioritising the natural values most at risk and identifying the sites where these values are greatest and controls are expected to be most effective, based on the likelihood of recovery or maintenance of biodiversity.

Biodiversity Priorities for Widespread Weeds (DPI & OEH 2011) and 13 regional documents produced by the CMAs have been developed to guide regional decision-making in:

- identifying weed priorities, asset importance and high value sites
- developing programs to control widespread weeds and manage assets and natural values.

Threat abatement plans (TAPs) have been developed to manage a number of invasive species identified as key threatening processes, including foxes (OEH 2011c), *Gambusia holbrooki* (NPWS 2003) and bitou bush (DEC 2006). All TAPs incorporate a monitoring program to measure their effectiveness and the response of the main threatened species affected.

As over 300 weed species are considered to have an impact on biodiversity, it is not practical to develop single-species TAPs for every weed species. Therefore, regional weed strategies which have a focus on protecting native species and ecosystems (DPI & OEH 2011) have been developed to apply to all widespread weeds.

Strategic priorities for weed management

Due to the number of invasive weed species that have become established in NSW, most CMAs have developed regional weed strategies, based on a strategic framework (DPI & OEH 2011) and a commonly accepted process for managing weeds (Randall 2000). These strategies take account of the weeds' impact, invasiveness, distribution and rate of spread. Highest priority is generally given to weeds that have a limited distribution and the lowest to those that are already widespread.

Controls for most pest animals and invertebrates are usually conducted individually, depending on the characteristics of the invasive species, even where the focus of the program is on protecting natural values.

Pest management strategies in national parks

Management of invasive species across NSW national parks and reserves is conducted in accordance with a statewide management framework (OEH 2011d) and 14 Regional Pest Management Strategies. These are consistent with the principles set out in the *NSW Invasive Species Plan 2008–2015* (DPI 2008a). The state strategy sets the high level goals, objectives and the prioritisation methods under which regional pest and weed programs operate.

Management of aquatic pests

The FM Act lists noxious fish species and marine weeds. The species listed pose a significant threat to wildlife, ecosystems, human health or the aquaculture industry. The list is divided into three classes representing the level of threat the species poses to the aquatic environment. Most noxious fish are listed in Class 1 which prohibits their live possession and sale and applies to 108 species, 25 genera, one subfamily and one family. There is also one Class 1 noxious species of marine vegetation: caulerpa. Fisheries officers have the power to seize and destroy any live fish or plants listed as a Class 1 or 2 noxious species.

Future opportunities

With the growth in global travel and trade, new and potentially invasive species will continue to be introduced into NSW, either deliberately or accidentally. Improvements to surveillance and biosecurity measures may be needed to prevent new incursions from threatening natural ecosystems and the productivity of farming systems.

Biological controls will continue to provide the best opportunities for effective and affordable management of widespread invasive species and further opportunities should continue to be explored.

Pathogens and diseases are emerging as an increasing threat to natural systems and are likely to present new challenges for effective management and control.

5.5 Fire

Fire is a significant and ongoing threat to human settlement. While fire plays an important role in the health of natural ecosystems, it is also a threat to ecosystem integrity. An improved understanding of the role of fire in natural systems is increasingly being factored into fire management.

Fire is a natural part of the Australian landscape. Altered fire regimes since European settlement – too much or too little fire, or fire of too high or too low an intensity – can have major detrimental effects on the structure of most ecosystems and many threatened species.

The key to achieving appropriate fire management is achieving the right balance between maintaining natural ecosystems and ensuring community safety and the protection of property, infrastructure and livestock.

One of the principal tools for fire management is hazard reduction burning. The level of hazard reduction activity in New South Wales has increased over the past three years to cover an average of about 138,000 hectares per year.

More than 50% of all bushfires are started by humans in most years, with arson being the major cause of such fires.

NSW indicators

Indicator and status	Trend	Information availability
Average area of bushfires in the NSW reserve system	Unknown	✓
Ratio – area of bushfires to area of management burns in the NSW reserve system	Unknown	✓

Notes: These indicators only apply to areas managed by the NSW National Parks and Wildlife Service (NPWS).
Terms and symbols used above are defined in *About SoE 2012* at the front of the report.

Introduction

Fire has been present on the Australian continent for millions of years and is a key factor in plant and animal population dynamics in most NSW ecological communities. Many Australian animals and plants have evolved not only to survive but also to benefit from the effects of fire. Much of the flora of NSW depends on fire to assist in reproduction and growth.

In Australia, fire has been managed since humans first settled on the continent. Although the fire regimes practised by Aboriginal people before the arrival of Europeans are not fully understood by the scientific community, the pattern of fire in the landscape has changed over the past 200 years (Williams et al. 2001). The introduction of property ownership by private individuals and corporations and the need to protect dwellings, infrastructure, such as fences and sheds, and livestock have altered fire regimes and resulted in ecological impacts across a variety of landscapes.

Status and trends

Incidence of fire

The effects of bushfires in NSW are generally described in terms of their extent, social impacts and costs. Bushfires can be extremely destructive and may result in substantial social costs, including the loss of human lives, buildings, infrastructure and livestock. In extreme cases, such as the Canberra bushfires of 2003 and the Victorian bushfires of 2009, they are natural disasters that have claimed many human lives, destroyed valuable property and infrastructure, and severely disrupted essential services.

The incidence of fire varies greatly each year (**Table 5.18**) with the number of fires closely linked to prevailing weather patterns. Total fire bans may be declared by the Minister for Emergency Services in any part of NSW, generally when hot, dry and windy conditions are predicted to occur in areas where vegetation is dry and fire could easily spread. The number of statewide total fire bans declared each year is indicative of the extent of forecast fire-weather conditions across NSW and hence the severity of the fire season.

The main factors determining the severity and extent of a bushfire are:

- weather conditions, including wind speed, temperature and relative humidity
- the dryness of the fuel, the type of fuel and the fuel load
- the physical structure of vegetation and the terrain in which the fire is burning
- the effectiveness of fire suppression actions.

Table 5.18 shows the number of fires and the severity and length of the fire seasons over the past nine years.

Table 5.18: Data on NSW bushfires, 2002–03 to 2010–11

Fire season	No. of bushfires*	No. of grass fires	Statewide total fire bans (days)	No. of s.44 declarations in a fire season**	Days between first and last s.44 declaration in a fire season**	Lives lost as a direct result of fire
2002–03	5,642	n/a	13	61	151	3
2003–04	1,764	n/a	0	10	31	0
2004–05	2,659	n/a	1	20	16	0
2005–06	2,865	n/a	5	38	150	2
2006–07	3,361	n/a	0	36	151	2
2007–08	2,271	2,157	0	7	75	0
2008–09	2, 522	2,689	0	10	60	1
2009–10	3,446	2,549	0	50	160	1
2010–11	1,897	2,316	0	0	0	2

Source: NSW Rural Fire Service (RFS) data 2011

Notes: * Derived by adding the number of fires from the four RFS regions. Any fire that occurred across the boundary of two regions has been counted twice.

** Section 44 declarations apply to fires where the RFS Commissioner controls operations.

Fire ecology

The impacts of bushfires are commonly described in terms of areas burnt and lives and assets lost, but this description provides little information on their ecological effects. These depend on:

- the intensity of a fire
- the season of the burn
- the previous fire history of an area
- the sensitivity of ecosystems affected.

Understanding the ecological outcomes of fire is further impeded by a poor knowledge of the responses of vegetation and wildlife to fire. Ecological communities are dynamic systems and fire is a natural disturbance that creates change. Fires shape the structure, composition and ecological function – including soil and nutrient cycles – of most plant communities, creating specific habitats required by a range of species. Differing patterns of fire history will favour some species and associations, and suppress others.

However when fires occur too frequently, even fire-tolerant species may become locally extinct due to their life cycles being interrupted. For example, a second fire in too short a time frame could kill all young plants and seedlings before they reach reproductive age, leading to the extinction of local populations of species. Conversely, the lack of fire may mean that fire-dependent species cannot regenerate, such as those that need fire for seed germination. Broad changes in fire patterns may result in habitat transformations, such as changes in the structure of vegetation, shifts from one vegetation type to another and reduced habitat resilience to invasive species.

Altered fire regimes have been described as a threat to over 80% of the state's vegetation classes (see Biodiversity 5.2). High-frequency fire has been identified as a significant cause of biodiversity loss in NSW and is listed as a key threatening process under the *Threatened Species Conservation Act 1995*.

The interval between fires is a critical factor in the capacity of individual species to survive and reproduce (Bradstock & Kenny 2003). Minimum fire intervals needed to maintain biodiversity have therefore been developed. These allow sufficient time between fires for species to complete the crucial stages of their life cycles essential for regeneration, such as plants being able to reach an age where they can produce adequate seed. **Table 5.19** presents minimum fire intervals for a range of vegetation formations. Table 5.19 also shows the maximum fire intervals generally needed by various vegetation formations to allow them to regenerate before they become too old. The greatest biodiversity is maintained by varying the length of fire intervals between the maximum and minimum requirements as well as the location of fires (Kenny et al. 2003).

Refining knowledge about the frequency of burning and appropriate fire intervals for various vegetation formations in NSW is likely to remain the subject of scientific investigation for some time, due to the diverse array of species and communities and the time taken to determine the long-term effects of fire.

A key component of long-term monitoring of the effects of fire on ecological systems is matching fire history to vegetation formations. The NSW Rural Fire Service (RFS) is compiling fire history data across NSW, in conjunction with land management agencies. While there are still some limitations due to the nature of the historical data, it is now being collected on an annual, coordinated basis. The information on statewide vegetation is also being improved.

Fire management

Fire management strategies

The emphasis of fire management should be on reducing fire hazard and minimising risk (Ellis et al. 2004). The primary objective of fire management is to protect human life and property, with biodiversity conservation an important, but secondary, consideration. Asset protection zones provide for reduced fuel loads near houses and other built structures. The most common method of reducing fuel in these zones is through mechanical means, such as bulldozing.

The RFS develops regional bush fire risk management plans in consultation with the community. To achieve the objectives of these plans, some areas called 'strategic fire advantage zones' require fuel loads to be reduced more frequently than is specified by the minimum intervals for maintaining biodiversity (Table 5.19). Reduced minimum intervals have been developed for these areas that are absolute minimums for maintaining biodiversity as they provide little or no buffer for adequate seed production.

Biodiversity requirements can often be incorporated into fire management practices. However, compromises that result in suboptimal outcomes for biodiversity conservation may be required at times (DEC 2005), particularly in asset protection zones. Appropriate assessment is undertaken on a case-by-case basis in these circumstances.

Table 5.19: Fire intervals for NSW vegetation formations

Vegetation formation	Minimum interval between fires where managing biodiversity is the focus (years)	Minimum interval between fires where reducing risk to human life and property is the focus (years)*	Maximum fire interval (years)
Rainforests	No fire	No fire	No fire
Alpine complex	No fire	No fire	No fire
Estuarine and saline wetlands	No fire	No fire	No fire
Grasslands	3	2	10
Grassy woodlands	8	5	40
Dry sclerophyll forests (shrub/grass subformation)	8	5	50
Dry sclerophyll forests (shrubby subformation)	10	7	50
Semi-arid woodlands (shrub/grass subformation)	9	6	40
Semi-arid woodlands (shrubby subformation)	15	10	40
Arid shrublands (chenopod subformation)	No fire	No fire	No fire
Arid shrublands (acacia subformation)	15	10	40
Forested and freshwater wetlands (excluding montane bogs and fens, coastal freshwater lagoons and montane lakes which have no tolerance of fire)	10	7	35
Heathlands	10	7	30
Wet sclerophyll forests (grassy subformation)	15	10	60
Wet sclerophyll forests (shrubby subformation)	30	25	60

Source: Department of Environment and Conservation (DEC) data 2005

Notes: Vegetation formations are as described in Keith 2004.

* These intervals are absolute minimums for maintaining biodiversity as they provide little or no buffer for adequate seed production.

Hazard reduction

Hazard reduction burning to reduce fuel loads is a key control strategy practised widely across the state. This burning is complemented by mechanical works, such as bulldozing, to maintain setbacks around properties, firebreaks and fire trails. The annual levels of hazard reduction burning and the total areas of hazard reduction management are described in **Table 5.20**. Over the past three years (for which data is available), the level of hazard reduction burning has increased to an average of about 138,000 hectares per year, from the previous level of about 112,000 hectares per year.

Rapid response to outbreaks of fire

The early detection and rapid suppression of bushfires is a key control strategy for managing and preventing their spread. As access to fires that start in remote areas is often difficult, special remote area fire teams have been set up by the RFS and the NSW National Parks and Wildlife Service (NPWS) to enable a rapid response to fires that start in such areas.

Ecological burns

Although some managed burns meet both hazard reduction and ecological needs, there is limited information on fires conducted solely for ecological purposes, such as those that aim to ensure the maximum fire interval is not exceeded. However, the NSW Government is identifying areas where vegetation formations are underburnt or overburnt, based on both fire history records and the fire intervals identified in Table 5.19.

Effectiveness of fire management

To monitor the effectiveness of fire management through hazard reduction burning and rapid response in NSW national parks and reserves, NPWS is developing performance indicators for fire management. 'Average area of bushfires in the NSW reserve system' gives an indication of the effectiveness of rapid response techniques in preventing the spread of fires. 'Ratio – area of bushfires to area of management burns' provides an indication of the effectiveness of bushfire suppression through hazard reduction burning, improved detection and rapid response techniques.

Table 5.20: Area of hazard reduction management by tenure

		Land tenure					
Year	**Hazard reduction methods**	**Local council land**	**NSW national parks**	**Private land**	**State forest**	**Other**	**Total**
2005–06	Burning only	838	29,070	3,155	38,008	790	**71,861**
	All methods*	31,387	32,026	3,647	38,008	2,674	**107,742**
2006–07	Burning only	177	23,718	8,498	43,715	1,905	**78,013**
	All methods*	25,495	23,840	8,892	43,716	2,295	**104,238**
2007–08	Burning only	1,163	48,497	13,958	30,719	3,861	**98,198**
	All methods*	10,464	49,514	21,656	30,719	12,203	**124,556**
2008–09	Burning only	35	59,068	8,214	29,008	7,360	**103,685**
	All methods*	12,304	60,117	8,897	30,652	11,364	**123,334**
2009–10	Burning only	981	93,424	16,072	36,083	7,945	**154,505**
	All methods*	16,091	95,673	16,758	36,216	9,968	**174,706**
2010–11	Burning only	396	56,060	4,734	10,857	2,811	**74,858**
	All methods*	31,573	58,092	7,398	10,884	9,686	**117,633**

Source: RFS annual reports, such as RFS 2011

Notes: All values in hectares

* Includes burning and mechanical works, but not grazing of land.

Table 5.21 shows that results for both indicators are well below the 10-year average over the past four years, which may appear to demonstrate that the two strategies are being implemented successfully. However, climatic conditions over this period have not produced extended seasons of severe fire-weather and it is still far too early to assess the overall effectiveness of these strategies in controlling bushfires.

Pressures

Since fire is itself a pressure on the environment, this section discusses the risk factors that exacerbate the threat of fire.

Causes of fire

Data has consistently shown that the incidence of fire is markedly higher in the more densely populated areas along the NSW coast than in less densely populated areas elsewhere. There appears to be a strong relationship between the incidence of fire and population density. The proportion of fires caused by humans is higher in RFS data than the data compiled by NPWS as many national parks are located in less accessible areas.

RFS and NPWS data on the causes of fires indicates that most fires are due to human intervention rather than natural processes (**Table 5.22**). Such fires may be caused by arson, accidental ignition or escapes from prescribed burn-offs. Arson is the most common cause, responsible for over half of all fires. Investigations by the Australian Institute of Criminology into the causes of 466 fires using RFS data between 2001 and 2004 found that 64% were deliberately lit (AIC 2005a; AIC 2005b). However the number and proportion of deliberately lit fires has decreased over the past three years.

The main natural cause of fires is lightning strikes and the number and proportion of natural fires is highly variable from year to year. The proportion of naturally caused fires is higher in national parks and reserves, which are generally more remote from human settlement.

Table 5.21: Areas of hazard reduction and bushfire in NSW national parks

Period	Number of fires affecting parks	Area of bushfires	Average area burnt	Area of hazard reduction burns	Ratio – area of bushfires: area of hazard reduction
2001–02	356	593,388	1,667	31,703	18.7
2002–03	433	1,001,854	2,314	42,827	23.4
2003–04	263	38,120	145	65,451	0.6
2004–05	211	16,887	80	41,037	0.4
2005–06	202	26,695	132	27,400	1.0
2006–07	372	254,727	685	23,718	10.7
2007–08	160	43,726	273	48,514	0.9
2008–09	166	21,745	131	59,202	0.4
2009–10	327	121,941	373	93,117	1.3
2010–11	78	1,080	14	55,976	0.02
10-year total	2,568	2,120,163		488,945	
10-year average			826		4.3

Source: NPWS data 2012

Notes: All areas shown are in hectares.

Fire and climate change

Bushfires are associated with high fire-weather risk which is expected to increase as a result of climate change (Hennessy et al. 2006). Projections indicate an increase in fire-weather is likely across south-eastern Australia (Lucas et al. 2007). The frequency of days with 'extreme' ratings on the forest Fire Danger Index (FDI) is predicted to increase by 5–25% for low climate change scenarios by 2020 and by 15–65% for high climate change scenarios. By 2050, the increases are forecast to rise 10–50% for low climate change scenarios and 100–300% for high scenarios.

A more recent study (Clarke et al. 2011) has predicted that the forest FDI is likely to increase strongly in southern NSW by 2100, but remain stable in the north of the state, as shown in **Figure 5.8**. Royal National Park and the forested escarpment behind Wollongong, including the Woronora Plateau, are at particular risk of more frequent and intense fires (Climate Commission 2011).

'Fire danger' seasons are predicted to become longer and start earlier in the year, but it is less certain whether the number of days when it is safe to conduct hazard reduction burning will decrease, or whether the window of suitable days will shift to earlier and later in the year. More intense fires will pose higher risks to human health, property and infrastructure (Williams et al. 2009) and increased fire frequency is likely to have detrimental effects on biodiversity and long-term consequences for terrestrial ecosystems (Banks et al. 2011).

Table 5.22: Causes of investigated bushfires in NSW

Period	Deliberate (includes juveniles, smoking)	Accidental (includes equipment use, rail, powerlines)	Natural (includes miscellaneous)	Debris burning (includes campfires)*	Undetermined	Total
RFS data						
2001–04	298	68	51	36	13	**466**
2005–08	450	30	75	73	92	**720**
2008–09	142	12	30	22	28	**234**
2009–10	217	36	182	58	74	**567**
2010–11	193	19	18	45	48	**323**
NPWS data						
2001–02	148	11	93	54	50	**356**
2002–03	85	13	236	42	57	**433**
2003–04	124	13	71	41	14	**263**
2004–05	111	16	52	20	12	**211**
2005–06	81	7	45	27	42	**202**
2006–07	79	4	201	30	58	**372**
2007–08	45	4	39	17	55	**160**
2008–09	46	3	73	13	31	**166**
2009–10	58	2	175	18	74	**327**
2010–11	34	1	12	5	26	**78**

Sources: RFS data 2012; NPWS data 2012

Notes: * Redefined from 'burn-off' in previous cycles of reporting

Responses

Established responses

Legislation

Under the *Rural Fires Act 1997* (RF Act), the RFS is responsible for preventing, mitigating and suppressing bushfires in rural fire districts. All functions performed by the RFS must be consistent with the principles of biodiversity conservation and ecological integrity stipulated by the *Protection of the Environment Administration Act 1991*.

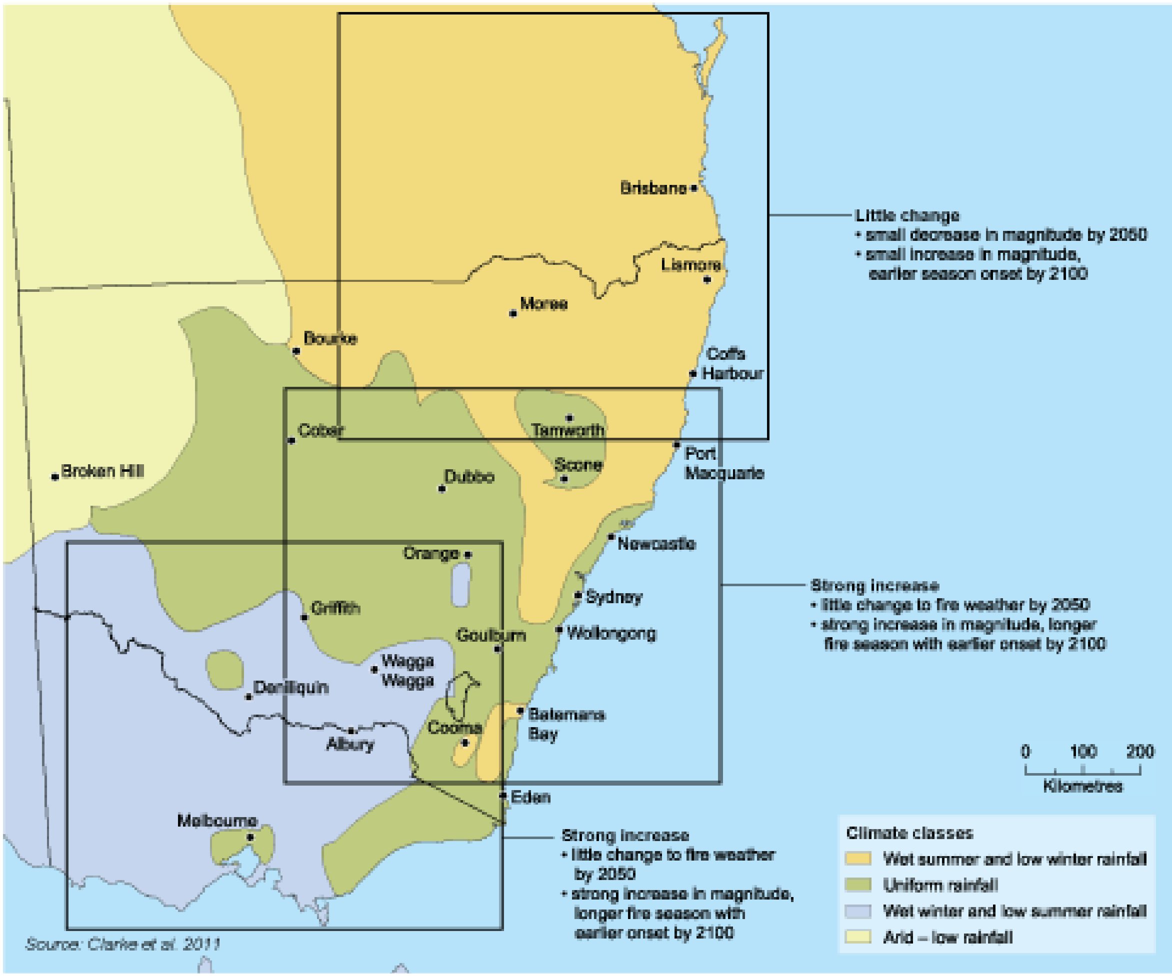
Coordination of fire management

The RF Act provides for the establishment of the NSW Bush Fire Coordinating Committee (BFCC) and district Bush Fire Management Committees (BFMCs) which prepare and adopt bush fire risk management plans and operations coordination plans for each rural fire district. The risk management plans identify assets at risk from bushfires, including environmental assets, and specify a range of strategies and actions to protect these assets and the agencies responsible for their implementation. Strategies and actions include hazard reduction, property planning, community education, preparedness and ignition management strategies.

Bush Fire Environmental Assessment Code

The Bush Fire Environmental Assessment Code 2006 provides a streamlined environmental assessment and approval process for bushfire hazard reduction works. Assessments under the code consider the impacts of prescribed burning and mechanical works on natural values, including vegetation, threatened species, heritage items, soil stability, and air and water quality. Minimum fire intervals for vegetation formations (see Table 5.19) and threatened species guidelines must be considered. The code is currently being reviewed to further streamline environmental approvals for hazard reduction.

Figure 5.8: Predicted changes in fire frequency and magnitude



Source: Clarke et al. 2011

Planning and land use

Land-use planning decisions are intrinsic to fire management and environment protection strategies. Integrating protection against bushfires into the planning and development system through the BAL Risk Assessment Application Kit ensures safer developments in bushfire-prone areas. One strategy is to set development back from bushland at the planning stage to protect dwellings from bushfires. Proposed developments may be re-sited or redesigned if the environmental impacts of these setbacks are likely to be significant. Higher building construction standards may also be adopted to offset the setback distance required and contingency measures for fighting fires incorporated into the construction design.

Enhanced Bushfire Management Program

The Enhanced Bushfire Management Program (EBMP) was set up by the NSW Government in response to the findings of the 2009 Victorian Bushfires Royal Commission to prepare for a potential increase in the threat of bushfires. EBMP funding has been allocated to NPWS between 2011 and 2016 to increase the level of hazard reduction works conducted annually and improve bushfire response capability in parks and reserves.

A key component of the EBMP is the establishment of teams across the state to conduct hazard reduction works and respond quickly to outbreaks of fire in remote areas. These teams include specially trained and equipped personnel with dedicated planes on standby to enhance the capacity for early detection and rapid suppression of fires in remote areas. NPWS will monitor the effectiveness of these strategies through a suite of key performance indicators.

Community education

Community engagement activities and resources are a key component of the bushfire risk management program. The Hotspots Fire Project involves state agencies and non-government organisations and provides landholders and land managers with the skills and knowledge they need to protect life and property while protecting and maintaining biodiversity. The project promotes the understanding that well-informed and prepared communities complement the roles of land managers and fire agencies.

The RFS has also established the AIDER Program to assist infirm, disabled and elderly residents living in bushfire-prone areas to undertake fuel reduction activities.

Arson prevention

A range of measures have been implemented to reduce the rate of arson in NSW. Information sharing between agencies responsible for preventing and investigating arson-related fires has vastly improved, through establishment of the Bushfire Arson Taskforce and a whole-of-government intelligence database. The development of cross-agency strategies by Arson Prevention District working parties has also reduced the incidence of arson-related fires in those areas where they have been established. NSW will continue to support the National Strategy for the Prevention of Bushfire Arson implemented in 2009.

Knowledge and information

The Bushfire Risk Information Management System (BRIMS) stores data on fires across the state and is maintained by fire authorities and public land managers. Long-term data on where fires start and how they spread will be invaluable for determining fire management strategies, the allocation of firefighting resources, and the prevention of fires caused by arson and accidental ignition. Collated data on prescribed burns will also provide greater insight into how fire history affects fire management and environmental impacts.

Future opportunities

Fire management strategies will increasingly be based on better knowledge of fire behaviour and ecology, and better techniques for fire suppression.

There is scope for better maintenance and use of the data and information that is collected about fire. Information is improving, leading to more sophisticated analyses of bushfire patterns, effects and environmental impacts, and the use of decision-support and related applications such as digital mapping systems for fighting fires and managing hazards.

Support for new and ongoing research is essential for all aspects of fire behaviour, management and suppression. There is a need to learn more about fire ecology and how to improve building design, property management and community resilience to better cope with fire.

The incidence of high fire-risk days – and consequently the frequency of bushfires – is expected to rise. The number of days when it is safe to conduct hazard reduction burning may be reduced or move to earlier and later in the year. Under such scenarios, fire management strategies will need to be flexible and informed.

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Acronyms and abbreviations

AAQ NEPM	National Environment Protection Measure for Ambient Air Quality
ABARE	Australian Bureau of Agricultural and Resource Economics
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BASIX	Building Sustainability Index
BFCC	NSW Bush Fire Coordinating Committee
BFMC	Bush Fire Management Committee
BioBanking	Biodiversity Banking and Offsets Scheme
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BoM	Bureau of Meteorology
BREE	Bureau of Resources and Energy Economics
BRIMS	Bushfire Risk Information Management System
C&D	construction and demolition (waste)
C&I	commercial and industrial (waste)
CAHC	Clean Air, Healthy Communities program
CAP	catchment action plan
CAR	comprehensive, adequate and representative (reserve system planning)
CCA	Comprehensive Coastal Assessment (Biodiversity)
CCF	Climate Change Fund
CFC	chlorofluorocarbon
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
DCC	Department of Climate Change (Cwlth)
DEC	Department of Environment and Conservation NSW
DECC	Department of Environment and Climate Change NSW
DECCW	Department of Environment, Climate Change and Water NSW
DEWHA	Department of the Environment, Water, Heritage and the Arts (Cwlth)
DII	Department of Industry and Investment (NSW)
DLWC	Department of Land and Water Conservation (NSW)
DoH	NSW Health
DPI	Department of Primary Industries (NSW)
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
DWE	Department of Water and Energy (NSW)
EBMP	Enhanced Bushfire Management Program
EC	electrical conductivity
EEA	European Environment Agency
ENSO	El Niño–Southern Oscillation (Index)
EOAM	Environmental Outcomes Assessment Methodology
EPA	NSW Environment Protection Authority
EPHC	Environment Protection and Heritage Council
ERA	Extended Regulated Area (waste)
FDI	Fire Danger Index
FM Act	*Fisheries Management Act 1994*
FMS	Fire management strategy
FMZ	Forest Management Zone
FSANZ	Food Standards Australia New Zealand
GDE	groundwater-dependent ecosystem
GGAS	Greenhouse Gas Abatement Scheme
GMR	Greater Metropolitan Region (see Glossary)
GSP	gross state product
HWC	Hunter Water Corporation
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Interim Marine and Coastal Regionalisation of Australia
IPCC	Intergovernmental Panel on Climate Change

IUCN	International Union for the Conservation of Nature
KTP	key threatening process (see Glossary)
LGA	local government area
LSC	land suitability class
LTAAEL	long-term average annual extraction limit (see Glossary)
LWU	local water utility
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
MDBC	Murray–Darling Basin Commission
MDBMC	Murray–Darling Basin Ministerial Council
MER	monitoring, evaluation and reporting
MIL	monitoring investigation level
MPA	Marine Parks Authority (NSW)
NABERS	National Australian Built Environment Rating System
NCT	Nature Conservation Trust of NSW
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NLWRA	National Land and Water Resources Audit
N	nitrogen
NO_2	nitrogen dioxide
NOW	NSW Office of Water
NO_x	oxides of nitrogen
NPI	National Pollutant Inventory
NPWS	NSW National Parks and Wildlife Service
NRA	Non-Regulated Areas (waste)
NRC	Natural Resources Commission
NRM	natural resource management
NRS	National Residue Survey (Land)
NRS	National Reserve System (Biodiversity)
NTU	nephelometric turbidity unit
NV Act	*Native Vegetation Act 2003*
NWI	National Water Initiative
OECD	Organisation for Economic Cooperation and Development
OEH	NSW Office of Environment and Heritage
O_3	ozone
P	phosphorus
PAH	polycyclic aromatic hydrocarbon
PAS	priorities action statement
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 micrometres (10^{-6} metres)
PM_{10}	particulate matter less than 10 micrometres (10^{-6} metres)
POEO Act	*Protection of the Environment Operations Act 1997*
PVP	property vegetation plan
RAMAs	routine agricultural management activities (by local government)
RFS	Rural Fire Service (NSW)
RIS	regulatory impact statement
RMS	Roads and Maritime Services
RRA	Regional Regulated Area (waste)
SCA	Sydney Catchment Authority
SD	statistical division
SEPP	state environmental planning policy
SLA	statistical local area
SMA	Sydney Metropolitan Area (waste)
SMU	soil monitoring unit
SO2	sulfur dioxide
SRA	Sustainable Rivers Audit
SSD	statistical subdivision
STA	State Transit Authority (NSW)
STP	sewage treatment plant
SWC	Sydney Water Corporation
TAP	threat abatement plan
TLM	The Living Murray program
TN	total nitrogen
TP	total phosphorus
TSC Act	*Threatened Species Conservation Act 1995*
TSR	travelling stock route
TSS	total suspended solids
UNESCO	United Nations Environmental, Scientific and Cultural Organization
VKT	vehicle kilometres travelled
VOC	volatile organic compound
VR1	Stage 1 vapour recovery (motor vehicle emissions)
VR2	Stage 2 vapour recovery (motor vehicle emissions)
WHO	World Health Organization

Units

μ	micro (10^{-6})
μg	microgram (10^{-6} grams)
μg/L	micrograms per litre
μg/m3	micrograms per cubic metre
μm	micrometre (10^{-6} metres)
μS/cm	microSiemens per centimetre
cm	centimetre
cm/y	centimetres per year
CO_2-e	carbon dioxide-equivalent units (see Glossary)
EC units	electrical conductivity units (see Glossary)
GL	gigalitres (10^9 litres)
GL/y	gigalitres per year
GWh	gigawatt-hour
ha	hectare
ha/y	hectares per year
kg	kilogram
kg/y	kilograms per year
kL	kilolitre (10^3 litres)
kL/y	kilolitres per year
km	kilometre
km/h	kilometres per hour
km^2	square kilometres
kWh	kilowatt-hour
L	litre
L/s	litres per second
m	metre
m^3	cubic metre
mg	milligram (10^{-3} grams)
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
ML	megalitre (10^6 litres)
mL	millilitre (10^{-3} litres)
ML/d	megalitres per day
ML/y	megalitres per year
mm	millimetre
Mt	megatonne (10^6 tonnes)
MW	megawatt (10^6 watts)
MWh	megawatt-hour
nm	nanometre (10^{-9} metres)
pH	measure of acidity or alkalinity
PJ	petajoule (10^{15} joules)
ppb	parts per billion
ppm	parts per million
t	tonne
t/ha	tonnes per hectare
t/ha/y	tonnes per hectare per year
t/y	tonnes per year
y	year

Glossary

acid sulfate soils: a mix of low-lying coastal clays and sands that contain sulfur-bearing compounds at concentrations above 0.05% in clays and 0.01% in sands

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, plant and animal life

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 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

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

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

bycatch: species taken incidentally in a fishery along with the target species and often discarded

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 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); methane, for example, 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 $5 \times 21 = 105$ tonnes of CO_2

connectivity: the degree to which the landscape facilitates animal movement and ecological flows

Country: the term used by Aboriginal people to describe both the land and waters, including the sea, to which they have a strong cultural connection

critically endangered species: species (or ecological community) facing an extremely high risk of extinction in NSW in the immediate future

disturbance: (ecology) any discrete event in time which disrupts ecosystem structure and resource availability

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

ecological community: an aggregation of organisms characterised by a distinctive combination of two or more ecologically related species

ecosystem processes: the numerous interactions between different components (both 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

electrical conductivity: a measure of charged particles in water used to estimate salinity in microSiemens per centimetre ($\mu S/cm$)

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

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) which are then allocated to scheme participants

endangered species: a species, 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 emerge and die in a seasonal cycle or plants that emerge and grow in response to short wet periods in arid climates

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 water body or aquifer for use (also called abstraction)

fishing effort: the amount of fishing gear used in a fishery over a unit of time, essentially fishing capacity times fishing activity

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 occurences (such as 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, section 3) and comprising the:

(a) Central Coast Metropolitan Area

(b) Newcastle Metropolitan Area

(c) Sydney Metropolitan Area

(d) Wollongong Metropolitan Area

(e) the 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_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

greater metropolitan region (GMR_2): comprising the Sydney, Illawarra and Lower Hunter regions

greater metropolitan region (GMR_3): (Air Emissions Inventory) the area of NSW having Australian Map Grid (AMG) coordinates at the south-west corner at (Easting: 21000, Northing: 6159000, Zone 56) and north-east corner at (Easting: 420000, Northing: 64320000, Zone 56)

greenhouse gases: atmospheric gases, including carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone and water vapour, which trap heat reflected from the Earth's surface

growth form: (vegetation) the general morphology or form of a plant type

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 at the expense of naturally occurring species

invertebrates: animals without backbones, such as insects, worms, snails, mussels, prawns and cuttlefish

key threatening process (KTP): a process defined under the *Threatened Species Conservation Act 1995* that significantly threatens, or may have the capability to significantly threaten, the survival or evolutionary development of species, populations or ecological communities

long-term average annual extraction limit (LTAAEL): the level of groundwater that can be extracted from an aquifer sustainably on an annual basis

macroinvertebrates: invertebrates visible to the naked eye, having a body length exceeding 1 millimetre

mosaic: (vegetation) a combination of distinct vegetation types within a spatial unit that cannot be discriminated by the mapping techniques employed

non-woody vegetation: vegetation formations that are less than two metres high or with less than 20% canopy cover (mainly grasslands, arid shrublands and woodlands)

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

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 productivity/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

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 a vegetation type 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

sclerophyll: vegetation type consisting of plants with hard, short and often spiky leaves, adapted to the low-phosphorus soil conditions often found in Australia

sequestration: the long-term storage of carbon dioxide

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

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

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

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 (compare 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 plant 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 (VKT): 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, including fishes, sharks and rays, amphibians, reptiles, mammals and birds

virtually certain: indicates that there is a greater than 99% probability of occurrence, based on the definitions in IPCC 2007

vulnerable species: a species, 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: 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

Index