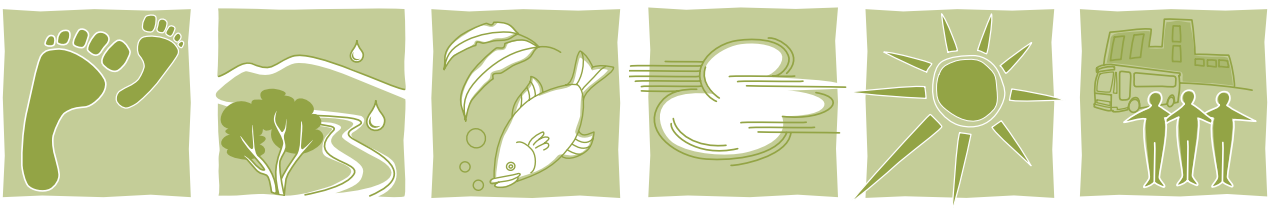
ACT State of the Environment Report 2011

Volume 2

Theme and Indicator Cluster papers:

- Land and Water
- Biodiversity
- Air

Office of the Commissioner for Sustainability and the Environment



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ACT State of the Environment Report 2011

Contents

Volume 1

Overarching papers

Executive Summary i

Acknowledgements xxxiii

Headline Indicators 1-3

Progressing Sustainability 4-19

Sustainability Stories (12 Stories) 20-32

Driving Forces 32-49

Appendix: Expert papers

- 2008-09 ACT Ecological Footprint
- Canberra's Ecological Footprint: What does it mean?
- Buying Choices for a More Sustainable Canberra
- Exploring Individual Values and Attitudes for a More Sustainable Canberra
- Horizon Scan: Issues for Future Sustainability and Environmental Management in the ACT & Region
- Weather and climate of the ACT 2007-11 and Decadal Trends

Volume 2

Land & Water, Biodiversity and Air Theme and Indicator Cluster papers

Land and Water Theme

Theme paper 50

Land Health 64

Rivers Lakes and Wetland Health 84

Water Quality 126

Water Supply 146

Groundwater 170

ACT State of the Environment Report 2011

Biodiversity Theme

Theme Paper 179

Flora 195

Fauna 209

Ecological Communities 245

Threatening Processes 275

Air Theme

Theme Paper 320

Local Air Quality 327

Indoor Air Quality 346

Volume 3

Climate and People Theme and Indicator Cluster papers

Climate Theme

Theme Paper 353

Emissions 367

Mitigation 382

Climate Vulnerability 403

Adaptation 416

Climate as a Resource 426

People Theme

Theme paper 438

Urban Quality 463

Transport 492

Waste 520

Heritage 546

Natural Hazards 558

Community Engagement 578

ACT State of the Environment Report 2011

THEME: Land and Water

Introduction to Theme

Land and water are the vital and interconnected resources on which all life depends. Land provides a range of ecosystem services, such as soil nutrients, water filtering and habitat, which in turn support food production and settlement. Water is essential for the maintenance and quality of both ecosystems and human settlement. Integrated management of land and water in catchment areas is essential for the health of waterways.

Five Indicator clusters are drawn on for the Land and Water theme:

- *Land health*
- *Rivers, lakes and wetlands health*
- *Water quality*
- *Water supply*
- *Groundwater*

Context

The effects of drought and fires dominated assessments of water and catchment health in the 2003 and 2007-08 ACT State of the Environment reports. Conditions have changed in this reporting period, with drought early on and wetter conditions more recently. The need to remain vigilant about the impacts of urban development on water quality and hydrology was highlighted in previous reports and has not diminished. Recommendations from previous State of the Environment reports focused on post-fire rehabilitation to protect catchments, and significant steps in post-fire recovery have been made. There has been little change in our knowledge of land health and urban impacts, despite several previous recommendations for improvement.

Data limitations have also been highlighted in previous State of the Environment reports, in particular relating to changes to soil condition, vegetation cover and diversity, and effects of urbanisation on catchments. There are encouraging signs that groundwater data collection and monitoring are improving, though more needs to be done to identify and manage this valuable resource. The need for long-term research and monitoring and for coordinated catchment management remains as valid today as it did when recommended in 2003 and 2007.

ACT State of the Environment Report 2011

The ACT Government is involved in the ongoing restoration and management of the lower Cotter catchment and in the Upper Murrumbidgee Demonstration Reach Project. These are examples of cooperative catchment management activities, and the learnings from these actions should be incorporated into other catchment initiatives. However, previous recommendations to improve cross-boundary catchment management have not been fully realised and require committed action.

- Many of these issues remain relevant in this reporting period and recommendations are provided at the end of this paper to assist progress.

Theme Summary: Key issues and outcomes

Land health, water use, water supply and quality, as well as the health of the ACT waterbodies, were affected by the two distinct phases in climatic conditions between 2007 and 2011 in the ACT. The first phase, from 2007 to May 2010, was dominated by drought, which had a significant impact on the condition of the ACT's land and water resources. The second phase, from June 2010 to June 2011, was associated with a break in the drought and above average rainfall (BoM 2011).

Significant management and infrastructure work has been undertaken to address water security during the reporting period. Climate change will mean that security of water supply will be a challenge for the ACT into the future. Impacts on water quality and water availability are likely, with increasing temperatures leading to increased water demand. The actions taken during the reporting period will provide a strong base for future adaptation.

The health of ACT waterbodies and their water quality are dependent on the land health and land uses of ACT catchments, with waterbodies in urban areas displaying less resilience than those that are non-urban. As identified in previous State of the Environment reports, greater knowledge of the impacts of urban areas on water quality and catchments would be beneficial for future catchment management. With expanding greenfield development increasing the urban footprint in the ACT, and increasing density in some areas of the urban area (see the *Urban quality* indicator cluster), understanding urban impacts on land and water will be essential for effective management.

Land health and erosion

Land use has significant impacts on catchment health and water quality. Land with poor vegetation or groundcover is more at risk of wind and water erosion. As in previous reporting periods, increasing urban development of greenfield sites continues to alter their hydrology. The previous *State of the Environment Report* recommended monitoring the effects of urbanisation on the ACT region's water catchments and using the information to respond to specific issues. While the ACT landscape, land uses and vegetation have been investigated in several catchments in the ACT, such as the Cotter catchment (ActewAGL 2010), the effects of urbanisation remain a critical area for further examination.

Vegetation mapping is being undertaken and will provide a baseline for future Territory-wide information on change in vegetation cover and quality. It is currently difficult to evaluate land health

in the ACT through changes in vegetation. Improving or maintaining vegetation and groundcover in both rural and urban land areas will help to reduce soil loss, and minimise impacts on waterways and catchments. Monitoring can assess the impact of erosion on local land and water resources, and help to detect the interactions between the catchment management and the ecosystem services the catchments produce in the ACT. Erosion potential throughout the ACT was mapped as part of a project to identify the impacts of fuel and fire management activities on soil erosion. This information should also be used by land and catchment managers to ensure a coordinated approach to land health.

The Australian Natural Resource Atlas (2009) suggests that over four million tonnes of sediment is delivered to the Murrumbidgee River from its catchment, which includes the ACT, annually. Most of this sediment entering the Murrumbidgee is derived from gully erosion (51%), a large percentage of which occurs upstream of the ACT (ANRA 2009). Gully erosion is caused by concentrated water flow over non-vegetated surfaces, which removes topsoil and subsoil. The risk of gully erosion is likely to increase, with extreme storm events predicted to occur in the ACT due to climate change (see the *Natural Hazards* and *Climate Vulnerability* indicator cluster papers for more information). However, the risk of gully erosion can be decreased through revegetation and other catchment management projects.

Little information is available about the acidity, salinity, carbon storage and overall condition of soils in the ACT. Soil type and soil condition affect land health, and improved knowledge of soil condition and the impacts of land uses on soils will be valuable for effective land management.

River health

The ACT lies within the Murray-Darling Basin (MDB). A Sustainable Rivers Audit was undertaken on the MBD between 2004 and 2007 to assess the ecological health of rivers in the Basin. It found the Murrumbidgee River was generally in 'very poor' condition (MDBA 2008). However, it is acknowledged that this audit was undertaken following the 2003 bushfire, which may have had severe impacts on some of the water quality monitoring sites.

Generally, river health and catchment condition are improving within the ACT. In recent years rivers and streams have been stressed by the extreme events of drought and fire. Sites outside the urban area have displayed resilience and appear to be recovering from the impacts of the 2003 bushfires. This is a result of the re-established vegetation within the catchments and the improvements in riparian zones following the bushfires (ACT NRMC 2009). As in previous reporting periods, the urban area continues to have a large impact on the health of the catchments and quality of river water in the ACT.

Source: Halcrow, 2011

Riparian vegetation influences river quality and aquatic ecosystems through filtering out sediments and nutrients from incoming runoff and by providing bank stability and in-stream habitat (e.g. tree roots, fallen logs, shade).

Over the reporting period, average nutrient concentrations within ACT's rivers were generally within the limits specified by Environmental Protection Regulations (DECCEW 2010a), but there were some exceedances. However, suspended solids within a number of the lakes and waterways exceeded the limit of 25 mg/L on a number of occasions. This may be because large rainfall events generated increased stormwater run-off after the drought broke in 2010.

Lake health

ACT lakes and ponds continue to have high concentrations of chlorophyll 'a', especially in warmer months. Chlorophyll 'a' is an indicator of photosynthetic microorganisms present in aquatic ecosystems, of which the potentially toxic blue-green algae or cyanobacteria are of most concern. Blue-green algae cell counts are carried out when sampling records a spike in chlorophyll 'a' readings at a particular location, or when large amounts of blue-green algae have been visually identified, in accordance with the *ACT Guidelines for Recreational Water Quality* (ACT Health 2009).

During the reporting period, sampling in ACT lakes measured elevated concentrations of chlorophyll 'a' and sporadic high or extremely high concentrations of blue-green algae. This occurred primarily between spring and autumn of each year when these waterbodies had correspondingly higher concentrations of available nutrients and relatively warm waters. Summer incidence of blue green algae in ACT lakes appears to be increasing. This is when lakes are most likely to be used for recreation. Over the last ten years, there has been a steady increase in the number of lake closures per year, because of either faecal contamination or potentially toxic blue-green algae in the water. Between 2007 and 2011 there were several instances of elevated concentrations of algae and pathogens in ACT lakes, which resulted in a number of human health alerts and lake closures.

Greater focus is needed on the management of ACT lakes to improve water quality so that recreation activities are not restricted.

The National Capital Authority was alerted to discharges of partially treated effluent from the Queanbeyan Sewage Treatment Plant entering the Molonglo River on 3 December and 8 December 2010. The discharges resulted in complete closure of Lake Burley Griffin to all recreational users, to avoid risks to human health. Also contributing to this closure were significant quantities of debris travelling down the Molonglo River into the lake following major flood events during the same period (NCA 2011).

Wetland health

Of the ACT's wetlands, 13 are listed in the national *Directory of Important Wetlands in Australia* (DSEWPaC 2009). One of them, the Ginini Flats Wetland Complex (made up of a series of interconnected flats known as Ginini Flats and Cheyenne Flats) in Namadgi National Park, is listed as a Ramsar site. Wetlands provide water filtering and groundwater recharge, and the Ginini Flats wetlands in particular help maintain streamflow into Canberra's domestic supply as well as providing habitat for a number of threatened species.

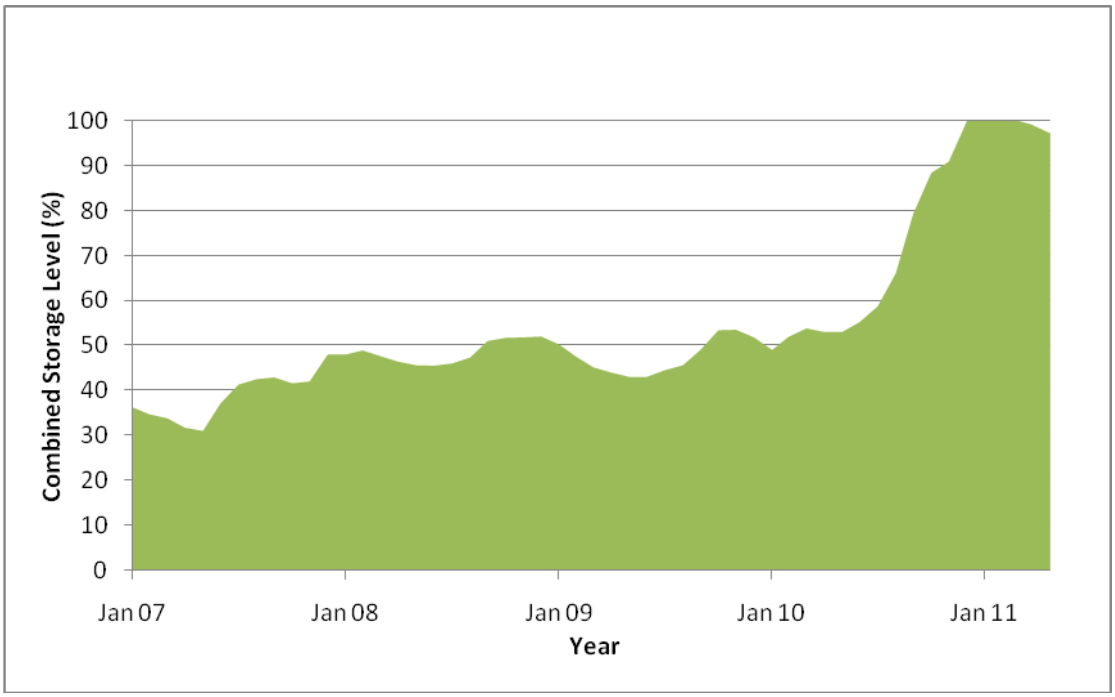
Information on the health of ACT wetlands is patchy with few projects surveying riparian health and water quality. Wetland health has been variable in those that have been surveyed. One of the challenges for management of wetlands is the individuality that characterises each wetland (Johnston et al. 2009).

During the reporting period wetlands have been constructed in urban areas across the ACT to improve the quality of stormwater. These wetlands reduce the quantity and velocity of peak flows in urban streams by capturing stormwater. Slowing water flow in the wetlands allows solids to settle out. Wetlands plants also bind phosphorus and nitrogen that are in the water, removing these contaminants (DECCEW 2011) so that the water leaves the wetland cleaner than it was when it entered.

Water use and drought

The recent drought had a significant impact on water resources. Water storage levels within the ACT were less than 40% of capacity in 2007-08. However, the significant rainfall in late 2010 increased the ACT's water supplies to 100% capacity (Figure 1). This marked the first time since 2000 that all ACT's water supply dams were more than 80% full.

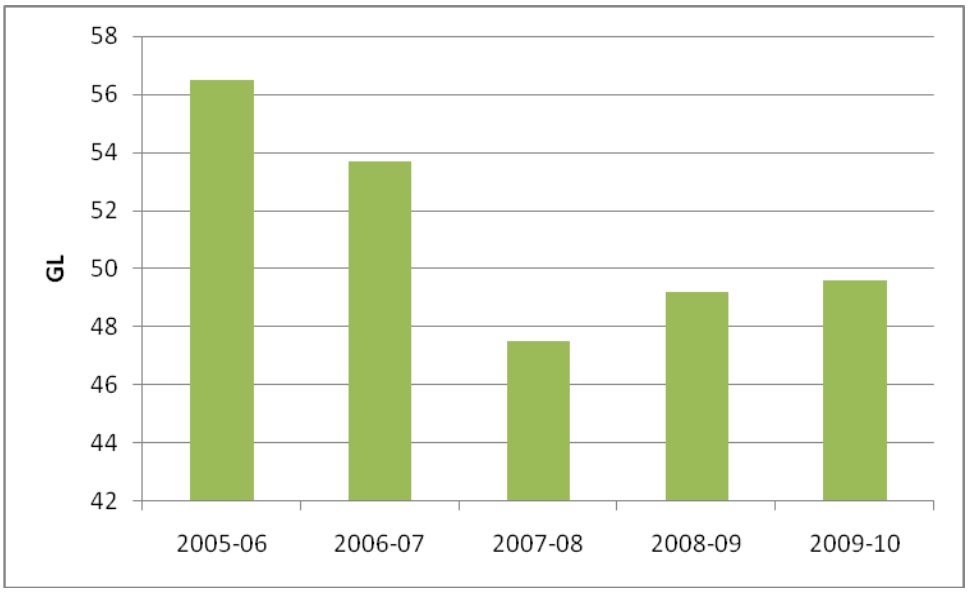
Figure 1: Water storage levels between January 2007 and March 2011



Source: ACTEW 2011a

Between 2005-06 and 2009-10, potable water use within the ACT decreased by approximately 7 GL per year (Figure 2), primarily because of a decrease in household water use. Household water use, the main use of water in the ACT (66.3%), decreased by 17% between 2006-07 and 2009-10 in response to the drought and associated water conservation measures. As ACT residents have only recently been allowed to adopt the more relaxed Permanent Water Conservation Measures, it is yet to be seen whether water-efficient behaviour is now embedded in the behaviour of Canberrans, or if water use will once again increase.

Figure 2. Total water use within the ACT



Source: ActewAGL 2010

Groundwater is an important localised water resource for the ACT, although it contributes only a small proportion of the overall water supply. Over-extraction could affect the health of groundwater-dependent ecosystems, and the continuing availability of groundwater for human use. Groundwater abstractions are limited to 10% of long-term recharge, and actual abstractions remain small. Improved monitoring of groundwater should provide greater knowledge and understanding of groundwater in the ACT.

Responses and effectiveness

Catchment management

A number of catchment management projects were implemented during the reporting period to improve the overall health of ACT's land and water resources. Catchment management is the management of land and water resources across a catchment. Catchment management can be used to minimise the risk of, and repair land affected by, erosion and other forms of land degradation.

The previous *ACT State of Environment Report* made a number of recommendations to improve catchment quality in the ACT relating to catchment management and the restoration of the Lower Cotter Catchment. In the Lower Cotter Catchment, a major restoration project has been undertaken to rehabilitate and restore native vegetation. The project is one of the largest land rehabilitation projects undertaken in Australia, and it involves the replanting of native vegetation on over 3500 hectares of former pine plantation destroyed by the 2003 bushfire (TAMS 2006). The project also aims to control weeds such as pine seedlings and blackberries, and also involves replanting native vegetation, managing fire risk, conducting monitoring and promoting natural regeneration. Native vegetation is now one of the most desirable land uses within the catchment; it should help improve soil stability and minimise erosion risk (TAMS 2006).

Maintenance and management of the roads and trails has also been undertaken within the Lower Cotter Catchment due to their identification as major sites of erosion, responsible for movement of sediment into watercourses and eventually the Cotter Dam (TAMS 2006). Many of the roads and trails needed for the management of the pine plantation are no longer required. As a result, these roads have been closed and rehabilitated. The remaining roads needed for land and fire management have been upgraded to minimise erosion risk.

Wetland management

As mentioned above, one of the challenges in managing wetlands is the variation of characteristics of each wetland (Johnston et al. 2009). A number of the sphagnum bogs burnt in the 2003 fires in the Cotter Catchment have been rehabilitated to prevent stream entrenchment and drainage and loss of the bogs. At the Jerrabomberra Wetlands near Lake Burley Griffin, the *Jerrabomberra Wetlands Nature Reserve Plan of Management* (TAMS 2010) has been completed, and willows and woody weeds have been controlled. The Capital Woodland and Wetlands Conservation Trust is being established to support projects in Jerrabomberra Wetlands Nature Reserve and Mulligans Flat Woodland Sanctuary. The Trust is intended to supplement rather than replace annual government support for normal ongoing management of these areas (OCSE 2011). For more information see the *Fauna* indicator cluster paper (*Biodiversity* theme).

Water quality

Water quality in the ACT's lakes and rivers is affected by the land use upstream in both the ACT and in NSW. Cross-boundary catchment management projects are continuing, with the aim of improving catchment condition and water quality within the ACT. For example, the Upper Murrumbidgee Demonstration Reach (UMDR) initiative focuses on approximately 100 km of the river, extending from the rural township of Bredbo in south-eastern NSW downstream to Casuarina Sands in the ACT. The UMDR initiative aims to provide the community with a visible demonstration that the health of the river, floodplain and wildlife depends upon aquatic habitats, and that these habitats can be restored to a better condition through coordinated actions that address the major threats. The UMDR initiative involves a suite of river rehabilitation methods, and complements other plans and activities that are ongoing under other programs (ACT Government 2010).

Another example is the current multi-jurisdictional investigation of the state of the waterways entering Lake Burley Griffin (commenced in June 2011), by the Commissioner for Sustainability and the Environment. The findings of this investigation will identify and recommend ways to improve management of the waterways and catchment.

Local water quality can also be improved through the implementation of Water Sensitive Urban Design initiatives, such as constructed wetlands, ponds and rain gardens. These initiatives aim to provide amenity to the urban landscape, whilst also improving and enhancing water quality within the urban environment. Since 2008, the ACT Government has constructed a number of new urban wetlands. Several are in the Sullivans Creek Catchment, including the Banksia Street wetland, as part of the Canberra Integrated Urban Waterways project (DECCEW 2011) to improve the creek's water quality. The Banksia Street wetland captures the local stormwater and naturally treats the water to

improve its quality, before it flows back into the stormwater network and eventually into Sullivans Creek.

The Canberra Integrated Urban Waterways project focuses on integrating stormwater and urban waterways, by investigating opportunities such as stormwater harvesting and injection to groundwater storages by managed aquifer recharge. By the end of 2011, the ACT Government aim to save 1.5 GL of potable water by using water from wetlands constructed along Sullivans Creek instead of the potable supply to irrigate local sportsfields. By 2015, the project aims to substitute 3 GL per year of potable water in this way (DECCEW 2010a).

Source: Halcrow, 2011

The previous ACT State of the Environment Report recommended developing an integrated water supply catchment management policy for the ACT, as well as a strategy to guide, among other things, coordination of scientific research, data collection, monitoring and reporting (including public information). While some projects such as the Canberra Integrated Urban Waterways project and the Upper Murrumbidgee Demonstration Reach initiative have demonstrated such an approach, catchment management in the ACT is still conducted by a number of different actors and agencies, creating challenges for an integrated approach. The ACT Government's review of the *Think water, act water* strategy (ACT Government 2004, DECCEW 2010b), is an appropriate forum to improve integration of research, monitoring reporting and policy and therefore strengthen water and catchment management in the ACT.

Community groups continue to play a significant role in the monitoring and management of the lakes, rivers and catchments of the ACT. Catchment Management Groups and Parkcare and Landcare groups undertake waterway and land-based conservation, management and restoration in ACT

catchments, while Frogwatch and Waterwatch groups raise awareness and monitor and conserve ACT waterways and their inhabitants.

Water security and efficiency

The ACT has been investigating and developing new water supplies in response to increased climate variability, drought, increasing population and water demand. A number of water supply enhancement projects have been implemented, including three major projects initiated during the reporting period (ACTEW 2011b, ICRC 2011):

- enlarging the Cotter Dam;
- pumping water from the Murrumbidgee River to Googong Dam to supplement the ACT's water supply; and
- purchasing general and high security water entitlements for the Tantangara Transfer project.

Stage 3 water restrictions were in place throughout much of the reporting period, but were gradually relaxed in late 2010 following significant rainfall. Permanent Water Conservation Measures remain in place to maintain water conservation efforts. The *Think water, act water* strategy set targets of a reduction in per capita water consumption of 12% by 2013 and 25% by 2023 compared with 2003 levels. These targets are to be met through water efficiency measures to reduce potable water use by recycling and use of stormwater, rainwater and recharging of aquifers for irrigation and other uses.

Water efficiency programs, including showerhead rebate and water tune-ups, have continued to be implemented during the reporting period. The residential water efficiency programs collectively accounted for approximately 1.22 GL (or around 11%) of demand management savings in 2008-09 (DECCEW 2010b). In 2008-09 demand management and water efficiency measures are credited with having saved 11.36 GL of water, equating to 16.5% of the expected baseline consumption of the ACT community (DECCEW 2010b).

Based on information from the Australian Water Resources Assessment (NLWRA 2000), groundwater management in the ACT is largely effective. However, it will be important to continue to improve understanding of 'at risk' aquifers, in particular, and manage impacts on groundwater quality from contaminated sites. In response to increasing demand for and use of groundwater, the ACT Government has also been targeting improvements in the accuracy of groundwater assessments and broadening groundwater monitoring. Monitoring of groundwater recharge will be a valuable contribution to understanding and quantifying of potential effects of changed rainfall patterns expected as part of climate change (as discussed in the *Climate Vulnerability* indicator cluster paper).

Emerging issues

Cross-boundary catchment management, including the impact of upstream land uses in NSW on the Murrumbidgee River, continues to be problematic and increasingly important. Cross-boundary catchment management issues relating to the Googong Dam were identified in the 2007 State of the

Environment report; a significant portion of the catchment lies within NSW. These cross-boundary issues can also relate to areas within the ACT, and occur at both state and federal levels. For example, Lake Burley Griffin is managed by the National Capital Authority (NCA), but is used mainly by Canberrans; and the Murrumbidgee River passes through the ACT but is affected by upstream water quality factors in NSW.

Cross-boundary catchment management is challenging. Management arrangements to facilitate cooperation on land and water issues are in place. However strengthening integrated management action would be beneficial. Integration might be helped by improved exchange and use of information, such as spatial information, between government agencies, Natural Resource Management groups and Catchment Management Authorities, and by promoting sustainable catchment management with landholders and the community.

Recent CSIRO research indicates that soil carbon is increasingly becoming an important land management issue. Soil can store more carbon than plants and the atmosphere combined and can therefore assist in mitigating climate change. In future, land capability assessment is likely to need to take account of this stored carbon (ACT NRMC 2009).

The Water Sensitive Urban Design treatments implemented during the reporting period will require ongoing maintenance to remain effective in improving local stormwater quality. Planning for and implementing this maintenance is a challenge facing many authorities in urban Australia (Water Sensitive Cities 2009) and is likely to remain important also within the ACT.

Recommendations

1. Establish cross-boundary management of the ACT's water resources including:
    a. developing catchment policy and an integrated water supply catchment management strategy, as recommended in previous State of Environment reports; and
    b. strengthening integrated management action by facilitating improved exchange and use of information, such as spatial information, between government agencies, Natural Resource Management groups and Catchment Management Authorities, and by promoting sustainable catchment management with landholders and the community.
2. Complete assessment of the ACT's at-risk groundwater resources.
3. Update water management, monitoring and reporting programs to inform:
    a. actions to mitigate impacts of urban development on water quality;
    b. the efficacy of Water Sensitive Urban Design measures;
    c. improvements in sediment and erosion mitigation actions; and
    d. management of ACT lakes.

4. Improve monitoring to assess the impact of erosion on local land and water resources, and to help to understand the interactions between the ACT's catchment and ecosystem services in particular:
    a. undertake baseline soils mapping for the ACT to facilitate monitoring and assessment of soil condition;
    b. identify indicators of land health including soil heath, vegetation quality and change and land use changes; monitor and publicly report on these on a regular basis;
    c. improve limited land health data by including land health assessments in water catchment data to inform soil condition across the ACT; and
    d. improve actions related to sediment and erosion mitigation.
5. Management of knowledge and the coordination of scientific research, data collection, monitoring and reporting (including public information) is an area of concern across all themes. A specific recommendation to address this is provided under the recommendations section of the *Biodiversity* theme paper.

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ACT Environmental Protection Agency (EPA) - now part of now Environment and Sustainable Development Directorate (ESDD)

ACT State of the Environment Report 2011

THEME: Land and water

Indicator cluster: Land health

The Land health indicator cluster covers eight indicators, including:

- *Soil condition* (C) - the extent, distribution and condition of soil classes, soil salinity and soil carbon;
- *Vegetation and ground cover* (C) - extent and distribution of vegetation and ground cover;
- *Erosion* (P) - extent, distribution and type of erosion and soil loss;
- *Soil acidity* (P) - extent and distribution of soil acidity;
- *Contaminated sites* (P) - extent and distribution of contaminated sites;
- *Catchment management* (R) - effectiveness of catchment management responses in the ACT;
- *Natural Resource Management (NRM) Plan* (R) - effectiveness of the ACT NRM plan; and
- *Contaminated site management* (R) - effectiveness of contaminated site management and remediation.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data for the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

Most ACT soil is infertile and has a high potential for water logging and erosion. However, there is little recent information available about the extent and locations of land in the ACT affected by soil erosion or soil acidity, nor about the factors contributing to land health. Improved data collection and monitoring of changes to natural resources in the ACT would be beneficial.

While over 50% of the land is managed as conservation areas, no data are available on the change in vegetation condition over time across the whole of the ACT.

ACT State of the Environment Report 2011

The ACT Government and community organisations have undertaken a range of catchment management activities over the reporting period, 2007-2011. In particular, the lower Cotter catchment has been the site of a major project to rehabilitate and replant native vegetation to areas previously given over to plantation forestry. This catchment area is expected to have greater soil stability and a lower risk of erosion as a result of this project.

During the reporting period the ACT Government undertook intensive remediation of groundwater contaminated by a hydrocarbon plume, and facilitated the remediation of soil from this and other contaminated sites.

Introduction

Land health is important for maintaining a range of ecosystem services including soil nutrients, water filtering, and habitats that support ecosystems and human settlement. Important factors contributing to land health in the ACT include soil condition, vegetation and ground cover. Pressures that impact on ACT land health include soil erosion, soil salinity and acidity, and contamination of land.

Condition indicators

Soil condition

Soil condition in the ACT is important for landscape health and ensuring the productivity of land for agriculture and other uses. Soils overall can hold more carbon than plants and the atmosphere combined. The carbon is in the form of decaying plant matter, soil organisms and microbes, and minerals in the soil. Management of soil carbon storage can assist in mitigating climate change.

ACT soils are highly variable, with most being infertile (ACT NRMC 2009). There are five dominant orders of soil in the ACT (ASRIS 2011):

- Chromosols: these soils have an abrupt increase in clay content below the top soil;
- Kandosols: these soils are massive and earthy;
- Kurosols: these soils have an abrupt increase in clay content from the top soil to subsoil and at depth they are strongly acidic;
- Sododols: these soils have an abrupt increase in clay content from the top soil to subsoil, with the subsoil being high in sodium; and
- Tenesols: these are sandy soils that are generally shallow.

Most (64%) of the Canberra urban area is built upon the Williamsdale soil type, which has a high potential for water logging, and is moderately to highly susceptible to erosion under non-concentrated and concentrated water flows (Jenkins 2000).

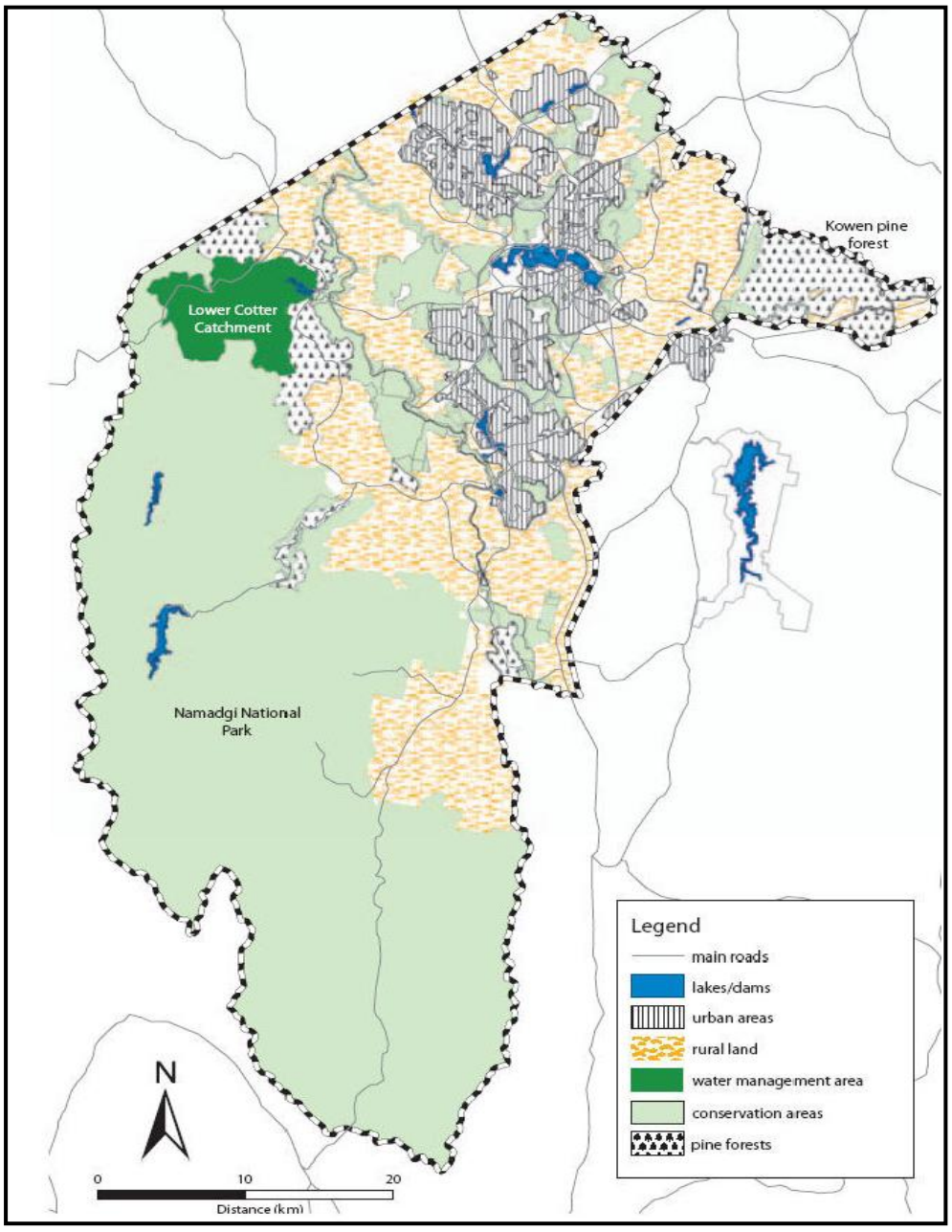
There is limited information on the extent of soil salinity, the storage of soil carbon, and the overall condition of soils in the ACT. The impacts of salinisation - including dryland, irrigation and urban salinisation - are evident across many rural areas in the major catchments surrounding the ACT as well as in the Murrumbidgee River catchment.

Soils in urban areas are also likely to be negatively affected by land use as well as by practices such as continuous and extensive application of greywater. Urban land is also quite likely to become contaminated (see Impact indicator below). However, only limited information is available on the impacts of pollutants on ACT urban soils, and more detailed studies are required to determine the extent of these impacts.

Vegetation and ground cover

Vegetation maps recently compiled by TAMS indicate that the primary land cover in the ACT conservation areas is woodland and forest. Vegetation and ground cover in the ACT are closely linked to land use (Figure 1), particularly because over 50% of the land is managed as conservation areas and approximately 20% used for rural production. The remainder is largely urban. While intensive agriculture and horticulture are conducted in some areas, the dominant rural land use is grazing (ACT NRMC 2009).

Figure 1. Land use in the ACT



Source: ACT NRMC 2009 (Map: Territory and Municipal Services)

No data are available on the change in vegetation condition over time across the whole of the ACT. However, research currently underway is classifying and mapping the distribution of ACT vegetation communities. This work will set a baseline of information about current vegetation communities, and is likely to identify and classify additional vegetation communities to those already listed. For more information on vegetation condition in the ACT see the *Ecological communities* indicator in the *Biodiversity* theme.

A landscape-function analysis of 34 nature reserves and one potential reserve was part of a recent Investigation into Canberra Nature Park (nature reserves); Molonglo River Corridor (nature reserves) and Googong Foreshores (OCSE 2011a). Landscape function condition was defined for each sample, based on three assessments: the measured landscape function; scores for bushland health, and on-site observation of a range of landscape condition values (including weediness, amount of bare ground, and soil disturbance) (Sharp 2011). This analysis (OCSE 2011a) indicated that:

- one nature reserve, Mount Painter, is in a critical condition;
- 17% are approaching a critical condition; and
- 80% are in overall satisfactory condition.

Even though most of the nature reserves in ACT were assessed as being in satisfactory condition, there are localised areas within these nature reserves that were assessed as being in critical condition or approaching critical condition (OCSE 2011a). This included a number of reserves with very high nature conservation values, in particular (Sharp 2011):

- Callum Brae, Gungaderra (woodland), Kinlyside, Tuggeranong Hill, Wanniassa Hills and West Jerrabomberra, where between 20% and 50% of the reserve area was approaching critical or in critical condition; and
- Googong Foreshores, Goorooyarroo, Mulligans Flat and Red Hill, where more than 50% of the reserve area was approaching critical or in critical condition (Sharp 2011).

The combined area of those reserves assessed as in overall critical condition or approaching critical condition covers about 4200 hectares (OCSE 2011a).

The urban area of Canberra includes significant vegetation. Nature reserves, together with street and park trees, form a major part of Canberra's green infrastructure, providing essential ecosystem services and supporting the Territory's economic and social systems and biodiversity. They provide important connectivity along routes for species' movements (see *Biodiversity* theme). The dominant vegetation types in ACT urban areas are introduced species, in gardens and as grassland, plantation trees and street trees.

Weed infestations are an issue in some parts of the ACT, often in areas in which the native vegetation has been suppressed. Where introduced pasture species are heavily grazed, there is an increased risk of weeds becoming established, such as Paterson's Curse (*Echium plantagineum*), Saffron Thistle (*Carthamus lanatus*), and St

John's Wort (*Hypericum perforatum*). For further information on weeds, refer to the *Threatening processes* indicator in the *Biodiversity* theme.

Land that has poor vegetation or ground cover is more at risk of erosion by wind or water. Improving vegetation condition and ground cover should help to reduce soil loss, and minimise impacts on waterways and catchments in the ACT. For further information, refer to the *Ecological communities* indicator cluster in the *Biodiversity* theme.

Cotter catchment

A large part of the Cotter River catchment is in Namadgi National Park. The catchment covers approximately 50,000 hectares and its vegetation is a mixture of sub-alpine wet and dry forests, perched swamps and valley floor grasslands (ACTEW 2009). In the areas of the catchment where native vegetation is dominant, the prevalent land cover is forest, open forest or woodland, with smaller areas of closed forest communities, and grasslands.

In contrast, the lower Cotter catchment is highly modified as a result of its past land use, in particular for Radiata Pine plantations. Weeds in the lower Cotter catchment forestry estate continue to be a problem (ACTEW 2009).

Vegetation in the Cotter catchment was significantly affected by the 2003 bushfires, but native vegetation has started to re-establish, especially in the upper Cotter catchment. Extensive plantings by community volunteers have also helped the re-vegetation process (see Catchment management section below and the *Community engagement* paper) in the lower Cotter catchment, but there are still some areas that have little vegetation and ground cover and are susceptible to erosion. The vegetation in these areas is in relatively poor condition, with introduced and weed species evident.

Googong water supply catchment (in NSW)

The catchment of the Queanbeyan River (in NSW) is an important part of the ACT water supply because it provides the water stored by the Googong Dam. The catchment has had a wide range of land uses, many of which have the potential to affect the condition of the landscape and the water quality in the river systems.

Over 30% of the catchment is used for agriculture and grazing. Plantation forestry is the second most common land use, although much of the pine forest continues to be essentially unmanaged (ActewAGL 2011). The catchment has significant wooded areas, including the Tallaganda, Yanununbeyan and the Gourock National Parks.

Pressure indicators

Vegetation clearing and overgrazing (removing ground cover) can significantly affect land health through facilitating soil erosion and loss of soil nutrients. Some types of erosion and nutrient loss occur through natural movement of soil by wind and water. However land can be degraded as a result of human activities such as urban development, some agricultural practices, or poor land management practices. Many types of land degradation, such as soil loss resulting from accelerated erosion and dryland salinity, have long-term or irreversible consequences for species and ecosystems and production. As identified in previous ACT State of the Environment Reports, limited information is available on the extent of land degradation in the ACT and how it changes over time.

The investigation into Canberra Nature Park (nature reserves); Molonglo River Corridor (nature reserves) and Googong Foreshores (OCSE 2011a) identified a number of disturbance factors observed as adversely affecting the condition of some nature reserves, including:

- clearing of native vegetation;
- grazing pressure and soil disturbance by herbivores;
- weed infestations, erosion and bare soil;
- impacts from fire events (operational burns and wildfires) and other bushfire operations; and
- impacts resulting from use by visitors and the maintenance of infrastructure within nature reserves.

The impacts of these factors are discussed in detail in the *Biodiversity* theme and *Threatening processes* indicator cluster.

Erosion

As noted above, soil erosion is a natural process that can be accelerated by inappropriate land use. Increased rates of erosion can result from deforestation, overgrazing, urban development and agricultural practices. Soil erosion can significantly reduce the health and productivity of land resources and waterways in the ACT.

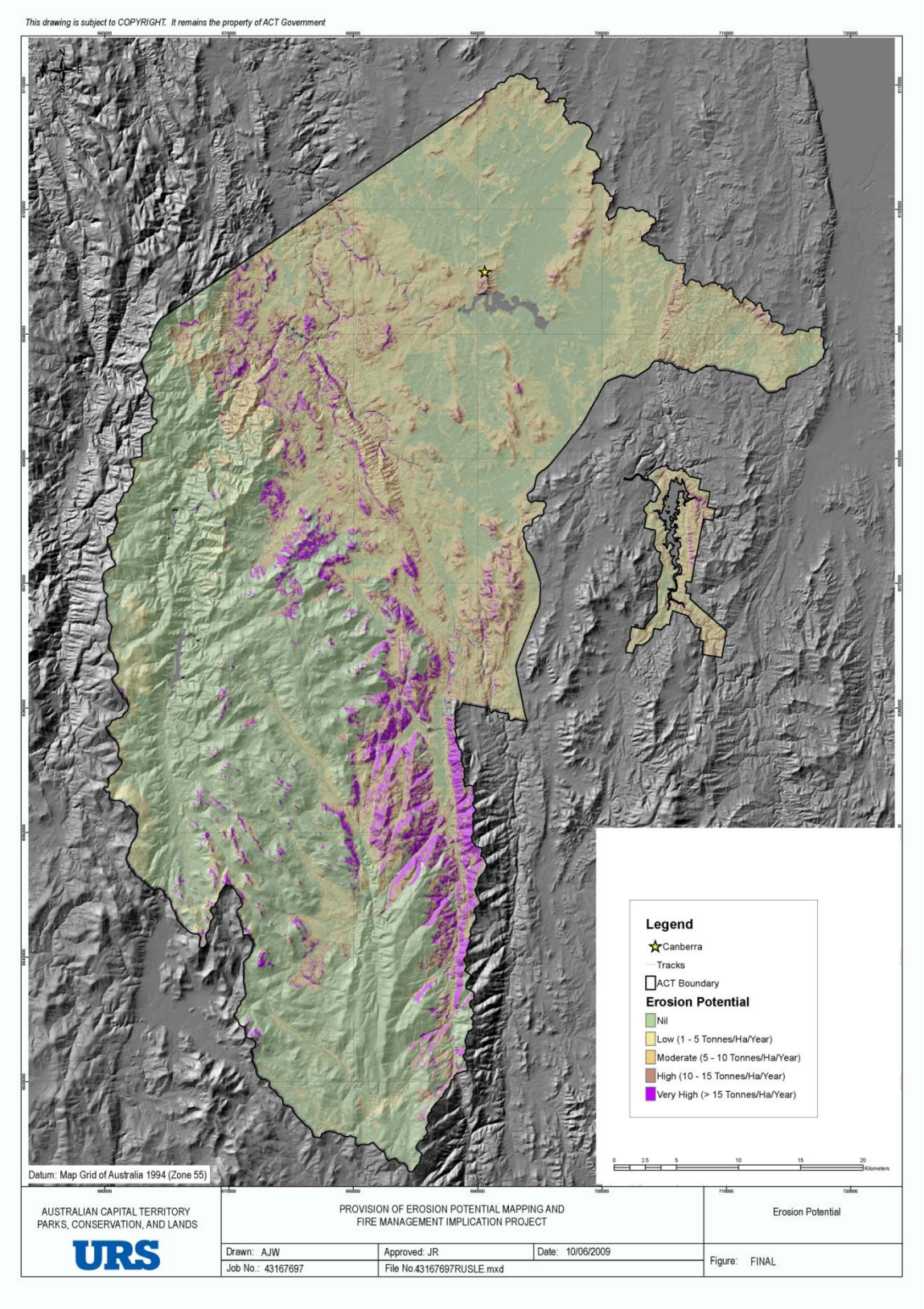
Key forms of soil erosion affecting the ACT are:

- sheet erosion, caused by rain and water flows that remove topsoil and reduce the productivity of agricultural land; when soil enters waterways it affects water quality and habitat quality for aquatic ecosystems and species;

- gully erosion, caused by concentrated water flow that removes topsoil and subsoil; reduces land management options; negatively impacts on water quality, aquatic condition and biodiversity; and may become more prevalent if extreme storm events are associated with climate change; and
- wind erosion that removes exposed soil; reduces land productivity and air quality; and may become more common with climate change and extreme storm events.

Erosion potential has been mapped for the whole of the ACT as part of a project to identify the impacts of fuel and fire management activities on soil erosion (Figure 2). Some individual catchments and forestry estates have also been assessed and mapped for erosion risk: for example, the Lower Cotter Forestry Estate in 2008 (Ecowise Environmental 2008). Areas of high erosion risk may also be a high risk for water quality.

Figure 2. Erosion risk in the ACT



Source: ESDD

Soil acidity

Soil acidification can reduce soil health and productivity. Acid dryland soils are those having a pH below 5.5 (when measured as 1:5 soil:water as defined for NSW Government State of the Environment reporting (NSW DECCW 2003). Leakage of nitrate below the root zone, oxidation of ammonium fertilisers, accumulation of soil organic matter, and export of plant and animal products from the land have been identified as the four main acidifying processes (Lockwood et al. 2003).

If left unchecked, soil acidification reduces pasture and crop growth, and can lead to a decline in vegetative cover and agricultural production. As soil acidity becomes more severe, its impacts begin to extend beyond agricultural production, contributing to impacts on groundwater recharge and pollution, and reducing water quality in catchments.

Overall there is limited information regarding soil acidity in the ACT. There are no recent data to indicate whether or not soil acidity is increasing in the ACT.

Contaminated sites

Contaminated land is land that is polluted by a hazardous substance that can pose a risk to the environment or human health. Land contamination can occur as a result of poor environmental management and waste disposal practices and spills from industrial and commercial activities. Managing the location and use of these potentially contaminating activities is critical to the control of contaminated sites in the ACT.

In the ACT between 2007 and 2011, 147 new contaminated sites were identified (Table 1), increasing the total reported contaminated sites in the ACT from 752 to 899. The sites have become contaminated during use as, for instance, sheep dips, service stations and other fuel storage sites, municipal landfills and uncontrolled fill sites. Each of these sites has the potential to cause land and groundwater contamination. The *2007-08 ACT State of the Environment Report* reported 754 contaminated sites, but that number has been revised down to 752 because sites were incorrectly counted in the previous reporting period.

Table 1. Contaminated sites identified between 2007 and 2011

Type	Number
Hydrocarbon sites	95
Landfill sites	20
Cattle/Sheep dip sites	1
Other sites	31
Total	**147**

Source: ACT Environment Protection Authority

The majority of the 95 hydrocarbon sites were identified as a result of redevelopment of commercial sites and during the Department of Education and Training fuel tank removal program. The majority of the 20 landfill sites were associated with uncontrolled fill identified in greenfield development sites. One new cattle dip was identified by the ACT Government Vet during the reporting period. The 31 other sites include former Parks and Gardens depots, defence sites and commercial storage facilities.

Fuel storage and uncontrolled landfill are the two most common uses associated with contaminated sites that required assessment and remediation. Fuel storage at a number of former service stations, subject to redevelopment over the reporting period, had resulted in identified hydrocarbon impacts to both soil and groundwater, requiring remediation. Also, as identified in previous ACT State of the Environment Reports, a hydrocarbon plume is present in groundwater to the east of the intersection of Bunda and Mort streets in Civic. The plume was a result of poor fuel storage practices in the area prior to the 1980s. Significant work has been undertaken during the reporting period to address this issue (see Response indicators section).

One example of contamination by landfill was a large quantity of uncontrolled fill in an area associated with the operation of the former Weston Creek Sewage Treatment Works found during the development of the North Weston Pond. Much of the fill contained fragments of asbestos sheeting and was geotechnically unsuitable for reuse in the area. It has been transported off-site for disposal at licensed landfill sites at Mugga Lane and West Belconnen.

Redevelopment, creating urban infill from former 'brownfield' sites such as service stations and uncontrolled fill sites, has created new challenges for both the ACT Government and developers with respect to the management, reuse and disposal of hydrocarbon- and asbestos-contaminated soils (see *Waste* indicator cluster in the *People* theme for further information).

Impact indicators

There are no specific impact indicators for Land health. However, poor land management can adversely impact on species and ecosystems, land productivity and people.

Clearing of native vegetation, for example, will reduce habitat for native species and increase the potential for soil erosion, which in turn affects water quality in streams and rivers. Remedying the effects of soil erosion may require costly rehabilitation and repair of affected roads and infrastructure. For more information see the *Water quality* indicator cluster.

Response indicators

Information on vegetation condition, soil condition and land condition and changes over time is important for understanding and managing the impacts and condition of catchments and natural resources. Improved data collection and monitoring of changes to natural resources in the ACT would provide a more informed basis for responses. Without this information it is difficult to assess the effectiveness of management responses. In the future, it is also likely that land capability assessments will need to take account of stored carbon (ACT NRMC 2009).

Catchment management

Effective catchment management - that is, management and enhancement of the land, water and related biological resources across a catchment - should minimise the risks of erosion, salinisation and other forms of land degradation, and enable rehabilitation of degraded land.

The previous ACT State of the Environment report recommended the development of an integrated management policy and strategy for ACT water supply catchments. There is action on data collection, research and monitoring, but an overarching coordination strategy is still not in place. The ACT Government's *Think water, act water* strategy (ACT Government 2004) is currently under revision, and it would be appropriate for the revised strategy to provide guidance and a framework for coordinating research, data and reporting to strengthen catchment management.

Since 2008, catchment management activities in the ACT have included rehabilitation of the lower Cotter catchment and initiation of restoration work on a reach of the Upper Murrumbidgee, as well as numerous smaller projects.

In the lower Cotter catchment, as recommended in the previous ACT State of the Environment Report, rehabilitation has continued. Over 3500 hectares of former pine plantation, destroyed by bushfire, have been planted to native vegetation in one of the largest land rehabilitation projects undertaken in Australia. The project aims to control weeds such as pine wildlings and blackberry, replant native vegetation, manage fire risk, and monitor and promote natural regeneration. Native vegetation has been identified as the most desirable land use within the catchment, helping to improve soil stability and minimise erosion risk. Pine plantations are less desirable because of the disturbance needed to either harvest the mature trees and replant, or clear and replant trees after fire (TAMS 2006).

Roads and trails across the lower Cotter Catchment were identified as sites where of erosion could provide sediment to watercourses and eventually to the Cotter Reservoir (TAMS 2006). Many of the roads and trails no longer required for management of the pine plantation have now been closed and rehabilitated. The remaining roads, needed for land and fire management, have been upgraded to a high standard to minimise the risk of erosion.

The Upper Murrumbidgee Demonstration Reach (UMDR) initiative (see *Rivers, lakes and wetlands health* indicator cluster) is one of a number of other relevant catchment management projects undertaken during the reporting period. Projects undertaken as part of the Australian Government's Caring for our Country program, include:

- Murrumbidgee Catchment Management Authority - Ecosystems: Murray Mouth to Mountains Climate Change Corridors. This project seeks to enhance and protect terrestrial and riverine vegetation. The project will connect ecosystems to support healthier riverine environments, maintain ecological processes, enhance migration opportunities for flora and fauna and improve key habitat for threatened and endangered species in an effort to build resilience in the face of climate change.
- Rural Landholders Association with Molonglo Catchment Group - Sustainable Farming in the Majura Valley. This project seeks to engage the local farming community to adopt sustainable farming practices, and reduce impacts on the surrounding environment, such as the local rivers and riparian zones.
- Ginninderra Catchment Group - Welcome to your Catchment information brochure. This project provides information and material on local catchment issues and community groups. The project targets new urban development suburbs in the lower Ginninderra catchment.

These projects aim to improve land health within the ACT, and minimise the risk of soil erosion, salinity and acidity.

Community groups also play a significant role in the monitoring and management of lakes, rivers and catchments in the ACT (see *Community engagement* indicator cluster in the *People* theme for more information). For example:

- ACT Catchment Groups, including Molonglo Catchment Group, Ginninderra Catchment Group and the Southern ACT Catchment Group, provide a network to support local community groups and oversee both waterway and land-based conservation and restoration in the catchment;
- Parkcare and Landcare groups undertake management and conservation activities including weeding, planting, erosion control and monitoring of condition in nature reserves;
- Frogwatch volunteers undertake frog monitoring, protection and conservation of frog habitats; and
- ACT Waterwatch raises awareness, monitors and conserves ACT waterways.

Natural Resource Management (NRM)

A number of NRM actions have been undertaken during the reporting period. The ACT Natural Resource Management Council, a non-statutory advisory body to the ACT Environment Minister, prepared a Natural Resource Management Plan for the ACT, *Bush Capital Legacy: Plan for managing the natural resources of the ACT*. It was released in 2009 and proposes a set of aspirational targets, both short- and long-term, to guide action to combat a number of issues threatening natural resources in the ACT (ACT NRMC 2009). The targets focus on community, land, water and biodiversity. Those relating to land health are shown in Table 2.

Table 2. ACT NRM targets on land health

Type	Timeframe	Target
Land Targets		
Urban land health	Intermediate	Achievement of urban soil health at above the average for large Australian cities and preservation of vegetation cover on buffer land (2015)
	Long-term	Maintenance of urban soil health at above the average for large Australian cities (to 2030)
Rural land health	Intermediate	80% of rural land meets the top standard for land health in relation to land capability (2015)
	Long-term	95% of rural land consistently meets the top standard for land health in relation to land capability (2030)

Adapted from: ACT NRMC 2009

A landscape analysis (Sharp 2011) was completed for the report Canberra Nature Park (nature reserves); Molonglo River Corridor (nature reserves) and Googong Foreshores (OCSE 2011a). The analysis identified a number of actions that would improve landscape function, including

- preparation and implementation of reserve specific Nature Reserve Operational Plans;
- monitoring of landscape function at prioritised locations;
- reduction of grazing pressure;
- a review of bushfire control measures in selected reserves;
- revegetation using shrubs, trees and perennial ground cover;
- weed control;
- incorporation of leaky rock weirs, branch erosion traps and coarse woody habitat in selected locations;
- promotion of visitor use while minimising impacts; and
- control of the impacts of infrastructure maintenance within reserves.

Further information on conservation and protected areas management is provided in the *Ecological communities* indicator cluster in the *Biodiversity* theme.

Licensing and administration can affect achievement of ACT NRM Plan targets. Leasing and ownership arrangements for land management in the ACT can lead to detrimental outcomes for land health. The *Investigation into ACT Lowland Native Grasslands* (OCSE 2009) identified complexity in the administration and enforcement of land management agreements in the ACT, which led to grassland areas not being

managed effectively (OCSE 2009). The ACT Government has reviewed provisions for agistment licences, which resulted in all new licences and all reviewed licences being changed to provide for a common seven-day termination provision. The only licences being left with longer termination provisions are those managed under a land management type agreement. They have also worked to strengthen provisions around grazing on rural lease and licence areas containing high conservation grasslands (OCSE 2011b).

Continual monitoring, and improvement of administration and enforcement of land management agreements to ensure appropriate protection of high value conservation or riparian areas, would be beneficial. Recent reports on riparian areas and their vegetation and management across the ACT (Johnston et al. 2009, Ishiyama et al. 2010) found the condition of riparian areas was largely dependent on surrounding land uses. (For more information see the *Rivers, Lakes and wetlands health* indicator cluster)

Soil management

As identified in previous ACT State of the Environment reports, there is limited soil management activity in the ACT, although groups such as landcare, members of the community are addressing soil management by undertaking work to improve topsoil and reduce erosion in small dispersed areas across Canberra. Soil management challenges include increasing soil permeability, structural stability, nutrient cycling, moisture holding capacity and storage of soil carbon, as well as reducing soil erosion and loss of topsoil, and enhancing hydrological connectivity (ACT NRMC 2009).

ACT Landcare has held a number of soil carbon workshops for land managers during the last few years (ACT Landcare 2011). The workshops provide information about managing soil through managing vegetative cover and water resources and through monitoring and reporting for the carbon market.

Contaminated site management

The *ACT Strategic Plan 1995: Contaminated Sites Management* (ACT Government 1995) provides for the investigation, management and, where necessary, remediation of contaminated land; that is, land that poses a risk to either human health or the environment.

The principal legislation for the regulation of contaminated sites management in the ACT is the *Environment Protection Act 1997*. The Act is supported by the ACT Environment Protection Authority (EPA) via the *Contaminated Sites Environment Protection Policy* (EPP) (EPA 2009), which contains information and policies relating to the assessment and remediation (including management) of contaminated land,

with the aim of minimising the risk of adverse impacts from contaminated land on the environment and human health. The EPP endorses the use of a number of guidelines for the assessment and remediation of contaminated sites, including the *Assessment of Sites Contamination 1999 National Environment Protection Measure* (NEPC 1999), which is the principal national guidance for assessing contaminated sites.

The ACT legislation implements the polluter-pays principle, whereby the polluter of the land pays for the clean up costs where possible. However, in many cases the polluter is no longer identifiable, and the land owner, often the ACT Government, is required to pay for the investigation and remediation of the contaminated site.

In total, 110 contaminated sites were assessed, remediated where required, and found suitable for their proposed or permitted land use under the Territory Plan during the reporting period. Of these, 23 sites were independently audited: 11 related to fuel storage, 5 located in the Kingston Foreshore development site, 2 sheep dip sites, 2 defence sites, 1 former timber mill site, 1 former abattoir site and 1 former uncontrolled fill site. The other 87 sites were audited by the EPA: most were associated with redevelopment, minor fuel storage, uncontrolled fill, or greenfield development.

Two additional sites where groundwater is contaminated have been identified since the last reporting period. These were both former service station sites in Braddon that are being redeveloped.

All sites with groundwater impacts are being actively monitored and managed. They include three landfill sites at West Belconnen, Mugga Lane and Stromlo, and one site with chromium contamination at Hume.

As identified in the previous ACT State of the Environment Report, there is a hydrocarbon plume present in groundwater to the east of the intersection of the Bunda and Mort streets in the City. During the reporting period the ACT Government undertook intensive remediation of site in this area.

Soil contaminated with hydrocarbons, in the ACT, is transported to a landfarming facility the ACT Government has established at the West Belconnen landfill site. Landfarming offers sustainable remediation of the contaminated soil, with a high level of environmental control (AES 2011).

In 2010, the ACT Government released a number of Information Sheets for Contaminated Sites to help Canberrans identify and manage the issue within the ACT:

- Information Sheet 1 - Contaminated Sites: Decommissioning, Assessment and Audit of Sites Containing Above Ground or Underground Fuel Storage Tanks;
- Information Sheet 2 - Contaminated Sites: Requirements for the Assessment and Validation of Former Service Station Sites in the ACT;
- Information Sheet 3 - Contaminated Sites: Requirements for the Assessment and Validation of Sites Containing Above Ground or Underground Fuel Storage Tanks in the ACT;
- Information Sheet 4 - Contaminated Sites: Requirements for Re-use and Disposal of Contaminated Soil;
- Information Sheet 5 - Contaminated Sites: Requirements for Transport and Disposal of Asbestos Contaminated Wastes; and
- Information Sheet 6 - Contaminated Sites: Management of Small Scale, Low Risk Soil Asbestos Contamination.

Glossary

Contaminated site: a site at which a hazardous substance occurs at concentrations above background levels and where assessment indicates it poses, or could pose if land use is changed, an immediate or long-term risk of harm to human health or the environment.

Ecosystem services: the benefits people obtain from ecosystems. These include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, such as spiritual, recreational and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Landfarming: a particular bioremediation technique that degrades, transforms, and immobilises hydrocarbons by use of microbiological processes and oxidation.

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

Environment Protection Authority (EPA) – now part of Environment and Sustainable Development Directorate (ESDD)

ACT Department of Territory and Municipal Services (TAMS) – now Territory and Municipal Services Directorate (TAMSD)

ACT State of the Environment Report 2011

THEME: Land and Water

Indicator cluster: Rivers, lakes and wetlands health

The Rivers, lakes and wetlands health indicator cluster reports on eight indicators, including:

- *Ecological health of streams, wetlands and rivers* (C) - broad measures of stream, wetland and river health;
- *Riparian and aquatic condition* (C) - broad measures of riparian and aquatic condition;
- *Urban wetlands* (C) - number, size, condition and influence of the wetlands on water quality;
- *Surface-water-dependent ecosystems* (C) - broad measures drawing on riparian condition, nature of species and ecological communities;
- *Stormwater discharges* (P) - non-point source discharges, including pervious and impervious surface areas;
- *Water management* (R) - effectiveness of water management for maintaining and enhancing catchment and river health;
- *Riparian management* (R) - effectiveness of riparian management for maintaining and enhancing catchment and river health; and
- *Urban wetland management* (R) - effectiveness of urban wetland management.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

During 2007-2011, the condition of the ACT's rivers, lakes and wetlands has been affected by a continuation of the drought observed in the previous reporting period, and more recently by significant rainfall in 2010 and 2011. Rivers in the Canberra area are either severely impaired or moderately impaired in their ecological health, and only those creeks running out of forested areas, and the Murrumbidgee River as it enters the ACT, have ecological health corresponding to their historical condition.

Management of wetlands health is challenged by the apparent individuality of each wetland (Johnston et al. 2009). Although 13 ACT wetlands are listed in the *Directory of Important Wetlands in Australia* (DSEWPaC 2009), information on the health of these wetlands is patchy. Urban wetlands have been constructed to improve the quality of stormwater by slowing the flow of water, to allow suspended solids to settle and to bind and remove phosphorus and nitrogen before the water is discharged.

Over the last 10 years, Canberra's lakes have been closed increasingly often, because of either faecal contamination or potentially toxic blue-green algae in the water. Greater focus is needed on the management of ACT lakes to improve water quality and lake health. An investigation into the state of the waterways associated with Lake Burley Griffin, recently begun by the Office of the Commissioner for Sustainability and the Environment, is likely to provide some guidance on improving the management of the waterways and catchment health for that lake.

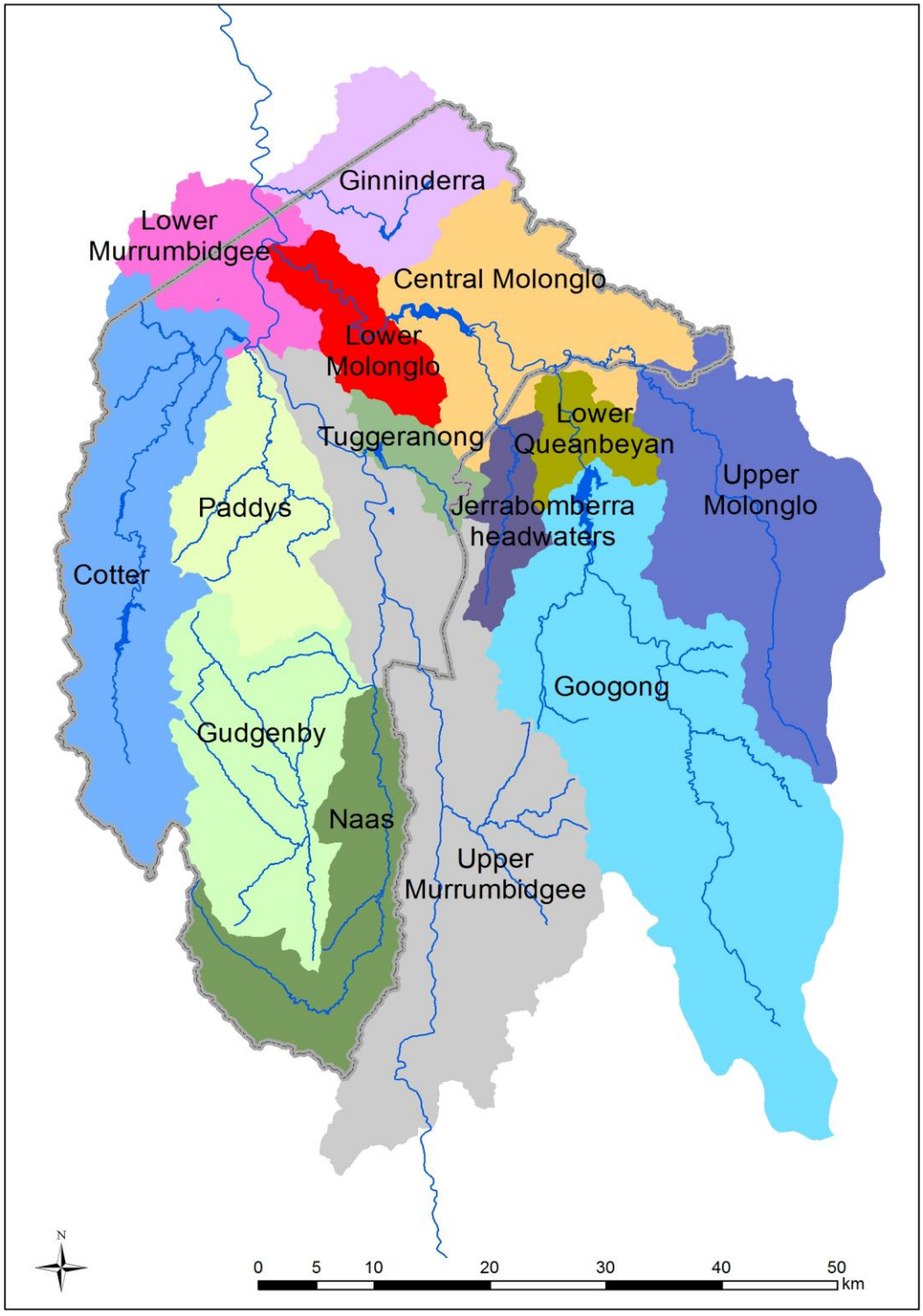
Introduction

Rivers, lakes and wetlands in the ACT are highly valued for their biodiversity, water supply, recreation, irrigation, aesthetic and cultural values. These waterways and waterbodies support native species and ecosystems, and contribute to community wellbeing and the ACT economy. The ecological condition, or 'health', of these waters can be affected by sediment and nutrients in runoff, chemical pollution, habitat degradation and river regulation. With the exception of river regulation, those pressures are all directly related to land use practices within a catchment. The indicator cluster describes these pressures and the management approaches undertaken in the ACT in response to maintain and enhance catchments and river, lake and wetlands health.

The major rivers flowing through the ACT are the Murrumbidgee River and tributaries of it. The Murrumbidgee originates in the alpine area to the south of the ACT and flows through the southern part of the ACT to eventually meet the River Murray in western NSW. Major tributaries include the Molonglo River (in the east of the ACT), the Cotter River (in the west of the ACT) and the Naas River (in southern ACT). The tributaries and subcatchments of the Molonglo River drain much of northern ACT.

The ACT is entirely in the Murray-Darling Basin (the Basin), and therefore land and water management in the ACT are subject to the stream salinity targets established as a part of the *Murray-Darling Basin Salinity Management Strategy (2001-2015)* (MDBC 2007). The ACT also includes 12 water management areas established under the ACT *Water Resources Act 2007* and Regulations (see Figure 1).

Figure 1. ACT water management areas



Source: DECCEW 2010

Condition indicators

Ecological health of streams, wetlands and rivers

Ecologically healthy waterways are critical to the maintenance of good water quality. They provide a number of ecosystem services, and they also support recreation, potable water supply and other uses.

During the reporting period there have been two distinct weather phases. The first phase, from 2007 to May 2010, was dominated by continued drought; the second phase, from June 2010 to June 2011, was associated with a break in the drought and above average rainfall (BoM 2011). Both these phases have affected the water quality within the Murrumbidgee catchment (see *Water quality* indicator cluster).

The prolonged drought over the last decade had a significant effect on the ecological health of waterways in ACT. An audit to assess the ecological health of rivers in the Basin during 2004-2007 found the Murrumbidgee River Catchment was generally in "very poor" condition (MDBA 2008). However, significant rainfall in 2010 and 2011 is likely to have had beneficial consequences for waterway health.

The Upper Murrumbidgee River and its tributaries are subject to stresses as a result of:

- diversion of natural flow by Tantangara Dam, upstream of the ACT;
- land clearing for agriculture, which results in increased runoff and erosion during storms;
- increased stormwater flows caused by urban development in Canberra and other municipal centres outside of the ACT, such as Queanbeyan and Cooma;
- bushfires, like the January 2003 bushfire, which result in increased transport of sediment and nutrients in runoff from the catchment;
- drought, which reduces runoff and river flow; and
- predicted long-term impacts from climate change.

Riparian and aquatic condition

A riparian zone is defined as "the area from the water's edge (under baseflow conditions) to a distance from the bank where the stream still interacts with and influences the type and density of the bank-side vegetation" (Nichols et al. 2000). Riparian vegetation influences the stream and in-stream ecology in a number of ways, including supplying nutrients (e.g. through leaf fall), filtering out sediments from runoff, stabilising the river bank and providing in-stream habitat (e.g. tree

roots, fallen logs, shaded areas). A healthy riverine system and associated riparian zones provide habitat and food sources for aquatic biodiversity.

In the ACT, the distribution, condition and management needs of riparian vegetation of the Murrumbidgee River have been assessed in two recent reports. These reports have created a condition assessment benchmark and management guidance for the Murrumbidgee (Johnston et al. 2009) and its major tributaries the Naas, Cotter and Molonglo rivers and their tributaries the Gudgenby and Paddys rivers (Ishiyama et al. 2010). The reports found riparian zones across the ACT are diverse, and their ecological health is largely dependent on surrounding land uses.

In summary, these studies identified that:

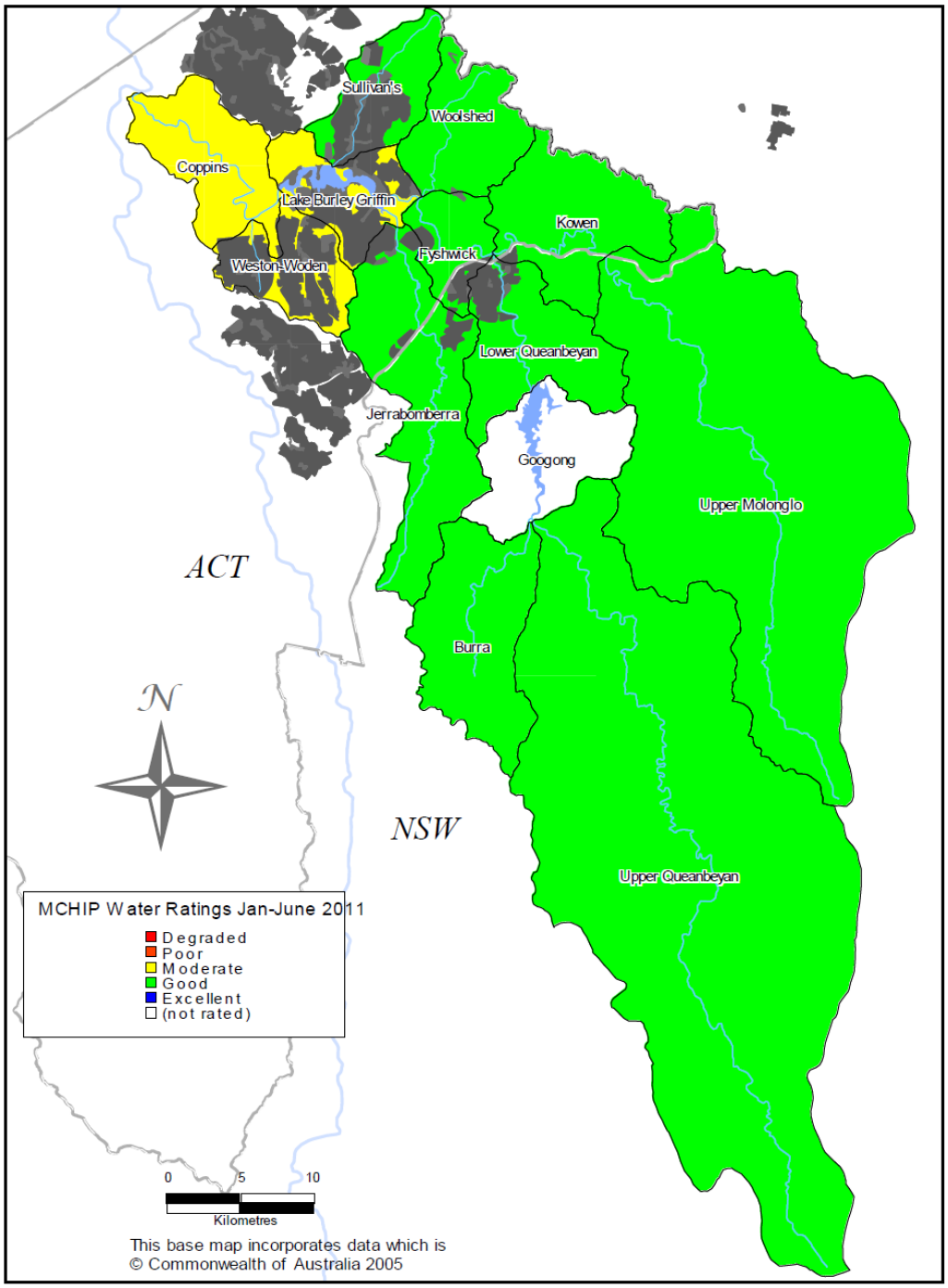
- the state of the riparian zone vegetation in the ACT section of the Murrumbidgee River was variable but overall assessed as poor, with Gigerline and Red Rocks Gorges containing the best examples of riparian shrubland (Johnston et al. 2009);
- the Ribbon Gum riparian woodland that used to occur between Angle and Point Hut crossings is now almost extinct within the ACT and in urgent need of protection and enhancement (Johnston et al. 2009);
- she-oak riparian woodland downstream of Point Hut Crossing has reduced in area, largely from the effects of the 2003 bushfire, and low soil-moisture conditions during the drought and reduced river flows have probably inhibited she-oak regeneration across the riparian floodplain areas that are not in close proximity to the moist riverbanks (Johnston et al. 2009);
- most of the Murrumbidgee riparian zones, other than where rocky substrates predominate, were found to contain a very high cover and abundance of weeds; the reduction of naturally occurring overhead tree and shrub canopy from land clearing and fire has also allowed many of the weed species to become dominant on the alluvial substrates (Johnston et al. 2009);
- the major portion of the Naas River is protected within Namadgi National Park, and riparian vegetation there is in moderately good condition; in downstream rural areas, native vegetation in riparian and floodplain areas has largely been removed (Ishiyama et al. 2010);
- the upper part of the Gudgenby River has areas with limited human access and is in good condition; the lower reaches of the river are in moderate condition overall, but there are degraded sections with significant management issues such as weed infestation and gully erosion (Ishiyama et al. 2010);

- overall, the vegetation communities of the Paddys River were in moderate to poor condition, and have been heavily affected by rural land use, plantation forestry, recreational use, drought, and the 2003 bushfire (Ishiyama et al. 2010);
- the condition of the Cotter River was extremely good in Namadgi National Park, but poorer in the former softwood plantation area of the lower Cotter (Ishiyama et al. 2010);
- the Molonglo River has been substantially modified since European settlement and there is no, or minimal, native vegetation in the most degraded areas (Ishiyama et al. 2010).

Complementing those reports is the latest (January-June 2011) catchment health assessment by Waterwatch volunteers for the Molonglo River catchment, reported in the *Molonglo Catchment Health indicator Program* (MCHiP) *Report* (Skinner 2011). The assessments are derived from sampling of the river waters and observations of the catchment land uses, rather than from its riparian zones.

Figure 2 shows that the ecological health of nearly all the Molonglo sub-catchments was in the 'good' range when assessed, and that catchment health overall is heading towards the moderate range (Figure 2). This assessment is based on the group's own 'MCHiP' rating, which determines a long-term average score for pH, electrical conductivity, turbidity, dissolved oxygen, phosphorus, nitrate, macroinvertebrate samples and landscape attributes, at a number of sites (Skinner 2011).

Figure 2. Catchment health for the Molonglo Catchment, January-June 2011 MCHiP ratings



Source: Skinner 2011

River health

The health of ACT surface waters is generally determined through assessments of the waters' biotic condition, using the Australian River Assessment System (AUSRIVAS). Via AUSRIVAS, samples of riverine aquatic macroinvertebrates (mainly insect larvae that live in rivers) are examined using nationally standardised methods and analysis protocols to provide information about river health (Gray 2004).

Macroinvertebrates are sensitive to water quality, habitat degradation and other changes in the aquatic environments, and therefore provide an 'integrated' indicator of human effects on the stream ecosystem.

Samples of macroinvertebrates are collected from riffles and stream edges, and the organisms are identified. The range of macroinvertebrates found at the site is compared with the indicator macroinvertebrate families expected to be found there (reference condition). The rating system for AUSRIVAS is shown in Annex 1, Table A1.

In the ACT, AUSRIVAS sampling is biannual, in spring and autumn of each year. DECCEW (2010) reports on 3 baseline assessment sites (shown in bold italics in Annex 1, Table A2) and 10 other assessment sites within the ACT. Each of these sites was selected based on the potentials for impact from the surrounding catchment, such as rural or urban runoff, discharge from sewage treatment plants, habitat degradation and river regulation (DECCEW 2010).

The condition of waterways in the Canberra area is evenly split between severely impaired (rated C or D in Table A2) and moderately impaired (rated B), with only the creeks running out of the forested areas, and the Murrumbidgee itself as it enters the ACT, having health corresponding to the reference condition. Nowhere in the ACT do the waterways exceed the reference condition.

Changes in fish populations can also be assessed as an indicator of river health. The populations of Two-spined Blackfish (*Gadopsis bispinosus*) and Macquarie Perch (*Macquaria australasica*) in the lower Cotter River (below Bendora Dam) appear to be recovering, indicating improvements in habitat quality at regulated sites following the 2003 fires. This is likely to result from environmental flow releases mitigating the effects of the drought (DECCEW 2010). The population of Macquarie Perch in the Queanbeyan River has dropped to below detectable limits, possibly as a result of the drought and the potentially poor genetic health of the population. For more information on fish status see the *Fauna* indicator cluster paper (*Biodiversity* theme). Despite the good biodiversity of native fish species, European Carp (*Cyprinus carpio*) continue to make up 80-90% of fish biomass in the Murrumbidgee River within the ACT (DECCEW 2010).

Lake health

The drought over the past decade, as well as the significant rainfall since mid 2010, has also affected the water quality in the lakes of the ACT. Over the last 10 years, Canberra's lakes have been closed increasingly often, because of either faecal contamination or potentially toxic blue-green algae in the water. The contamination

may be related to Canberra's growth which has enlarged the urban areas draining into the lakes.

During the reporting period, ACT lakes and waterways experienced a number of outbreaks of blue-green algae, resulting in lake closures in order to minimise risks to the health of recreational users. Lake Tuggeranong has had a high-level or extreme-level alert every summer from 2007 to 2011, while Lake Ginninderra and the Molonglo Water Ski Area have experienced algal blooms less frequently. In most cases in the ACT during the reporting period, the high to extreme alerts occurred in the summer months. This is when recreation would be expected to be highest.

Algal blooms can have an impact on the ecosystem health of ACT's waterways, which also provide a number of important ecosystem values, wildlife habitat (see *Fauna* indicator cluster) and visual and recreational amenity. More information on algal blooms is provided in the *Water quality* indicator cluster.

Wetland health

Wetlands can provide many important benefits to the surrounding environment, including:

- improved water quality;
- flood protection;
- aquatic habitat; and
- stormwater harvesting.

Natural wetlands

Thirteen wetlands in the ACT are listed in the *Directory of Important Wetlands in Australia* (DSEWPaC 2009). Of these, the Ginini Flats Wetland Complex (made up of a series of interconnected flats known as Ginini Flats and Cheyenne Flats) in Namadgi National Park is listed as a Ramsar site. Ramsar wetlands are internationally recognised under the *Convention on Wetlands of International Importance* (DSEWPaC 2011a) for the conservation and sustainable utilisation of wetlands. Information on the health of these wetlands is patchy with few projects surveying their riparian health and water quality.

The ACT *Sphagnum* bogs, such as those at Ginini and Cheyenne Flats in upstream parts of the Cotter River catchment, are important because they provide water filtering, groundwater storage and release of water to maintain stream flow into Canberra's domestic supply (Macdonald 2009). These bog communities are also critical habitats for species such as the endangered Northern Corroboree Frog and

rare Broad-toothed Rat. Rehabilitation of a number of the *Sphagnum* bogs burnt in the 2003 fires has been carried out (Macdonald 2009). Previous rehabilitation assessments suggest that it may take 20-30 years for full recovery of bog functionality to occur (Macdonald 2009). Overall, it has been observed that the *Sphagnum* bogs are showing good post-fire recovery. This is particularly evident where restoration efforts have been targeted. The recovery is being recorded through an ongoing photo-monitoring program in selected bog systems.

The larger urban wetlands, such as Point Hut Pond, Gungahlin Pond, Yerrabi Pond and Flemington Road Pond are regularly monitored by the ACT Government. As with other lakes and ponds, data indicates high chlorophyll 'a' levels especially in warmer months. Chlorophyll 'a' is an indicator for all of the algal organisms present in aquatic ecosystems. Of these algal organisms, the organisms of most concern are blue-green algae, or *cyanobacteria.* See the *Water quality* indicator cluster for more information.

The ACT Murrumbidgee River Corridor contains three significant groups of wetlands (Johnston et al. 2009):

- perched off-stream wetlands in the Gigerline Gorge ;
- smaller specialised perched wetlands in Red Rocks Gorge; and
- a wetlands complex at Woodstock Reserve.

These wetlands are important habitats for aquatic and semi-aquatic vegetation assemblages either found only in those areas or with limited distribution in the ACT (Johnston et al. 2009). The main threats to the health of these wetlands ecosystems are flow management and invasion by exotic and native plant species.

Constructed wetlands

Canberra's large urban wetlands, such as Point Hut Pond, Gungahlin Pond, Yerrabi Pond and Flemington Road Pond, are regularly monitored by ACT Government staff. As with other lakes and ponds, data indicate high chlorophyll 'a' levels especially in warm months. Chlorophyll 'a' is an indicator for all of the algal organisms present in aquatic ecosystems. Of these algal organisms, the organisms of most concern are blue-green algae, or cyanobacteria. See the *Water quality* indicator cluster for more information.

A number of new artificial wetlands have been constructed over the reporting period as a part of the urban stormwater drainage system in the ACT, including:

- Flemington Road Ponds, Mitchell (constructed 2009);

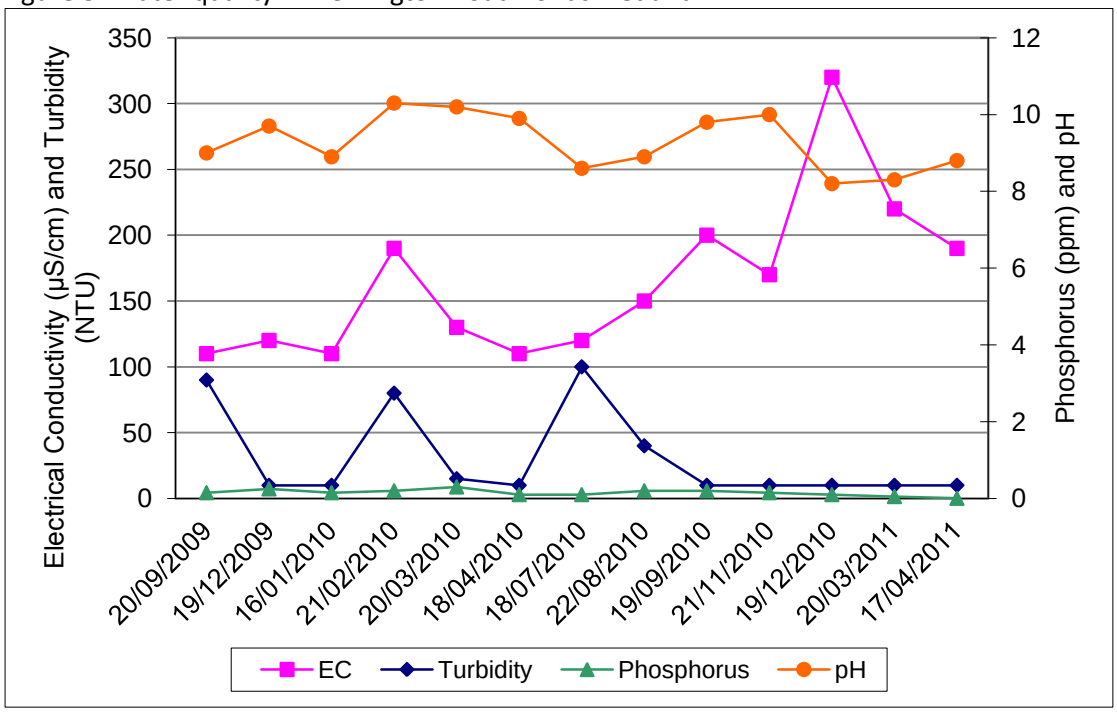
- Banksia St, O'Connor (constructed 2010); and
- Dickson and Lyneham wetlands (construction commenced September 2010).

Urban wetlands have been constructed to improve the quality of stormwater by slowing the flow of water (relative to its pace in concrete channels) to allow suspended solids to settle. Wetlands plants also bind phosphorus and nitrogen in the stormwater, removing these contaminants before the water is discharged (DECCEW 2011). As a result, the stormwater has better quality when it leaves the wetlands than when it entered.

Recently constructed wetlands are part of a project to enhance the ecosystem health and water quality of the Sullivans Creek concrete channel, which flows into Lake Burley Griffin. As yet, there is limited information available on the condition of these wetlands and their impact on water quality within the ACT. Further constructed wetlands are planned for Gungahlin in 2010-2012. Water quality in Sullivan's Creek was reported, in the latest *Molonglo Catchment Health indicator Program Report* (January-June 2011, Skinner 2011), as remaining poor because of either weather or the on-going construction of the Lyneham ponds. The percentage saturation of dissolved oxygen rarely approached levels that would encourage the reappearance of historically-good frog populations (Skinner 2011).

At the Flemington Road Ponds wetland, the Molonglo Catchment Waterwatch teams have sampled water quality since their construction in 2009. The measured water quality characteristics are shown in Figure 3. The large variations in the pH, electrical conductivity and turbidity of the water were attributed to the wetland base settling after construction, and to significant inflows of stormwater into the wetland (DECCEW 2010). There have been reports of algal growth in the wetlands in November 2009, February 2010 and early 2011.

Figure 3. Water quality in Flemington Road Ponds wetland



Source: MCG 2011

Note: Legislated water quality standards for these parameters are: Phosphorus 0.1 mg/L; Turbidity below 30 NTU; pH between 6 and 9. There are no standards set for electrical conductivity.

Pressure indicators

Stormwater discharges

River, lake and wetland health can come under pressure from non-point source pollution and discharges into the waterways. Non-point source pollution is discharge to a waterway that does not come from one identifiable location: for example, runoff from diffuse agricultural and urban sources, rather than from a single outlet.

In the ACT the land uses include forestry plantations, agriculture, urban and industrial, and conservation. Land use influences the types of substances that are transported and discharged into waterways by runoff following rain events. For example, in native forested mountain catchments, runoff generally contains small amounts of sediment and nutrients, whereas the runoff from agricultural, industrial or urban land contains relatively large amounts of sediment and nutrients, as well as other contaminants such as heavy metals and hydrocarbons.

There are limited data available on the quantity and quality of non-point source discharges into the ACT's waterways. However, as a result of the drought and water conservation measures, there has been a decrease in runoff generated from various

land uses in the ACT. This is likely to have reduced the volume of water discharged into the waterways over the reporting period.

Impact indicators

There are no specific impact indicators for the Rivers, lakes and wetlands health indicator cluster. However, this indicator cluster highlights the importance of good catchment management both for the enhancement and protection of species and ecosystems, and for the use of waterways for recreation and production.

Contaminants from human activities impact negatively on river health. Pollutants, including phosphorus, nitrogen, sediment, salt, heavy metals and pesticides, can enter rivers with stormwater runoff and affect the short-term or long-term health of a river, lake or wetland. For example, in Lake Burley Griffin, water quality can be significantly impaired by urban land uses that provide large amounts of sediment and nutrients to the water body. These nutrients can lead to an increased risk of algal blooms within the lake. For further information see the *Water quality* indicator cluster. The Lower Molonglo Water Quality Control Centre is the largest potential point source of pollutants to the Territory's rivers, and the Queanbeyan Sewage Treatment Plant is also a potential point source (see *Water quality* indicator cluster for more information).

As in the previous reporting period, increasing urban development of greenfield sites continues to alter the hydrology of these areas, with impacts on associated sub-catchments and catchments. The Australian Natural Resource Atlas (2009) suggests that over 4 million tonnes of sediment annually is delivered to the Murrumbidgee River from its catchment, which includes the ACT. Most of this sediment entering the Murrumbidgee is contributed from gully erosion (51%), much of which occurs upstream of the ACT (ANRA 2009).

Climate change is predicted to have a substantial impact on river, lake and wetland health, through increasing temperatures, decreasing stream flows and causing more extreme events, such as bushfires (Climate Commission 2011). These can potentially have a profound impact on waterway health. For further information on predicted climate change impacts refer to the *Climate vulnerability* indicator cluster.

Response indicators

Water management

Catchments and waterways in the ACT are managed by Government agencies through catchment management that incorporates planning, development controls,

restrictions and regulations on water extraction, licensing discharges, and managing erosion and sediment. The success of the integrated approach relies on the cooperation and coordination of community groups and of the differing agencies responsible for specific components of water management. This can be problematic.

Over the previous reporting period, to June 2007, catchment and river health were still affected by the 2003 bushfires. For the ACT catchments, recovery from fire effects has been a priority. However, low soil moisture content as a result of the drought was a major constraint to the re-establishment of vegetation, until the significant rainfall that occurred during 2010 and 2011. Vegetation recovery within the catchments has been enhanced by the rain and will contribute to improving catchment and river health within the ACT.

A number of projects have been undertaken over the reporting period 2007-2011 to improve catchment and river health. Restoration of the Lower Cotter Catchment, a project which began in 2008 with the aim of achieving clean water and a healthy vegetated landscape in the Lower Cotter Catchment, has so far made a substantial improvement to the lower catchment. The project incorporates a number of actions to improve waterway health, including planting native trees and removing pine tree saplings from the ex-plantation areas, erosion control works, and creation and restoration of recreation areas (DECCEW 2010). A number of stakeholders are delivering these projects through partnerships between agencies and community groups.

Community-based catchment groups in the ACT are funded by the ACT NRM Council, the regional Natural Resource Management body. The funds allow each group to employ a catchment coordinator and a part-time Waterwatch coordinator, and also cover program and administration expenses. These groups coordinate the community-based water-quality monitoring for each catchment, as a part of the Waterwatch program. The Waterwatch program is an environmental education and awareness program that encourages and supports the local community to take responsibility for improving the quality of water throughout the upper Murrumbidgee catchment.

This funding has also helped to implement a number of catchment-management and waterway-protection projects over the reporting period (see the *Community engagement* indicator cluster for more information). For example, the Molonglo Catchment Group, in partnership with other agencies, implemented a Molonglo River Rescue project, which seeks to improve critical aquatic habitats in the Molonglo River and limit threats to the ecosystem (MCG 2010). The project was implemented as a part of the Australian Government's Caring for Our Country program.

A number of other catchment-management projects were funded in the ACT as a part of the Caring for Our Country program. These projects are outlined in the *Land health* indicator cluster. All these projects are diverse in nature; most importantly, they engage the local community in the environment and waterway health. The projects help to improve the overall waterway and catchment health in the ACT and collect information that is incorporated into the annual *ACT Water Reports*.

The *Source Water Protection Program* (SWPP) is a 5-year program funded by ACTEW Corporation. It aims to raise awareness that protecting water supply catchments is an important and efficient means of minimising the risk to drinking water quality. The SWPP supports activities, policies and programs that will assist in achieving these goals, and includes an education and awareness component and a grants and incentive scheme (ACTEW 2011).

The first two years of the program have improved understanding of current catchment health. Research has been documenting the condition, status, hazards and risks across the major catchments. These include potential sources of contamination, land use activities, and areas of environmental degradation that may contribute sediment and turbidity to the waterways (ActewAGL 2010).

A number of turbidity events in 2008 and 2009 in reaches of the upper Murrumbidgee River were the catalyst for various organisations to come together to discuss how the health of the river can be improved. The Upper Murrumbidgee Catchment Coordinating Committee (UMCCC) hosted a meeting of organisations with an interest in the Murrumbidgee River in April 2009. The partner organisations are: Australian and NSW Governments, Murrumbidgee Catchment Management Authority, ActewAGL, ACTEW Corporation, ACT NRM Council, UMCCC and Upper Murrumbidgee Waterwatch.

This group of organisations pooled resources and funding in 2011 to commence the development of the Actions for Clean Water (ACWa) Project. The ACWa Project, to be completed by March 2012, will identify strategies to enhance surface water quality and reduce turbidity in the Murrumbidgee River upstream of the confluence of the Murrumbidgee and Cotter rivers, across NSW and the ACT. The collaborative project will undertake all work necessary to develop a plan of action in 1-, 3- and 10-year time frames. Actions may include on-ground works, education, promotion, and development of policy and programs by the private sector, government organisations and individuals (MCMA 2011).

An investigation into the state of Lake Burley Griffin's waterways, by the Office of the Commissioner for Sustainability and the Environment commenced in June 2011.

This investigation is likely to have an impact on the management of the waterways and catchment health for Lake Burley Griffin for improved water quality.

Riparian management

In 2007 the ACT Government implemented the *ACT Aquatic Species and Riparian Zone Conservation Strategy* (TAMS 2007), which is intended to take an integrated approach to the management and protection of rivers and riparian zones. The Strategy seeks to maintain and improve the integrity of the rivers and riparian zones and acts as the statutory action plan for riparian and aquatic threatened species. Key considerations include:

- the need for improvements in the knowledge of vegetation and habitat in riparian zones;
- recovery of riparian areas severely affected by the January 2003 bushfires;
- protection of the river corridors from the effects of existing and proposed urban development, possible expansion of recreational infrastructure, and other threats such as inappropriate grazing regimes;
- restoration of riparian habitat including control of weed species such as willows;
- maintenance and improvement of in-stream habitat (including stream flow) and where feasible, rehabilitation of native fish populations;
- maintenance of wildlife corridors; and
- maintenance and protection of aquatic ecosystem processes and water quality.

The upper Murrumbidgee River is a high conservation value ecosystem containing critical aquatic habitats of several nationally-listed threatened species (notably Trout Cod, Murray Cod and Macquarie Perch); for example, see Table 1. Along the Murrumbidgee River, a 2009 survey of key riparian zones recommended a number of actions to enhance riparian vegetation and biodiversity. They included monitoring, protection and re-establishment of native vegetation, weed management, full wetland appraisals, and management and careful planning of water resource allocations (Johnston et al. 2009). These recommendations should be integrated into management of the Murrumbidgee River corridor and the *ACT Aquatic Species and Riparian Zone Conservation Strategy*.

Table 1. Six declared threatened aquatic and riparian species in ACT

Species / Ecological community	Status
Two-spined Blackfish (*Gadopsis bispinosus*)	Vulnerable
Trout Cod (*Maccullochella macquariensis*)	Endangered (Special Protection Status)
Macquarie Perch (*Macquaria australasica*)	Endangered (Special Protection Status)
Murray River Crayfish (*Euastacus armatus*)	Vulnerable
Silver Perch (*Bidyanus bidyanus*)	Endangered
Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)	Endangered (Special Protection Status)

Source: DECCEW 2010

An initiative that began in November 2010 aims to provide the community with a visible demonstration that multiple improvements to a stretch of river can have a positive impact on river biota, particularly fish. The Upper Murrumbidgee Demonstration Reach (UMDR) initiative focuses on a reach approximately 100 km in length, extending from the rural township of Bredbo in south-eastern NSW downstream to Casuarina Sands in the ACT. The UMDR initiative involves a suite of river rehabilitation methods and complements other plans and activities that are ongoing under other programs (ACT Government 2010).

In the Cotter River catchment a number of actions have been undertaken with the aim of improving water health. The Cotter River has been recognised as a High Ecological Value Aquatic Ecosystem (HEVAE), to assist the Australian Federal Government to prioritise funding by the Caring for Our Country program. The Cotter River was recognised because it is fed by *Sphagnum* bog wetlands recognised under the Ramsar Convention and the *Environment Protection and Biodiversity Conservation Act 1999* (DSEWPaC 2011b), and it is habitat for endangered animals and plant species. The Cotter also has diverse aquatic ecosystems, and is an excellent representation of a Murray-Darling Basin upland aquatic ecosystem, with its upland bogs and fens, and small sub-alpine creeks. It is a moderate size permanent upland river with both regulated and unregulated reaches, and medium and large water-storage reservoirs.

In the lower Cotter catchment, since 2006 when the draft Strategic Management Plan for the Lower Cotter Catchment was created, a major restoration project has been rehabilitating and restoring native vegetation. The project is one of the largest land rehabilitation projects undertaken in Australia and involves the rehabilitation of over 3500 hectares of land formerly under pine plantations that were destroyed by the 2003 bushfires (see *Land health* indicator cluster for more information). Reduction of the extensive forest road network (which was identified as being a

significant contributor to stream turbidity) has been completed. Revegetation works are ongoing in areas where natural regeneration was low. There has been significant improvement in the vegetation cover of the catchment since 2003, which will contribute to reducing in-stream turbidity. Monitoring over at least a few more years should continue to detect the general trend of reduced turbidity.

Wetland management

Natural wetland management

The most significant management challenge for wetlands is the apparent individuality of each wetland (Johnston et al. 2009). Assessment of early *Sphagnum* bog recovery work indicated that previous rehabilitation of the bogs appeared to aid recovery in the vegetation at many sites; however, the integration of vegetation and subsurface peat was such that it did not withstand the 2003 fires at all sites (Macdonald 2009). Rehabilitation of a number of the *Sphagnum* bogs burnt in the 2003 fires has been carried out to prevent stream entrenchment and subsequent drainage and loss of these bogs. Trials to assess other bog rehabilitation techniques were also carried out (Macdonald 2009).

Restoring and maintaining functional bogs is not simple and is not achievable through revegetation alone. Assessment needs to focus on monitoring of recovery of bog function, not just vegetation recovery (Macdonald 2009). While current observations indicate that the *Sphagnum* bogs are showing good post-fire recovery, previous rehabilitation assessments suggest that it may take 20-30 years for full recovery of bog function (Macdonald 2009). The recovery is being recorded through an ongoing photo monitoring program in selected bog systems.

For wetlands along the Murrumbidgee River in ACT, the main issues for management are river flows and invasion by exotic and native plant species, as well as climatic conditions (Johnston et al. 2009). Environmental flows should be designed to allow the river to show both seasonal and incidental variations in flow, at a level and intensity or duration that meet the requirements of off-stream wetlands. Flows close to the calculated minimum just to keep the system alive will not allow the system to thrive, let alone refresh itself after a major perturbation, and will encourage species depletion (Johnston et al. 2009).

In the Molonglo River catchment, significant work has occurred at the Jerrabomberra Wetlands during the reporting period. The ACT Government has completed the *Jerrabomberra Wetlands Nature Reserve Plan of Management 2010*, which sets out management zones, goals, objectives and actions for the next 10 years (TAMS 2010). Work is also being undertaken to control willows and woody weeds and to follow-up revegetation works along Jerrabomberra Creek.

Recently the ACT Government has taken a new approach to conservation management. The Capital Woodland and Wetlands Conservation Trust is being established to support projects in Jerrabomberra Wetlands Nature Reserve and Mulligans Flat Woodland Sanctuary. This partnership between Government and the community has the aim of integrating private sector and community funding into conservation projects. The Trust is intended to supplement rather than replace annual government support for normal ongoing management of these areas (OCSE 2011). For more information see the *Fauna* indicator cluster paper (*Biodiversity* theme).

Constructed wetland management

In 2008, the ACT Government implemented a revised *Territory Plan* (ACT Government 2008) that includes a *WaterWays: Water Sensitive Urban Design General Code*. The code seeks to develop and manage stormwater infrastructure and water quality, including gross pollutant traps, water quality control ponds, wetlands and vegetated overland flowpaths (ACT Government 2008). The continuing implementation of Water Sensitive Urban Design within the ACT urban landscape will help improve and enhance the quality of water within the urban wetlands.

Extensive research, particularly in Canberra and Melbourne, during the 1990s, determined the principles for constructing urban wetlands that are generally effective in removing stormwater pollutants, such as suspended solids and nutrients. A major factor in determining this effectiveness is the detention time of water within the wetlands, which itself depends on the volume of water flowing into the wetland (Wong et al. 1999).

During the reporting period, the significant drought between 2007 and June 2010 (BoM 2011) resulted in limited inflows into the constructed wetlands and the likelihood of a long detention time. Since June 2010, the ACT has experienced high rainfall and a number of extreme rainfall events (BoM 2011), which are likely to have decreased the detention time and the effectiveness of these wetlands in removing sediments and nutrients from the urban stormwater (Wong et al. 1999).

Glossary

AUSRIVAS (Australian River Assessment System): a classification system that uses riverine aquatic macroinvertebrates to provide information about river health

Macroinvertebrates: animals without backbones (largely insect larvae) that are larger than ½ millimetre and live on or under rocks, logs, sediment, debris and aquatic plants

MCHiP: The Molonglo Catchment Health indicator Program (MCHIP) uses and builds on existing data sources and community-based resource assessment techniques, to enable informed decisions and a framework for future monitoring of catchment health

Riffle: in a stream, a rapid, formed by shallow broken water running over a stony bed

Turbidity: a measure of water clarity or the cloudiness of water because of the presence of suspended material, such as silt and clay

Water Sensitive Urban Design: the integration of urban planning with the management, protection and conservation of the urban water cycle that ensures urban water management is sensitive to natural hydrological and ecological processes

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACT Department of Territory and Municipal Services (TAMS) – now Territory and Municipal Services Directorate (TAMSD)

ACT State of the Environment Report 2011

Annex 1: AUSRIVAS results for the ACT

Table A1. AUSRIVAS classifications for assessment of aquatic condition

Band	Condition	Taxa interpretations
X	More Biologically Diverse than Reference	More families found than expected Potential biodiversity "hotspot" Loss of pollution tolerant taxa
A	Similar to Reference	Expected number of families
B	Significantly Impaired	Fewer families than expected - Potential impact on aquatic condition or riparian zone (habitat) resulting in a loss of families
C	Severely Impaired	Many fewer families than expected - Loss of families from substantial degradation of the aquatic condition and riparian habitat
D	Extremely Impaired	Few of the expected families - pollution tolerant families remain

Source: DECCEW 2010

Note: "Taxa interpretations" shortened

Table A2. Summary of AUSRIVAS assessment for the ACT

Site name	Spring 2005	Autumn 2006	Spring 2006	Autumn 2007	Spring 2007	Autumn 2008	Spring 2008	Autumn 2009	Spring 2009	Autumn 2010
Murrumbidgee River at Angle Crossing	***B***	***B***	***C***	***A***	***B***	***A***	***A***	***A***	***B***	***A***
Tidbinbilla River at Paddys River Road	***B***	***B***	***A***	***A***	***A***	***A***	***A***	***A***	***A***	***A***
Paddys River at Murray's Corner	***A***	***B***	***B***	***B***	***B***	***A***	***B***	***A***	***C***	***A***
Gudgenby River at Smiths Road	A	A	A	B	C	B	A	B	B	B
Tuggeranong Creek Drive	C	B	B	B	C	A	C	B	C	B
Molonglo River at Yass Road	B	B	B	B	D	B	A	B	C	B
Queanbeyan River at ACT border	C	C	C	C	C	C	D	C	B	C
Jerrabomberra Creek at Hindmarsh Drive	D	B	B	C	B	C	C	B	C	C
Yarralumla Creek at Cotter Road bridge	C	C	C	C	B	C	C	C	B	C
Ginninderra Creek at Latham	D	B	C	B	D	C	D	C	C	C
Ginninderra Creek at Baldwin Drive	D	C	C	C	C	C	C	C	C	C
Ginninderra Creek Drive	C	B	C	C	C	C	C	C	C	B
Murrumbidgee River at Halls Crossing	B	A	A	B	B	B	A	B	B	B

Source: adapted from DECCEW 2010

Note - Baseline sites are bold, italic and shaded in grey

ACT State of the Environment Report 2011

THEME: Land and Water

Indicator cluster: Water quality

This indicator cluster focuses on water quality in streams, rivers, lakes and wetlands. The indicators for this cluster are:

- *Surface water quality* (C) - broad measures of surface water quality of streams, wetlands and rivers;
- *Discharge to waters* (P) - point source discharges;
- *Algal blooms* (I) - number, area, frequency and toxicity of algal blooms;
- *Water quality and human health impacts* (I) - health impacts from poor water quality and algal blooms;
- *Effluent treatment* (R) - level of treatment of wastewater discharges and effluent water quality; and
- *Water reuse and stormwater harvesting* (R) - amount of water reuse from wastewater and stormwater harvesting.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data for the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

During the reporting period, ACT waterways were under significant stress: first because of the severe drought over the past decade that ended in 2010, and more recently because of the volume of rainfall experienced in 2010 and 2011. This has affected the water quality in the ACT with a number of lake closures due to blue-green algae (cyanobacteria).

Surface water quality in the lakes and rivers monitored was very varied, possibly as a result of the extremes of weather. There were a number of exceedances of the limits set by the ACT Government.

During the reporting period the ACT Government introduced *Guidelines for Recreational Water Quality* which provides a framework to guide the management of recreational water sites within the ACT. The guidelines address risks to humans from blue-green algae as well as microbial pathogens.

A number of projects have been implemented in the ACT over the reporting period that could improve the water quality of rivers and waterbodies. They include a pilot stormwater harvesting and injection project, and constructed wetlands in urban areas. It is too early to assess the effectiveness of these projects in relation to water quality.

ACT State of the Environment Report 2011

Introduction

The *Water quality* indicator cluster describes the physical, chemical and biological characteristics that are monitored in the waters of ACT's rivers and lakes, excluding those that supply potable water. The water quality of most of Canberra's major urban lakes is monitored by the ACT Government through the ACT Environmental Protection Agency (EPA) and Waterwatch volunteers. The main exception is Lake Burley Griffin which is a Commonwealth responsibility; its waters are monitored by the National Capital Authority. Downstream of ACT, ACTEW monitors water quality in Burrinjuck Reservoir in NSW which is the receiving water for ACT stormwater and treated sewage discharged via the Murrumbidgee River. Urban impact on the Murrumbidgee River cannot be identified beyond Burrinjuck Reservoir because of the reservoir's size and the residence time of water in it. All the lakes and rivers reported here have been monitored since the late 1990s. Water quality monitoring at Yerrabi Pond in Gungahlin (at the dam wall) was only established in 2009-10 and is not reported here. Other stormwater control ponds and wetlands, including those recently built such as Flemington Road Ponds, are discussed in the *Rivers, lakes and wetlands health* indicator cluster.

Many human activities and aspects of the environment affect water quality: for example, after heavy rain, particularly where land is used for agriculture and urbanisation, there can be increased movement of soil in runoff, resulting in higher readings for suspended solids and turbidity in the receiving waters.

A number of ecosystem services are highly dependent on or affected by water quality, including provision of drinking water and recreational and cultural amentity, cycling of nutrients, and maintenance of biodiversity. The purer the water, the more its potential uses. Guidelines, both national and regional, for water quality and its monitoring and reporting, guide the management of water resources to help prevent impacts of unsuitable quality water on humans and the environment.

Condition indicators

Surface water quality

Monitoring of water quality measures the water's acidity and salinity, its degree of oxygenation, and its concentrations of nutrients, chlorophyll 'a', suspended solids (and turbidity), and faecal coliform bacterial cells, relative to standards chosen for the region according to the intended uses of the water. This *Water quality* indicator cluster discusses ACT waters that are not for intended for human consumption. (Quality of potable (drinkable) water is discussed in the *Water supply* indicator cluster.)

During the reporting period, water quality was very varied, possibly as a result of the extremes of weather. There were a number of exceedances of the limits set by the ACT Government.

As identified in the last *State of the Environment Report*, the data recorded during the reporting period provide a series of snapshots of water quality, not the full story. The waters of Canberra's lakes are sampled in only 8 months of the year: during August, October to March, and May. However, monitoring of blue-green algae is more frequent during the summer months and at sites that encompass the recreation zones of the lakes and the Molonglo River. During peak use times, monitoring includes recreational areas of other rivers as well as the lakes, and faecal coliform bacteria are measured as well as chlorophyll 'a' (DECCEW 2009).

Water quality sampling of ACT rivers generally is based on flow events. During the drought that meant samples were taken less regularly from the rivers than the lakes: 4 samples in 2007-08, 3 in 2008-09 and 5 in 2009-10.Waterwatch groups also monitor water quality across a number of ACT waterways, providing data that are included in the *ACT Water Report*. AUSRIVAS data, which measure rivers' water quality as their ecological condition, are presented in the *Rivers, lakes and wetlands health* indicator cluster. Whatever the measurement technique, monitoring cannot be done when river conditions pose a danger to the monitoring team.

Water quality is assessed against water quality standards. The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000) provide general guidelines and recommend local standards be developed to suit local uses of the water, based on local historical data. Water quality in the ACT continues to be assessed against water quality standards set out in the *Environment Protection Regulation 2005*, the *ACT Guidelines for Recreational Water Quality 2009* and the *NH&MRC Australian Drinking water Guidelines 2004* (NHMRC 2004). It is expected that ACT Water Quality Standards will be reviewed as part of the review of the EPA Act which is currently underway.

A summary of ACT water quality monitoring data for 1998 to 2011 is presented in Annex 1.

Table 1. Water quality standards (*Environment Protection Regulation* 2005)

	Water-based recreation		Water supply		Aquatic habitat	Potential consequence of exceeding limits
Indicator	**Swimming (REC/1)**	**Boating (REC/2)**	**Stock (STOCK)**	**Irrigation (IRRIG)**	**Wetland (AQUA/1 to AQUA/6)**	
Total phosphorus (mg/L)	< 0.1	< 0.1			< 0.1	High total phosphorus, turbidity, water temperature and low flow, may lead to cyanobacterial bloom.
Turbidity (NTU)	Not-objectionable	Not-objectionable			< 10 - < 30	Modification of biological light regime; poor aesthetics, effects on plant and algal growth.
Suspended solids (mg/L)					< 12.5 - < 25	Silt slugs; bank scouring; burial of riffles or aquatic vegetation; increased (long-term) turbidity.
Chlorophyll 'a' (µg/L)	< 10	< 10	< 10		< 2 - < 10	Poor aesthetics; scums; unpleasant smells; blooms outside of normal population fluctuation.
Faecal coliforms (cfu/100 mL)	≤ 150	≤ 1000	≤ 1000	≤ 1000		Closure of recreational waters because of health risk from associated (hard to monitor) pathogens.
Dissolved oxygen (mg/L)					> 4	Hot weather and low flows drive oxygen out of water, leading to biological stress, with fish kills being the worst outcome.
Acidity (pH)	6.5-8.5	6.5-8.5	6.5-9.2	4.5-9.0	6-9	Altered pH could significantly change the biodiversity in waterways. Changes to biodynamics; may release toxic metals.
Total dissolved solids (mg/L)			< 3000	< 500		Water above 500 mg TDS/L (approximately equivalent to 800 µS/cm, in general) is unsuitable for irrigation, although some plants can tolerate higher concentrations.

Source: ACT Water Reports

(Note:This table does not include the *ACT Guidelines for Recreational Water Quality 2009*, which include monitoring and standards for blue-green algae and enterococci and are discussed later.)

ACT lakes and ponds

As in previous reporting periods, water samples from ACT lakes and ponds continue to have high concentrations of chlorophyll 'a' especially in warmer months. Chlorophyll 'a' is an indicator for photosynthetic microorganisms present in aquatic ecosystems. Of these organisms, those of most concern are the potentially toxic blue-green algae, the cyanobacteria. See the Impact indicator in this paper for more information.

During the reporting period all 4 sampled lakes exceeded the ACT standards for phosphorus, dissolved oxygen, alkalinity, suspended solids and turbidity, one or more times. Faecal coliform bacteria were lowest in Point Hut Pond and Gungahlin Pond, where the measured value sometimes exceeded the standard for swimming (150 colony forming units (cfu) per 100 mL water) but remained below the limit for boating (1000 cfu/100 mL). Lake Tuggeranong reached the limit for boating in 2008-09, and Lake Ginninderra in 2010 had 1 record of 2000 cfu/100 mL. The high value possibly resulted from cleaning of a gross pollution trap, because most measurements recorded only 100-200 cfu/100 mL at the 2 sites sampled in Lake Ginninderra.

Overall, during the reporting period, the concentrations of faecal coliforms in ACT waterways were mostly within regulation limits, but there were exceedances in 2007 at 7 sites, and in 2009-10 at 5 sites. Recorded concentrations that far exceeded the limits included Paddy's River at Riverlea where faecal coliform concentration reached 4587 cfu/100 mL in 2007, compared to a limit of 150 cfu/100 mL. The exceedances in 2009-10 were attributed to the effects of significant rainfall.

Salinity in ACT is measured as electrical conductivity (in microSiemens per centimetre, µS/cm, also called EC units). The salinity standard in Table 1 is set at 500 mg/L (milligrams total dissolved solids (TDS) per litre of water) for use in irrigation, a value that approximates to 800 EC units. During the reporting period, the salinities recorded in all waterbodies were less than 800 EC units. Maximum readings were around 550 EC units, recorded occasionally in the Murrumbidgee, Molonglo and Queanbeyan rivers during 2009 and 2010.

Long term data on water quality in ACT lakes, including data for this reporting period, are presented in Annex 1.

Lake Burley Griffin

The water in Lake Burley Griffin is monitored by the National Capital Authority, and data are not reported here. Monitoring is undertaken at the four specified swimming areas: Black Mountain Swimming Area, Weston Park (west) Swimming Area, Weston Park (east) Swimming Area, and Yarralumla Swimming Area.

A recent draft water quality assessment of the lake (Lawrence 2011) across all the monitored sites, has identified that in recent years, as compared to 1978, there have been:

- high levels of blue-green algal growth, frequently exceeding Health Guideline values;

- a shift towards greater blue-green algal dominance;
- a recent reduction in pH levels, as a result of increased organic material decomposition activity; and
- serious water quality degradation within the Beach embayments, as a result of shallowness, poor mixing, and trapping of open water wind-blown blue-green algal scum in these areas.

Lake Tuggeranong

There are two water monitoring sites on Lake Tuggeranong, one located at the Kambah Wetland (Site 248), which is near the northern inflow to the Lake, and the other at the dam wall (Site 249). During the reporting period there have been many exceedances of the standard for phosphorus and for chlorophyll 'a', the latter possibly indicating the presence of blue-green algae. These happen especially during warmer months, and result in lake closures to reduce the risk to public health (for more information refer to the Impact indicator in this paper).

During the reporting period, measured turbidity concentrations, which are somewhat related to rainfall conditions, ranged from within the standard in 2007 to exceeding it several times in 2009 and 2010. There has been a decrease in electrical conductivity since 1998, which is likely to reflect a reduction in nearby construction work. Water quality (especially faecal coliform concentrations) in Lake Tuggeranong is affected by gross pollutant trap effectiveness.

Lake Ginniderra

There are two monitoring sites on Lake Ginninderra, one near the inflow of Ginninderra Creek in the east arm (Site 321) and the second near the dam wall (Site 318). During the reporting period, there were a number of exceedances of the chlorophyll 'a' standard, possibly indicating blue-green algae during warmer months. The readings caused lake closures for body-contact water sports.

Water quality monitoring for Lake Ginninderra also showed exceedances of suspended solid and turbidity concentrations, especially at the east arm site. This is likely to have resulted from local construction activity. Longer term trends show that water quality in the lake is generally good.

Point Hut Pond

There is one monitoring site on Point Hut Pond (Site 207). Exceedances of chlorophyll 'a', suspended solids and turbidity standards were common during the reporting period. The standard for phosphorus was also exceeded several times in 2007, and once or twice in 2008, 2009 and 2010. Faecal coliform readings were generally within the standard during the reporting period. However, Point Hut Pond water quality has historically been poor; its catchment is primarily urban (DECCEW 2010).

Gungahlin Pond

At the one monitoring site on Gungahlin Pond (Site 346), water quality generally remained within regulation limits. As with the other lakes and ponds, exceedances were experienced in chlorophyll 'a' during the reporting period. The limits for turbidity and suspended solids were exceeded several times, with a high reading in February 2010 likely to have resulted from the storms in January 2010. Longer term trends indicate improved water quality in the Pond, particularly in dissolved oxygen, conductivity and faecal coliform concentrations.

Lakes and ponds generally show improvement in water quality between the inflow points and the dam walls, indicating the lakes are fulfilling the important role of improving water quality before it discharges into our river systems.

ACT rivers and creeks

The drought and extreme rainfall during the reporting period affected the water quality of rivers and creeks in the ACT and as a result surface water quality in the rivers was very varied. Sites affected by the 2003 bushfire appear to have recovered from the impacts and accommodated the ongoing periods of low flow, albeit at lower quality. Sites in urban and peri-urban areas appear generally affected by human actions such as altered flow regimes, nutrient enrichment, weed infestation and increased pollutants (DECCEW 2009, DECCEW 2010).

Murrumbidgee River

The Murrumbidgee River is the main river in the ACT and receives most of the material transported throughout ACT waterways (DECCEW 2010). There are three monitoring sites on the Murrumbidgee River: at Angle Crossing (Site 213) as the river enters the ACT, at Kambah Pools (Site 209), and Halls Crossing (Site 204) in NSW just downstream of the ACT.

The Halls Crossing site (204) is more alkaline and has higher conductivity and nitrogen levels than the other sites, which are upstream of urban areas (DECCEW 2009). Exceedances of chlorophyll 'a' were recorded at all sites during the reporting period, indicating that the river has become eutrophic and likely to be heavily contaminated by blue-green algae. Exceedances of the limits for faecal coliforms and turbidity also occurred at all sites in 2007-08 and 2009 and 2010, most likely due to low flows in 2007-08 and heavy rains in February 2010 (DECCEW 2008, 2010). Longer term trends indicate a rise in suspended solids and turbidity in the year following the 2003 fires and spikes in these indicators following high rainfall events since then. This indicates that the Murrumbidgee catchment remains fragile following the fire, and that storm events have a significant impact on the quality of the water (DECCEW2009).

Molonglo River

There are two monitoring sites on the Molonglo River: Dairy Flat Bridge (Site 601), near the water-ski area, and Yass Road Bridge (Site 608) downstream of the Molonglo Gorge. The river runs through a highly urbanised catchment and is subject to pressures from urban and

industrial sites including Queanbeyan and other NSW towns such as Captains Flat. It also receives the discharge from the Queanbeyan sewage treatment plant near Oaks Estate in the ACT.

The Dairy Flat Bridge site (601) continued to show elevated levels of chlorophyll 'a' throughout the reporting period. The readings were identified as due to the toxic blue-green alga *Microcystis aeruginosa* and they resulted in closures of the site to recreational water users. Both nitrogen and phosphorus concentrations at the Dairy Flat Bridge site remain high, and management of these related parameters is encouraged.

Dissolved oxygen concentrations at the Yass Road Bridge site (608) increased during the period, though the readings were below the regulation limit. Long-term trends in dissolved oxygen continue to show fluctuations, which appear to be correlated with the mean annual flow in the river (DECCEW 2009).

There were exceedances in both suspended solids and turbidity during 2010 at both sites following high rainfall events (DECCEW 2010).

Paddy's River

Water quality samples for Paddy's River (Site 842) showed the water quality was generally good over the reporting period. The catchment has a mix of conservation, agricultural and forestry land uses, and large parts of the catchment were affected by the 2003 bushfire.

High electrical conductivity readings recorded in 2009 are likely to result from low flows during this time. In December 2009 there was no water flow recorded in the river below the Riverlea homestead (DECCEW 2009, 2010).

Faecal coliform concentrations over the period which consistently exceeded the limit for swimming were likely to result from rural activities and slow post-fire stabilisation of catchment areas (DECCEW 2010). With a popular picnic spot at Murray's Corner, management of faecal organism concentrations is important.

Gudgenby River

Water quality samples for Gudgenby River are taken at Tennant (Site 901). The Gudgenby River catchment is dominated by native species and limited agriculture. Large parts of the catchment were affected by the 2003 bushfire. During the reporting period, water quality in Gudgenby River was generally good. There was a significant peak in faecal coliform concentration in 2008 and fluctuations over the reporting period, which may be explained by changing stock densities in the rural catchment. Faecal coliform bacteria of livestock origin can affect human health, and efforts to reduce these concentrations are encouraged.

Turbidity concentrations also fluctuated throughout the period, with several exceedances likely to have resulted from rain events. Phosphorus concentrations also exceeded the limit on several occasions during the reporting period.

Ginninderra Creek

Water quality samples for Ginniderra Creek are taken at Parkwood (Site 301). The creek runs through a highly urbanised catchment, including Gungahlin where significant construction has been occurring in recent years. Very high concentrations of faecal coliforms were recorded during the reporting period and may be associated with low water levels and flows, urban run-off or sewage contamination. Elevated turbidity and suspended solids concentrations occurred in 2010 as a result of storms.

Queanbeyan River

Water quality in the Queanbeyan River is sampled at the ACT border (Site 769), before the river reaches the Molonglo River. (Quality of potable water supplied from upstream parts of the Queanbeyan river via Googong Reservoir is reported in the *Water supply* indicator cluster.) The catchment includes the city of Queanbeyan. Water quality over the reporting period was generally good. However, concentrations of dissolved oxygen dropped below regulation limits in 2007 and 2009. This was associated with low flow in the river. Quality over the period is reflective of longer term trends which show fluctuations in dissolved oxygen correlated with the mean annual flow in the river (DECCEW 2009).

Pressure indicators

Discharge to waters

Discharges to waters from known point sources can place significant pressures on water quality. In the ACT the two main point sources for discharge are the Lower Molonglo Water Quality Control Centre (LMWQCC), and the Queanbeyan Sewage Treatment Plant. The LMWQCC treats most of ACT's wastewater and sewage and discharges it to the Molonglo River, approximately 1.4 km upstream of the confluence of the Molonglo and Murrumbidgee rivers.

The LMWQCC is the single largest point source of pollutants within the ACT. The LMWQCC treated 26,769 ML of sewage in 2009-10, and 32,336 ML in 2010-11 (ActewAGL 2011). Because of the environmentally sensitive nature of the receiving waters the LMWQCC has implemented a comprehensive environmental monitoring program, which includes biological monitoring of the receiving waterways (DECCEW 2010). The LMWQCC and its discharge are regulated through an Authorisation issued by the EPA. During the reporting period, data were reported to the EPA, and the EPA has not recorded any breaches to the limits and conditions of the Authorisation.

The Queanbeyan Sewage Treatment Plant (QSTP) discharges treated effluent into the Molonglo River just inside the ACT. During the reporting period, effluent discharge increased from an average of 8.71 ML/day in 2007 to 9.22 ML/day in 2010. The EPA notes the Queanbeyan City Council (QCC) was generally compliant with its Authorisation for the plant during the reporting period with the only non-compliances relating to reporting times or data formatting. The discharge requirements imposed through their Authorisation are

consistent with those that apply to the LMWQCC. However, there was an incident at the QSTP during December 2010 which potentially posed environmental harm to downstream waters such as Lake Burley Griffin. At that time, during localised flooding, a breach of a wall at a secondary treatment maturation pond released partially treated sewage into the Molonglo River. The EPA is currently investigating this incident. Both the EPA and the QCC recognise that the ageing plant is near the limit of its capacity to treat the effluent generated by the growing city of Queanbeyan. Unless the plant is upgraded it is likely that non-compliances with the Authorisation will become more frequent.

A recent draft water quality assessment of Lake Burley Griffin indicated that there has been a significant reduction in total phosphorus and biochemical oxygen demand (BOD) in the treated water discharged from the QSTP over the past 30 years. This is a result of major upgrades to the plant (Lawrence 2011).

Nutrients in stormwater may be the largest factor leading to poor water quality and excessive concentrations of blue-green algae in Lake Burley Griffin (Lawrence 2011). Perhaps one of the less notable but extremely significant modifiers of water quality is the contribution that diffuse sources make, through the Canberra stormwater system.

Land use can also have a significant impact on the quality of water in rivers, lakes and wetlands as well as in groundwater. For example, land use can affect the total amounts of suspended solids and nutrients (phosphorus and nitrogen) in the waterways. As outlined in the *Land health* indicator cluster, over 50% of the ACT is managed as conservation reserves, which are characterised by less runoff and erosion than urban and rural land uses, and therefore contribute smaller amounts of suspended solids and nutrients to waterways. When waters contain too high concentrations of nutrients relative to their capacity to assimilate them, the excess nutrients can promote growth of cells such as algae including blue-green algal blooms (see Impact indicator below).

Impact indicators

Water quality and human health impacts

Pathogens

Water quality standards are set with the aim of protecting the community and ecosystems from adverse health impacts. Water bodies generally contain a mixture of pathogenic and non-pathogenic organisms which can cause infection or disease. These pathogens may derive from a number of sources including sewage effluent overflows, as well as domestic, rural and native animals (ACT Health 2009). Human exposure to pathogens in water can occur through swallowing water or by water coming into contact with ears, eyes, nasal passages, mucous membranes or cuts in the skin (e.g. when swimming, diving, waterskiing, windsurfing, whitewater canoeing).

A pathogen's potential health impacts on a person depend on the specific pathogen, the form in which it is encountered, the conditions of exposure, and the person's susceptibility and immune status (ACT Health 2009).

The most common health impacts are enteric illnesses, such as self-limiting gastroenteritis, which may often be of short duration and may not be formally recorded in disease surveillance systems. Other adverse health effects such as respiratory illness, ear infections and skin and eye problems are also associated with recreational activities in contaminated water (ACT Health 2009).

Testing conducted at various sites across the ACT checks surface waters for potentially harmful bacteria. High concentrations of bacteria in the water could be harmful to human health, although they are not necessarily a problem for organisms in aquatic ecosystems that can feed on the bacteria. One method used to quantify the water quality and its potential impacts on human health is to measure the faecal coliforms in the water bodies. The World Health Organization advocates the use of intestinal enterococci as the single preferred indicator of faecal contamination. The presence of faecal coliforms or enterococci in a water sample is an indication that human or animal faeces may have contaminated the water. The standard (maximum advised) for recreational swimming is 150 colony forming units (cfu) of faecal coliforms per 100 mL of water, or 200 cfu of enterococci per 100 mL of water. For boating and other secondary contact the regulation limit or standard is 1000 cfu/100 mL. The EPA has set the faecal coliform standard at 1000 cfu/100 mL of water at all but five monitoring sites. The faecal coliform standard is set at 150 cfu/100 mL of water at Lake Tuggeranong at Dam (Site 249), Lake Ginninderra at Dam (Site 318) and at all 3 sites on the Murrumbidgee River (Halls Crossing – Site 204 , 209, Kambah Pool – Site and at Angle Crossing – Site 213). The limits are lower at these sites because primary contact with water (usually recreational swimming) is most likely near these sites.

As reported above (in Condition indicators) during the reporting period, the levels of faecal coliforms in ACT waterways occasionally exceeded regulation limits for swimming or boating. Bacterial levels in surface waters are generally higher following rainfall events, as a result of runoff from the surrounding urban and rural catchments. For example, the runoff collects pollutants from urban stormwater pipes and rural grazing land.

It should be noted that high concentrations of faecal coliforms do not necessarily indicate that human sewage is present in waterways; rather it is more likely a result of organic matter and rural animal waste attached to suspended solids. Faecal coliforms of livestock origin are frequent causes of adverse human health outbreaks.

A number of the ACT's rural rivers were closed to primary contact because of human health concerns as a result of the significant rainfall in late 2010.

Blue-green (cyanobacterial) algal blooms

Blue-green algae are common and naturally occurring organisms that can affect the recreational use of ACT waterways because of the public health risk they pose when present

in high concentrations. Blue-green algal blooms are of particular concern for human health because of the variety of toxins which may be produced (Falconer 2005). Blooms generally occur where waters are warm and have high concentrations of nutrients, often in summer.

Blue-green algal cells in low numbers in a water body are not necessarily a risk. However, when these organisms multiply they form scums on the water surface which drift downwind into swimming areas and pose an increased health risk. In the ACT, the main toxic blue-green algae of concern are free floating forms such as *Microcystis* and *Anabaena* species, and also *Tychonema* species that live on the beds of rivers or lakes. These organisms present a particular health risk to humans and animals if taken in by mouth or by inhalation. Skin contact can cause allergic reactions.

Monitoring of ACT rivers and lakes includes counts of blue-green algae cells as well as measurement of chlorophyll 'a' concentrations to estimate the total quantity of algae (cyanobacteria and green algae) present. Chlorophyll 'a' is an indicator of the extent to which aquatic ecosystems have been affected by nutrient inputs. All rivers, urban lakes and ponds in the ACT are expected to contain no more than the standard, 10 µg/L (10 micrograms of chlorophyll 'a' per litre of water). For more information see *Rivers, lakes and wetlands health* indicator cluster.

Blue-green algal cell counts are carried out when samples are taken in accordance with the *ACT Guidelines for Recreational Water Quality*; that is, when a high value for chlorophyll 'a' has been measured at a particular location, or when high concentrations of blue-green algae have been visually identified. Blue-green algal monitoring can also be carried out by visual inspection, because clumps of the organisms can be seen in lake water when present.

Over the reporting period, ACT lakes contained elevated concentrations of chlorophyll 'a' and sporadic high or extremely high concentrations of blue-green algae. These elevated concentrations generally occurred between spring and autumn of each year, with peaks in February or March.

In December 2009, the ACT introduced new *ACT Guidelines for Recreational Water Quality.* Prior to the new guidelines, if a sample triggered a high-level alert (≥50,000 blue-green algae cells/mL) the lake from which the sample was taken was closed to primary and secondary contact. Under the new guidelines a lake is only closed to primary contact (e.g. swimming) at a high- or extreme-level alert. At extreme levels (>125,000 blue-green algae cells/mL, or scums are consistently present) the public must also be advised that contact with water poses an increased level of risk for secondary contact users (e.g. boating) (ACT Health 2009).

Over the reporting period, there were a number of outbreaks of blue-green algae in ACT lakes and waterways. Lake Tuggeranong had a high- to extreme-level alert every summer from 2007 to 2011, while Lake Ginninderra and the Molonglo Reach Water Ski Area were affected less frequently by blue-green algal blooms. In most cases during the reporting period, the high- to extreme-level alerts in the ACT occurred in the summer months. This is generally when more people use these waterways. Table 2 gives a summary of the blue-green algal outbreaks and monitoring.

Table 2. Alert dates for algal blooms in ACT lakes

Lake	Date	Alert
Lake Tuggeranong	6 weeks, 2 days from 27 November 2007	High
	3 weeks, 2 days from 12 March 2008	High
	2 days from 3 February 2009	Medium
	10 weeks, 2 days from 5 February 2009	High
	13 weeks, 2 days from 18 May 2009	Medium
	11 weeks from 28 January 2010	Extreme
	6 weeks from 15 April 2010	Medium
	4 weeks 1 day from 10 February	High
	3 weeks from 11 March 2011	Extreme
	2 weeks from 1 April 2011	Lake Closed
Lake Ginninderra	1 week 1 day from 3 February 2009	Medium
	13 weeks 4 days from 11 February 2009	High
	13 weeks 2 days from 18 May 2009	Medium
	7 weeks from 22 April 2010	Medium
Molonglo Ski Area	1 week 1 day from 3 February 2009	Medium
	18 weeks 1 day from 11 February 2009	High
	8 weeks, 6 days from 18 2009	Medium
	1 week from 14 January 2010	Medium
	1 weeks from 21 January 2010	Extreme
	4 weeks from 28 January 2010	High
	5 weeks from 8 April 2010	Medium

Source: DECCEW

The most recent 2010-11 recreational season closures for Lake Burley Griffin were (NCA 2011):

- “closure to all recreational users (excluding commercial ferry boat operators) for a period of less than two weeks of the six month recreational season due to high levels of faecal pollution, in part due to a Queanbeyan Sewage Treatment Plant spill in early December 2010”.
- “the entire lake closed to primary contact users only for a total of three weeks throughout the six month season, although there have been scattered closures to primary contact users across the lake sites at various points in time”.
- “the lake was open to all users across the majority of sites for a period of 20 weeks throughout the season and open across all sites for 16 of these weeks.”

Results from samples taken on 28 February 2011 reflected a spike in bacteria at Black Mountain Beach, Weston Park East and Weston Park West. Further investigation revealed that this spike was the result of ACT Roads cleaning out the Gross Pollutant Trap in Sullivans

Creek on Thursday, 24 February 2011. Levels returned to normal within two weeks following this event (NCA 2011).

Response indicators

Recreational water quality

The *ACT Guidelines for Recreational Water Quality*, introduced in December 2009, provide a current framework for the management of recreational water sites within the ACT (ACT Health 2009). This document introduced new guidelines for managing recreational water quality, including the risks from blue-green algae and microbial pathogens.

Under the *Lakes Ordinance 1976*, the National Capital Authority (NCA) is responsible for the management of Lake Burley Griffin and undertakes regular water quality testing for blue-green algae and bacteria. The NCA takes weekly samples and tests water across 7 sites between mid-October and mid-April each year. Based on the *ACT Guidelines for Recreational Water Quality* (2010), these results are assessed and a decision is reached as to the status of each site around the lake for that week (NCA 2011).

In addition to weekly sampling throughout the recreational season, a routine sampling program is conducted across 5 mid-stream sites within the Lake. Water quality conditions are assessed and reported on a monthly basis (for 8 months of the year) to determine the overall water quality at these sites. The results from these reports are analysed annually and compared with historical data and the benchmark values of the Lake Burley Griffin Water Quality Management Plan.

During the reporting period the Office of the Commissioner for Sustainability and the Environment was requested to undertake an investigation into the state of the watercourses and catchments for Lake Burley Griffin. This is expected to be completed in 2012 and will provide an assessment of the origins of the poor water quality in the lake and may impact on future water quality management.

Effluent water treatment

Wastewater in the ACT is treated at the Lower Molonglo Water Quality Control Centre (LMWQCC), to a tertiary level. This includes screening to remove solids, biological treatment by activated sludge to remove organic material, and tertiary filtering to remove suspended solids and produce a clear effluent. The effluent is then dosed with chlorine to remove any remaining microbiological pathogens, and discharged to the Molonglo River. On average, LMWQCC treats 80-100 ML of wastewater each day. The sludge and screenings from the wastewater is converted to Agri-Ash, which can be used as a soil conditioner for agricultural purposes. To minimise waste from the wastewater treatment (apart from carbon dioxide), the LMWQCC produces approximately 16 tonnes of Agri-Ash a day.

Effluent is also treated at the Queanbeyan Sewage Treatment Plant and discharged into the Molonglo River. During the reporting period, effluent discharge increased from an average of 8.71 ML/day in 2007 to 9.22 ML/day in 2010.

Water reuse and stormwater harvesting

Reusing water is an alternative to using potable water, and can reduce the demand for ACT's water supplies and the associated withholding of water from aquatic environments (see *Water supply* indicator for further details). In the ACT, water reuse provides water for irrigation of playing fields, and industrial and commercial uses.

The Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) outline a national framework for water recycling management, including appropriate qualities of water for different uses. However, it is the responsibility of each state and territory government to ensure that appropriate health and environmental standards are being met by water reuse initiatives.

Currently there is no legislation in the ACT primarily focused on the safe management and use of greywater. Rather, the installation and use of greywater systems is guided by various pre-existing acts and regulations:

- *ACT Public Health Act 1997, Public Health Regulations 2000* - the Act protects the public by preventing the creation of unsanitary conditions (conditions that may risk, damage or offend public health) and gives ACT Health the power to rectify the condition and penalise offenders.
- *Water and Sewerage Act 2000, Water and Sewerage Regulations 2001 (under Construction Occupations (Licensing) Act 2004 (COLA), AS/NZS 3500* - the regulation requires all plumbing work to be undertaken by licensed plumbers. While greywater systems do not need to be formally registered on installation, the plumber is required to notify ACTPLA prior to beginning work.
- *Environment Protection Act 1997* - this Act protects the environment against activities that cause environmental harm. Greywater systems are thus prohibited from contaminating environmental flows, groundwater and surrounding biodiversity. Greywater cannot be the source of offensive odours or other forms of pollution.

Stormwater is also used as a water resource throughout the community. Over the reporting period, the ACT Government implemented the Canberra Integrated Urban Waterways project, to improve water quality within Sullivans Creek (DECCEW 2011). The project focuses on integrating stormwater and urban waterways, by investigating opportunities such as stormwater harvesting and injection to groundwater storages by managed aquifer recharge.

The project will develop a non-potable water reticulation system, which includes direct injection of stormwater to underground aquifers for storage and recovery.

Three pilot stormwater harvesting and injection projects have been implemented as part of the Urban Waterways project:

- Inner North Stormwater Reticulation Network (Flemington Road Ponds and Dickson and Lyneham Ponds);
- Weston Creek Stormwater Reticulation Network (North Weston Pond); and
- Tuggeranong Stormwater Reticulation Network (Lake Tuggeranong and Isabella Pond).

Also during the reporting period a number of wetlands were constructed in the urban area with the aim of providing a range of benefits including water quality improvements (see *Rivers, lakes and wetlands health* indicator cluster for further information). It is too early to assess the effectiveness of these wetlands in relation to water quality.

Gross pollutant traps are intended to capture coarse pollutants from stormwater before it drains into receiving waters. As identified in the last reporting period, there are no data available on the overall adequacy of the urban gross pollutant traps or their maintenance. Such information is important in assessing the effectiveness of these structures in controlling pollution in surface water, and should be collected and monitored on a regular basis.

Glossary

Electrical conductivity: a routinely used measure of salinity in water. While an appropriate concentration of salts is vital for aquatic plants and animals, salinity that is beyond the normal range for any species of organism will cause stress or even death to that organism. Salinity also affects the availability of nutrients to plant roots.

Eutrophic: waters containing large quantities of dead plant material that uses up dissolved oxygen as it decays, and adds nutrients in the process, which can lead to algal blooms

Greywater: untreated domestic or industrial wastewater

Turbidity: a measure of water clarity or the cloudiness of water resulting from the presence of suspended material such as silt and clay; turbidity is recorded in NTU (nephelometric turbidity units), based on how much light is scattered by the suspended particles

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Other data sources

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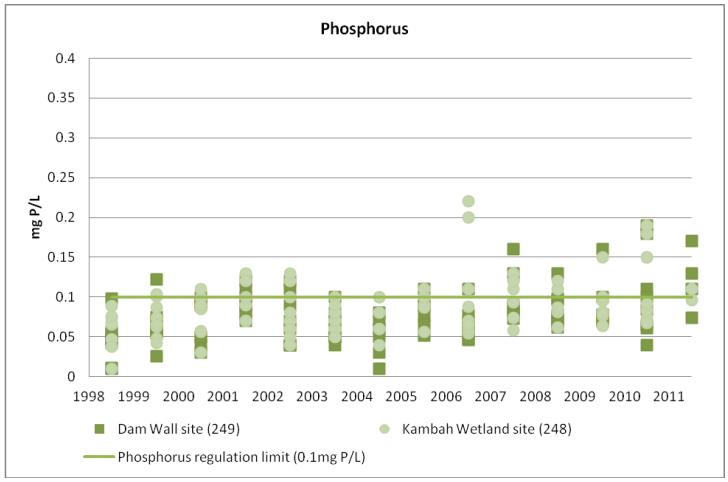
ACT State of the Environment Report 2011

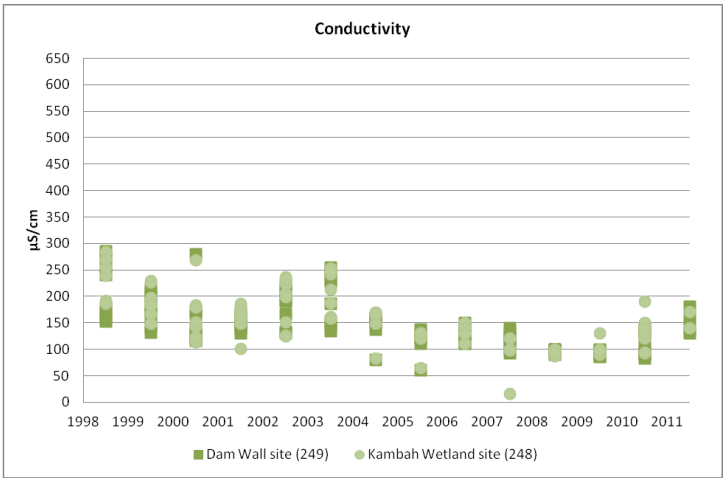
Land and Water: Water quality indicator cluster paper

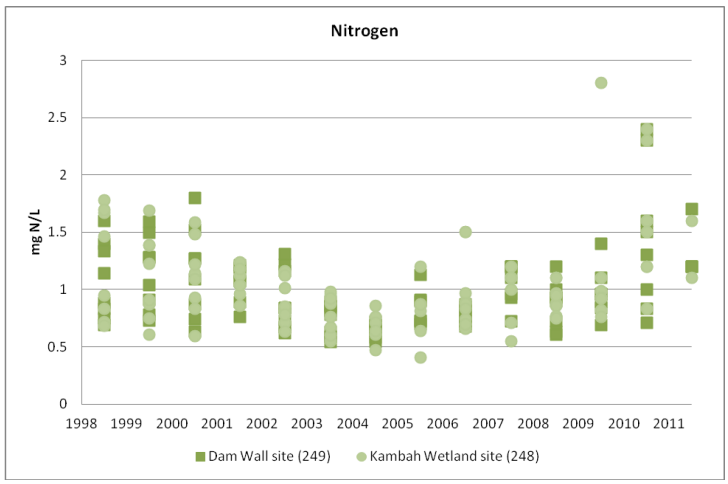
Annex 1

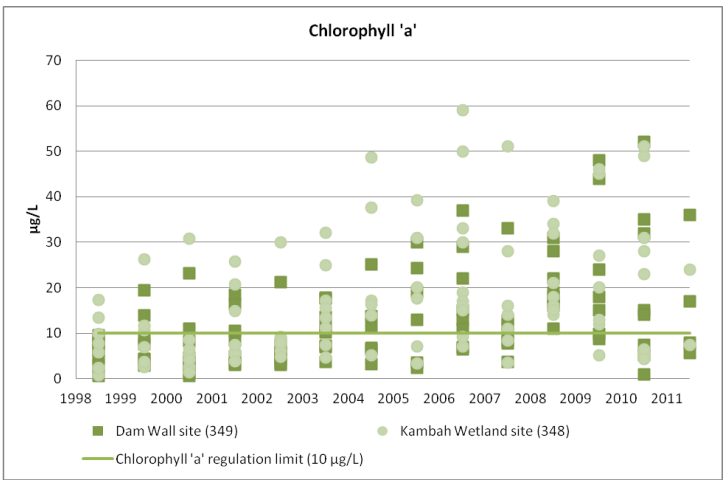
ACT Lakes Water Quality

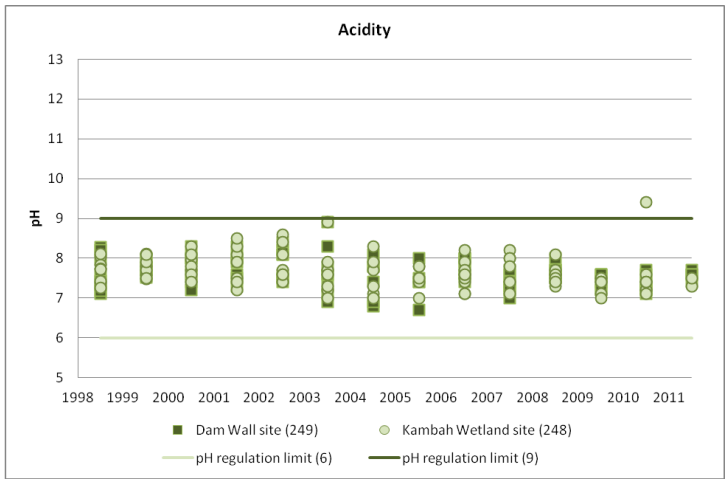
Lake Tuggeranong water quality indicators

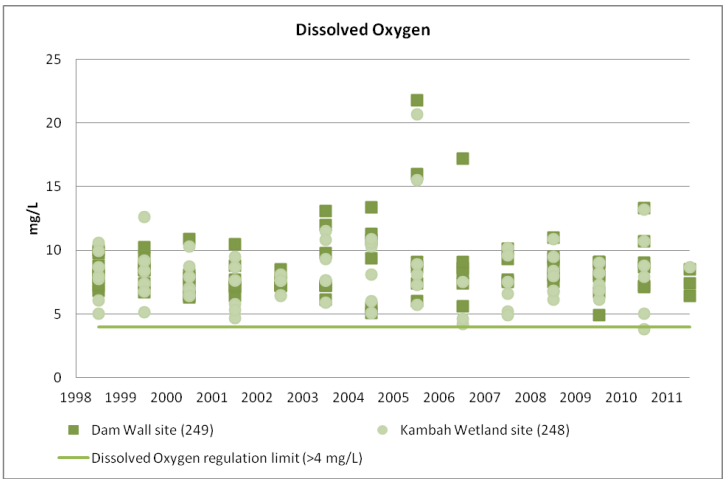


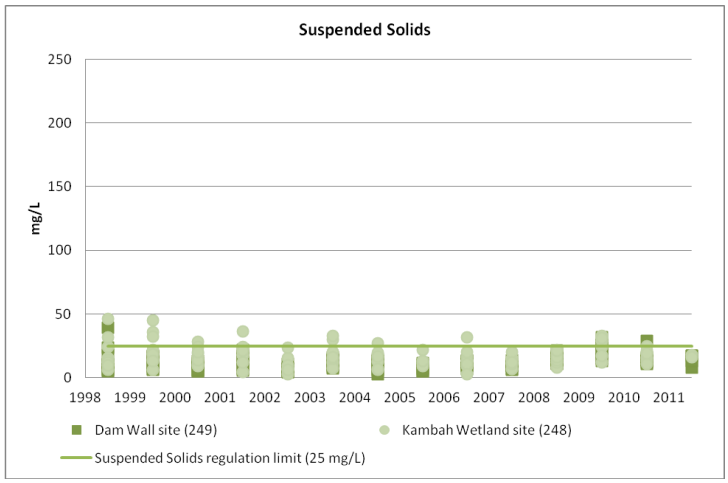








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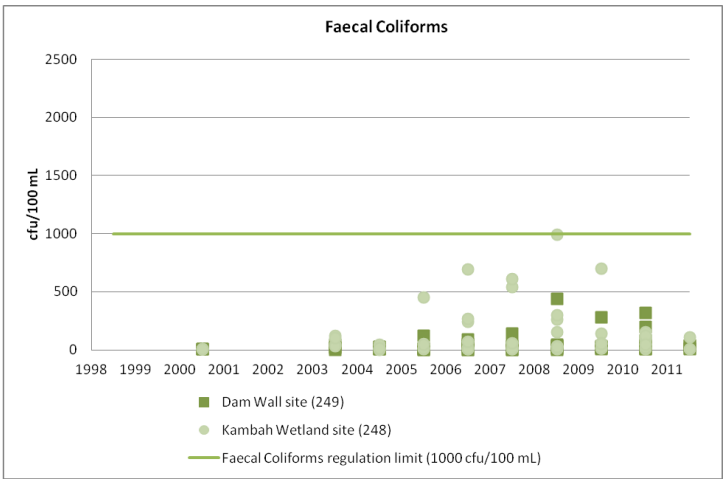
Kambah Wetland site (248)
Suspended Solids regulation limit (25 mg/L)


Faecal Coliforms
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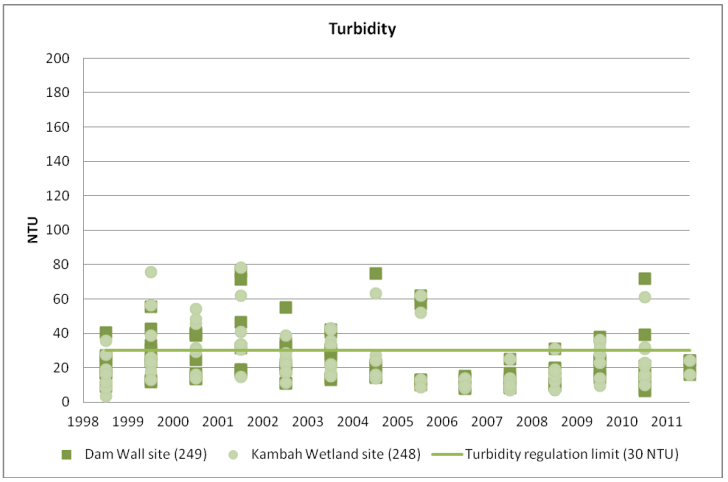
Dam Wall site (249)
Kambah Wetland site (248)
Faecal Coliforms regulation limit (1000 cfu/100 mL)


Turbidity
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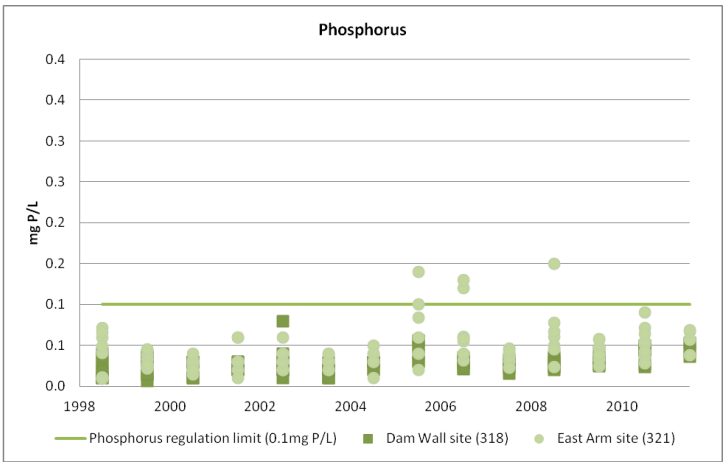
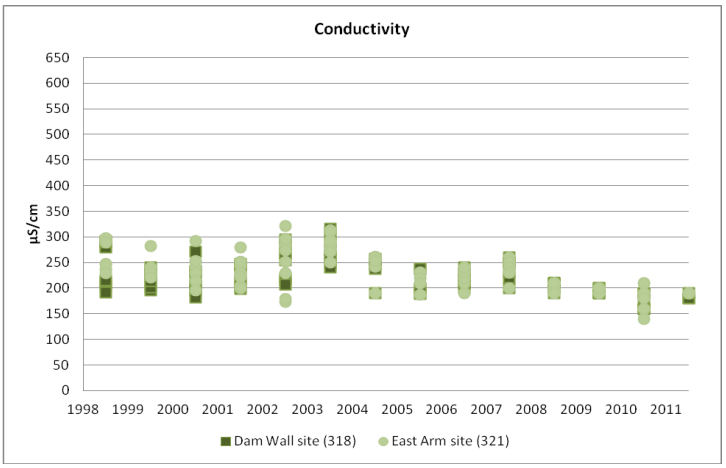
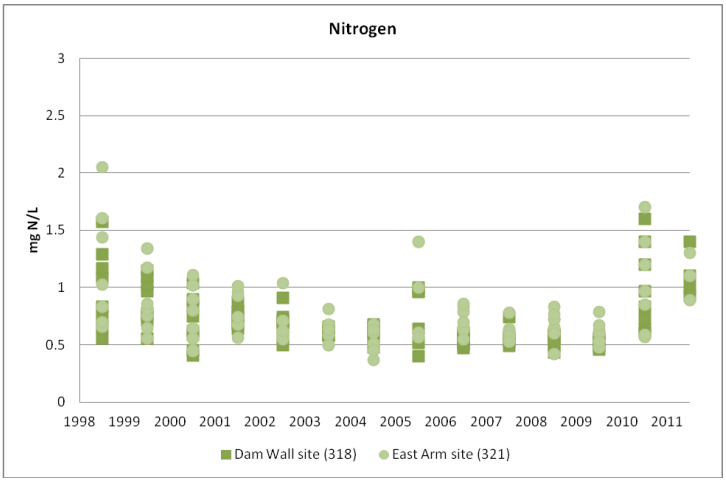
Dam Wall site (249)
Kambah Wetland site (248)
Turbidity regulation limit (30 NTU)

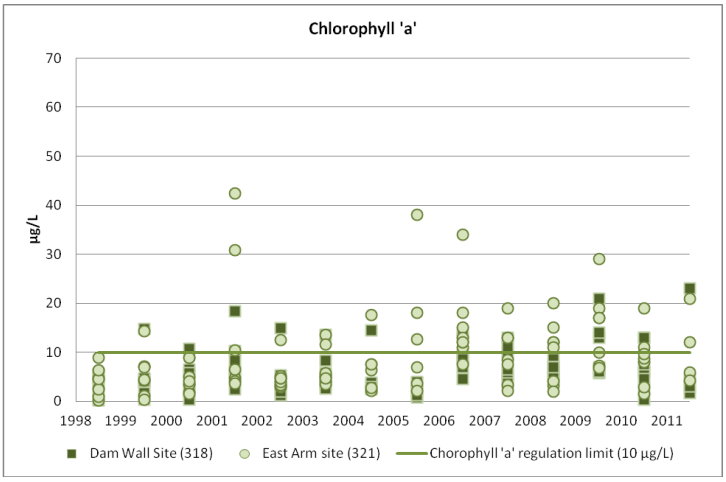
ACT State of the Environment Report 2011

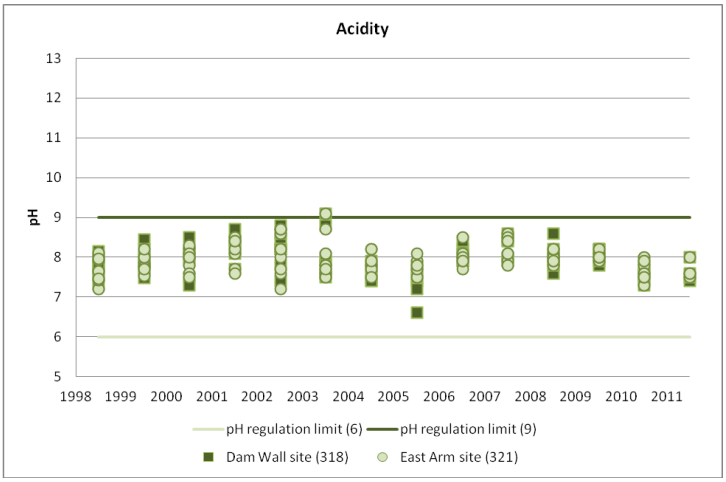
Lake Ginninderra water quality indicators

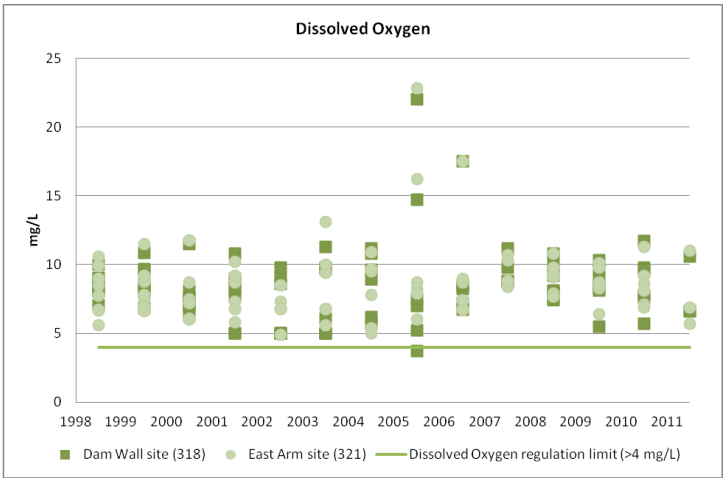


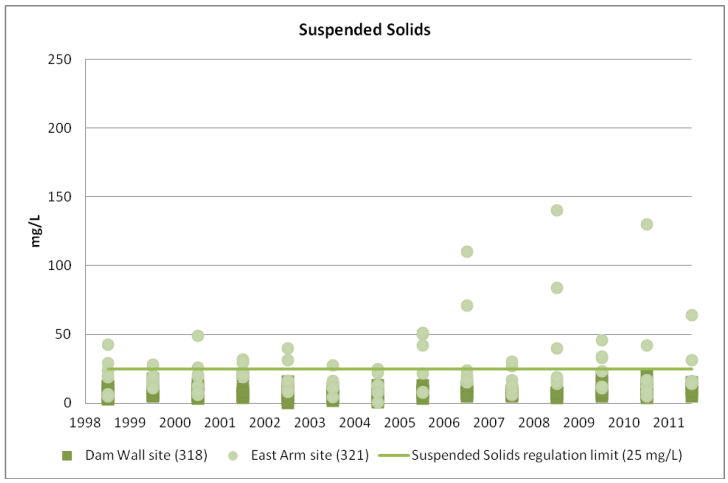


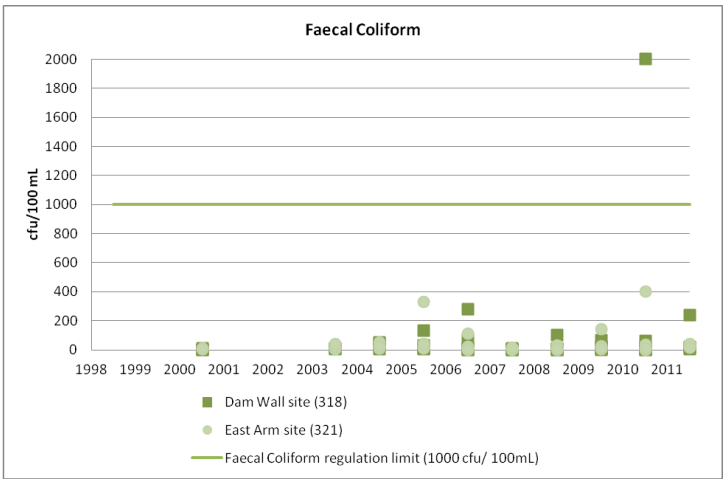


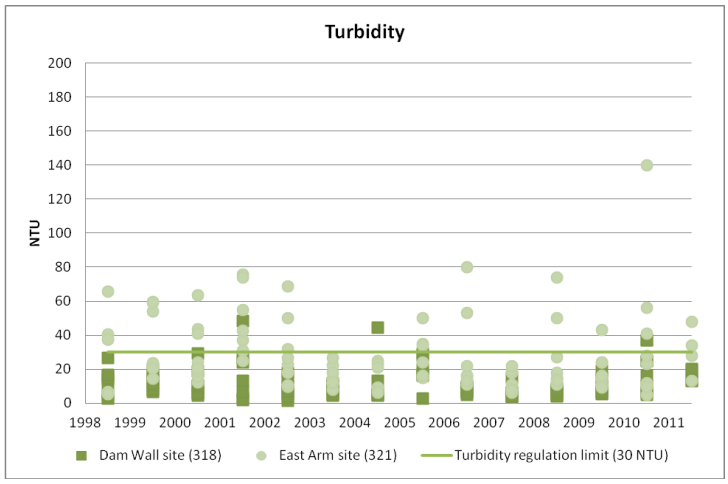






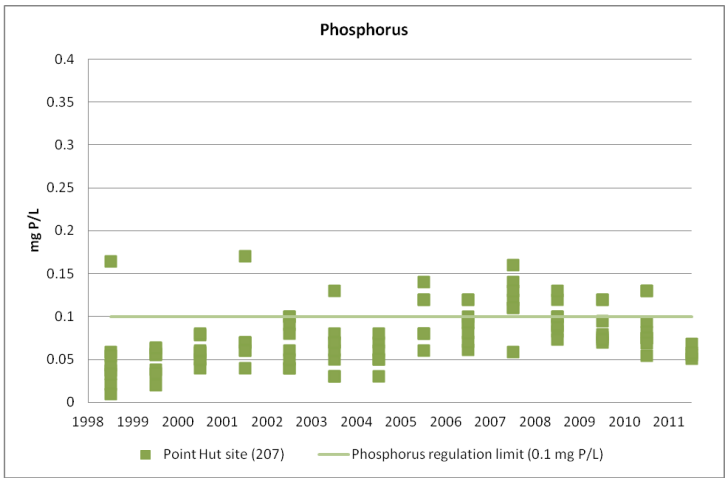

Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dam Wall site (318)
East Arm site (321)
Suspended Solids regulation limit (25 mg/L)

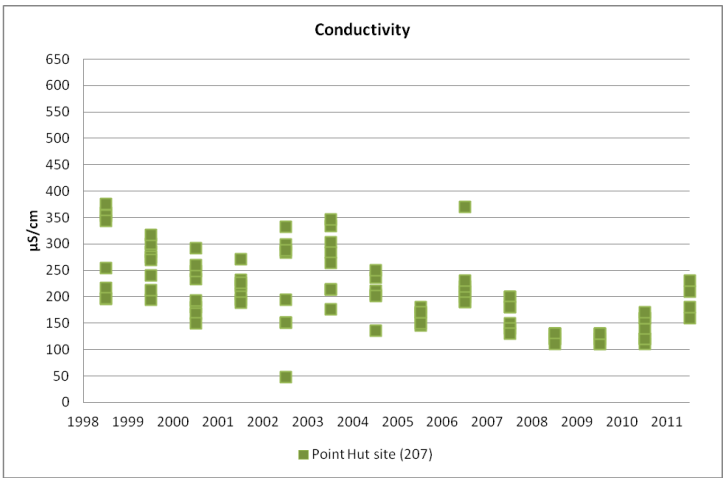

Faecal Coliform
cfu/100 mL
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dam Wall site (318)
East Arm site (321)
Faecal Coliform regulation limit (1000 cfu/ 100mL)

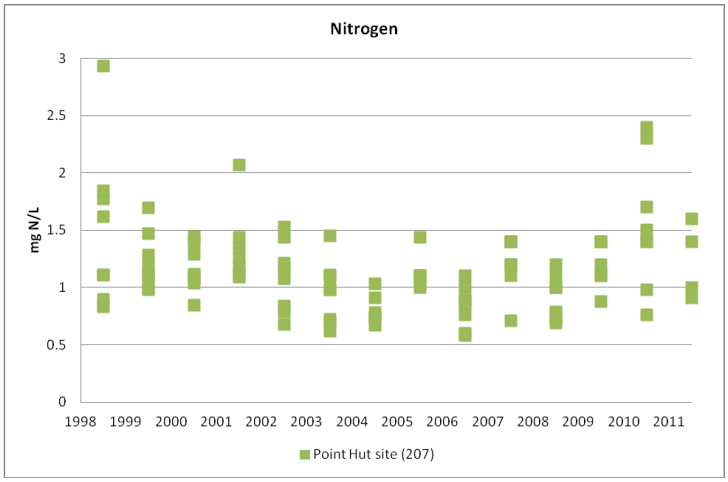

Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dam Wall site (318)
East Arm site (321)
Turbidity regulation limit (30 NTU)

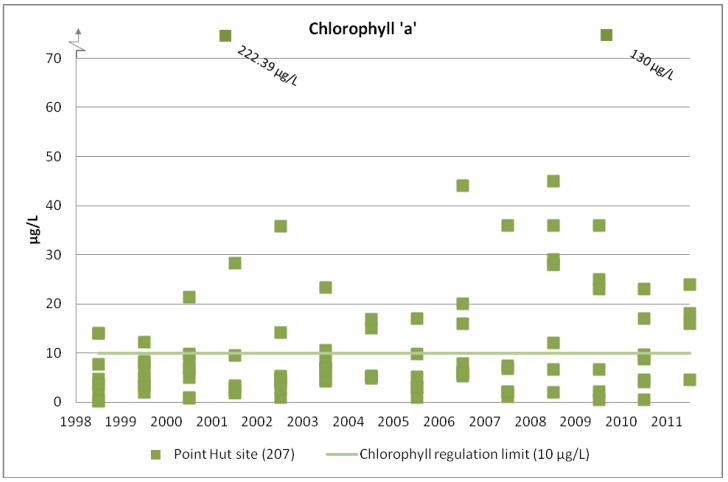
ACT State of the Environment Report 2011

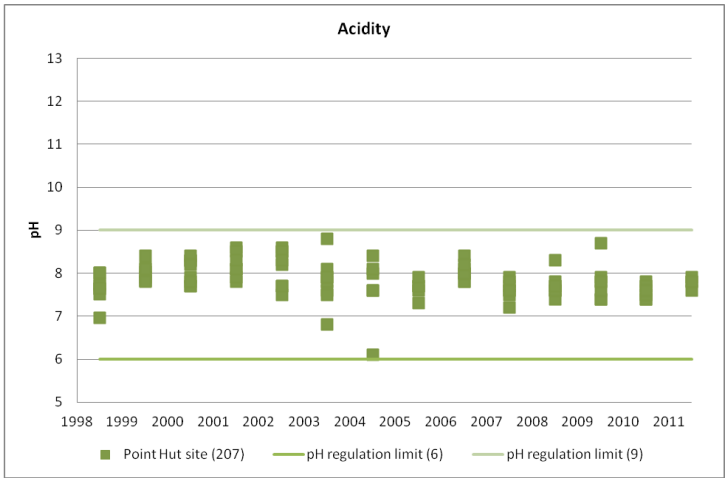
Point Hut Pond water quality indicators

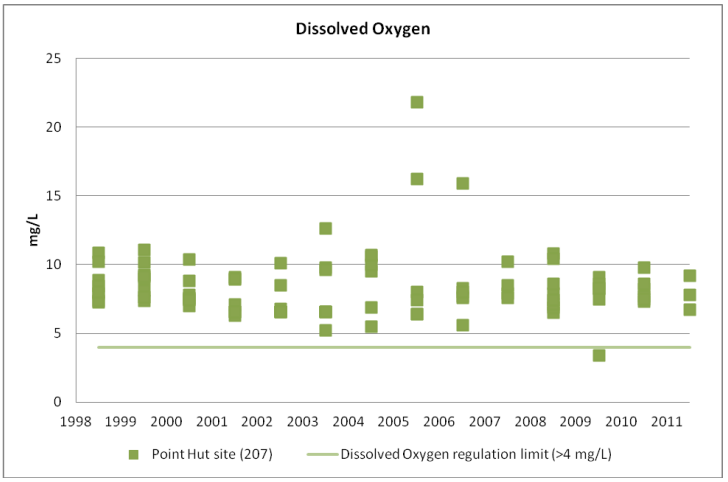


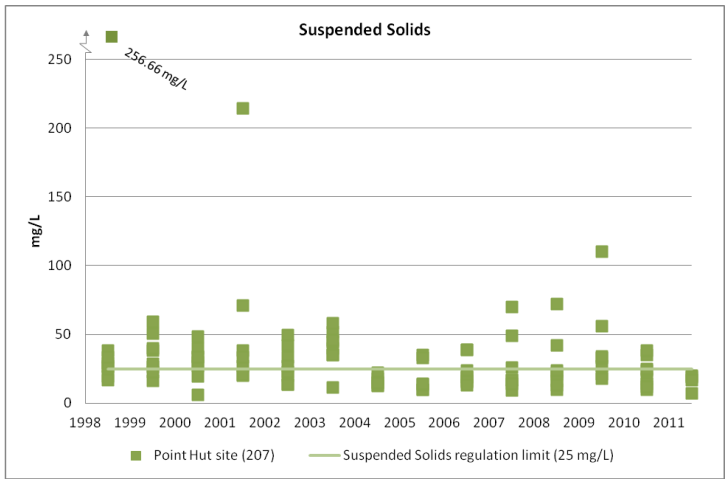


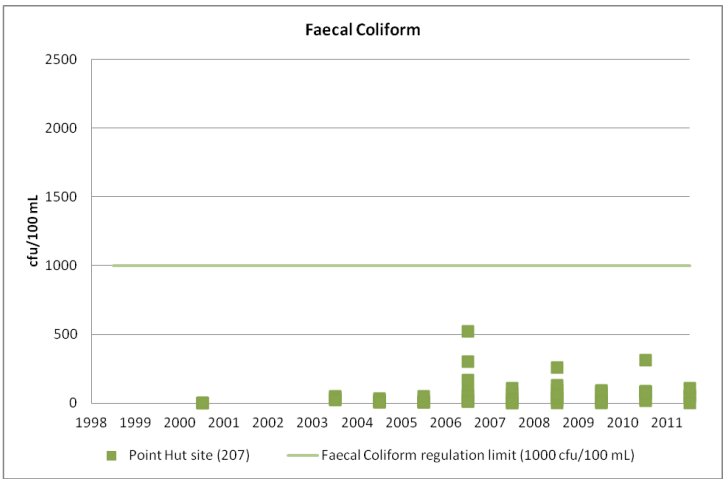


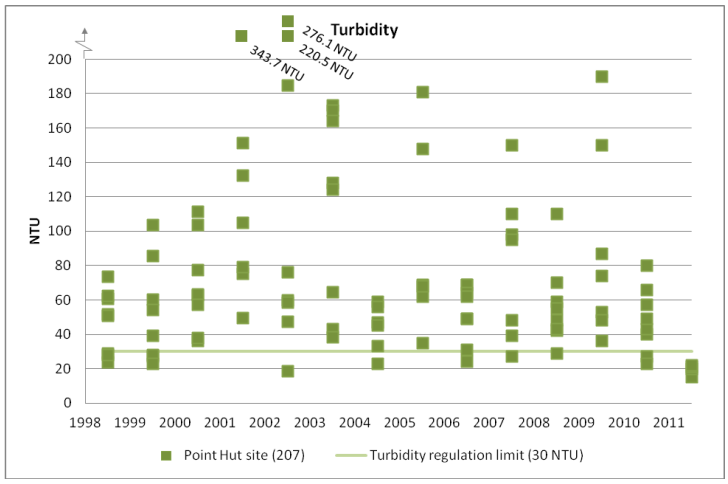






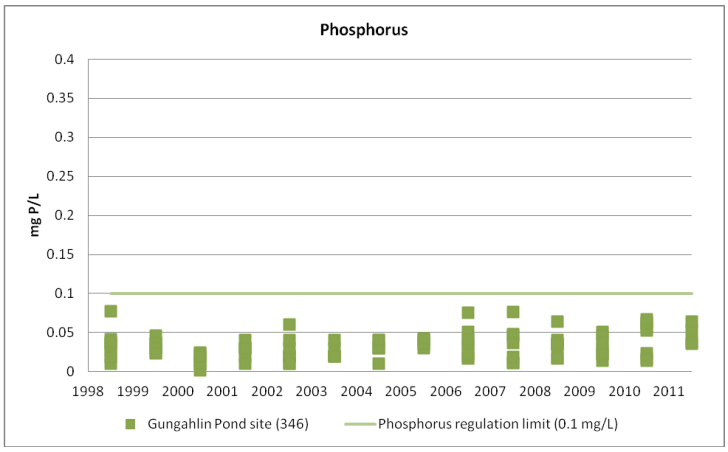

Suspended Solids
256.66 mg/L
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Point Hut site (207)
Suspended Solids regulation limit (25 mg/L)

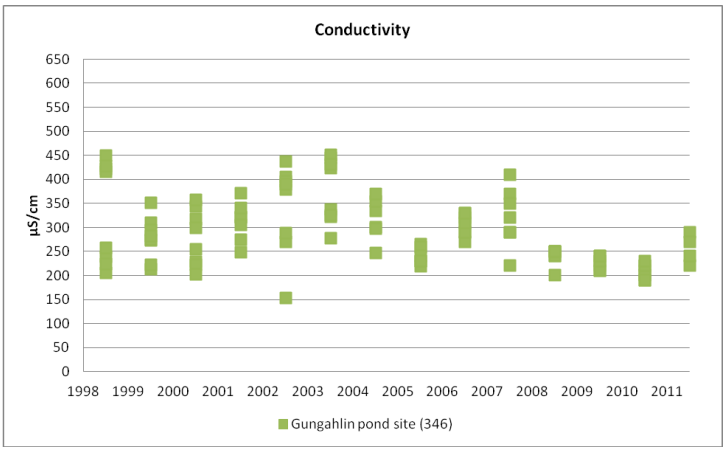

Faecal Coliform
cfu/100 mL
2500
2000
1500
1000
500
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Point Hut site (207)
Faecal Coliform regulation limit (1000 cfu/100 mL)

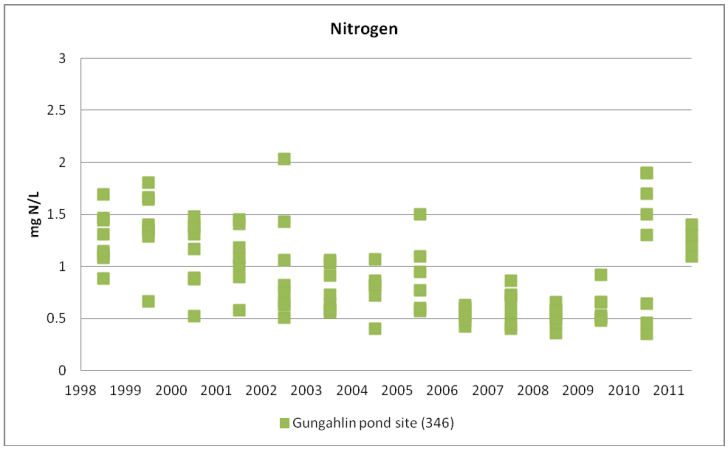

Turbidity
276.1 NTU
220.5 NTU
343.7 NTU
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Point Hut site (207)
Turbidity regulation limit (30 NTU)

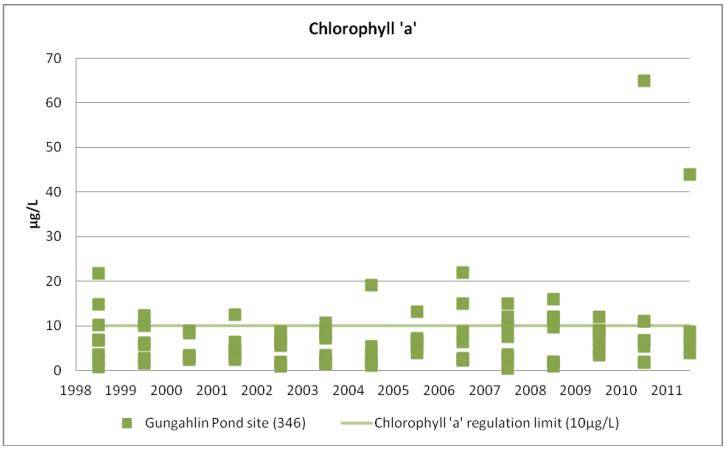
ACT State of the Environment Report 2011

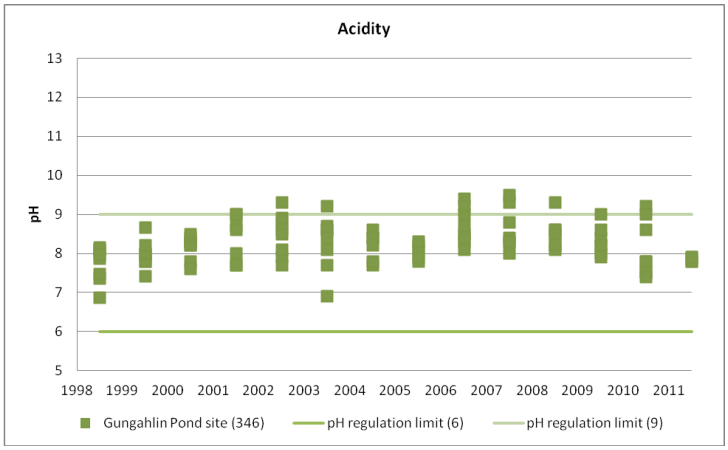
Gungahlin Pond water quality indicators

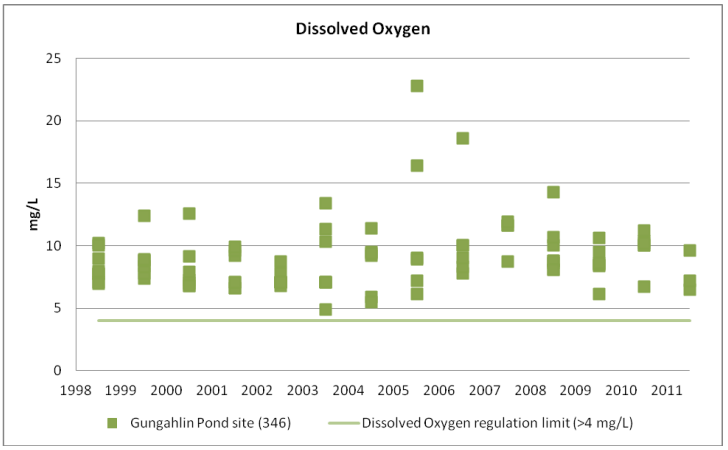












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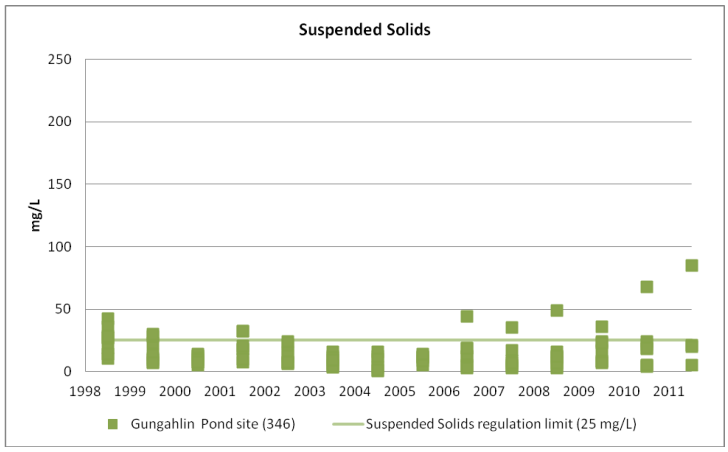
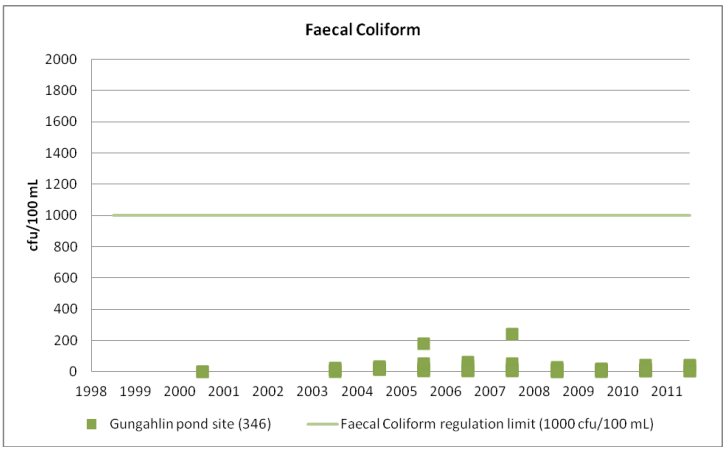
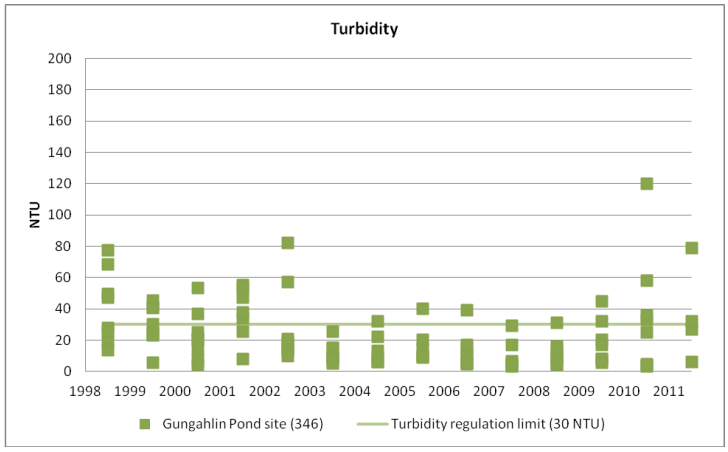


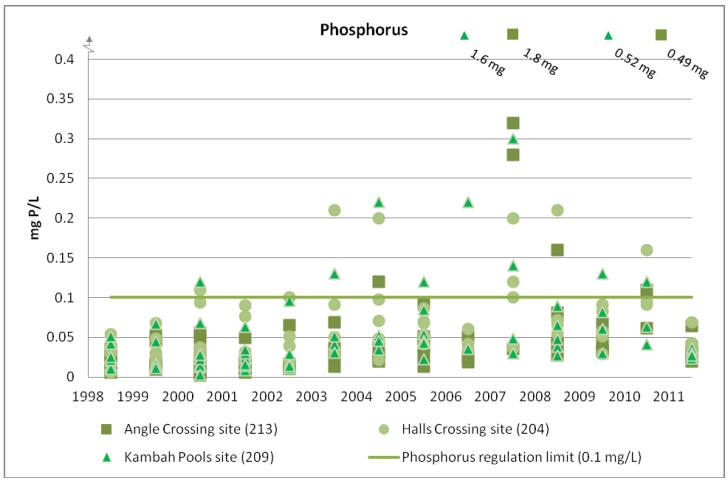


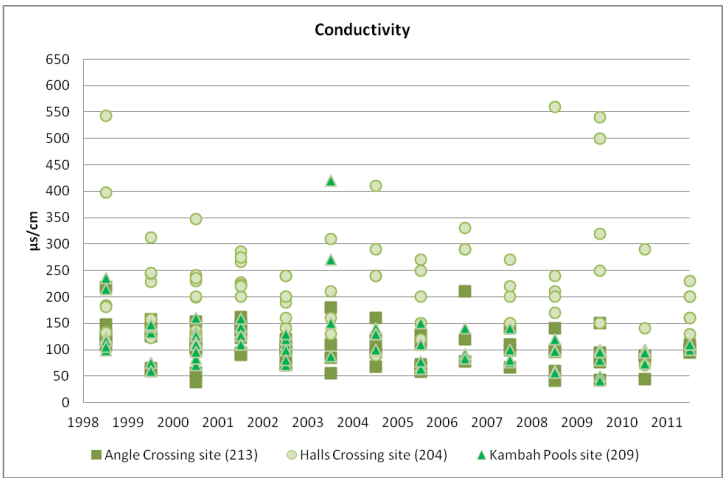


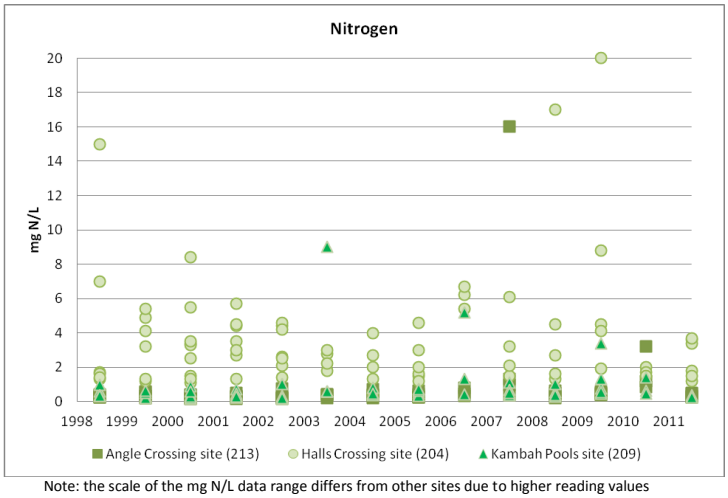
ACT State of the Environment Report 2011

ACT Rivers and Creeks Water Quality

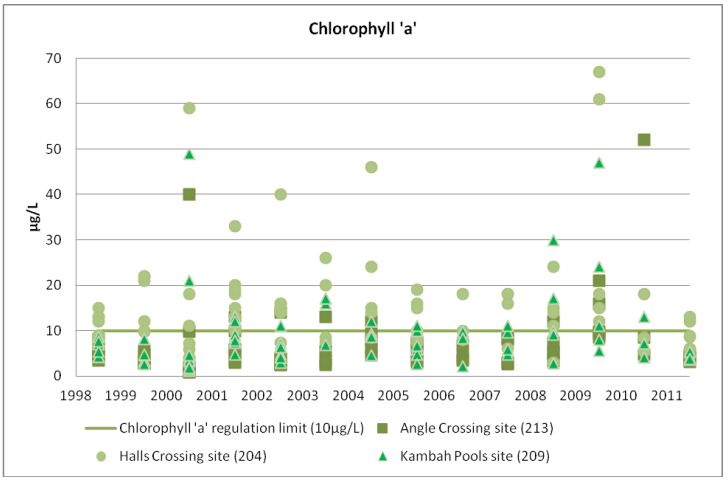
Murrumbidgee River water quality indicators

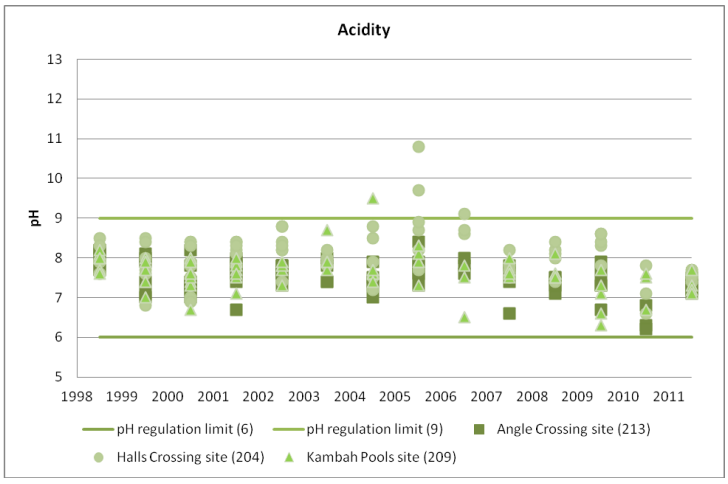


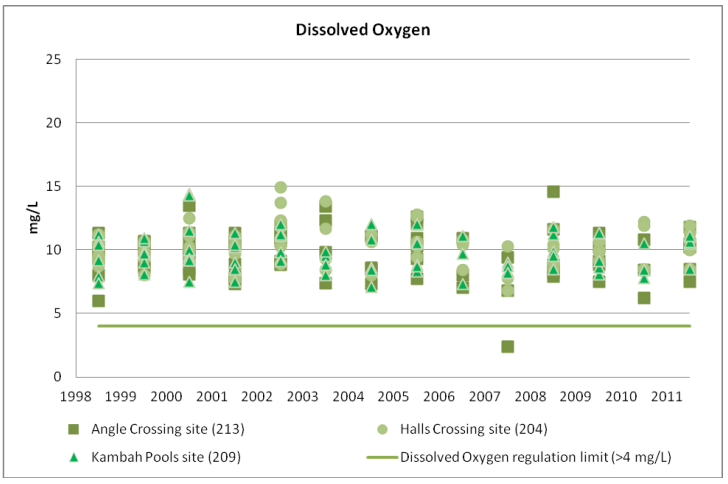




Note: the scale of the mg N/L data range differs from other sites due to higher reading values







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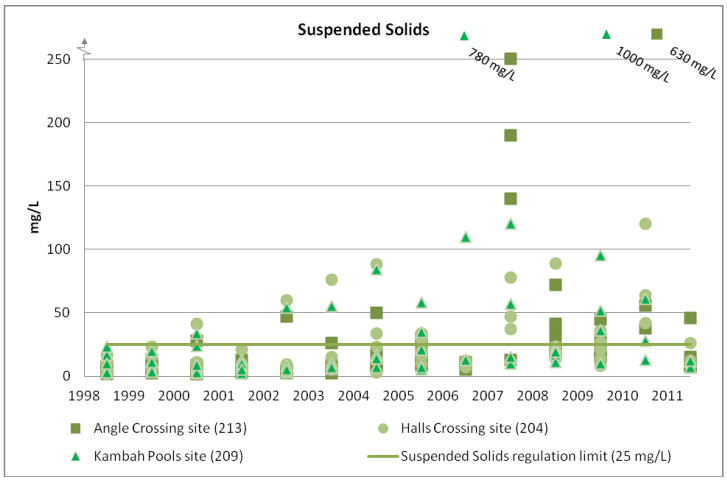

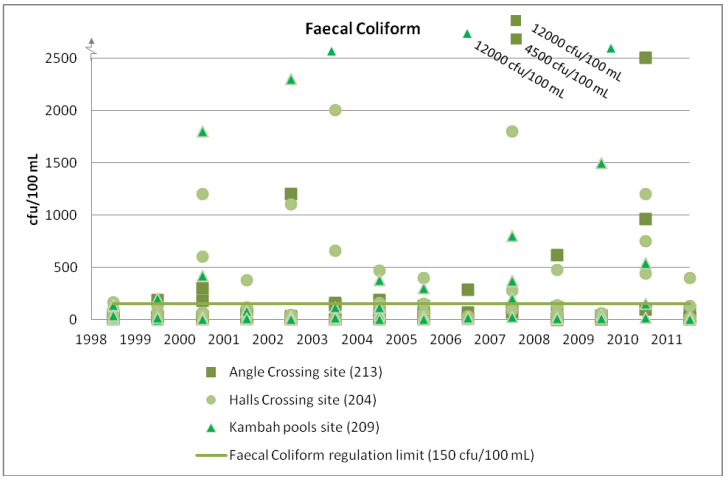

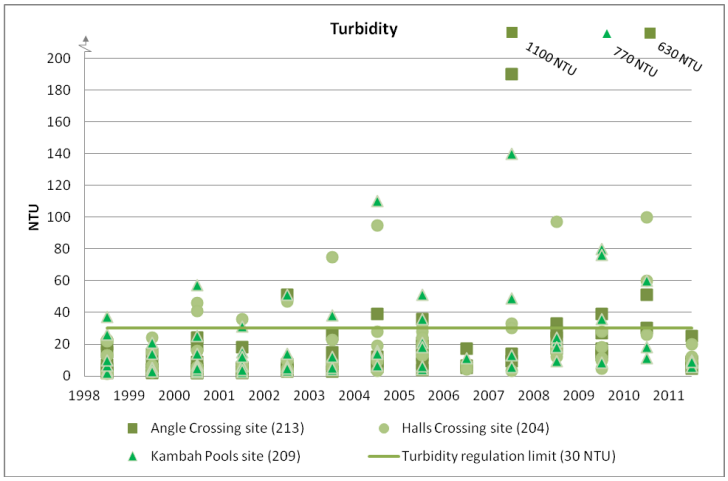

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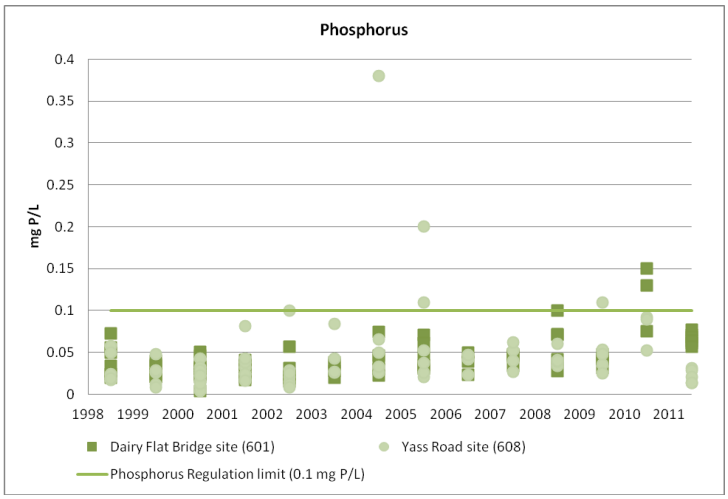
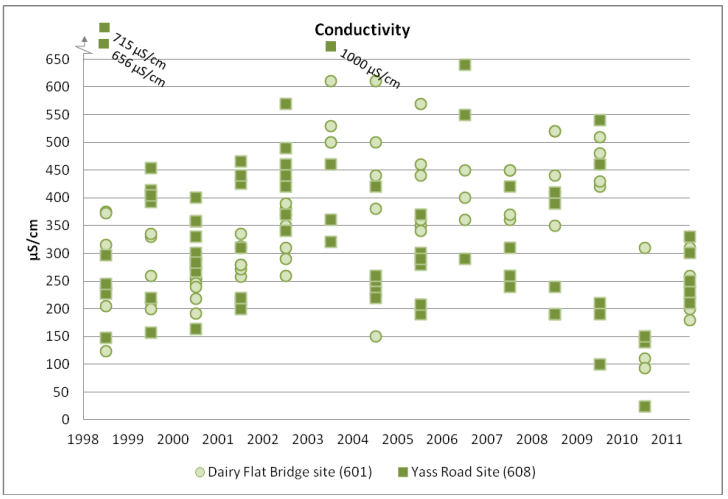
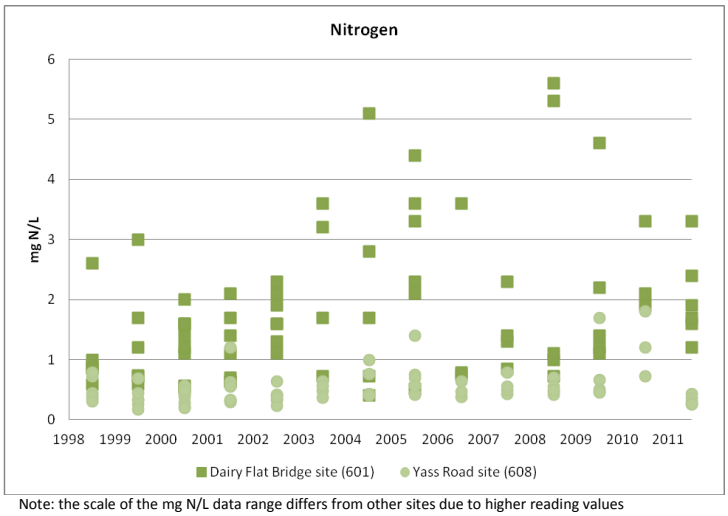
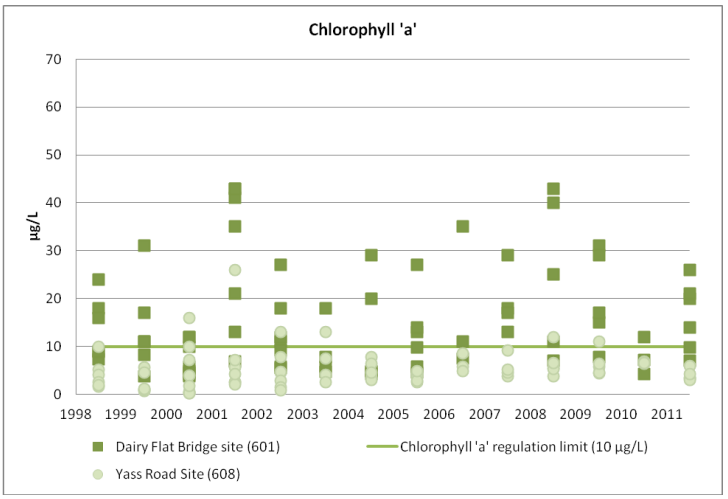
Molonglo River water quality indicators

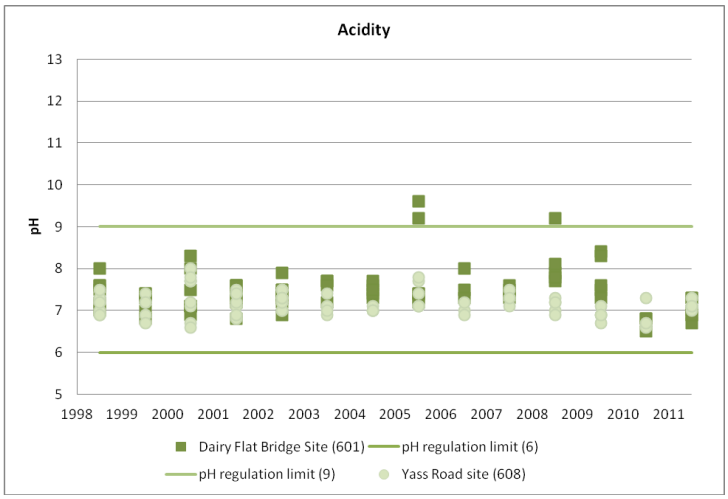


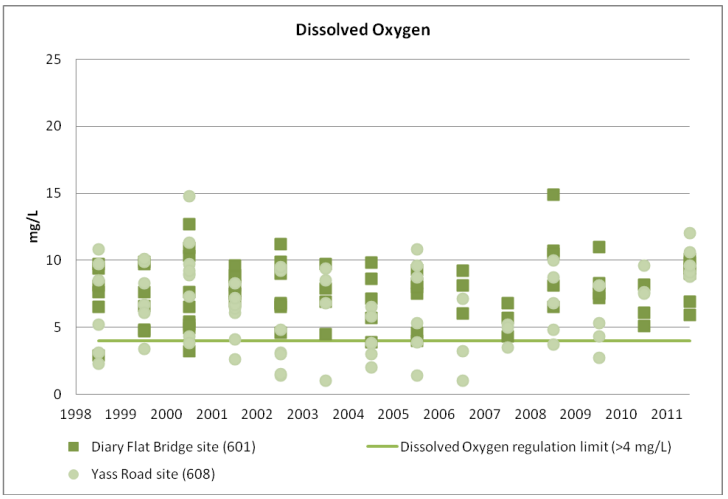




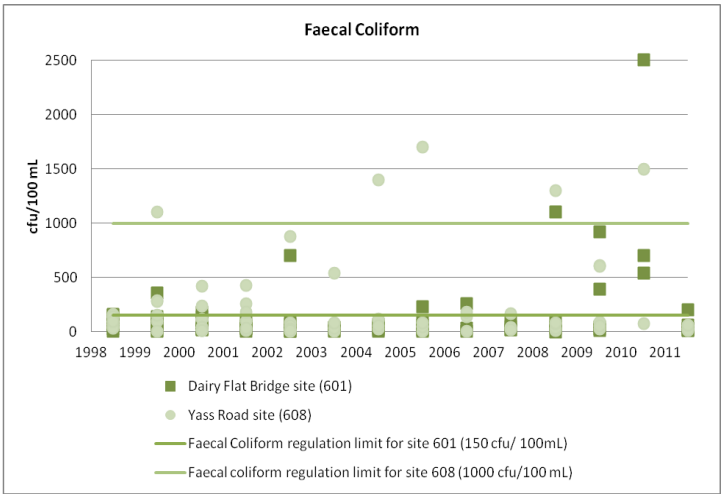
Note: the scale of the mg N/L data range differs from other sites due to higher reading values

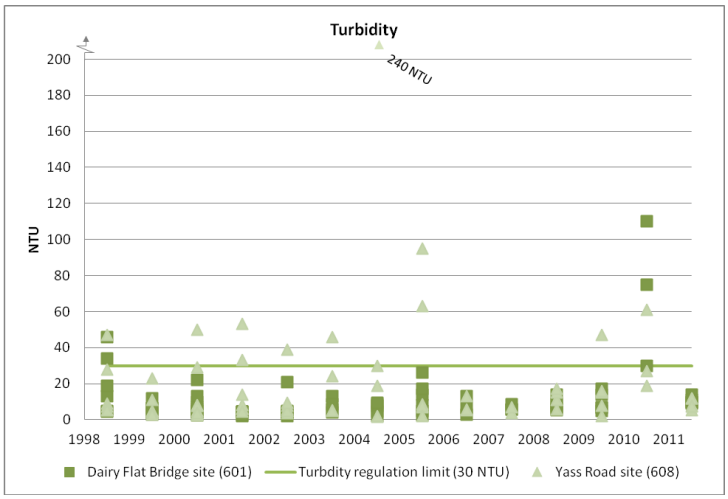






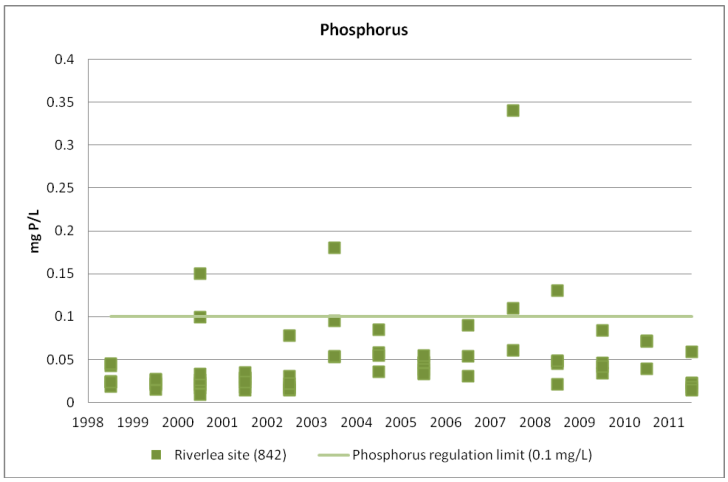
Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dairy Flat Bridge site (601)
Suspended Solids regulation limit (25 mg/L)
Yass Road site (608)

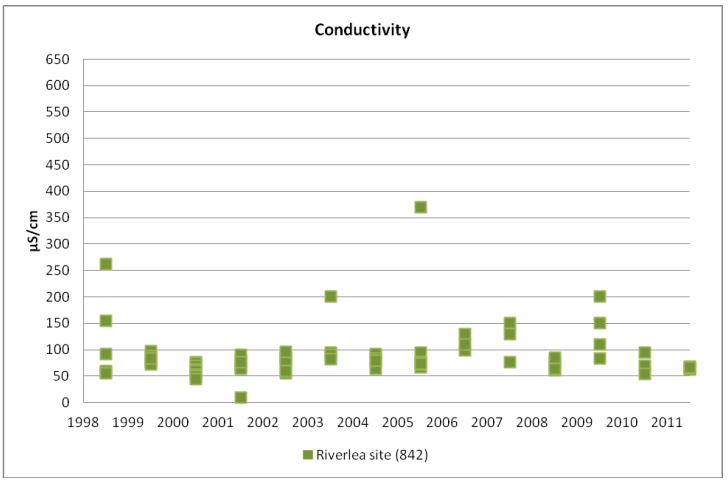

Faecal Coliform
cfu/100 mL
2500
2000
1500
1000
500
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dairy Flat Bridge site (601)
Yass Road site (608)
Faecal Coliform regulation limit for site 601 (150 cfu/ 100mL)
Faecal coliform regulation limit for site 608 (1000 cfu/100 mL)

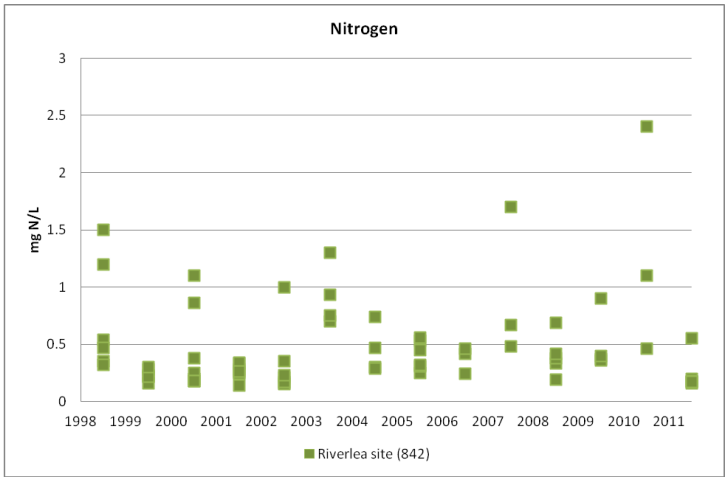

Turbidity
240 NTU
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Dairy Flat Bridge site (601)
Turbdity regulation limit (30 NTU)
Yass Road site (608)

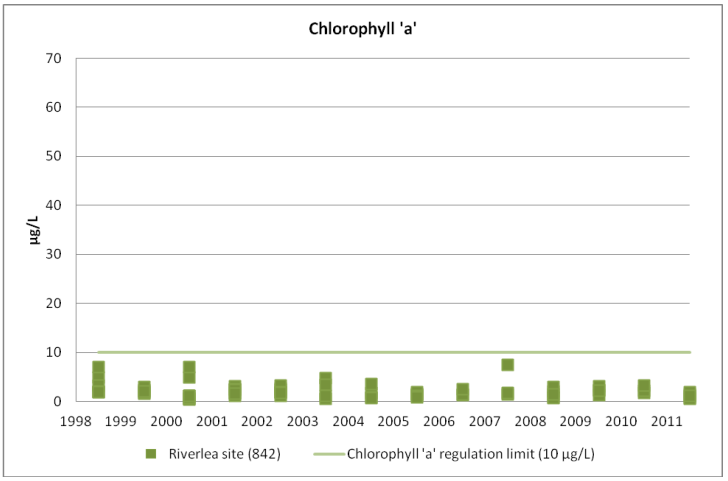
ACT State of the Environment Report 2011

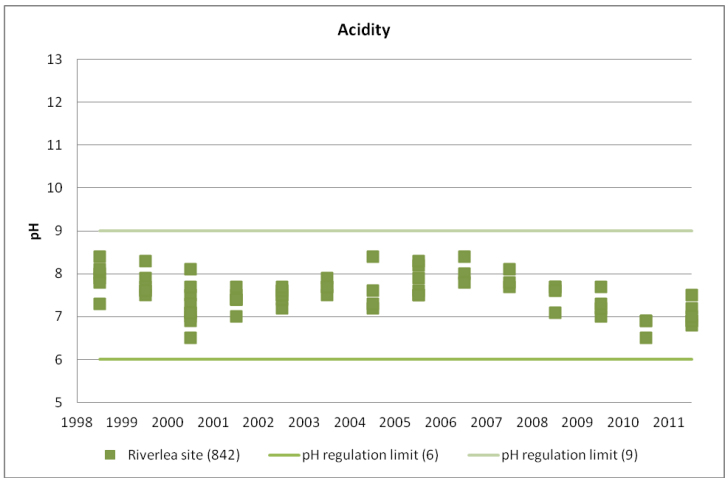
Paddy's River water quality indicators

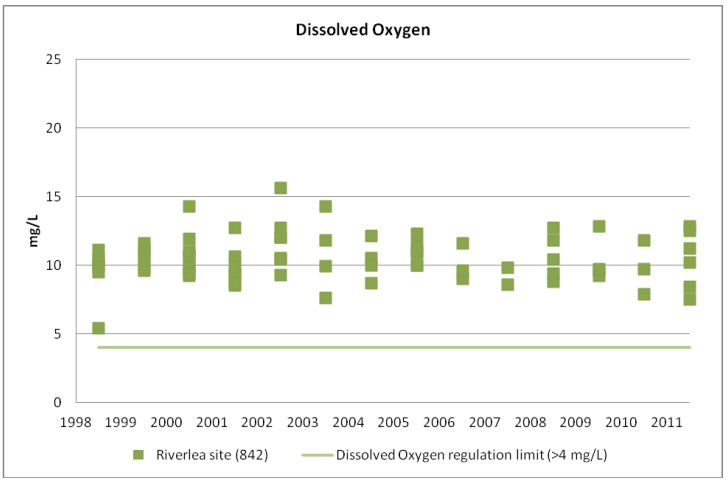


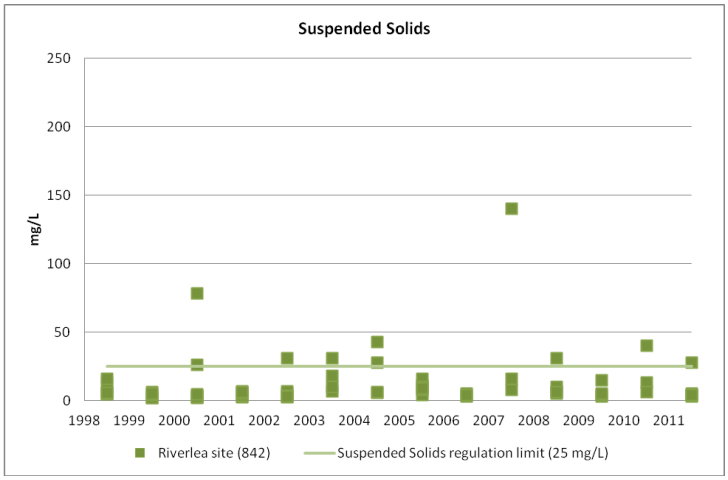


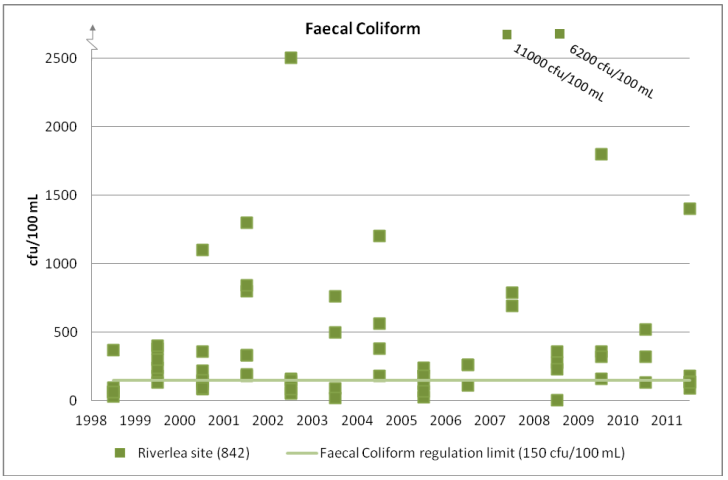


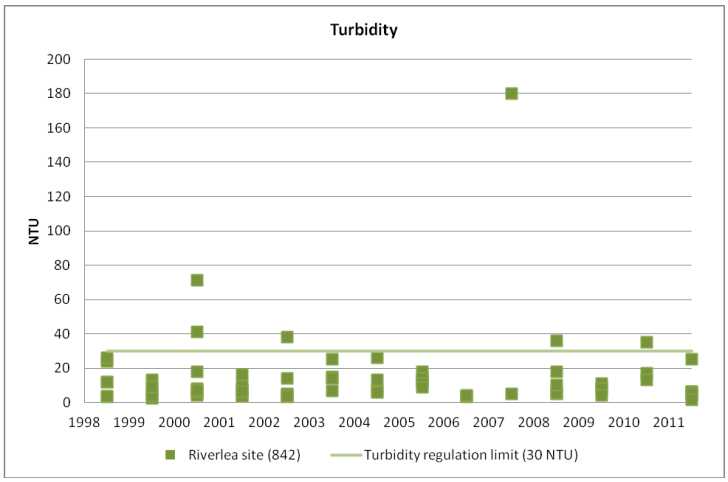






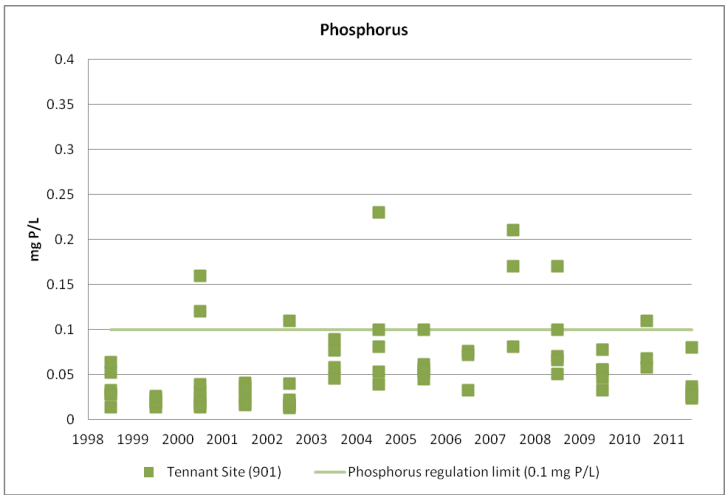

Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Riverlea site (842)
Suspended Solids regulation limit (25 mg/L)

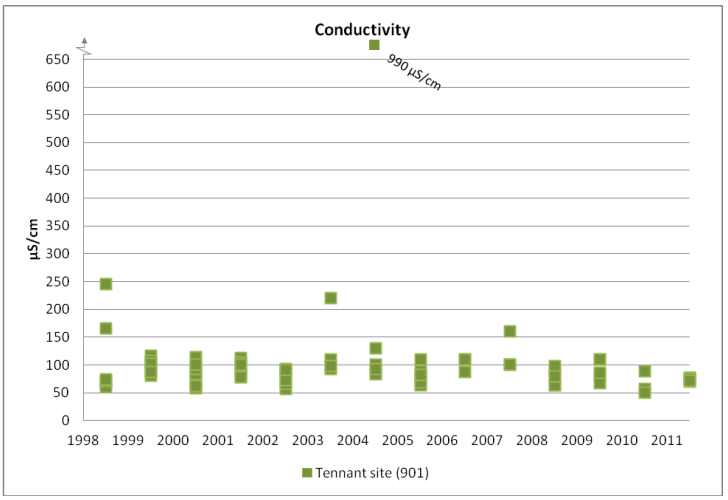

Faecal Coliform
cfu/100 mL
2500
2000
1500
1000
500
0
11000 cfu/100 mL
6200 cfu/100 mL
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Riverlea site (842)
Faecal Coliform regulation limit (150 cfu/100 mL)

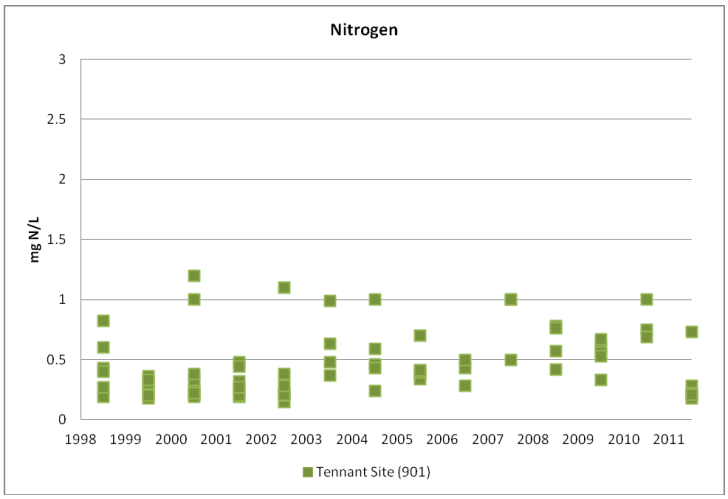

Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Riverlea site (842)
Turbidity regulation limit (30 NTU)

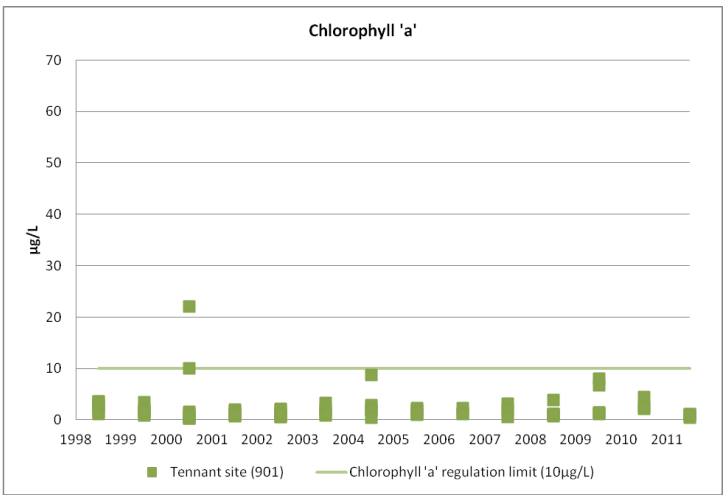
ACT State of the Environment Report 2011

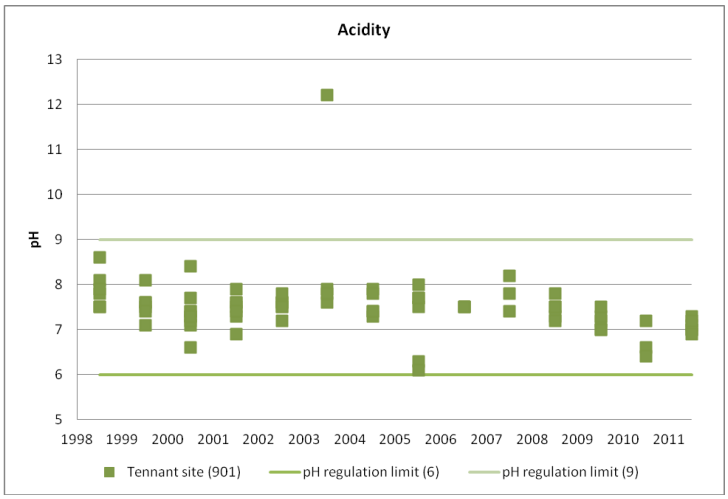
Gudgenby River water quality indicators

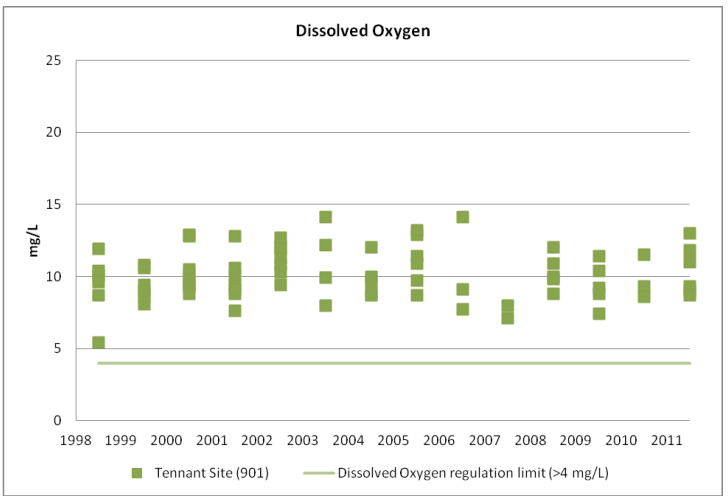




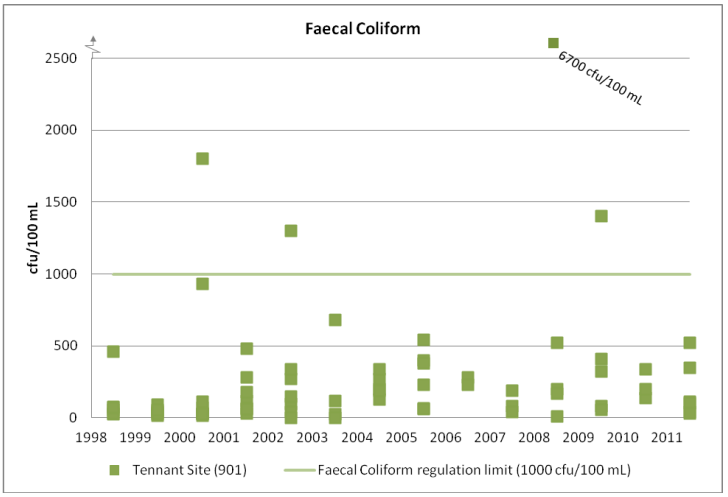


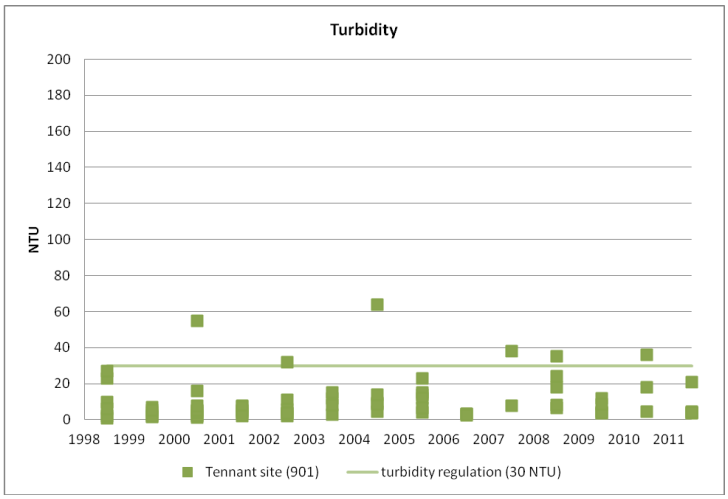






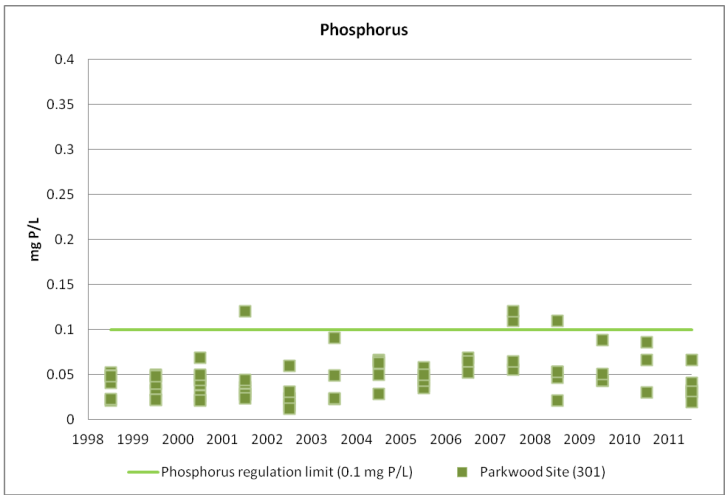
Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Tennant Site (901)
Suspended solids regulation limit (25 mg/L)

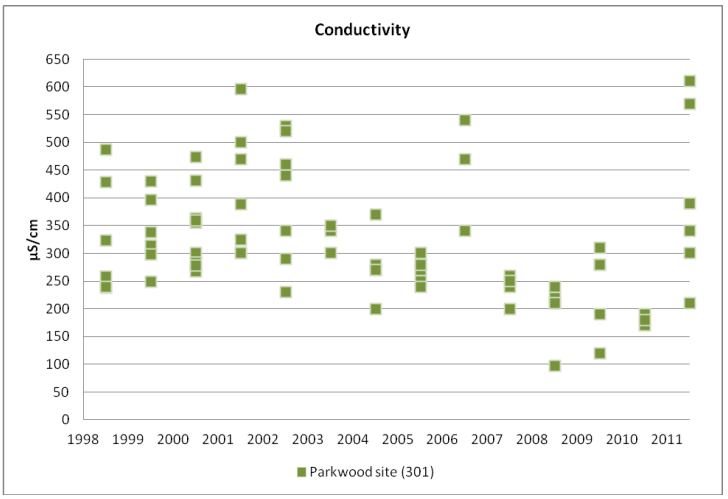

Faecal Coliform
cfu/100 mL
2500
2000
1500
1000
500
0
6700 cfu/100 mL
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Tennant Site (901)
Faecal Coliform regulation limit (1000 cfu/100 mL)

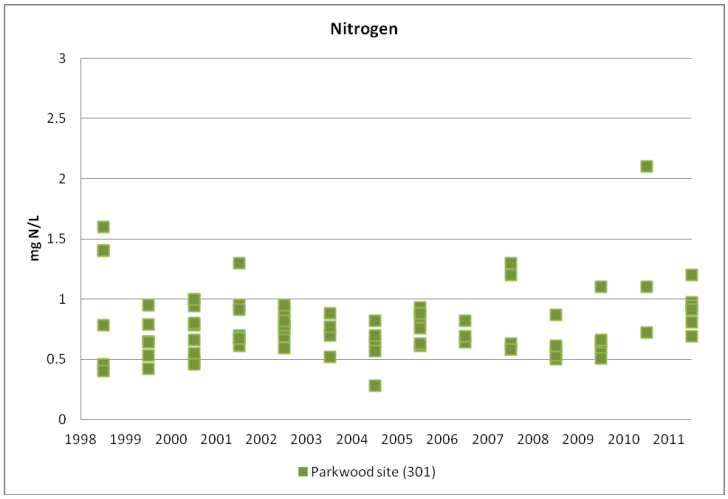

Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Tennant site (901)
turbidity regulation (30 NTU)

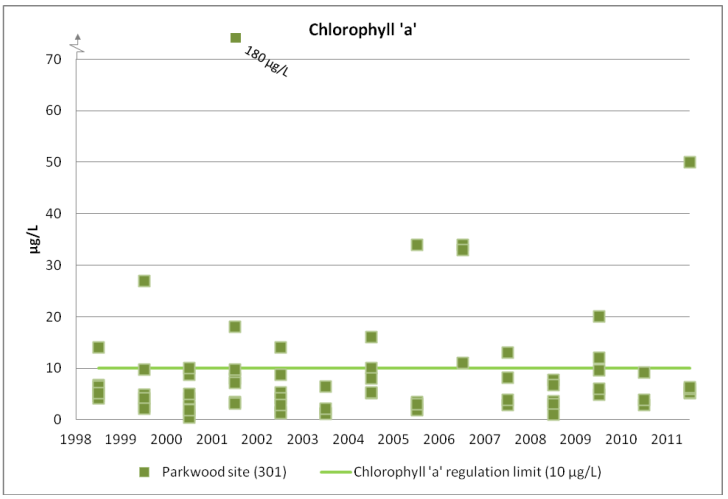
ACT State of the Environment Report 2011

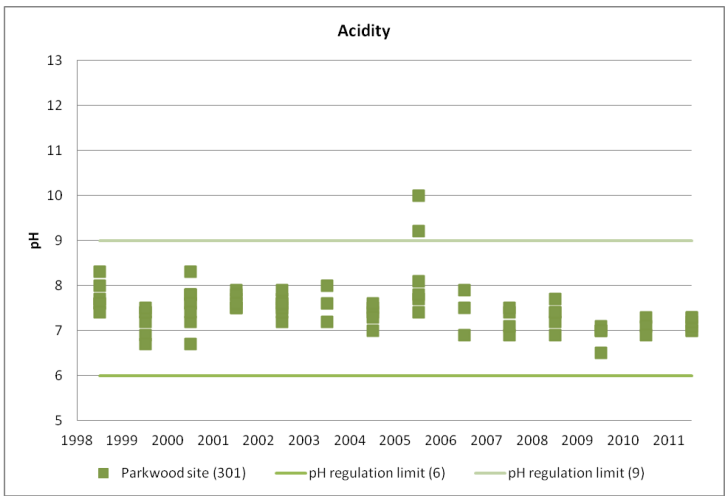
Ginninderra Creek water quality indicators

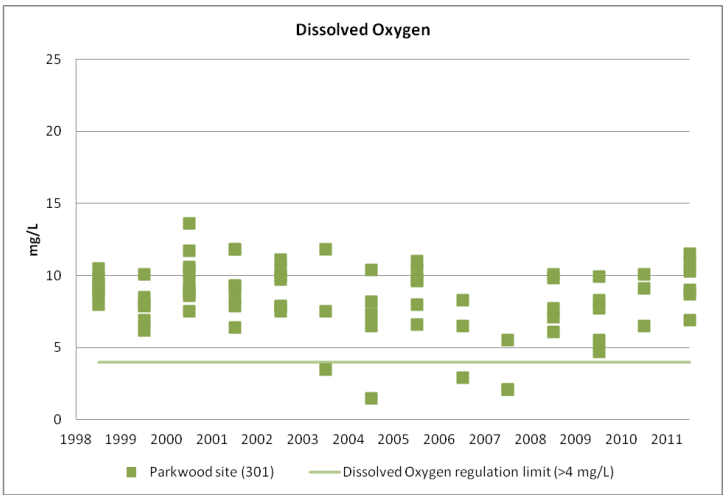


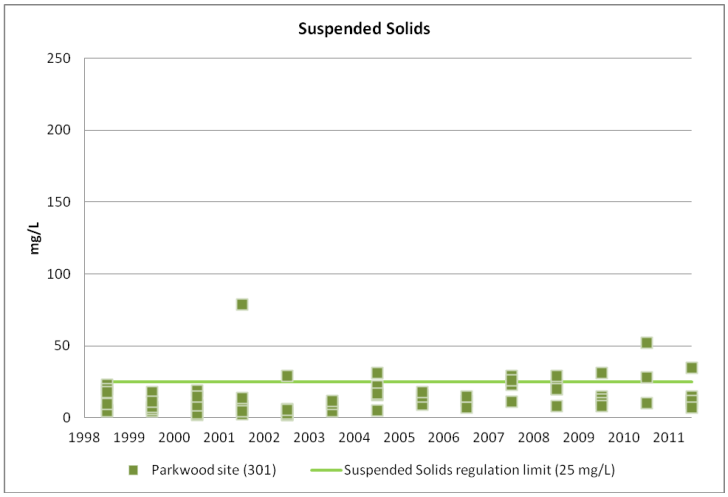


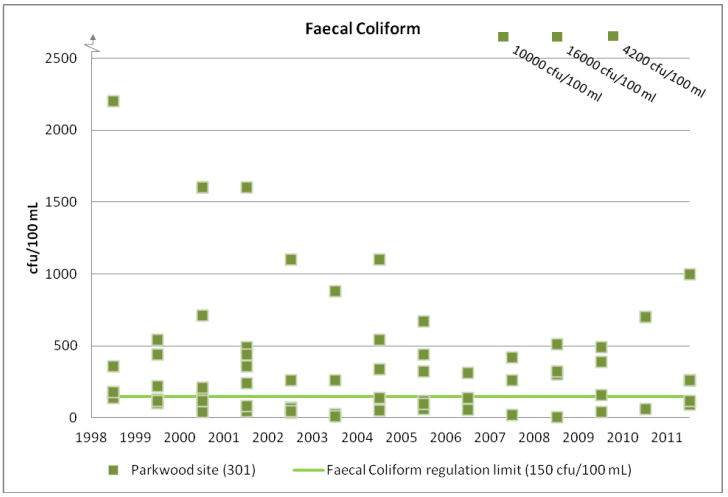


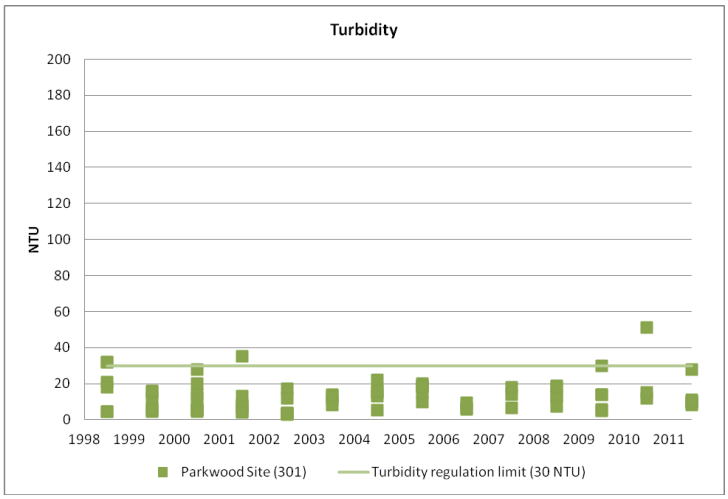






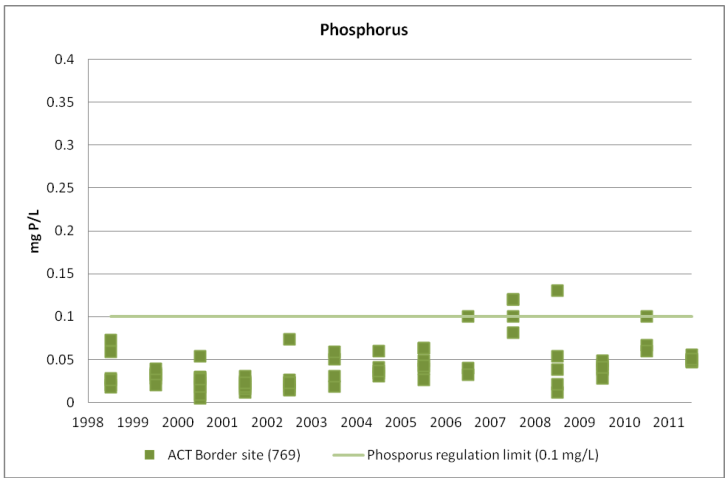

Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Parkwood site (301)
Suspended Solids regulation limit (25 mg/L)

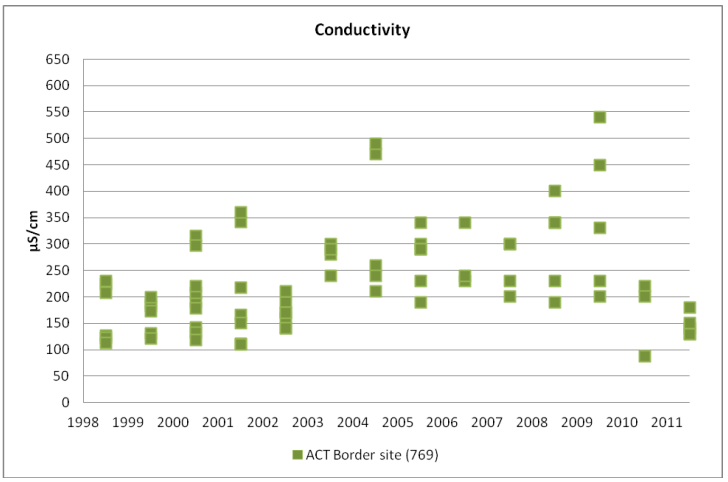

Faecal Coliform
cfu/100 mL
2500
2000
1500
1000
500
0
10000 cfu/100 ml
16000 cfu/100 ml
4200 cfu/100 ml
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Parkwood site (301)
Faecal Coliform regulation limit (150 cfu/100 mL)

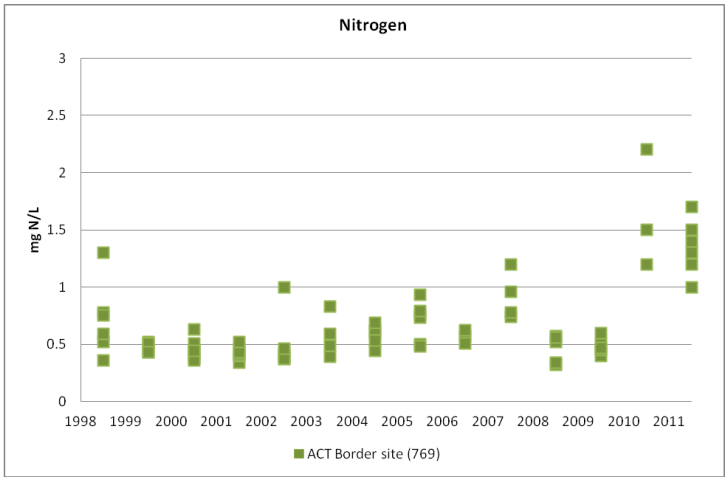

Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Parkwood Site (301)
Turbidity regulation limit (30 NTU)

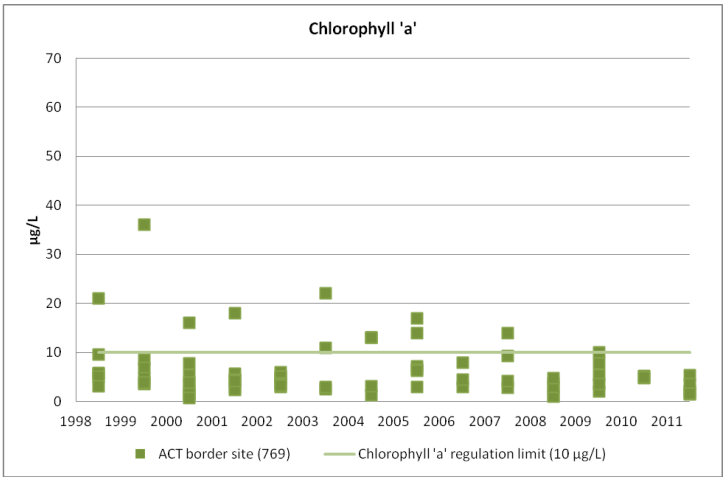
ACT State of the Environment Report 2011

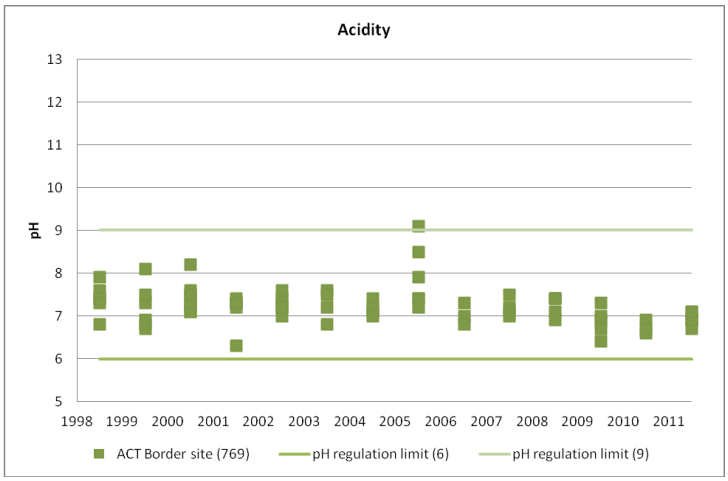
Queanbeyan River water quality indicators

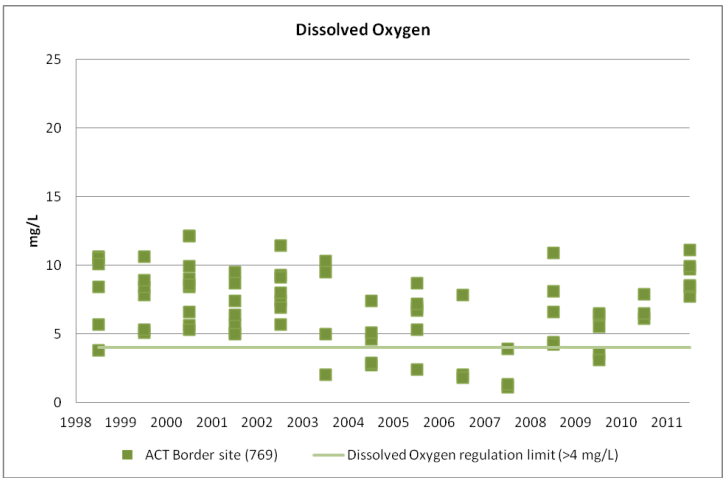


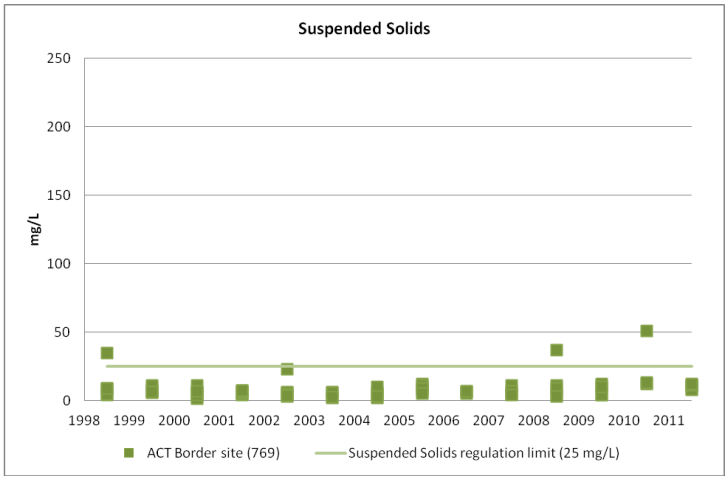


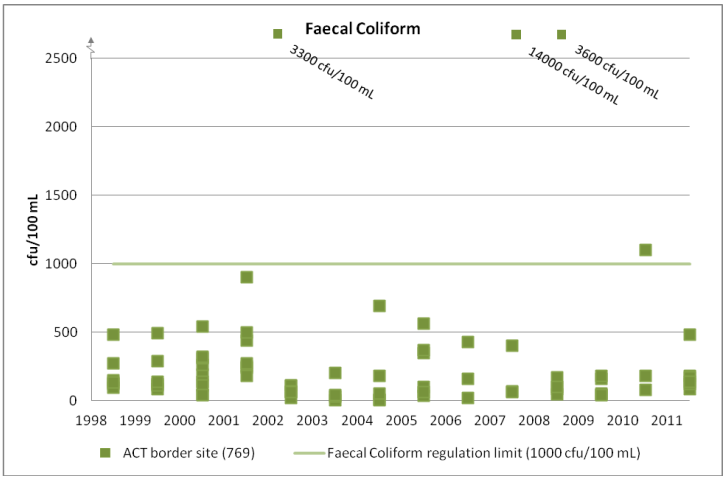


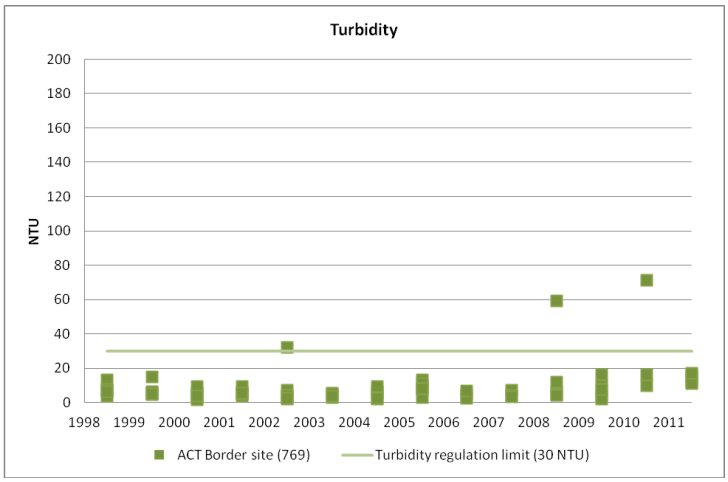







Suspended Solids
mg/L
250
200
150
100
50
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
ACT Border site (769)
Suspended Solids regulation limit (25 mg/L)


Faecal Coliform
3300 cfu/100 mL
14000 cfu/100 mL
3600 cfu/100 mL
cfu/100 mL
2500
2000
1500
1000
500
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
ACT border site (769)
Faecal Coliform regulation limit (1000 cfu/100 mL)


Turbidity
NTU
200
180
160
140
120
100
80
60
40
20
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
ACT Border site (769)
Turbidity regulation limit (30 NTU)

ACT State of the Environment Report 2011

THEME: Land and Water

Indicator cluster: Water supply

This indicator cluster focuses on the supply and use of potable water for ACT, and related impacts such as on environmental assets. The indicators for this cluster are:

- *Dam storage* (C) - Drinking water storage levels;
- *Dam water quality* (C) - Dam water-quality prior to treatment;
- *Drinking water quality* (C) - Treated drinking water quality;
- *Water use* (P) - Water use by sector;
- *Environmental flows* (I) - Including volume, quality, nature, regime, timing and effects of dam releases;
- *New water supplies* (R) - New sources of water supply;
- *Water demand management* (R) - Effectiveness of water demand-management; and
- *Environmental flow management* (R) - Effectiveness of implementation of environmental flow guidelines.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

The ACT relies on a range of water-supply sources including dams, rivers, groundwater, rainwater tanks, stormwater harvesting, and recycled water.

During the reporting period, like much of south-eastern Australia, the ACT continued to experience severe drought until 2010-11 when there was significant rainfall. Since 2007-08, water storage levels have increased from less than 40% to 100% capacity. Above average rainfall between June and December 2010 led to significant inflows into the storages, making them more than 80% full for the first time since 2000. The water quality from these storages was good in each year of the reporting period, meeting the standards in the *Australian Drinking Water Guidelines*.

ACT State of the Environment Report 2011

In response to the drought and the consequent reduced inflows into the ACT's water-supply storages, the ACT Government endorsed water restrictions and a number of water conservation measures, and developed new water-supply augmentation projects. There was also a continued focus on water-demand management.

Introduction

The *Water supply* indicator cluster for the reporting period includes 8 indicators that collectively report on water supply, water use, drinking water quality, environmental flows and demand management. While the indicator cluster focuses on 2007–11, it needs to be considered in the context of the decade-long drought in eastern Australia, which ended in 2010 (BoM 2011). As with many cities and regions, the ACT is taking an integrated approach to water supply and demand management, with further investment in both traditional and alternative water supply sources.

Condition indicators

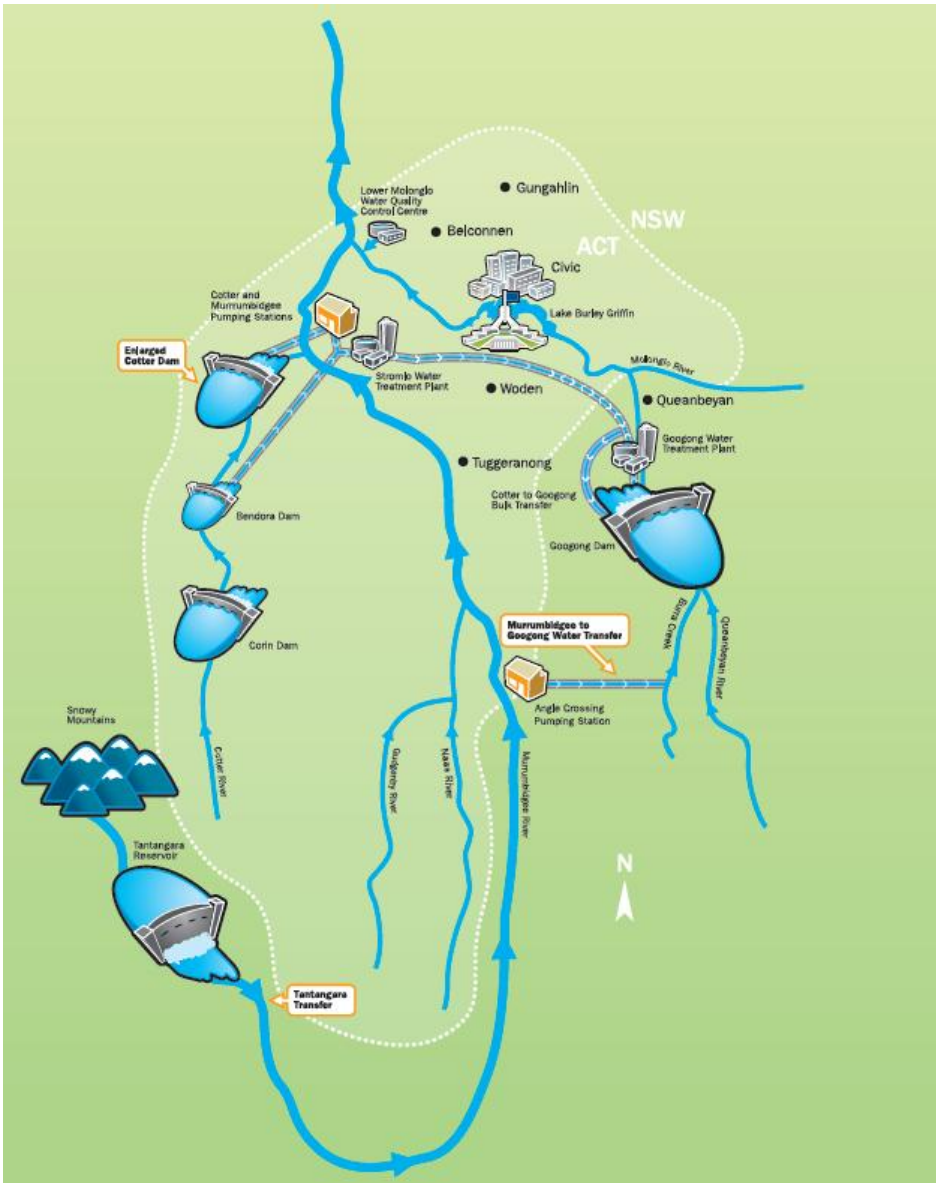
Dam storage

The ACT draws water from 3 separate catchments (Figure 1) and associated infrastructure:

- the Cotter River catchment and its 3 reservoirs: the Cotter, the Bendora and the Corin;
- the Queanbeyan River catchment, which supplies the water held by Googong Dam in NSW; and
- the Murrumbidgee River catchment, via Cotter Pump Station rather than a reservoir.

The 4 reservoirs have a combined storage capacity of 207 GL (ACTEW 2011a).

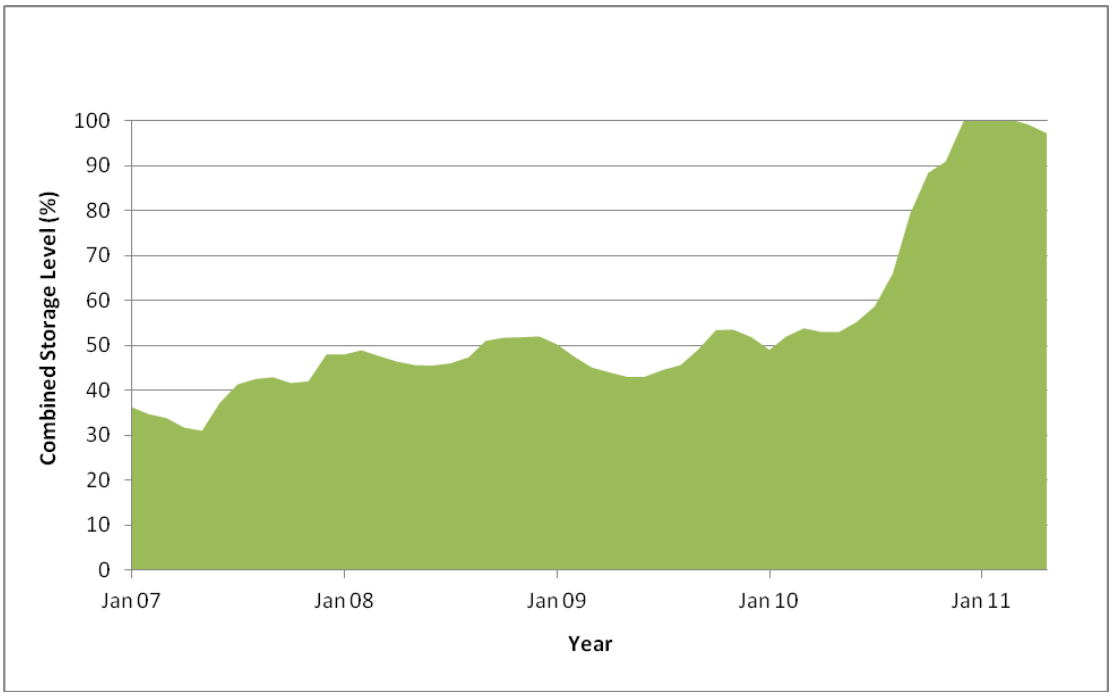
Figure 1. Water supply network and dam catchments that provide water to the ACT



Source: map courtesy of ACTEW Corporation
Note: map includes approved infrastructure still under construction

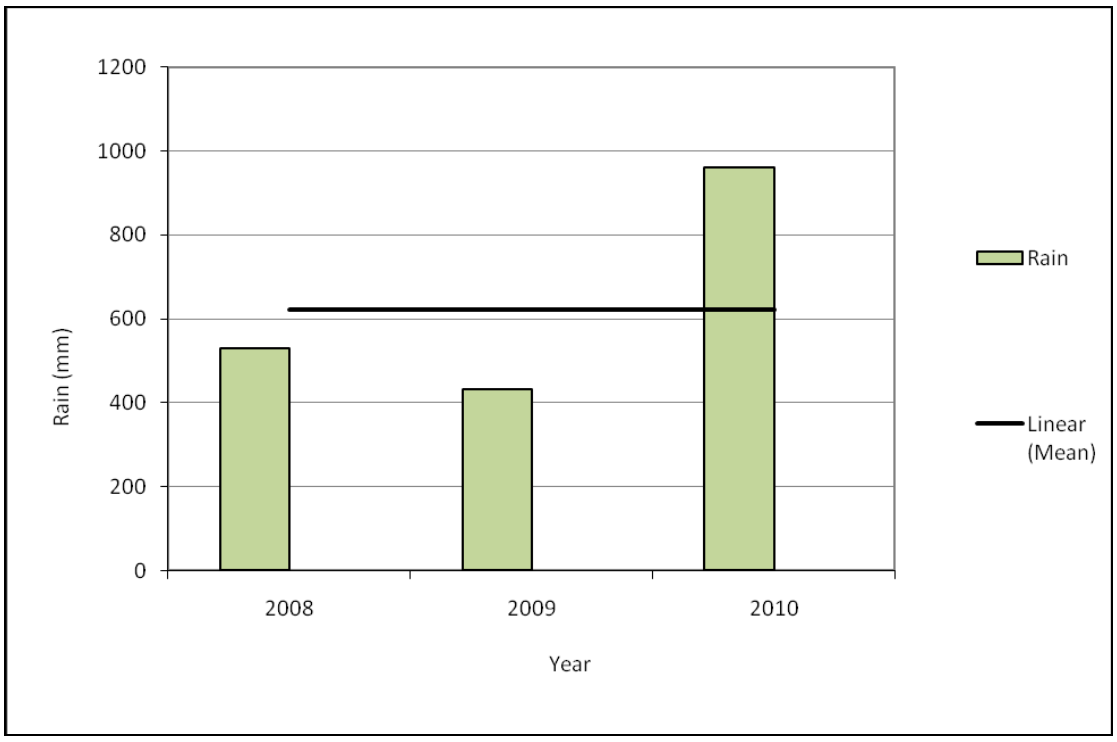
Since 2007-08, water storage levels have increased from less than 40% to 100% capacity (Figure 2). Above average rainfall between June and December 2010 (Figure 3) led to significant inflows into the storages, making them more than 80% full for the first time since 2000. Between October and December in 2010, the Cotter Reservoir overflowed on 6 different occasions for a total of 36 days.

Figure 2: Water storage levels between January 2007 and March 2011



Source: ACTEW 2011a

Figure 3. Trends in rainfall at Canberra Airport 2008-2010



Source: Davis and Lindesay 2011

Between 2007 and 2009, water storage levels for the ACT were kept low by inflows that were much smaller than the historical average. Table 1 shows that an annual average of 70 GL of water flowed into the storages during 2005-2010, compared to an annual average since records began of 228 GL (ACTEW 2011a).

Climate-change predictions of increased air temperatures and reduced rainfall and runoff in the region are likely to challenge future water supply for the ACT. Based on advice from CSIRO, ACTEW is using inflow reductions of 50% of long-term average in its water-planning scenario modelling (ACTEW 2011b). The *Water Security for the ACT and Region* report (ACTEW 2007) estimated average annual inflows of approximately 105 GL to the 3 main dams. This estimate is significantly lower than the average annual inflows estimated by CSIRO research in 2005 (132 GL per year) and the historical average annual inflows (Table 1).

For more information see the *Climate vulnerability* indicator cluster.

Table 1. Average water inflows into water storages prior to June 2010

Reservoir	Average annual inflow, ML (1928-2009)	Average annual inflow, ML (2000-2010)[1]	Average annual inflow, ML (2005-2010)[1]
Corin	59	37	29
Bendora	38	18	14
Cotter	39	17	12
Googong	92	16	16
All reservoirs	**228**	**88**	**70**

Source: ACTEW 2011a

Notes: [1] – Average inflow into water storages calculated at June 2010. Inflows have since increased with significant rainfall.

Dam water-quality

Dam water-quality before treatment is strongly dependent on the quality of the surface waters that flow into the storages.

ActewAGL, which operates the ACT water-supply infrastructure, has an extensive program of monitoring the reservoir water quality for microorganisms, blue-green algae and pesticides. Overall, the water quality within the reservoirs over the reporting period was good (ActewAGL 2010a). This is an improvement on the previous reporting period, when dam water quality was affected by sediment and debris from the 2003 bushfires. However, concentrations of blue-green algae were higher in the Googong Reservoir over the current reporting period. As a result, additional activated carbon treatment was applied to the water to remove potential

toxins, odour and taste. The untreated water quality in the Cotter River catchment is generally better because of the protection of the catchment from human-based land uses (ActewAGL 2010a). Further information on the health risks posed by blue-green algae is presented in the *Water quality* indicator cluster.

Water from the Upper Murrumbidgee River, while not in a reservoir, is now an important part of the overall ACT water supply network. The water is directly used for drinking by the populations of Cooma-Monaro, ACT and Queanbeyan. Water quality in the Upper Murrumbidgee River varies considerably, mostly because of sediment inflows and the resulting turbidity. Lower treatment costs and better quality drinking water should result if the turbidity can be reduced or prevented.

Drinking water quality

Water is treated at 2 water treatment plants before it is supplied for use in the ACT:

- the Mount Stromlo Water Treatment Plant treats water from the Cotter River reservoirs and the Murrumbidgee River; and
- the Googong Water Treatment Plant treats water from Googong Reservoir on the Queanbeyan River.

Both of these water treatment plants are able to treat enough water to supply the daily average summer demand for Canberra and Queanbeyan. This is necessary to ensure that water can continue to be provided to the ACT if either reservoir has significant water quality issues, such as blue-green algal blooms or sediment and turbidity from bushfires or erosion. Over the reporting period, the Mount Stromlo Water Treatment Plant supplied most of the water customers in ACT.

Water quality is monitored at the water treatment plants to ensure the drinking water meets the *ACT Drinking Water Code of Practice 2007*, which refers to the *Australian Drinking Water Guidelines* (NHMRC 2004), and is suitable for human consumption. In the Code of Practice, the concentration for each water quality characteristic is set to a level that does not pose a significant risk to human health from consumption of water.

Annex 1 outlines the monitoring results for quality of ACT drinking water during 2007-08 to 2009-10 (Tables A1-A3). The drinking water quality was good in each year of the reporting period. Drinking water quality was consistent across the parameters and met the standards in the *Australian Drinking Water Guidelines*. The pH varied between 6.2 and 9.2, but on average it was within the limits (6.5 to 8.5) in approximately 97% of samples.

The percentage of water samples with exceedances in total coliform bacteria was highest in 2007-08, when 1.6% did not meet the standard set in the Guidelines. However, none of the bacteria was identified as faecal coliform. In only one sample in 2008-09 were faecal coliforms detected (Annex 1, Tables A1, A2, A3). For more information on faecal coliform bacteria, see the *Water quality* indicator cluster.

Over the reporting period, there was an average of one complaint per 1000 properties each year regarding drinking water quality (ActewAGL 2010a), equivalent to approximately 137 complaints per year. The complaints have decreased significantly from the previous reporting period (for example, there were 792 complaints in 2005-06), when drinking water quality was extensively affected by debris in the storage dams following the 2003 bushfire.

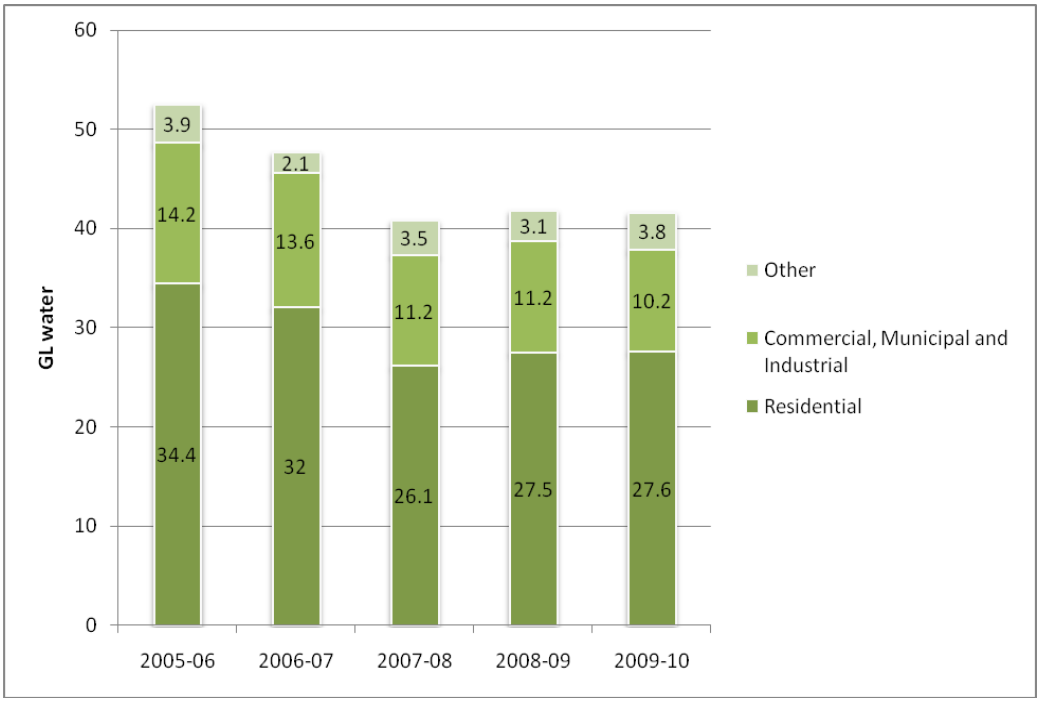
Pressure indicators

Water use

As reported in the previous *ACT State of the Environment Report*, use of potable water in the ACT was severely affected by drought until 2010. The total potable water use decreased by approximately 11 GL between 2005-06 and 2009-10 (Figure 4). The lower water use was probably a result of water restrictions and permanent water conservation measures in ACT. The National Water Commission has observed (NWC 2011) a national decline in water use as a result of a number of factors, such as water restrictions, community education campaigns and an enduring community commitment to efficient water use.

With increased rainfall and removal of water restrictions in ACT, it will be interesting to see if water use increases again.

Figure 4. Total potable water use within the ACT



Source: based on data from ActewAGL 2008a, 2009a and 2010a, and Annex 1 Table A4

Notes: [1] – 'Other' includes the volume of water supplied to miscellaneous uses, including losses from the distribution network.

Most of the potable water in the ACT is used by households (58%) and industry (23%). Household and commercial water use during the drought decreased from an average of 240 kL/year in 2006-07 to 199 kL/year on average in 2009-10 (Table A4, Annex 1). This represents a 17% decrease in household consumption in 4 years. Overall, this reduction in household water use was greater than the national average reduction in residential water use (228 kL/year in 2003-04 to 192 kL/year in 2009-10; NWC 2011). Table 2 compares the average water consumption recorded in major cities around Australia during 2005-2010.

Table 2. Average residential water supplied (kL/property) to major cities by water supply companies

	2005-06	2006-07	2007-08	2008-09	2009-10
Canberra (ACTEW)	261	240	195	201	199
Sydney (Sydney Water)	203	199	182	198	205
Perth (Water Corporation)	268	281	268	277	276
Adelaide (SA Water)	233	235	195	190	191
Melbourne (Yarra Valley Water)	198	178	157	151	144
Brisbane (SEQ Water)	185	153	128	133	143

Source: NWC 2011

In the ACT, groundwater is also used as a water resource for rural communities and agriculture. For further information about groundwater, refer to the *Groundwater* indicator cluster.

Impact indicators

Environmental flows

Environmental flows are the flows of water in streams and rivers that are necessary to maintain the health and functions of aquatic ecosystems. Environmental flows are designed to mimic natural river flows. Unnatural flow patterns, especially over long periods of time, have the potential to adversely affect aquatic biodiversity and riparian vegetation. Flow regimes in working rivers have changed to suit human needs and agriculture based on introduced crops, often to the detriment of indigenous riverine flora and fauna adapted to the local conditions. In heavily used river systems such as in water supply catchments, environmental flows can be delivered in ways that protect specific components of the flow regime, to help keep stream ecosystems healthy (ACT Government 2006).

The *ACT Environmental Flow Guidelines* (ACT Government 2006) protect particular components of natural streamflow:

- baseflow;
- small floods (riffle maintenance flows);
- larger floods (pool or channel maintenance flows); and
- special purpose flows.

The baseflow is the flow component that a stream needs to support fish, plants and insects, and sustain water quality. In upland areas such as the ACT, it is contributed mostly by groundwater. The volumes of baseflow have been determined for each month for each stretch of stream or river in the ACT (ACT Government 2006).

Environmental flows in the ACT are provided through releases and spills from the reservoirs on dammed rivers, and on other rivers they are provided through restrictions on the amount of water that can be withdrawn. The total volume of water available for abstraction and use is limited by the ACT compliance to the Murray-Darling Basin Cap, and by the volume of water remaining after environmental flow volumes have been provided (ACT Government 2006).

Environmental flows required to be released from water storages in the ACT varied significantly over the reporting period. ACTEW has a *Licence to Take Water*

(ActewAGL 2008b, 2009b, 2010b) that specifies the minimum volumes and timing of flows required to be released by each dam. The volume and timing of releases change with water supply levels (environmental flows can be larger when there are no water restrictions; smaller, more managed volumes were released during the different stages of water restrictions). The environmental flows downstream of each dam differ to reflect the varied aquatic values of downstream reaches of river. For example, the reach downstream of Bendora Dam is of a higher ecological value than the reach downstream of the Cotter Dam.

The total volume of water released from dams as environmental flows decreased from 131 GL in 2005-06 to 29 GL in 2007-08 as a result of the drought (Table 34). However, water released for environmental flows in 2010-11 has increased significantly because of the spills caused by flood flows in December 2010, and a rapid increase in water stored within the water supply system.

Table 3. Environmental flow volumes downstream of water supply dams

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Releases and spills (ML)	131,226	63,287	29,451	32,473	42,432	543570
Minimum required environmental flows (ML)	23,859	24,383	22,505	20,794	22,572	49,260

Source: ActewAGL 2008a, 2009a, 2010a

Note: the volumes are the sums of volumes of water relating to the 4 water supply dams only (Corin, Bendora, Cotter and Googong) and are only the volumes leaving the water supply catchments, not the total of all the environmental flows in the ACT

Over the reporting period, monitoring data for water-supply catchments indicated that most reaches were in an impaired condition. For a short time, during extreme water scarcity, the reach downstream of the Cotter Dam was in a poor condition before improving to an impaired condition once flows returned to a higher level. ACTEW has complied with all the environmental flow conditions of its licence to take water. An adaptive management approach that balances ecological needs with human consumption needs has aimed to meet the critical needs of aquatic and riparian ecosystems during severe drought.

Response indicators

Policy framework

The ACT is within the Murray-Darling Basin and is subject to a limit, or 'cap', on the amount of surface water that can be taken (diverted) for consumption. The current

cap on surface-water diversions across most of the Basin was set at a level based on the 1993-94 level of use and development. It may no longer be a sustainable level across the Basin as a whole. In addition, the existing cap does not limit the use of groundwater, which has been increasing across the Basin. The ACT has met its required cap to date.

Through a new Basin Plan the Murray-Darling Basin Authority (MDBA) is establishing new sustainable diversion limits on both surface and groundwater extractions in the Basin, with the aim of better reflecting more sustainable use. The new Basin Plan will also identify risks to Basin water resources, such as from climate change, and it will propose strategies to manage those risks. Examples may include a water quality and salinity management plan, and requirements that State water-resource plans will need to comply with if they are to be accredited under the *Water Act 2007* (MDBA 2011).

In 2004, the ACT Government released its water resource strategy *Think water, act water - a strategy for sustainable water resource management* (ACT Government 2004). The strategy provides a framework for water resource management including security of supply, efficient use and management. A review of the *Think water, act water* strategy is currently underway. Measures implemented under the strategy are discussed below.

Water policy in the ACT is also guided by requirements set out in the national reforms embodied in the Intergovernmental Agreement on a National Water Initiative, of June 2004, and the Council of Australian Governments (COAG) water reform program of 2008.

Water security

The ACT has been investigating and developing new water supplies in response to increased climate variability, drought, increasing population and water demand. A number of water supply improvements have been implemented. The 3 major projects initiated during the reporting period are (ACTEW 2011c, ICRC 2011):

- Enlarged Cotter Dam - in October 2007, the ACT Government announced an expansion of the Cotter Reservoir from 4 GL to 78 GL to provide additional storage capacity;
- Murrumbidgee to Googong Water Transfer - this project includes pumping water from the Murrumbidgee River, near Angle Crossing south of Canberra, to Googong Reservoir to supplement the ACT water supply (ACTEW 2011c);

- Tantangara Transfer - ACTEW has purchased 4145 ML of high security water licences and 12,523 ML of general security water entitlements for the Tantangara Transfer project.

Reuse of water is another way of lessening the demand for fresh potable water, reducing the use of the ACT's stored water supplies and therefore potentially increasing the amount of water available for the environment. ActewAGL has operated 3 wastewater reuse projects in the ACT during the current reporting period (ActewAGL 2011):

- 195 ML/year of treated wastewater is reused from the LMWQCC and supplied for irrigating 100 hectares of nearby vineyards and 30 hectares of a golf course.
- Southwell Park Watermining Project, which supplied treated effluent for 10 hectares of sporting fields, but was decommissioned in 2011 because of high maintenance costs; and
- North Canberra Water Reuse Scheme, which supplies irrigation water to 7 sites totalling 70 hectares.

Other key water supply projects during the reporting period include (ICRC 2011):

- sourcing more than 15 GL of water from the Murrumbidgee River, which can account for up to 33% of water supplied to the ACT and Queanbeyan;
- upgrades to the north Canberra recycled water treatment facility - its capacity was increased to allow for a greater supply of recycled water to north Canberra;
- provision of recycled water from Lower Molonglo Water Quality Control Centre - via a new pump, pipeline and filling station, installed to access to recycled water from the treatment plant;
- district and large-customer metering - ACTEW continued to monitor and reduce water leakage from large customers, reducing leakage by 450 ML in 2008-09; and
- Canberra Integrated Urban Waterways project - which focuses on integrating stormwater and urban waterways, by investigating opportunities such as stormwater harvesting and injection to groundwater storages via managed aquifer recharge techniques.

Many of these projects have been completed during 2011, but with increased rainfall over the last year it will be some time before their impact on water security can be

fully assessed. For further information on climate change adaptation, refer to the *Adaptation* indicator cluster in the *Climate* theme.

Water demand management

Water demand management is primarily concerned with the implementation of policies or measures to control or influence the amount of water used in ACT. The policies encourage efficient water use and minimal waste of water (ACT Auditor-General's Office 2010).

Throughout much of the reporting period, Stage 3 water restrictions were in place. These restrictions aimed to reduce water consumption by 35% compared to consumption under unrestricted demand (DECCEW 2010). Following the significant rainfall in 2010, the restrictions were reduced to Stage 2 (aiming to reduce water consumption by 25%), and on 1 November 2010 they were replaced by Permanent Water Conservation Measures.

Permanent Water Conservation Measures are designed to secure permanent water efficiencies without making unreasonable impositions on the lifestyle of ACT residents (DECCEW 2010). The main permanent water conservation measures are:

- restriction of watering of lawns and gardens to morning and evening hours (except in winter);
- banning of hosing of hard surfaces including driveways, paved areas and windows; and
- compulsory use of trigger hoses for car washing and watering lawns and gardens (DECCEW 2010).

The *Think water, act water* strategy set targets of 12% less per capita consumption of water by 2013 and 25% less by 2023, compared with 2003 levels. These targets are to be met through water efficiencies that reduce use, and partially replace use of mains water sources by recycling and use of stormwater and rainwater, and by recharging of aquifers. *Think water, act water* also set a target of increasing the use of reclaimed water (treated wastewater) from approximately 5% in 2003 to 20% in 2013.

Water efficiency programs

Since 2004, a range of residential water efficiency programs have been implemented under the *Think water, act water* strategy, including (DECCEW, 2010):

- showerhead rebate programs conducted by the ACT Government in 2004-05 and 2005-06 during which 10,953 rebates were issued for 3-star showerheads.
- the WaterSmart Homes Program offered to ACT residents from 2004 to 2007 to upgrade home plumbing, resulting in 7260 WaterSmart Home visits during 2004-2007;
- Dual Flush Toilet Rebate Program / ToiletSmart, which helped homeowners change to 3L/6L dual-flush toilet cisterns.
- a more efficient ToiletSmart program, offering $100 rebates (larger for pensioners) for homeowners to change from single-flush to 3L/4.5L dual-flush cisterns; this had brought the total number of replacements to 5860 by the end of March 2011;
- the GardenSmart Program, offered since December 2004, to help homeowners be more water-efficient in the garden, with rebates of up to $50 on selected water-saving products, which had issued 1980 rebates to the end of March 2011 and made 5956 GardenSmart visits;
- the Rainwater Tank Rebate scheme that had issued 1962 rebates for household rainwater tanks connected to the ACTEW water supply network, by the end of March 2011.

The ACT Government released the *2009 Demand Management Progress Report* in 2010. This report examines the progress made towards meeting the *Think water, act water* strategy water efficiency targets from April 2004 to June 2009.

Table 4 summarises the calculated water savings attributable to demand management measures and permanent water conservation measures in the ACT from 2005-06 to 2008-09, as reported in the *2009 Demand Management Progress Report* (DECCEW 2010). Over the period it can be seen that of the demand management strategies and programs, permanent water conservation measures (saving 5.45 GL in 2008-09) and information and awareness programs (saving 3.39 GL in 2008-09) are by far the most effective measures in contributing to water savings.

The residential water efficiency programs collectively accounted for approximately 1.22 GL (or around 11%) of demand management savings in 2008-09. Overall, Table 4 shows that in 2008-09 demand management and other water efficiency measures are credited with saving 11.36 GL of water, equating to 16.54% of the expected baseline consumption of the ACT community.

Based on projected consumption and water savings from demand management programs, DECCEW (DECCEW 2010) has reported that the 2013 targets outlined in *Think water, act water* can be easily met (12% reduction in per capita use of mains water). However, based on projected consumption and water savings, a reduction of 25% from baseline consumption by 2023 will be challenging to meet unless further demand management programs are implemented (DECCEW 2010).

Table 4. Effects of *Think water, act water:* water efficiency measures (GL), 2005-06 to 2008-09

Water consumption	2005-06	2006-07	2007-08	2008-09
Expected baseline consumption	66.31	66.76	67.73	68.71
Actual consumption	54.34	51.06	43.56	44.95
Water savings	11.97	15.70	24.17	23.76
Percentage savings	18%	24%	36%	35%
***Think water, act water* strategies**				
Permanent water conservation measures	5.29	5.53	5.40	5.45
Information and awareness	3.30	3.33	3.36	3.39
Water efficiency labelling and standards (WELS)	0.08	0.16	0.25	0.33
Water Sensitive Urban Design (WSUD)	0.00	0.00	0.22	0.49
New regulations	0.15	0.20	0.20	0.20
***Think water, act water* residential programs**				
WaterSmart Homes	0.12	0.15	0.16	0.16
GardenSmart	0.04	0.07	0.11	0.14
ToiletSmart	0.01	0.02	0.04	0.16
Showerhead programs	0.19	0.29	0.42	0.44
Rainwater tank	0.09	0.10	0.11	0.13
Greywater hose giveaway	-	-	0.19	0.19
***Think water, act water* commercial and government programs**				
Government and school irrigation	-	-	0.17	0.27
***Think water, act water* total water savings (GL)**	**9.29**	**9.68**	**10.62**	**11.36**
***Think water, act water* total water savings (%)**	**14.00%**	**14.50%**	**15.68%**	**16.54%**

Source: DECCEW 2010

In addition to the demand management responses outlined above, ACTEW implemented a Large Customer Demand Management program in 2007. The program monitors the water use of the 100 largest water users within the ACT and enables leaks in the system to be identified and fixed.

Over the reporting period, the program has achieved water savings of approximately 600 ML per year and was awarded the 2010 *National Program Innovation Award* by the Australian Water Association (ActewAGL 2010a).

In 2010 the ACT Government engaged Hunter Water Australia to undertake an independent assessment of the implementation of the *Think water, act water* strategy and review any need to change targets. In general the report (Hunter Water 2010) concluded that:

- good progress had been made in meeting the objectives, with the majority of actions being either already completed or subject to ongoing review;
- the reclaimed water target of 20% by 2013 is not likely to be met based on current and committed reuse initiatives and should be reviewed in light of current commitments to supply augmentations;
- the reduction in per capita consumption of mains water by 12% by 2013 and 25% by 2023 is expected to be met based on current and committed initiatives and the best available data at this time.

The report recommended that the objectives of *Think water, act water* should be reviewed and possibly reset to reflect what has been achieved over the last years and where the ACT is now headed in terms of future water resource management and security (Hunter Water 2010).

Pricing

In February 1994, the Council of Australian Governments identified six major areas where the Australian water industry needed reform; among these was charging for water services. Following identification of reforms, a Council of Australian Governments agreement was reached that requires urban water prices to adopt consumption-based, full cost recovery pricing and removal or transparency of cross-subsidies. Prices are to reflect the volume of water supplied, encourage more economical water use and defer the need for costly infrastructure investments such as new dams.

The Independent Competition and Regulatory Commission (ICRC) is an ACT statutory body established to regulate prices, access to infrastructure services and other matters in relation to regulated industries, and to investigate competitive neutrality

complaints and government-regulated activities. The Commission set out a price path to apply to water and wastewater tariffs from 1 July 2008 to 30 June 2012 and within this is a water abstraction charge (ICRC 2008). Water charges are mainly based on volumetric usage with a relatively smaller proportionate fixed charge. There is also a water abstraction charge which is a government charge on a volumetric basis to cover the environmental costs of providing water services; it includes a component to cover the scarcity value of water.

From 2007-08 to 2010-11, the fixed water charge has increased from $75.00 to $92.08. This includes the step increase to $85.00 in 2008-09 as part of the ICRC's 2008 price determination. For the reporting period, the fixed charge component has increased by approximately 23%, while the fixed sewerage charge has increased by approximately 25%.

With water restrictions and other measures in place, it is difficult to determine the impact of changes to water pricing on water demand and use.

Environmental flow management

To manage environmental flows in the ACT, the Government reviewed and released the 2006 *Environmental Flow Guidelines* (the Guidelines) (ACT Government 2006), to provide guidance on volumes and timings of environmental flows in the ACT, and the abstraction limits from the ACT waterways. The Guidelines are implemented in accordance with the ACT *Water Resources Act 2007* which requires that water be provided to maintain river systems and associated ecosystem health.

The Guidelines apply a rules-based approach to the governance of environmental flows, whereby water is protected under legislation for the purposes of environmental flows. The management of environmental flows considers the complete river ecosystem and seeks to identify and imitate features of the flow regime, including the natural variability, seasonal variation, floods and intermittent dry periods (ACT Government 2006).

Over the reporting period ActewAGL reported (ActewAGL 2008b, 2009b, 2010b) that environmental flows release targets were generally achieved for all dams and abstraction requirements for the Murrumbidgee River. However, targets were not achieved in several months of 2007-08 for Bendora and Googong Dams. In February and June 2008 temporary changes to the licence were issued to reduce flows for research projects relating to the Enlarged Cotter Dam Project, and in December 2008 a 'Fish Habitat Study' was implemented. Although there was no change to the actual licence conditions, the operation of the Cotter Reservoir for the study was noted to

be outside the licence requirements. Approval from EPA for these licence variations was given on 19 December 2008.

Some impact of the environmental flows in non-water-supply catchments can be inferred from the AUSRIVAS study reported in the in the *Rivers, lakes and wetlands health* indicator cluster. Each sampling site was selected based on potential impacts from the surrounding catchment and environmental flows and river regulation. Overall, the study found that, consistent with previous sampling undertaken on the rivers, the aquatic condition in ACT waterways in non-water-supply catchments was generally considered to be poor. However, this condition cannot solely be attributed to lack of environmental flow provisions but includes other catchment stressors.

Glossary

Activated carbon water treatment: use of adsorbent carbon products to remove organic pollutants from water

AUSRIVAS: Australian River Assessment System: a classification system that uses riverine aquatic macroinvertebrates to provide information about river health

Environmental flows: managed flows of water in streams and rivers that are designed to maintain aquatic ecosystems

Turbidity: a measure of the clarity or cloudiness of water affected by the presence of suspended material, such as silt and clay

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACTEW monitoring data 2011

ACT State of the Environment Report 2011

Annex 1. Summary drinking water quality monitoring results, 2007-2010

Table A1. Drinking water quality monitoring results, 2007-08

Parameter	Target/ Units	All data based on customers' taps					
		No. of samples	No. meeting target	% meeting target	Mean	Min	Max
pH	6.5 to 8.5	958	927	96.8%	7.9	7.1	9.2
Alkalinity [a]	<200 mg/L	275	275	100%	40	18	72
Hardness [a]	<200 mg/L	239	239	100%	47	28	72
Turbidity	<5 NTU	958	957	99.9%	0.42	<0.1	63
Colour	<15 Pt-Co	958	958	100%	1.3	<1	6
Chlorine	<5 mg/L	958	958	100%	0.55	<0.01	2
Fluoride	<1.2 mg/L	238	238	100%	0.83	0.09	1.1
THMs	<0.25 mg/L	238	238	95th percentile = 0.098 mg/L			
Aluminium	<0.2 mg/L	239	239	100%	0.035	0.013	0.069
Iron	<0.3 mg/L	958	957	99.9%	0.022	<0.02	4.5
Manganese	<0.1 mg/L	958	957	99.9%	0.011	<0.0005	0.23
Copper	<2 mg/L	958	958	100%	0.022	<0.001	0.77
Lead	<0.01 mg/L	958	958	100%	0.0002	<0.0002	0.0046
Total coliforms	0 cfu/100 mL [b]	958	943	98.4%	<1 (median)	<1	3100
Faecal coliforms	0 cfu/100 mL [c]	958	958	100%	<1 (median)	<1	<1

Source: ActewAGL2008a.

Notes: a - measured as calcium carbonate ($CaCO_3$) content; b - 95% of samples; c - 98% of samples

Key: cfu = colony-forming units; NTU = nephelometric turbidity units; Pt-Co = platinum-cobalt units; THMs = trihalomethanes (total)

Table A2. Drinking water quality monitoring results, 2008-09

Parameter	Target/ Units	All data based on customers' taps					
		No. of samples	No. meeting target	% meeting target	Mean	Min	Max
pH	6.5 to 8.5	971	937	96.5%	7.86	6.2	9
Alkalinity [a]	<200 mg/L	260	260	100%	43.74	31	77
Hardness [a]	<200 mg/L	130	130	100%	48.57	26	70
Turbidity	<5 NTU	522	520	99.7%	0.39	0.1	8
Colour	<15 Pt-Co	535	535	100%	1.04	<1	5
Chlorine (tot.)	<5 mg/L	977	977	100%	0.6	<0.01	2.58
Fluoride	<1.2 mg/L	149	149	100%	0.84	0.2	1
THMs (tot.)	<0.25 mg/L	238	238	95th percentile = 0.108 mg/L			
Aluminium [b]	<0.2 mg/L	127	127	100%	0.045	0.021	0.210
Iron	<0.3 mg/L	301	300	99.7%	<0.02	<0.02	0.41
Manganese [b]	<0.1 mg/L	394	391	99.2%	0.012	0.0007	0.28
Copper [b]	<2 mg/L	392	392	100%	0.025	<0.001	0.38
Lead [b]	<0.01 mg/L	171	171	100%	0.0003	<0.0002	0.0061
Total coliforms [c]	0 cfu/100 mL[b]	976	975	99.9%	0.09	<1	74
Faecal coliforms [d]	0 cfu/100 mL[c]	975	974	99.9%	<1	<1	50

Source: ActewAGL 2009a

Notes: a - measured as calcium carbonate ($CaCO_3$) content; b - more than one set of results available. Those results with most samples reported; c - 95% of samples; d - 98% of samples

Key: cfu = colony-forming units; NTU = nephelometric turbidity units; Pt-Co = platinum-cobalt units; THMs = trihalomethanes (total)

Table A3. Drinking water quality monitoring results, 2009-10

Parameter	Target/ Units	All data based on customers' taps					
		No. of samples	No. meeting target	% meeting target	Mean	Min	Max
pH	6.5 to 8.5	979	962	98.3%	7.8	7.1	8.9
Alkalinity [a]	<200 mg/L	255	255	100%	39	28	59
Hardness [a]	<200 mg/L	120	120	100%	45.1	31	70
Turbidity	<5 NTU	485	485	100%	0.4	0.1	1.4
Colour	<15 Pt-Co	484	484	100%	1	<1	3
Chlorine (tot.)	<5 mg/L	976	976	100%	0.66	<0.01	1.69
Fluoride	<1.2 mg/L	120	120	100%	0.69	<0.05	1
THMs	<0.25 mg/L	241	241	95th percentile = 0.084 mg/L			
Aluminium [b]	<0.2 mg/L	120	120	100%	0.04	0.02	0.11
Iron	<0.3 mg/L	239	239	100%	<0.02	<0.02	0.06
Manganese [b]	<0.1 mg/L	438	438	100%	0.006	0.001	0.058
Copper [b]	<2 mg/L	359	359	100%	0.027	0.002	0.41
Lead [c]	<0.01 mg/L	116	116	100%	0.003	<0.0002	0.0043
Total coliforms [d]	0 cfu/100 mL	981	975	99.4%	<1	<1	19
Faecal coliforms [e]	0 cfu/100 mL	981	981	100.0%	<1	<1	<1

Source: ActewAGL 2010a

Notes: a - measured as calcium carbonate ($CaCO_3$) content; b - more than one set of results available. Those results with most samples reported; c - more than one set of results available. Most extreme result reported;

d - 95% of samples; e - 98% of samples

Key: cfu = colony-forming units; NTU = nephelometric turbidity units; Pt-Co = platinum-cobalt units; THMs = trihalomethanes (total)

Table A4. Use of potable water supplied 2005-06 to 2009-10

Potable water supply	2005-06	2006-07	2007-08	2008-09	2009-10
Volume of potable water supplied - residential (GL)	34.4	32.0	26.1	27.5	27.6
Volume of potable water supplied - commercial, municipal and industrial (GL)	14.2	13.6	11.2	11.2	10.2
Volume of potable water supplied - Other[1] (GL)	3.9	2.1	3.5	3.1	3.8
Total urban water supplied (GL)	52.5	47.7	40.7	41.8	41.6
Average annual residential use (kL/property)	261	240	195	201	199
Volume of bulk water exports[2]	4.4	4.1	3.4	3.6	3.7

Source: ActewAGL 2008a, 2009a, 2010a

Notes: 1 - 'Other' includes the volume of water supplied to miscellaneous uses, including losses from the distribution network. 2 - 'Bulk water exports' are water exported and used outside of the ACT (Queanbeyan)

ACT State of the Environment Report 2011

THEME: Land and Water

Indicator cluster: Groundwater

The Groundwater indicator cluster includes four indicators that collectively report on groundwater availability, quality, use and management in the ACT:

- *Groundwater availability* (C) - the volume and distribution of available groundwater;
- *Groundwater quality* (C) - the quality of groundwater including pollution from contaminated sites;
- *Groundwater use* (P) - the amount and distribution of groundwater use; and
- *Groundwater management* (R) - the effectiveness of groundwater management responses.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data for the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

ACT groundwater resources overall are relatively low in yield, but that can vary significantly between local areas. Groundwater recharge in ACT is closely related to recent rainfall history. Overall a maximum of 7458 ML is available for use annually, based on estimates of sustainable yield. ACT groundwater is relatively fresh compared to other areas of south-eastern Australia.

Groundwater extraction has increased to approximately 550 ML since the last reporting period, but is still relatively small. In 2008, an assessment report indicated that, historically, groundwater monitoring and data collection in the ACT had not been managed systematically. As a result, knowledge of the impacts of groundwater use on the aquifers in the Territory was not comprehensive, resulting in reduced ability to manage groundwater resources sustainably. Monitoring of groundwater extraction continues to expand, particularly where the resource is considered to be at risk of overuse or contamination.

Introduction

Groundwater is essential for the ongoing health and maintenance of many terrestrial ecosystems and surface water bodies such as rivers, wetlands and lakes, especially

those connected to, and dependent on, groundwater. Changes in groundwater quantity and quality have the potential to degrade these ecosystems and may cause the loss of terrestrial and aquatic species. In the ACT, groundwater typically flows through fractured rock aquifers that are relatively shallow, and connects to wells, springs and streams (ACT NRMC 2009).

Groundwater is also a valuable resource for a range of locally important domestic, agricultural and industrial uses. Changes in the availability and quality of groundwater can adversely affect these sectors.

Condition indicators

Groundwater availability

The ACT generally has low-yield fractured rock aquifers. This means that groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass, and consequently groundwater is a limited resource compared to surface water. Groundwater recharge in the fractured rock aquifers is closely related to recent rainfall history (DECCEW 2011).

The *ACT Water Resources (Water available from areas) Determination 2007 (No 1)* (ACT Government 2007) lists volumes of surface water and groundwater available for taking from each Water Management Area, and water reserved for future use. Overall, a maximum of 7248 ML of groundwater is available for use in the ACT per year (Table 1). The groundwater available has been assessed by specific investigations undertaken by the ACT Environment Protection Authority (EPA) to determine sustainable yields in particular areas.

Table 1. Groundwater available for taking from each ACT Water Management Area

Water Management Area	Maximum groundwater volume available for taking (ML)
Upper Murrumbidgee	640
Lower Murrumbidgee	189
Naas	855
Gudgenby	1170
Cotter	2050
Paddys	909
Tuggeranong	190
Upper Molonglo	24
Central Molonglo	685

Water Management Area	Maximum groundwater volume available for taking (ML)
Lower Queanbeyan	0
Jerrabomberra headwaters	0
Lower Molonglo	297
Googong catchment	0
Ginninderra catchment	239
Total	**7248**

Source: ACT Government 2007

To further improve understanding of ACT groundwater availability and potential use, in 2009, the National Water Commission (NWC) began an *ACT Aquifer Storage and Recovery Feasibility Study* (NWC 2010). The initial results from the study confirm that ACT groundwater resources have a relatively low yield that varies significantly from place to place (NWC 2010). Groundwater bores in the ACT typically yield 0.1 - 24 litres per second (L/s), with the majority of bores yielding between 1.5 and 2.5 L/s. These yields are low when compared to bores in the Great Artesian Basin, which have yields of up to 235 L/s (NWC 2010). The study is due to be completed in December 2011 and will provide important information to further assess groundwater availability and ensure appropriate groundwater management.

Groundwater quality

The quality of groundwater in the ACT is similar to the quality of nearby surface waters, except that electrical conductivity (a measure of salinity) tends to be higher because of the longer residence time within the aquifers' geology. Overall, groundwater in the ACT is fresh when compared to other areas of south-eastern Australia (Slatter et al. 2008).

As outlined in the Contaminated sites indicator (refer to the *Land health* indicator cluster), underground fuel storage at service stations and other facilities can affect groundwater quality, as also can spills at the ground surface. Groundwater can become contaminated when oils, chemicals, pathogens and other pollutants seep into the soil and enter aquifers. Monitoring of the quality of groundwater aquifers at risk of contamination is performed under authorisation by assessments at places where contamination has been identified, mainly landfill and service-station sites.

Pressure indicators

Groundwater use

Groundwater use is relatively small in the ACT compared to surface water use. However, groundwater use has increased considerably over the last decade in response to the prolonged drought and demand for additional and reliable sources of water.

The volumes licensed for extraction in ACT and the amounts of groundwater actually extracted between 2007-08 and 2009-10 are reported in Table 2. Since 2007-08, the licensed volume has increased by 135 ML (or 18%) but the amount of groundwater extracted has remained largely constant at around 550 ML per annum. This is an increase from the previous reporting period, to June 2007, when between 249 ML and 345 ML was extracted each year.

Table 2. Licensed volumes and volumes of groundwater extraction in the ACT, 2007-08 to 2009-10

Year	Licensed volume (ML)	Groundwater extraction (ML)
2007-08	741	549
2008-09	799	530
2009-10	876	550

Note: data were not available for 2010-11. Source: DECCEW

Groundwater extraction remains less than the sustainable yield as determined by the licensing framework for all water management units. It will be important to continue to monitor groundwater extraction in high-use areas, because of the increase in licensed volume and the potential for further extraction.

The number of entitlements issued in the ACT to extract groundwater is outlined in Table 3. Most groundwater licences are within the Central Molonglo water management area covering the Kowen, Fyshwick, Jerrabomberra, Lake Burley Griffin, Woolshed and Sullivans subcatchments (Table 3).

Table 3. Number of entitlements to take water, by Water Management Area and water type

Water Management Area	Number of entitlements to take water	
	Groundwater only	Surface and groundwater
Cotter	-	-
Googong	-	4
Total	**0**	**4**
Upper Murrumbidgee	17	6

Lower Murrumbidgee	0	2
Naas	1	-
Gudgenby	1	2
Paddys	3	2
Tuggeranong	3	1
Upper Molonglo	1	-
Central Molonglo	93	19
Lower Queanbeyan	-	-
Jerrabomberra Headwaters	-	-
Lower Molonglo	10	3
Ginninderra	11	5
Total	**140**	**40**

Source: DECCEW 2011.

In 2011, DECCEW recognised that there may still be bores in use without entitlements, and that existing entitlement holders may exceed their entitlement volume (DECCEW 2011). The EPA conducts groundwater compliance and enforcement monitoring programs to detect issues such as over-use of groundwater from licensed bores and unauthorised bore work, and to ensure licence/entitlement instruments are registered against active bores. There have been few instances of enforcing groundwater offence provisions in the ACT during the reporting period. In one example, unlicensed groundwater use was detected on a property, and using the provisions of the *Water Resources Act 2007* the use was stopped.

Monitoring has identified that around 5% of groundwater licensees were using more than their entitlements. Where over-use was identified the use was reduced back to appropriate volumes within a year, suggesting existing education efforts and penalties are effective.

Impact indicators

There is no specific indicator for groundwater impact. However, as outlined above, over-extraction of groundwater can adversely impact on groundwater-dependent ecosystems as well as on environmental flows and limit the future availability of groundwater for human uses. The current groundwater abstraction limits for all ecosystems is 10% of the long-term recharge (ACT Government 2006).

If groundwater becomes polluted it may be unusable for many years and affect the environment and human health. Polluted groundwater can be difficult and costly to

clean up. A recent example is the remediation of groundwater at Civic, polluted by a petrol plume. For more information see the *Land health* indicator cluster.

Response indicators

Groundwater management

Groundwater management in the ACT includes assessment, water resource planning, licensing, education, monitoring, enforcement and reporting. In 2008, a groundwater data assessment report (Slatter et al. 2008) indicated that, historically, groundwater data in the ACT had not been managed systematically. Further, the ongoing monitoring program was not designed systematically and so did not provide a comprehensive picture of the impacts of groundwater use on the aquifers in the Territory. As a result, ability to manage groundwater resources sustainably was reduced.

The *Water Resources Act 2007* (the Act) provides a framework for the sustainable management of ACT water resources including groundwater. Under the Act, it is a requirement to hold a Water Access Entitlement (WAE) before a Licence to Take Water can be issued. A WAE is a right to an amount of surface water or groundwater within a Water Management Area. *The 2006 Environment Flow Guidelines* set a limit on groundwater abstraction for all ecosystems at 10% of the long-term recharge (ACT Government 2006). The current draft of the *2011 Environmental Flow Guidelines* indicates that this limit will be maintained. It would appear to be a reasonable limit. Information from the *ACT Aquifer Storage and Recovery Feasibility Study* (NWC 2010) due to be finalised late in 2011, as well as possible climate change implications, should guide future groundwater abstraction limits.

DECCEW maintains 14 dedicated monitoring bores, and additional information is supplied from another 6 monitoring sites by groundwater users (DECCEW 2011). This monitoring provides information about the movement of groundwater, and the hydraulic conductivities, potential storage capacities, chemical compositions, and recharge rates of the various aquifers within each Water Management Area. Monitoring of the recharge is important for assessing aquifer responses to climate change, for quantifying the potential effects of changing rainfall patterns, and for identifying sustainable limits for each groundwater aquifer.

In response to increasing demand for and use of groundwater since 2002, the ACT Government has been aiming to improve the accuracy of groundwater assessments and expand groundwater monitoring. A risk-based approach to groundwater monitoring has been developed, whereby the amount of monitoring of an area is proportional to the risk posed to the groundwater by abstraction, contamination or

land use change. In 2010, three additional monitoring bores were proposed for construction in Weston, Wanniassa and Kambah in recognition that these areas were coming under pressure from current levels of extraction (DECCEW 2011).

Monitoring of groundwater recharge will improve understanding and quantification of potential effects and implications of changed rainfall patterns from climate change, for determining future groundwater extraction limits. The groundwater data assessment report (Slatter et al. 2008) provided a number of recommendations to improve data collection, management and analysis. These should guide improved monitoring of groundwater in the ACT.

Education and information programs are also important for groundwater management. In 2009, the Upper Murrumbidgee Catchment Coordinating Committee (UMCCC) released a fact sheet for rural landholders titled *Groundwater in the Upper Murrumbidgee*. The purpose of the fact sheet was to increase local knowledge and awareness of groundwater, its sustainable use, and impacts of land use in the catchment (UMCCC 2009).

The ACT Government is participating in a national framework during 2011 to 2016 to improve compliance and enforcement systems for water resources. The national framework will implement:

- consistent provisions for treating water resource offences;
- strategies for best practice compliance and enforcement;
- catchment risk assessments;
- review of monitoring activity; and
- stakeholder education.

The NWC has recommended that “ultimately all surface and groundwater extractions, including for stock and domestic purposes, should be licensed and metered or otherwise measured. However, the NWC also recognises the practical constraints to universal metering of groundwater extractions.” The NWC acknowledged the need for “a risk-based approach taking into account the water management benefits of better metering, the level of risk to the groundwater resource, impacts on third parties, and cost effectiveness” (NWC 2009:37).

Groundwater management in the ACT is largely effective given current levels of use and ongoing improvements in monitoring of groundwater extraction compared to sustainable yield. It is important to continue to improve understanding of aquifers at

risk of over-use and contamination, and to identify and manage impacts on groundwater quality.

Glossary

Aquifer: a geological formation that contains and transmits groundwater

Bedding planes: the surfaces between the different layers in sedimentary rock

Confined aquifer: an aquifer that is covered (confined) by a layer of impermeable rock and not recharged by vertical infiltration

Groundwater-dependent ecosystems: ecosystems that are dependent on groundwater for their existence and health

Sustainable yield: the amount of water extraction from a particular system which, if exceeded would compromise key environmental assets, or ecosystem functions and the productive value of the resource

Unconfined aquifer: an aquifer that is covered by permeable rock and that is recharged from vertical infiltration; its upper surface is the water table

Upper Murrumbidgee Catchment Coordinating Committee (UMCCC): a community-based organisation made up of agencies and groups that are responsible for, or contribute to, natural resource management in the upper Murrumbidgee catchment

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACT water quality database, http://incp.environment.act.gov.au/water/index.aspx

ACT Department of the Environment, Climate Change, Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

Environment Protection Authority (EPA) – now part of Environment and Sustainable Development Directorate (ESDD)

ACT State of the Environment Report 2011

THEME: Biodiversity

Introduction to Theme

Biodiversity is a term that embraces the full variety of ecosystems, species and the ecological processes. Through their normal functions, ecosystems and ecological processes provide essential services, such as clean air, fresh water, soil and habitat for plants and animals. Biodiversity is also valued for recreational, cultural, and landscape characteristics that help form the ACT identity.

The ACT is situated within two bioregions, the Australian Alps and the South Eastern Highlands (Commonwealth of Australia 2005) and has a wide range of landscapes and ecological communities, from natural temperate grasslands in the lower valleys to sub-alpine woodland and bog complexes in the mountains and a diverse range of plants and animals living in these habitats.

Four indicator clusters are drawn on for the Biodiversity Theme:

- *Native species - flora;*
- *Native species - fauna;*
- *Ecological communities; and*
- *Threatening processes.*

Context

- During the past two periods of reporting on the State of the Environment the impacts of fire and recovery from it, have been the focus of biodiversity conservation in the ACT. Much has been achieved in fire management to reconcile the need to protect life and infrastructure and the need to achieve biologically appropriate fire regimes.
- Pest plant and animal species remain a significant threat. New strategies to address invasive and overabundant species have been developed and to some extent implemented. Now there needs to be more effective evaluation of the outcomes of the actions applied, in terms of benefits to threatened ecosystems. *The 2007-08 State of the Environment Report* highlighted the impact of an overabundance of kangaroos in the ACT. As recommended, a *Kangaroo Management Plan* has been developed; it has not been in operation long enough yet for its efficacy to be fully determined.
- Progress has been made over the last two reporting periods in protecting areas of Yellow Box-Red Gum Grassy Woodland and Natural Temperate Grassland. These ecological communities remain under pressure because of the continued clearing of lowland woodlands and grasslands primarily for urban development. In each new reporting period there is also a small increase in new plant and animal species that are declared as threatened.

- Many of the plans and strategies recommended in the 2003 and 2007-08 State of the Environment reports have been implemented to varying degrees. However, long-term research, monitoring and evaluation remain limited; many of the recommendations made in 2003 and 2007 about improvement of data and knowledge have only been partially implemented at best.

- Across all State of Environment reporting periods, community involvement in and support for biodiversity conservation has made significant and valuable contributions.

- Many issues discussed in previous years remain relevant and the recommendations made here, while based on the current State of the Environment reporting, also relate to previous years.

Theme summary: Key issues and outcomes

Several key issues with respect to biodiversity in the ACT have emerged again during the current reporting period:

- the fragmentation of habitat and the removal of native vegetation through ongoing land use change remains a severe pressure on biodiversity;

- the number of species listed as threatened continues to increase over each reporting period; and

- management needs to capture more relevant and timely data to assist in better understanding the condition of ecological communities and native species in the ACT, along with the pressures that are being placed on them.

The ACT retains a diverse range of landscapes that support a high diversity of native plants and animals. A sizeable proportion of land in the ACT is designated for the primary purpose of protecting significant natural landscapes, threatened and common species and recreational assets. For instance, approximately 40% of the areas occupied by endangered ecological communities in the ACT are protected in either a national park or one or more nature reserves. Three new reserves have been established during the report period (Callum Brae, Jerrabomberra West and Kama). However, nature reserves alone do not ensure the recovery or survival of threatened species and communities. Ongoing habitat fragmentation and native vegetation clearance to satisfy ongoing land use change, will continue to place pressure on species and ecological communities.

Territory-wide planning and management of threatened species and communities remains a key focus of conservation activities. For example, species such as the Northern Corroboree Frog (*Pseudophryne pengilleyi*) and ecological communities such as the Natural Temperate Grasslands have been the subject of a number of conservation and management actions over the period. However, each reporting period a few more species are listed as threatened, and the Northern Corroboree Frog and the Grassland Earless Dragon (*Tympanocryptis pinguicolla*) continue to face real risk of extinction.

There is a pressing need to capture more relevant and timely data to assist in better understanding the condition of ecological communities and native species in the ACT. Data on the distribution and abundance of our native fauna and plant species and on the continuing pressures on ecological communities is sorely needed. A more strategic monitoring and knowledge-gathering program would assist in co-ordinating current efforts and identifying precise knowledge gaps. Such a strategy should building on existing government and non-government skills and programs, and focus on supporting evidence-based natural resource management and periodic reporting. Regular monitoring of wider changes in the ACT, such as the extent and condition of native vegetation, would also be valuable, although the resource implications of such an undertaking are acknowledged.

All these issues have been indentified in previous reporting periods.

Source: ACT Government

Ecological communities

Thirty vegetation ecological communities have been recorded within the ACT. Of these, the Yellow Box-Red Gum Grassy Woodland, the Alpine Fens and Bogs, and the Natural Temperate Grassland are listed as endangered ecological communities (EEC) under the ACT *Nature Conservation Act 1980* or the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act). Currently in the ACT there are approximately 1000 ha of Natural Temperate Grassland spread over 43 scattered and isolated sites (Cooper 2009). In the case of Yellow Box-Red Gum Grassy Woodland, only 6160 ha is currently protected in parks and reserves in the ACT (ESDD).

Recent connectivity mapping and modelling in the ACT shows several locations where high priority should be given to maintaining or improving connectivity in the ACT between separated patches of these ecological communities.

No additional new ecological communities were declared as threatened under ACT legislation between 2007 and 2011. Listing of ecological communities in surrounding NSW can be a guide to species or communities needing to be considered for protection in the ACT. The Nature Conservation Act allows the listing of a species or ecological community to be considered 'in relation to the Territory and the surrounding region'.

Coordination with regional assessments and listings is particularly important if the biodiversity of the Australian Capital Region is to be preserved and enhanced, with both ecological communities and threatening processes (such as the 2003 bushfire), occurring at regional scales and crossing the NSW-ACT border.

Native fauna

Among the ACT native fauna, 15 species are listed as vulnerable and 9 are listed as endangered under the Nature Conservation Act (ACT Government 2011). These include 3 new species (the Little Eagle *Hieraaetus morphnoides*, Glossy Black-cockatoo, *Calyptorhynchus lathami* and Pink-tailed Worm Lizard, *Aprasia parapulchella)* that have been listed as vulnerable under the Act during the reporting period.

Monitoring of birds, frogs and other fauna species continues to be carried out by community organisations. For example, thanks to the Canberra Ornithologists Group, it is known that during the reporting period bird species richness has remained stable at around 233 species. For amphibians, Frogwatch volunteers have found that the 2009 season appeared favourable for frogs, with more species (10) detected overall, and a larger average number of species at each site than in previous years (GCG 2009).

As previous State of the Environment Reports have indicated, the Northern Corroboree Frog and Grassland Earless Dragon face a real risk of extinction. There has been no recovery of the endangered Northern Corroboree Frog population in the wild, which is now estimated at fewer than 100 individuals. The conclusion is that this species is likely to become extinct within the next 5-10 years unless its decline can be halted. A successful captive breeding program has continued during this reporting period, and it is a expected that a release of adult frogs into the wild expected in 2011 may improve the outlook for this species. The Grassland Earless Dragon is found in only two places in the ACT, one in the Majura Valley and one in the Jerrabomberra Valley. Loss and degradation of habitat are the main causes of its decline and development is still proposed for a number of sites, including in the Majura Valley, where the species is known to occur, mainly north of the airport. The population declined significantly during 2005 and 2006, and research indicates there is a real risk that the species will become extinct in the ACT. A captive breeding program currently being established for the Grassland Earless Dragon, along with habitat protection may hold the key to preventing total loss the species in the ACT. If those are unsuccessful, this species could become

the first confirmed reptile extinction in Australia since European settlement (Diamond et al. unpublished).

Other issues concerning native animals in the ACT include:

- expiry of the period set in some existing Action Plans for their performance criteria; a review of the Action Plans, including the development of an updated set of performance criteria for each plan, is warranted;
- there is no census of native vertebrates in the ACT; by contrast, the native plant species are subject to a census which lists the names of the native and naturalised plants that are known to occur in the ACT;
- knowledge of native animals in the ACT relates primarily to vertebrates; much less is known or understood about the ACT invertebrates and their contribution and importance to ecosystem health.

Native flora

In the ACT, 1655 plants species (native and introduced) are recorded as occurring in the ACT. A total of 8 plant species is listed as threatened under the ACT Nature Conservation Act, and an additional 6 species that are predicted to occur within the ACT are listed under the Commonwealth EPBC Act. No new plant species have been listed as threatened since the 2007-08 State of the Environment reporting period, but the riparian shrub *Bossiaea grayi* (only known from the ACT) is being assessed for listing as a threatened species.

Source: ACT Government

In recent years, significant changes to land use have occurred in the northern parts of the ACT with the rapid development of residential and industrial land and associated infrastructure. This

development has led required clearing of land occupied by native vegetation, including mature trees. The list of plant species in the ACT, recorded by the ACT Government and the Australian National Herbarium Centre for Plant Biodiversity Research, was last updated in 2008. With recent and ongoing urban development it would be valuable to continue to update information on the number and distribution of plant species.

There is ongoing management planning and some limited monitoring of known populations of threatened plant species. Some species such as the endangered Button Wrinklewort (*Rutidosis leptorrynchoides*) are surveyed only once every 5 years; the next survey is planned for 2012-13. Other endangered species including the Canberra Spider Orchid (*Arachnorchis actensis Syn. Caladenia actensis*), the Brindabella Midge Orchid (*Corunastylis ectopa*) and Leek Orchid (*Prasophyllum petilum*) are monitored annually. However, sporadic growth and flowering in some plants can make monitoring challenging for land managers. For example, the Canberra Spider Orchid was surveyed for the first time in 2008 and no plants were located, but during the 2009-10 flowering season around 100 plants were observed. Another example is the Leek Orchid at the Hall cemetery. The population of this particular species has fluctuated widely since 1991 and in 2009, 26 flowering plants were recorded while in 2010 a total of 47 flowering plants were observed. Management of the Hall Cemetery, including proposed expansions, should be consistent with the conservation of the Leek Orchid and Yellow Box-Red Gum Grassy Woodland, which is also found there.

Securing the survival of endemic plant species will continue to be an issue for the ACT. This should build on our knowledge of such plants and the importance of seed collection and propagation to ensure the future survival of the species well into the future. It is noted that some action has been taken to address this issue in collaboration with the Australian National Botanic Gardens now maintaining a seed collection of the endangered Ginninderra Peppercress (*Lepidium ginninderrense*). In addition, more than 90 clones from the 10 known wild plants of the endangered Tuggeranong Lignum (*Muehlenbeckia tuggeranong*) have been introduced into suitable habitat in the Murrumbidgee River corridor. Approximately 50% of these new plants were alive when inspected in 2011.

Threatening processes

During the reporting period there has been pressure on biodiversity conservation because of the continuing need to develop land for residential and industrial purposes in response to ACT population growth. Development is proceeding not only in the ACT but also in surrounding areas including Queanbeyan, Goulburn and the Yass Valley. While the ACT has large areas of nature reserve, national park and green infrastructure within and around the city, changes at the urban fringe are placing significant pressures on local native vegetation and are threatening some very important biodiversity assets. The continued growth of the ACT highlights why biodiversity conservation might be important to the image of Canberra as the 'bush capital', and to the health of ecosystems in the ACT.

Changes at local scale (human population increase and associated pressures) and global scale (global warming and climate change) are placing the ecosystems of the ACT under increasing pressure. Impacts from climate change, changed fire regimes and pest and weeds continue to challenge the

survival of native species or ecological communities in the ACT. Because of a paucity of ongoing monitoring, knowledge about specific impacts and the status of many threatening processes is very limited, and more information is required to guide effective management.

There are concerns related to threatening processes in the ACT and their impact on biodiversity. No threatening processes have been formally determined under the ACT Nature Conservation Act. However, the ACT Government has given consideration to threatening processes, through the Conservator for Flora and Fauna, and the Flora and Fauna Committee. A broad approach to managing threatened species and communities has been adopted in *Action Plan 27: ACT Lowland Woodland Conservation Strategy*, *Action Plan 28: Lowland Native Grassland Conservation Strategy* and *Action Plan 29: ACT Aquatic Species and Riparian Zone Conservation Strategy*, by including management of the threats relevant to the suite of species and communities covered in each Action Plan. Whether this creates enough focus and impetus to act on the threatening process should be assessed.

In relation to weed impacts, the Australian Government recently announced that the loss and degradation of native plant and animal habitat by invasion of escaped garden plants was threatening biodiversity in the ACT. This announcement may assist in guiding potential threatening processes determinations in the ACT. There are now 6 Weeds of National Significance that have established populations in the ACT:

- Blackberry (Rubus fruticosus agg.)
- Chilean Needle Grass (*Nassella neesiana*);
- Gorse (Ulex europaeus);
- Serrated Tussock (*Nassella trichotoma*);
- Willow (*Salix* spp.); and
- Alligator Weed (Alternanthera philoxeroides).

The ACT Government maintains records of the known distribution of these weeds in the ACT that informs control efforts by Government and private landholders, coordinated through programs developed by the ACT Weeds Committee. Work has begun to map species and density of weeds in priority areas, including locations of rare or threatened plant species that may be at threat from weed invasion. This will help with setting priorities for control work.

On a positive note in relation to threatening processes, effort is being made to monitor pest species. For example, data show that despite the ACT having a biologically diverse array of native fish species, the European Carp (*Cyprinus carpio*) continue to make up 80–90% of fish biomass in the Murrumbidgee River within the ACT. In addition, feral deer populations are increasing and as is evident from the recording of incidental sightings.

Further, foxes have been removed from part of Mulligans Flat Nature Reserve following the erection of a fence. The Mulligans Flat Woodland Sanctuary can now be maintained as a fox-free area

ACT State of the Environment Report 2011

Responses and effectiveness

Native species and protected area management

The ACT currently maintains a comprehensive reserve system that covers over 50% of the Territory, and a management approach which aims to conserve habitat for a range of native plant and animal species. The recent report *Building Nature's Safety Net 2011*: *The state of protected areas for Australia's ecosystems and wildlife,* identified that the ACT has a reserve system which can be regarded as very close to adequate, with the chief remaining priority being the improved protection of Yellow Box-Red Gum grassy woodlands and Natural Temperate Grasslands. However, as already mentioned, during the reporting period 32 species in the ACT remain threatened, and new species have been added or are under consideration to be added to the list of threatened species under the Nature Conservation Act.

Source: ACT Government

The existing high degree of habitat fragmentation in the northern half of the ACT makes it difficult for many organisms to move between across patches of habitat in these modified landscapes. The interaction of climate change and land use change is having a far more detrimental effect on biodiversity than either factor in isolation. Habitat connectivity, enhanced by managing off-reserve lands in a manner which recognises the need for wildlife to move across the whole landscape, is essential to managing our biodiversity.

During the reporting period, the ACT Government commissioned a connectivity analysis identifying priority areas for action. This work prepared a biodiversity connectivity map for the ACT and region,

based on specific modelling of the connectivity needs of 6 types of animals. From this starting point, an ongoing whole-of-landscape connectivity approach to planning can follow. Work is continuing with more detailed analysis of connectivity requirements for priority areas that will show how to improve connectivity between ecological communities through a system of corridors and 'stepping stones' linked by corridors, integrating reserve-based and off-reserve conservation. Some of this is already planned. Integrating connectivity into urban planning and development in the ACT, through the Territory Plan, would be an important step towards achieving a higher level of protection for the ecological systems in Canberra's reserves.

During the reporting period, several important research projects relevant to native fauna and their habitat within the ACT have been continued or established. They include:

- the Mulligans Flat–Goorooyarroo Woodland Experiment - a partnership between the Australian National University, the ACT Government and CSIRO which aims to assess ways of restoring Box-Gum grassy woodland to benefit biodiversity; research so far has generated more than 10 publications in national and international journals, and others are in preparation; and

- kangaroo management - research to better understand the movements and home ranges of kangaroos in urban Canberra, including use of GPS tracking collars in a pilot study of 25 individuals over 2 years; other research is seeking to develop immunocontraceptive vaccines that could be applied to manage kangaroo fertility.

These projects are demonstrating the benefits of research and monitoring that provides a more informed and evidence-based management response to threats and changing conditions. The challenge remains: that of implementing relevant findings into conservation management across the ACT.

Another innovative development is the Capital Woodland and Wetlands Conservation Trust, a partnership between Government and the community. This newly established Trust aims to access private sector and community funding for projects in Jerrabomberra Wetlands Nature Reserve and Mulligans Flat Woodland Sanctuary, over and above normal government funded operations.

Also, investigations into the management of lowland native grasslands and Canberra Nature Park have provided some guidance to improve management of some of our important conservation areas in the ACT.

Management of pest species

The release and implementation of the *ACT Weeds Strategy 2009-2019* addresses a key recommendation of the *2007-08 ACT State of the Environment Report*. The Strategy prioritises weed species of national significance, and is guided by the Weeds of National Significance (WoNS) guidelines. In high priority areas, the species and density of weeds since 2009 has been mapped. Ongoing control work is ongoing expected to continue, included in future ACT Environmental Weed Control Operations Plans.

In line with the recommendations of the *2007-08 ACT State of the Environment Report*, the ACT Government has continued programs to manage known pest animals and is monitoring emerging pests such as deer. A Draft *Pest Animal Management Strategy 2011-2021* has been developed which require preparation of Pest Animal Management Plans, consistent with national threat abatement plans, as a key strategic action. The *2011-12 Vertebrate Pest Management Plan* is being developed.

Overabundant native species

Canberra is unusual in having large populations of free-ranging kangaroos in the urban areas. However, kangaroo populations in some parts of the ACT are unnaturally high, resulting in ecological damage through overgrazing. In response to community and scientific concern about the overabundance of kangaroos and associated ecological, social and economic impacts the ACT Government released the *ACT Kangaroo Management Plan* in 2010 (TAMS 2010). The plan represents a significant advance in the management of kangaroos in the ACT, and its finalisation is consistent with the recommendations of the *2007-08 ACT State of the Environment Report*. The adaptive management approach, outlined in the plan, provides a framework to link research, monitoring and action to manage plants and animals affected by overgrazing by kangaroos.

Climate change and fire

Predicted climate variability and climate change will have significant implications for biodiversity and the management of parks and reserves. The potential rate, scale and geographic extent of climate change make it even more significant than other threats (Webb 2011).

Bushfire frequency and intensity, reduced productivity in plants, interaction with other existing pressures, changes in rainfall patterns involving intensified seasonality, increased grazing pressure from native herbivores, and increased weed incursions will all drive changes in ecosystems in the region. Ecosystems' structure, composition and function are likely to alter, and the distributions of individual species and invertebrate populations are likely to change; high-altitude ecosystems are expected to contract in area (NSW Government 2010).

During the reporting period, a report on the implications of climate variability and change (Webb 2011) recommended a series of response strategies, including: maintaining and enhancing ecosystems processes and services; enhancing ecosystem resilience through by maintaining diversified habitats, refugia and connectivity; facilitating ecosystems and species development (including 'novel ecosystems'); land use planning; fire management; integrated governance; and adaptive management. Such response strategies should be integrated into conservation management in the ACT.

Balancing the protection of life and infrastructure against the maintenance of biologically appropriate fire regimes is a challenge in the ACT. During the reporting period, the ACT Government released the *Strategic Bushfire Management Plan* for the ACT (ACT Government 2009). The plan attempts to balance the protection of human life and infrastructure with the fire management practises which minimise adverse impact on biodiversity. To minimise the risk of ecosystem impacts from fuel reduction activities, ecological guidelines have been prepared for the conduct of prescribed burns in the ACT. Annual surveys to record potential changes in vegetation composition

and structure as a consequence of prescribed burning are also undertaken to monitor biodiversity impacts of prescribed burns and future management decisions. However, currently only 10% of prescribed burns are monitored for ecological effects, and only for a 5-year period (OCSE 2011).

Emerging issues

During the reporting period, it has emerged that there are issues that have the potential to become particularly relevant over the next 5 years.

Legislative and policy action

To improve transparency of biodiversity integration into legislative and planning frameworks it is important that recognition of 'biodiversity' is improved and better defined in all relevant ACT legislation. Further, making biodiversity conservation a more important element of the land use planning process in the ACT, by integrating connectivity opportunities in all planning decisions and including a connectivity overlay in the Territory Plan, would help provide greater clarity when integrating biodiversity needs into the ACT planning framework.

Source: ACT Government

Road design

Fauna sensitive road design is considered an emerging issue because of the relative increase in the number of road-deaths of native fauna and of fauna-related vehicle accidents in the ACT in recent years. The increase has led to collision avoidance policies being included in the ACT Kangaroo Management Plan; 'Slow down' road signs are being installed at kangaroo-crossing 'hot spots'. During research in preparation for this State of the Environment Report, it was noticed that that the ACT lacks design guidelines for road design that would help fauna move across new and existing

roads in the ACT through infrastructure such as land and canopy bridges and fauna culverts. The design of future projects, such as the Majura parkway should take this into account.

Access to data

While not a new issue, having good biodiversity data in the ACT is increasingly important. Government, the community and industry need access to wildlife data to guide better planning and development decisions. Several areas of data management need strengthening.

- Recording and accounting for the ACT's biodiversity assets would mean that when planning and development decisions are made and individual species, populations and ecological communities are removed, the register would be updated to show the biodiversity assets that remain.
- Public reporting about biodiversity matters needs to be done in a way that clearly quantifies and qualifies the outcomes of decisions and activities as they relate to individual species, populations and ecological communities in the ACT.
- Finally, collaboration with the NSW Government and regional local governments should continue to be effective, to ensure that data and information gathering and reporting is consistent and continuous.

Recommendations

A number of recommendations to improve the management of nature reserves and many of the protected areas and grasslands in the ACT have been developed through the investigations into Lowland Native Grassland and Canberra Nature Park, Molonglo River Corridor and Googong Foreshores. These recommendations should be implemented. Given the continued loss of lowland native grassland habitats, recommendations (i.e. recommendation 23 and 24 of the Lowland Native Grassland Investigation) to enhance the protection afforded to areas of natural temperate grassland, particularly in the Majura valley, should be urgently implemented.

The recommendations below build on and complement recommendations developed through these investigations.

1. Strengthen research, planning and practical projects to enhance biodiversity conservation in the ACT through:
    a. developing a biodiversity monitoring strategy, building on existing government and non-government skills, capacity and programs, and focused on periodic reporting. This should include, where appropriate, systematic statistical methodologies which support monitoring of trends and changes to biodiversity assets in the ACT;
    b. funding a dedicated senior officer position to facilitate knowledge development and consolidation, across disparate sources, including more strategic integration within and between government, research/academic institutions and community groups and members. To support this role, systems should be developed to provide wide

public access to information to guide research, teaching, planning and practical projects to enhance the sustainability of the ACT and Region;

c. identifying opportunities to integrate multiple environmental assessments. For example, when monitoring nature reserves for vegetation qualities, land-health indicators and grazing impacts should also be monitored at the same sites. Assessing sites in Canberra Nature Park on a rolling 3-year basis over a 10-year period would provide the basic information for monitoring trends in environmental condition;

d. publicly reporting decisions and activities relating to individual species, populations and ecological communities in the ACT. This should include both qualitative and quantitative information;

e. reviewing and updating Action Plans where appropriate, and publicly reporting on progress against Action Plan objectives and proposed actions; and

f. collaborating with NSW Government and regional organisations to contribute to regional and national biodiversity data sets.

2. Better integrating biodiversity values within urban planning through:
    a. integrating biodiversity corridors and habitat connectivity in the Territory Plan process;
    b. identifying, where possible, appropriate clearance thresholds for ecological communities across the ACT to maintain and improve biodiversity values and guide development decisions. To complement this the draft biodiversity offset policy should be finalised to ensure no net loss in ecosystems; and
    c. developing and implementing an ACT fauna sensitive road design manual.

3. Improve transparency of biodiversity integration into legislative and planning frameworks through:
    a. including objectives for the protection of biodiversity and a definition for 'biodiversity' as part of the Nature Conservation Act 1980 review;
    b. aligning provisions in the Environment Protection Act 1997 and Planning and Development Act with any relevant changes to the NC Act including biodiversity definitions and reviewing the definition of environmental harm to determine whether unauthorised loss of biodiversity should be included as an offence; and
    c. assessing the effectiveness of managing threatening processes through Action Plans and determining if management of key threatening processes needs strengthening through listing under the NC Act.

Glossary

Canopy bridge: a rope or pole suspended above a road and connected to vertical poles or trees for use by arboreal marsupials and other climbing species

Ecological communities: in the ACT, ecological communities are defined by the *Nature Conservation Act 1980* as being groups of ecologically related species with shared characteristics that inhabit a particular place and vary in composition

Endemic species: species only found in a particular region and nowhere else in the world

Fauna culvert: a square or circular structure beneath a road designed for non-aquatic fauna passage

Land bridge: a bridge over a road, covered in soil and planted with native vegetation and enhanced with habitat features such logs and rocks

Native fauna: in the ACT, native fauna species are defined by the *Nature Conservation Act 1980* as native animals that are indigenous to Australia or are migratory in that they periodically or occasionally visit Australia or have been introduced into Australia directly or indirectly by Aboriginal people before the year 1788

Native flora: in the ACT, native flora species are defined by the *Nature Conservation Act 1980* as native plants that are indigenous to Australia or have been introduced into Australia directly or indirectly by Aboriginal people before the year 1788

Threatening processes: in the ACT, threatening processes are defined by the *Nature Conservation Act 1980* as processes that threaten or may threaten the survival, abundance or evolution of a native species or an ecological community

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACT Department of Territory and Municipal Services (TAMS) -now Territory and Municipal Services Directorate (TAMSD)

Parks, Conservation and Lands (PCL) - now part of the Environment and Sustainable Development Directorate (ESDD)

ACT State of the Environment Report 2011

THEME: Biodiversity

Indicator cluster: Native species - flora

The indicators in this cluster are:

- *Status of native species* (C) - status of native plants including threatened species listings and other data for common species;
- *Native seed harvesting* (P) - extent and distribution of native seed harvesting;
- *Weed impacts* (I) - nature of weed impacts on native species; and
- *Threatened species conservation* (R) - effectiveness of threatened species plant conservation.

Condition indicators (C) present data on the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effects of environmental changes on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

Currently 1655 plant species (native and introduced) are recorded as occurring in the ACT, but this list is not exhaustive and is expected to increase as additional species become naturalised, and as species of moss and lichen are included in the future.

In total, 8 plant species are listed as threatened with extinction under the ACT *Nature Conservation Act 1980*. There have been no new listings of plant species as threatened since the 2007 reporting period, but the riparian shrub *Bossiaea grayi* (only known from the ACT) is currently being assessed for listing as a threatened species.

Introduction

Both native and introduced plants provide habitat and food for fauna. Changes in patterns of abundance of native plant species in a given area can occur naturally, as a result of seasonal conditions or because of significant events such as fire or storms. Disappearance of a significant native plant species from an area is typically an indicator of a major impact to an ecosystem. It may be a result of loss of habitat because of urban development, agriculture or competition from introduced species. The species composition of a native plant community can also be affected by overgrazing, weed infestation, seed gathering and/or firewood harvesting.

This indicator cluster focuses on native plant species listed as threatened under the ACT *Nature Conservation Act 1980* (ACT Government 2011). Species that are of concern to the Flora and Fauna Committee are those that are uncommon and/or are declining in abundance. The committee is interested in the likely reasons for a

decline or change in abundance of any threatened species, and whether those reasons are being addressed by Recovery Plans and Action Plans.

Condition indicators

Status of native species

As of December 2008, there were 1655 native plant species recorded in the ACT by the ACT Government and the Australian National Herbarium Centre for Plant Biodiversity Research. This number includes 1575 vascular flowering plants including grasses, herbs, shrubs and trees. The remaining 80 records are for non-vascular cryptogamic flora such as hornworts and liverworts (Lepschi et al. 2008). The census list includes 550 exotic species (not native to ACT) that display varying degrees of persistence and naturalisation in the ACT (Lepschi et al. 2008).

The Nature Conservation Act makes provision for the protection and conservation of native plants. Under the Act, a species may be declared as vulnerable or endangered if there are reasonable grounds for believing that the species is threatened with extinction. The Act establishes a formal process for the identification and protection of threatened plant species in the ACT, and lists:

- vulnerable species - species that are likely to become endangered in the next 25 years; and

- endangered species – a species in immediate danger of extinction, unless the circumstances and factors threatening its distribution composition and viability cease.

In the ACT, 8 native plant species are listed as endangered under the Act. These are given special protection status; none is listed as vulnerable. Under the Act all orchids local to the ACT, most native local ferns and 28 other native plants are listed as protected. A licence must be obtained prior to any destruction or damage of these species.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) lists species of flora and fauna declared nationally as threatened or endangered (Australian Government 2011). In the ACT, 12 species that are nationally threatened and listed under the EPBC Act are considered to have suitable habitats (Table 1). Each of these species is given special protection status under the Nature Conservation (Special Protection Status) Declaration 2011 under the ACT Nature Conservation Act. The list of protected plants is currently under revision.

All threatened plant species that occur in the ACT and are listed under the ACT Nature Conservation Act and EPBC Act are shown in Table 1, along with their status. The *2007-08 ACT State of the Environment Report* reported that two threatened plant species had been listed under the Act during that reporting period. The EPBC Act had listed 4 species which are known or predicted to have occurred in the ACT during the same period. However, during the current reporting period no additional threatened plant species have been listed under the Act, while 1 species has been

listed under the EPBC Act. A nomination to list the riparian shrub *Bossiaea grayi* (known only from the ACT) as a threatened species under the Nature Conservation Act is currently under assessment.

Table 1. Threatened species listings and status for the ACT
(NC Act indicates ACT Nature Conservation Act)

Name	Protection listing	Status
Canberra Spider Orchid (*Arachnorchis actensis* *Syn. Caladenia actensis*)	NC Act - Endangered EPBC Act - Critically Endangered	Currently the species is known only from the lower slopes of Mt Majura and Mt Ainslie in the ACT. This species was surveyed for the first time in 2008. No plants were located but this was likely due to seasonal factors. More than 100 plants were observed during the 2009-10 flowering season.
Brindabella Midge Orchid (*Corunastylis ectopa*)	NC Act - Endangered EPBC Act - Critically Endangered	The species was first discovered in 1992 as a small population of approximately 70 plants. Endemic to the ACT, and known only from a single site in the Brindabella Range. The largest number of Brindabella Orchids was recorded in the 2009-10 season, with 78 plants counted and tagged. In 2011, 72 plants were tagged. Total number of individual plants tagged in the last 2 years is 110 (CPR 2010).
Small Snake Orchid (*Diuris pedunculata*)	NC Act - Special Protection species EPBC Act - Endangered	Spatial data on the distribution of this species in the ACT is maintained (G. Baines pers. comm 2011).
A subalpine herb (*Gentiana baeuerlenii*)	NC Act – Endangered EPBC Act - Endangered	Annual counts have been carried out at the last known location of this herb, but it has not been observed since 1998.
Ginninderra Peppercress (*Lepidium ginninderrense*)	NC Act - Endangered EPBC Act - Vulnerable	This species only occurs on land owned by the Australian Government Department of Defence which monitors it on a regular basis. The data are not routinely provided to the ACT Government. The National Botanic Gardens maintains a seed collection and propagates this species.
Hoary Sunray (*Leucochrysum albicans var. Tricolor*)	NC Act - Special Protected Species EPBC Act - Endangered	Spatial data that includes the distribution of this species is maintained and updated as required. The species is too numerous within the ACT to estimate abundance (G. Baines pers. comm 2011).
Tuggeranong Lignum	NC Act -	There are 10 known wild plants, all of which were

Name	Protection listing	Status
(*Muehlenbeckia tuggeranong*)	Endangered EPBC Act - Endangered	healthy during inspections undertaken in 2011; 93 clones of these wild plants have been introduced into suitable habitat in the Murrumbidgee River corridor. Approximately 50% of these plants were alive when inspected in 2011.
Pale Pomaderris (*Pomaderris pallida*)	NC Act - Special Protected Species EPBC Act - Vulnerable	Spatial data that include information on distribution of this species are kept and maintained by ACT Government
Leek Orchid (*Prasophyllum petilum*)	NC Act - Endangered EPBC Act - Endangered	The species is known from only one site in the ACT in the Hall cemetery, where more than 70 plants have been recorded. The abundance of the flowering population at Hall cemetery has fluctuated widely since monitoring began in 1991. This trend was again evident in the 2010 annual survey with an increase in the total flowering plants recorded from 26 in 2009 to 47 in 2010. However in 2010 the number of new plants flowering declined. The low abundance in 2009 was not unexpected given the species annual abundance has regularly fluctuated since monitoring began in 1991. No obvious link has been identified between marked fluctuations and the preceding year's abundance (CPR 2010). The survey will be repeated at the same time in spring 2011.
Button Wrinklewort (*Rutidosis leptorrynchoides*)	NC Act - Endangered EPBC Act - Endangered	The recovery actions for this plant species require completion of full quantitative surveys once every 5 years. The next full survey is due in 2012-13 (CPR 2010).
Small Purple Pea (*Swainsona recta*)	NC Act - Endangered EPBC Act - Endangered	This species is found in 5 locations within the urban areas of Canberra. The largest population occurs in the Mount Taylor Nature Reserve with a stable population of over 300 individual plants recorded at this site. A total of 337 individuals have been recorded across all 5 locations since surveying began in 2001. Abundance of plants at the 4 other sites is low. Surveys have revealed that the populations at the other 4 locations have remained steady but no new plants have been identified since 2003.
Austral Toadflax (*Thesium australe*)	NC Act - Special Protected Species. Species is common in the ACT.	Spatial data on species distribution are kept and maintained by the ACT Government

Name	Protection listing	Status
	EPBC Act – Vulnerable	

Source: Australian Government 2011

Pressure indicators

Key pressures on native flora include climate change, fire, weeds and urban development. These are discussed in the *Threatening processes* indicator cluster paper.

Native seed harvesting

Sustainable native seed harvesting opportunities are properly a response indicator. Harvesting helps provide vital resources for the restoration of degraded landscapes and assists in enhancing native biodiversity. It is particularly important for the recovery of areas of high conservation value including endangered ecological communities. However, there are pressures that occur with high demand and reduced availability. Consequently this report has highlighted seed harvesting as a pressure indicator rather than including it as a response indicator.

In 2009, there were 6 ACT-based Seed Production Areas (SPAs) that had been established to produce and supply native seed to the ACT (Australian Government 2008). The SPAs help to complement stocks of native seed sourced to support revegetation projects. However, in the last 2 years, 3 of the SPAs have ceased production as a result of either a change in land ownership, where the new owners have not been interested in supporting the SPA, or a lack of landholder commitment, or species failures.

The *2007-08 ACT State of the Environment Report* reported that there is limited seed kept in store, and there is frequently a turn-around time of over a year to collect adequate seed locally for some of the large-scale projects.

The quantity of seed stored has been improved in this reporting period, with approximately 1000 kg from 150 species of local provenence stored in Greening Australia's seed bank. Seed collection has focused primarily on understorey species of the Yellow Box-Red Gum Woodlands. Greening Australia, with funding from a variety of sources, continues to work closely with the CSIRO, the Australian National Botanic Gardens and the ACT Natural Resources Management Council (ACT NRMC) in relation to seed collection programs (Greening Australia).

Impact indicators

Weed impacts

Weeds in the ACT cause concern in relation to biodiversity and agricultural productivity. They invade native plant communities and can out-compete native species, resulting in a reduction in plant diversity and loss of habitat for native animals. Once weeds establish in a native plant community they can change its structure and species composition. This has a flow-on effect to native fauna and water resources.

There are over 500 species of naturalised exotic weeds (i.e. species from outside Australia) in the ACT. The composition and abundance of weeds is influenced by previous and current land use and land management practices. Some weed species have been intentionally introduced as ornamental species; others as pasture grasses in grazing areas.

Some of these species have become environmental weeds - that is, plants that represent a threat to the conservation values of natural ecosystems. The level of environmental impact associated with an environmental weed depends on its ability to invade and change the diversity and balance of a vegetation community. African Lovegrass (*Eragrostis curvula*) is an example that has established along the Murrumbidgee and Molonglo rivers, not as a direct result of development. In those valleys it forms dense swards, and out-competes native vegetation for space, nutrients and sunlight, changing the habitat characteristics that formerly suited native plants and animals.

Weeds reduce the productivity of agricultural lands, and some weeds, such as St Johns Wort (*Hypericum perforatum*) and Paterson's Curse (*Echium plantagineum*), are toxic to stock. The main pathways for weed-spread include transported livestock and fodder, contaminated crop and pasture seeds, deliberate introductions of new species, and the movement of contaminated machinery such as harvesters, recreational vehicles, cars, and mowers or slashers used in the maintenance of lawns and grassland areas.

Currently 78 weed species are declared pest plants in the ACT. Increasing development in the ACT is exacerbating the impact of weeds across all ecosystems in the ACT, particularly in locations with threatened or endangered species.

Land infested with weeds is a source of infestation for other areas. The risk of infestation is greatest where the boundaries of developed areas adjoin native vegetation. The weed species considered to be the greatest potential threat to the ACT will depend on the location and situation. A candidate for greatest potential threat is African Lovegrass in the Murrumbidgee River Corridor and surrounding areas. Understanding the specific impacts of weeds on various native plant species and communities will assist to improve management options.

The status of weeds is further discussed in the *Threatening processes* indicator cluster paper.

ACT State of the Environment Report 2011

Response indicators

Threatened species conservation

Conservation of threatened plant species in the ACT is an important part of protecting biodiversity and maintaining healthy ecological communities. The capacity of a human community to maintain threatened plant species in a landscape largely depends on eliminating or mitigating urban development, weed invasion, pests and disease, fire and climate change. For more information on strategic conservation management, including the management of protected areas, see the *Ecological communities* and *Threatening processes* indicator cluster papers.

The ACT Nature Conservation Act requires an Action Plan to be prepared in response to each declaration of a threatened species. Action Plans outline conservation and protection proposals for threatened plants, along with actions to minimise the effect of threatening processes. The details of Action Plans for the 8 threatened plant species under the Act, and details of national Recovery Plans for the 12 EPBC Act listed threatened plants of the ACT are summarised in Table 2.

Table 2. Action Plans and Recovery Plans for listed plants

Threatened species	Action Plans prepared under Nature Conservation Act	Recovery Plans prepared under EPBC Act
Canberra Spider Orchid (*Arachnorchis actensis* Syn. *Caladenia actensis*)	No ACT Action Plan has been produced. A National Recovery Plan has been prepared for this species and published and adopted under the EPBC Act.	A National Recovery plan was prepared in 2010. The duration of the Recovery Plan is for a period of 5 years (2010-2015).
Brindabella Midge Orchid (*Corunastylis ectopa*)	No ACT Action Plan has been produced. A National Recovery Plan has been prepared and published and adopted under the EPBC Act.	A National Recovery plan was prepared in 2010. The duration of the Recovery Plan is for a period of 5 years (2010-2015).
A subalpine herb (*Gentiana baeuerlenii*)	*Action Plan No. 5 (A subalpine herb* Gentiana baeuerlenii*) 2007*. Action Plan to be reviewed 3 years after commencement (April 2010).	A National Recovery plan was prepared in 2005 (based on Action Plan No. 5 prepared under the Act). That Action Plan was reviewed in August 2011.
Ginninderra Peppercress (*Lepidium ginninderrense*)	Included in *Action Plan No. 28 (ACT Lowland Native Grassland Conservation Strategy) 2005*. Action Plan to be reviewed in 2010.	A National Recovery plan was prepared in 2005 (based on Action Plan No. 25 prepared under the Act). The duration of the Recovery Plan is for a period of 3 years (June 2008).
Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)	Included in *Action Plan No. 29 (ACT Aquatic Species and Riparian Zone Conservation Strategy) 2007*. Action Plan to be reviewed in 2010.	A National Recovery plan was prepared in 2005 (based on Action Plan No. 24 prepared under the Act). The duration of the Recovery Plan is

Threatened species	Action Plans prepared under Nature Conservation Act	Recovery Plans prepared under EPBC Act
		for a period of 3 years (June 2008).
Leek Orchid (*Prasophyllum petilum*)	Included in *Action Plan No. 27 (ACT Lowland Woodland Conservation Strategy) 2004*. Action Plan to be reviewed in 2009.	A National Recovery plan was prepared in 2010. The duration of the recovery Plan is for a period of 5 years (2010-2015).
Button Wrinklewort (*Rutidosis leptorrynchoides*)	Included in *Action Plan No. 28 (ACT Lowland Native Grassland Conservation Strategy) 2005*. Action Plan to be reviewed in 2010.	A Recovery Plan is currently being prepared.
Small Purple Pea (*Swainsona recta*)	Included in *Action Plan No. 27 (ACT Lowland Woodland Conservation Strategy) 2004*. Action Plan to be reviewed in 2009.	A Recovery Plan is currently being prepared.
Small Snake Orchid (*Diuris pedunculata*)	N/A	A Recovery Plan is currently being prepared.
Hoary Sunray (*Leucochrysum albicans var. Tricolor*)	N/A	A Recovery Plan is currently being prepared.
Pale Pomaderris (*Pomaderris pallida*)	N/A	No Recovery Plan
Austral Toadflax (*Thesium australe*)	N/A	A Recovery Plan is currently being prepared.

Source: ACT Government 2008, 2010a, 2010b, DSEWPaC 2009

ACT Action Plans have been prepared for 6 of the 8 threatened plant species. The Canberra Spider Orchid and Brindabella Midge Orchid are managed under a National Recovery Plan.

Actions Plans need to be continually reviewed and updated to ensure that the species' current status is understood (i.e. vulnerable, endangered or critically endangered). Implementation reports on each Action Plan are considered by the Flora and Fauna Committee every 3 years. Reviews of the Action Plans should be made publicly available.

During the reporting period, the ACT Government has undertaken monitoring, planting and surveying projects for threatened plants listed under the Act. All plant species listed under the Act are monitored annually and recovery actions continue to be implemented by the ACT Government. A summary of the status of each species, and the management actions undertaken in the reporting period, is provided below.

Canberra Spider Orchid - Arachnorchis actensis

Management actions undertaken have included fencing the 3 main populations to reduce impacts of kangaroos and rabbits on the orchid. Relatively large clumps of the plants were protected with herbivore-proof cages to reduce grazing and increase seed set. Fewer than 5% of caged plants were grazed, compared to more than 50% of non-caged plants.

Brindabella Midge Orchid - Corunastylis ectopa

Little is known about this species in relation to its ecology and preferred habitat. As such, active adaptive management will be needed for the future management of this population (CPR 2010). Management of vegetation may be required, to maintain an appropriate habitat structure. The population is extremely small and isolated, and the threatening processes include expansion of nearby infrastructure and habitat change.

A subalpine herb - Gentiana baeuerlenii

The last known site where this herb was seen is now fenced to reduce rabbit grazing and pig rooting, but kangaroos still graze the site. Implementation of a burn is being considered, with the aim of removing the thick grass thatch to assist germination of any remaining seed.

Ginninderra Peppercress - Lepidium ginninderrense

The ACT Government has provided funding to the Australian National Botanic Gardens for a seed collection and storage project with the aim of propagating plants for the establishment of a second population (CPR 2010). This would reduce the stochastic environmental risks to this species.

Tuggeranong Lignum - Muehlenbeckia tuggeranong

ACT Government staff and Southern ACT Catchment Group Landcare staff participated in the planting of cuttings of male and female plants in five suitable areas along the eastern bank of the Murrumbidgee River within the Pine Island Reserve, to increase the population at the site. The Conservation Planning and Research team made a thorough survey of the plantings in the summer of 2010-11, alongside the annual survey of the remnant population during spring 2011. There are 10 known wild plants, all of which were healthy when inspected in 2011. Of the 93 planted clones, approximately 50% were alive when inspected in 2011.

Leek Orchid - Prasophyllum petilum

The current management plan and monitoring program for this species at the Hall cemetery appears to be effective in maintaining the population. However, surveys have shown a decrease in the recruitment of new flowering plants since 2007. If recruitment continues to fall, management procedures will need to be reviewed and more detailed monitoring applied, to identify possible causes (Cook 2010).

The continued operation of the area as a cemetery is a threat to this species. Management requirements for grave digging, vehicle access and movement, weed control and mowing are outlined in the Hall Cemetery Management Plan that was developed in 2005. The fragile nature of this small population means that in-situ conservation and monitoring of the Hall Cemetery population is crucial for the survival of the species in the ACT. Management of the Hall Cemetery, including proposed expansions, should be consistent with the conservation of threatened communities and species, in particular the Leek Orchid.

Button Wrinklewort – Rutidosis leptorrhynchoides

All known sites were inspected in 2009-10; threats at each site were identified and the information was provided to the relevant land managers. As a result, extensive woody weed control has occurred at the Stirling Ridge and State Circle sites (CPR 2010).

Small Purple Pea – Swainsona recta

Abundance records indicate that the population at Mount Taylor is stable, with numbers steadily increasing since plants were first tagged in 2001. Surveys have revealed that the populations at the other 4 locations have remained steady, but no new plants have been identified since 2003. The lack of recruitment of *Swainsona recta* could be attributed to dense native shrub and grass cover which is potentially out-competing this threatened species. The survey will be repeated at the same time in 2011 and site inspections will be carried out. Management actions that would potentially assist recruitment of the species, such as the controlled burning of dense native grass growth, will be implemented (Cook 2010).

Monitoring of non-threatened species

In addition to the monitoring and recovery actions undertaken for species and communities in the ACT listed as threatened under ACT or Commonwealth legislation, the ACT Government monitors non-listed species if their conservation status is of concern. Two non-listed plant species currently being monitored include the riparian shrub *Bossiaea grayi* and a small perennial sub-shrub *Dampiera fusca.*

Bossiaea grayi

A nomination of *Bossiaea grayi* as a threatened (either vulnerable or endangered) species is currently under assessment. This species is only known to exist in the ACT; it has been recorded in several locations in the riparian zone of the Murrumbidgee River and its tributaries within the ACT. To clarify the condition, extent and number of plants, site assessments of new and known locations were undertaken by CPR in May and June 2010.

During the 2010 surveys between 200 and 300 individual *Bossiaea grayi* plants were observed at the known locations. In addition the species was observed at a number of new localities, including a site with over 200 plants in the Paddys River area. At two sites where plants have previously been recorded, no plants were found during

this survey (CPR 2010). Systematic surveys should be considered for all areas of suitable habitat in the ACT to establish the full extent, the status and condition of populations of *Bossiaea grayi* across the ACT.

Dampiera fusca

Dampiera fusca is a small perennial sub-shrub found in the ACT after the 2003 fire, this being the first time this genus had been recorded in the ACT. In 2007 a quantitative monitoring program of the known population of the species was established. The *Dampiera fusca* population flowered rapidly and profusely after the 2003 fire, then declined as a result of increased competition from other plants for light and resources. The population increased in 2009, perhaps because of favourable seasonal conditions. Further monitoring will be undertaken to establish how long this species remains detectable following fire.

Rabbit and wombat scats were observed across the area occupied by *D. fusca*, and some grazing was observed on the adjacent native grasses. The threat of grazing by mammals is not regarded as a major threat to this species, but the issue of rabbit control is likely to require management (CPR 2010).

Seed collection policy

In 2010, the Conservator of Flora and Fauna endorsed an interim policy for limited commercial seed collection, addressing a recommendation in the *2007-08 State of the Environment Report*.

Collection of native seed from wild populations is constrained by legislation and licensing. Consideration of commercial seed collection policy or legislation is included in the scope of the review of the Nature Conservation Act 1980. The interim policy outlines policies for seed collection on unleased areas including reserves, roadsides and urban parks. This will benefit conservation community groups and commercial seed collectors that wish to provide for large amounts of seed for revegetation projects, and it will facilitate an increase in the number of revegetation projects using local native species.

Specific rehabilitation guidelines should be developed to complement the interim policy on seed collection. Such guidelines would assist conservation groups and land holders in identifying the most suitable areas in the landscape to be targeted for rehabilitation works. Updating the interim policy and relevant guidelines (e.g. revegetation guidelines) would be appropriate following outcomes from the review of the Nature Conservation Act.

Greening Australia has identified that there is a demand for collecting native seed within the ACT by a number of regionally based non-government conservation community groups and commercial seed collectors. They have developed guidelines for collecting seed for use in revegetation in the ACT and surrounding regions. The guidelines outline principles for areas of high, moderate, low and minimal conservation in the ACT, and provide soil and vegetation community maps to help guide where seed should be sourced.

Currently Greening Australia, supported by the ACT NRMC, is coordinating the development of a community seed bank to manage collections of native seed, its processing, and storage. They also maintain records of seed held and they manage a supply of local provenance seed for revegetation projects in the ACT region.

Following the 2003 bushfire in the ACT, the Seeds for Survival project was initiated to increase the availability and diversity of local native seed in the ACT (Australian Government 2008). This project is a partnership between the Australian National Botanic Gardens, CSIRO Plant Industry, ACT Government, and Greening Australia. A total 238 kg of seed representing 170 species had been collected by June 2008 and approximately 100 kg of native seed has been collected since 2009. Most of this supply has been used in direct seeding activities across the ACT.

Community engagement

Volunteers from organisations such as Parkcare, Landcare and Greening Australia are active in monitoring biodiversity in ACT nature reserves.

Each year the ACT Government provides ACT Environment Grants for projects that support community engagement in relation to implementing nature conservation strategies. During the reporting period, none of the funded projects has supported threatened plant species conservation or review of existing Action Plans (ESDD 2011). However, a number of projects have been funded to enhance native vegetation, including:

- Scrivener Hill Lookout - environmental repair of Scrivener Hill (O'Malley) though training of volunteers in vegetation monitoring techniques by Greening Australia;

- ACT Community Weed Control Assistance - strategic weed control assistance to ACT rural landholders and community Landcare through training and a weed spray trailer managed by Southern ACT Catchment Group;

- Crace Grassland Restoration: Consolidation and Care - consolidation and maintenance of grasslands rehabilitated by the Belconnen Model Aero Club;

- Restoring Native Grasses to the Understorey of The Pinnacle - a research project studying soil nutrient levels for the improved restoration of the Yellow Box-Red Gum Grassy Woodlands formation, by Ginninderra Catchment Group.

For more information on the role of community groups in conservation see the *Community engagement* indicator cluster in the *People* theme.

Glossary

Stochastic: A process where behaviour or outcomes are random

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACT Department of Territory and Municipal Service (TAMS) now Territory and Municipal Service Directorate (TAMSD)

ACT Department of the Environment, Climate Change Energy and Water (DECCEW) – now Environment and Sustainable Development Directorate (ESDD)

Greening Australia

ACT State of the Environment Report 2011

THEME: Biodiversity

Indicator cluster: Native species - fauna

The indicators for this cluster are:

- *Status of native species* (C) - status of native species including threatened species listings and other data for common species;
- *Threatened species conservation* (R) - effectiveness of threatened species conservation management; and
- *Native species conservation* (R) - native species population trends and management issues, such as kangaroo management.

Condition indicators (C) present data on the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effects of environmental changes on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

The ACT has a diverse range of landscapes and ecological communities. They range from natural temperate grasslands on the tablelands to sub-alpine woodland and bog complexes in the mountains. The fauna living in these habitats are diverse, but 15 animal species are listed as vulnerable and 9 are listed as endangered under the ACT *Nature Conservation Act 1980*. Three new species (the Little Eagle, the Glossy Black-cockatoo and the Pink-tailed Worm Lizard) have been listed as threatened under the Act since the last reporting period.

A set of conservation Action Plans focusing on particular ecological communities, provides direction for the threatened fauna conservation effort in the ACT. An Action Plan for a species or community outlines proposals either to increase its conservation and protection or to minimise the effects of threatening processes.

Action Plans exist for all but 2 threatened species, the Little Eagle and the Glossy Black-cockatoo, and these are in preparation. Action Plans warrant individual review, which should include updating the performance criteria for each plan. This process should also address any deficiencies in data on population trends of threatened animal species in the ACT, such as the status of threatened woodland birds.

Introduction

This indicator cluster paper reports on the information available about the status of threatened and other native species in the ACT, along with actions being undertaken to secure the future of native fauna in the ACT. Fauna that are sensitive to changes in the environment can, by their presence, abundance or absence, be a valuable indicator of changing environmental conditions or impacts that may be otherwise hard to detect. Assessment of the effectiveness of native species conservation

measures and pest management helps identify successes and/or gaps in regulation, programs and initiatives to improve future management.

Condition indicators

Status of native species

In total, 24 animal species are currently listed under the *ACT Nature Conservation Act 1980* (ACT Government 2011a), comprising 15 vulnerable and 9 endangered species. During the reporting period the Little Eagle (*Hieraaetus morphnoides*), the Glossy Black-cockatoo (*Calyptorhynchus lathami*) and Pink-tailed Worm Lizard (*Aprasia parapulchella*) were listed as vulnerable (ACT Government 2011a). (Tables A1-A7 in the Annex give more detailed information.)

Action Plans have been developed in consultation with the ACT community for all species, ecological communities or threatening processes that are listed under the ACT Nature Conservation Act. These plans (TAMS 2006) outline conservation and protection proposals for the species or ecological community concerned, or proposals to minimise the effect of threatening processes. Monitoring of the threatened species is an action listed in the Action Plans; there is no wider census of native animals in the ACT.

Monitoring of native species in the ACT is carried out by a number of government agencies, university groups and community organisations. The ACT Government supports some university and community-based monitoring work through grants, scholarships, direct funding and technical support. Examples include monitoring of threatened grassland fauna by University of Canberra researchers, of woodland birds by the Canberra Ornithologists Group, and of frogs by the Frogwatch program volunteers.

Birds

The Canberra Ornithologists Group (COG) is the main organisation monitoring birds in the ACT. Each year COG produces an Annual Bird Report, which provides a valuable indication of trends in bird abundance within the Canberra region. During the reporting period bird species richness has remained stable in the ACT with around 233 species being recorded. Note that information the group collects about threatened species is generally insufficient to assess trends in populations because of the small sample size (Bounds et al. 2010).

During the reporting period, the drought and resulting dry conditions across south-eastern Australia meant that some inland bird species were seen in Canberra: for example, the Black-tailed Native-hen (*Tribonyx ventralis*), and Singing Honeyeater (*Lichenostomus virescens*), White Fronted Honeyeater (*Purnella albifrons*) and Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), which are rarely seen in the ACT.

Regrowth in the wet forest areas following the 2003 fires has allowed resident species such as the Eastern Whipbird (*Psophodes olivaceus*) and Red-browed Tree Creeper (*Climacteris erythrops*) to return to their pre-fire habitats. In spite of 2009-10 being significantly wetter than the previous years the continuing low levels of

Lake Bathurst and Lake George reduced the number of wader species recorded at these sites and also within the ACT at sites such as the Jerrabomberra Wetlands.

The results of 10 years of woodland bird monitoring in the ACT (1998-2008) were published by COG in 2010 (Bounds et al. 2010). The results highlight the complexities of natural systems and show there is still a lot to learn about the factors influencing species abundance. Species that were reported in more than 1% of the surveys were analysed for trends in the numbers reported. In total 55 species were considered (34 woodland dependent species and 21 non-woodland species). Of these:

- 15 species (9 woodland-dependent) showed some evidence of a declining trend over the ten years;
- 25 species (17 woodland-dependent) showed no overall change; and
- 15 species (8 woodland-dependent) showed an increasing trend.

Why some species have increased while others declined is not clear.

It is of concern that species such as the Hooded Robin (*Melanodryas cucullata*) listed as vulnerable in the ACT and NSW) and the Diamond Firetail (*Stagonopleura guttata*) (listed as vulnerable in NSW but not listed in the ACT) have declined to a point where trends cannot be determined from the Woodland Project. The Scarlet Robin (*Petroica boodang*), recently listed as vulnerable in NSW but not listed in the ACT, continues to decline in the ACT. While the woodland bird survey provides a valuable record of trends of more common woodland birds it is clear that a targeted monitoring program is required to evaluate the status of birds present at low densities.

The trends of more common species with wider ecological tolerances (see bullet points above) may mask a continuing decline in woodland function, potentially highlighted by the status of more sensitive species like the Hooded Robin, which are sensitive to disturbance and require large areas of structurally diverse habitat (Freudenberger 1999). A targeted program that monitors population trends of sensitive species may provide more robust data on the status of woodland birds, allowing establishment of monitoring 'surrogates' for threatened populations.

One threatened woodland bird species that is on the increase in the ACT is the Superb Parrot (*Polytelis swainsonii*). The ACT is near the south-eastern extent of the summer breeding range for this species. The COG records indicate that numbers of Superb Parrots visiting the ACT during the spring breeding season have increased over the past few years. The reason for this increase is unclear; some possible explanations include an increase in the species' population, unfavourable conditions elsewhere in its distribution, or the attraction of foraging and nesting opportunities in the ACT. A targeted study during the 2009-10 breeding season by COG in the Gungahlin area identified breeding activity within the proposed suburb of Throsby. Behavioural observations suggested breeding may have also occurred in the central Molonglo Valley in the vicinity of the Kama Nature Reserve, south-west of Hawker. Both these areas have the potential to be directly or indirectly affected by proposed urban expansion zones.

In contrast, the Little Eagle population appears to continue to decline. A nest study in 1990-1992 found 11 nesting sites actively in use by the species. In 2008 only 4 active nests were found. A similar decline has been noted in the Wedge-tailed Eagle (*Aquila audax*); 12 of 21 nests actively in use in 2002-03 were found to be abandoned in 2008. The continued population growth and urban expansion of the ACT is likely to further pressure large raptors because these species are often sensitive to disturbance by people during nesting.

With funding from the ACT Government, the Fenner School of Environment and Society at the Australian National University (ANU) has two PhD research studies investigating why woodland birds are apparently continuing to decline. The studies aim to identify urban planning design principles that are sympathetic to woodland bird conservation.

Amphibians

The ACT and Region Frogwatch program is a community frog-monitoring program that conducts a frog census in spring each year. The major aim of the program is to monitor frogs by involving community volunteers to help collect information about the presence and abundance of frog species.

During the reporting period, the three most commonly recorded species were Spotted Grass Frog (*Limnodynastes tasmaniensis*), Plains Froglet (*Crinia parinsignifera*) and Common Eastern Froglet (*Crinia signifera*). The Spotted Burrowing Frog (*Neobatrachus sudelli*) was detected during Frogwatch-monitoring at 4 sites in 2009, whereas during 2008 it was only recorded at 1 site; previously it had not been recorded since 2005.

The 2009 season appeared favourable for frogs: more species (10) were detected overall, and the average number of species detected at each site was higher than in previous years (GCG 2009). Rains prior to the 2009 census may have been responsible for the higher diversity of frogs recorded.

Numbers of the endangered Northern Corroboree Frog (*Pseudophryne pengilleyi*) are critically low and continued to decline during the reporting period. A chytrid fungus is now considered to be the primary cause of decline (Australian Government n.d.), and dry years have further reduced the species' breeding success. In the ACT there are now estimated to be fewer than 100 Northern Corroboree Frogs left in the wild, and wild populations are likely to become extinct within the next 5-10 years unless their decline can be halted (TAMS 2010a).

Invertebrates

Invertebrates are vital for ecosystem function and comprise a significant proportion of the species diversity of any ecosystem. Less is known about the status of invertebrates in the ACT than about other animal groups.

Two terrestrial invertebrates are listed under the ACT Nature Conservation Act: the Golden Sun Moth (*Synemon plana*), which is also listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act*

1999 (EPBC Act), and the Perunga Grasshopper (*Perunga ochracea*) (Australian Government 2011).

Recent surveys for the Golden Sun Moth since 2009 identified 16 new sites of occurrence for this species. Most of the new sites of occurrence are secondary grassland sites found throughout the areas of Gungahlin not yet under urban development. These sites generally appear to maintain relatively small Golden Sun Moth populations but they show, nonetheless, that this species is not exclusively a natural temperate grassland species as first thought. The Golden Sun Moth is now recorded in 60 sites across the ACT including large grassland reserves and small unreserved areas. Several Golden Sun Moth sites are located in future urban development areas. Any clearing of habitat should be avoided. Where such clearing is to occur, funding paid as compensation by developers will contribute to research to improve understanding of the ecology and biology of this species.

There is no practical method of survey for the Perunga Grasshopper and so information on its abundance and distribution in the ACT continues to come from opportunistic sightings by the public or during surveys for other species.

It is likely that other invertebrates that are associated with Lowland Woodlands and Lowland Native Grassland communities within the ACT have suffered similar declines to the Golden Sun Moth and Perunga Grasshopper. An absence of baseline data and subsequent surveying means that any such population declines have gone unnoticed. Other insect species identified as species of concern in the Action Plans for threatened species and ecological communities within the ACT include the Canberra Raspy Cricket (*Cooraboorama canberrae*), Key's Matchstick Grasshopper (*Keyacris scurra*) and Lewis's Laxabilla Grasshopper (*Laxabilla smaragdina*). No formal monitoring has been undertaken for these species, though opportunistic sightings are recorded and collated.

During the reporting period research, the ecology of crayfish in the Cotter and Murrumbidgee rivers was studied as part of the development of the Enlarged Cotter Dam Fish Management Plan. It was found that the Murray River Crayfish (*Euastacus armatus*) continues to have a patchy distribution in the Murrumbidgee River and lower Cotter River within the ACT. The species was most often found where public access was difficult, and most catches were of individuals that had not yet reached sexual maturity.

Mammals

Fauna surveys in Namadgi National Park and Tidbinbilla Nature Reserve have shown that small mammal populations, devastated by the 2003 bushfire, have recovered to about pre-fire levels. Examples are the Agile Antechinus (*Antechinus agilis*), Dusky Antechinus (*Antechinus swainsonii*) and Bush Rat (*Rattus fuscipes*). In particular, the Dusky Antechinus, a fire-sensitive species, was not recorded again until 5 years after the 2003 fire. This species has now been recorded at 2 locations in Namadgi National Park, indicating a slow population recovery.

Surveys by the ACT Government in urban nature reserves have not detected any small mammals, indicating that some small mammal species (such as the Brown

Antechinus (*Antechinus stuartii*), Common Dunnart (*Sminthopsis murina*) and Bush Rat are either absent or occur at very low density (PCL). Historical data indicate that small mammals were present in significant numbers in these reserves 2 decades ago. The decline of small ground-dwelling mammals in Canberra's urban nature reserves has been attributed to habitat fragmentation, reduced groundcover (through fire and clearing) and predation by foxes and cats. Studies indicate that the Common Dunnart is still present at Mulligans Flat and Goorooyarroo nature reserves. There are some data to indicate recovery of the Common Dunnart within the predator-proof fence in Mulligans Flat Nature Reserve.

Information on the current status of all threatened animal species listed under the ACT Nature Conservation Act can be found in Tables A1-A7 in the Annex to this paper.

Reptiles

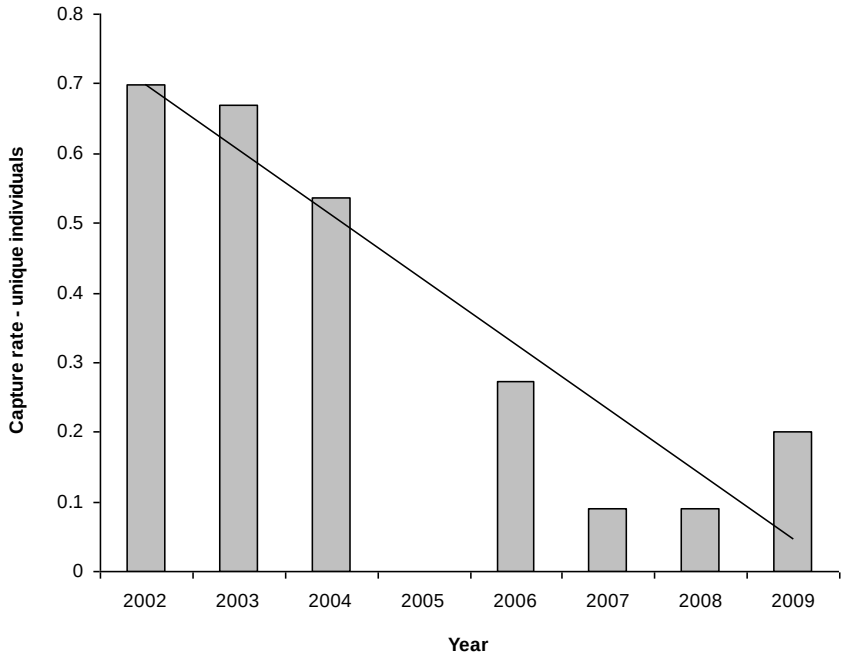
The ACT is home to three reptile species listed as threatened under the ACT Nature Conservation Act: the Grassland Earless Dragon (*Tympanocryptis pinguicolla*), the Striped Legless Lizard (*Delmar impar*) and the Pink-tailed Worm Lizard (*Aprasia parapulchella*) (ACT Government 2011a). All three are also listed as threatened under the Commonwealth EPBC Act (Australian Government 2011), with the Grassland Earless Dragon listed as endangered.

In the ACT, the Grassland Earless Dragon is found in two disjunct populations, one in the Majura Valley and one in the Jerrabomberra Valley. The species has been monitored at the Majura Training Area since 2002 and at the Jerrabomberra Grasslands Reserve since 2005, and it has been the subject of surveys at a number of other locations in the ACT by University of Canberra researchers. The results show a dramatic decline in the Grassland Earless Dragon since 2005 across the species distribution in the ACT; currently it is found in very low numbers (Diamond 2010).

Loss and degradation of habitat are the main causes of decline, and development proposals are still current for a number of sites where the species is known to occur. Monitoring since 2002 (Figure 1, based on occupancy of burrows) has found that the population of the species declined during 2005 and 2006, largely the result of drought, exacerbated by loss of cover through overgrazing (TAMS 2010a). Research indicates a real risk of extinction of the species in the ACT within the next 10 years if current trends continue. If this occurs, this species could become the first confirmed reptile extinction in Australia since European settlement (Diamond et al. unpublished).

The predicament of the Grassland Earless Dragon after this significant decline in numbers was highlighted in the *2007-08 State of the Environment Report*. The report recommended urgent action to relieve the pressure of grazing by kangaroos at the site of the Majura population.

Figure 1. Monitoring results for the Grassland Earless Dragon at the Majura Training Area, ACT, 2002-2009, with trend line (no data are available for 2005)



Source: TAMS 2010a

Plans for urban expansion in the Lower Molonglo Valley have prompted pre-development studies including a number of surveys for the Pink-tailed Worm Lizard and mapping of the species' habitat in the Molonglo and Murrumbidgee river corridors. These maps and data provide baseline data that are valuable to guide current and future urban planning and conservation management actions for the species. The results show that substantial areas of habitat exist in the river corridor (Wong and Osborne 2010a, 2010b). While much of the habitat has been set aside for protection from development, some fragmentation of habitat and effects such as extra weeds, fire, rock removal, trampling and contamination by nutrients, from adjacent new urban areas are still likely to have an impact on the species.

The Striped Legless Lizard occurs in three grassland reserves set aside for its conservation in the north of the ACT (Mulanggari, Crace and Gungaderra) as well as on Commonwealth land in the Jerrabomberra valley. Substantial areas of habitat also lie outside these reserves and are subject to planned urban development. The results of pre-development surveys indicate that the species is still present in reasonable numbers in suitable habitat.

A study by members of the Institute for Applied Ecology at University of Canberra (Roe et al. 2011) on freshwater turtles in Gungahlin found the species to be relatively common in urban areas and in nature reserves, and no evidence that suburbs were having an overall impact on the population. Losses through road deaths were

compensated by the extra wetland habitat in the urban area. The research identified road-death hotspots and potential locations for barriers to reduce turtle mortality on roads.

Fish

Two-spined Blackfish (*Gadopsis bispinosus*) in the ACT occur only in the Cotter River, above, but not in, the Cotter Reservoir. The population appears to be recovering in the lower Cotter (below Bendora Dam) following on from the effects of the 2003 bushfire, which is likely to result from the environmental flows in that reach. Data indicate an increase in fish numbers and breeding records at the lower sites (TAMS 2010a). Fish numbers in the unregulated upper Cotter River (above Corin Dam) have been variable, reflecting responses to environmental conditions such as drought and flooding. An increased proportion of juveniles found in 2010 at sites that receive regulated environment flows suggests that there have been improvements in habitat quality following the 2003 fire and that environmental flow releases have been effective at mitigating the effects of the recent drought (TAMS 2010a).

Two populations of Trout Cod (*Maccullochella macquariensis*) occur in the ACT region: in Bendora Reservoir on the Cotter River, and in the Murrumbidgee River. Both result from conservation stocking. The Bendora Reservoir population appears to have reproduced infrequently since 2004, which may be related to variations in water level; the population appears to have smaller numbers of fish but of a larger size. No juvenile Trout Cod were caught in Bendora in 2010. It is encouraging that these relatively large Trout Cod are surviving in Bendora Reservor, where the ACT's largest recorded specimen was caught in 2010. A single Trout Cod was captured from the Murrumbidgee River stocking sites during 2010. The low capture rate may be related to extensive dispersal of individuals from the stocking site within the 2 years (TAMS 2010a). In Autumn 2011, a juvenile Trout Cod was recorded at Angle Crossing on the Murrumbidgee River for the first time since stocking ceased in 2005, suggesting that the stocked population is now breeding.

The status of the Macquarie Perch (*Macquaria australasica*) population in the Cotter River has improved since 2003, and numbers counted in the annual monitoring remain consistently high. It appears that Macquarie Perch are becoming well established in the Cotter River upstream of the Cotter Reservoir, assisted by a fishway installed at Vanities Crossing. As part of mitigating adverse effects of enlarging the Cotter Dam, the developer has committed to improving the road crossings for fish at Pipeline and Burkes creek crossings to help extend the available range and habitat for Macquarie Perch in the Cotter River (TAMS 2010a). However, this is yet to occur because of construction delays and high river flows. In the Queanbeyan River, the population of Macquarie Perch has reduced to below detectable limits. The Queanbeyan River was not surveyed in 2009-10 but it is proposed to resurvey the site now there have been 1-2 years of average or better flow (TAMS 2010a).

The expanded range of Macquarie Perch may result in additional illegal and/or inadvertent capture of this species by anglers despite the species' protected status.

An increased visibility of rangers, and enforcement of fishing regulations in the open section of the Cotter River, particularly during the breeding period of October to December, is warranted to reduce potential impacts of fishing (TAMS 2010a).

Silver Perch (*Bidyanus bidyanus*) are surveyed during the bi-annual Murrumbidgee River fish survey. Silver Perch have not been captured in the Murrumbidgee River for 20 years within the ACT (TAMS 2010a).

Further information on aquatic condition in the ACT is included in the *Rivers, lakes and wetlands health* indicator cluster paper.

Pressure indicators

There are no Pressure indicators for this indicator cluster. Many pressures on fauna populations arise from local factors related to the growing population of the ACT: for example, increases in roads and traffic, impacts of hazard reduction activities to reduce the threat of bushfires, and firewood gathering. Other pressures operate at a larger scale, such as effects attributed to climate change. These pressures are examined in detail in the *Threatening processes* indicator cluster.

Impact indicators

There are no Impact indicators for this indicator cluster. Impacts on fauna are discussed in detail in the *Threatening processes* indicator cluster. Threatening processes currently affecting fauna in the ACT include:

- weed invasions, resulting in habitat degradation, added fire hazard, and suppression of native plant species needed by the fauna;
- pest animal invasions, resulting in habitat degradation, added likelihood of parasites and diseases, competition for common food sources, and predation;
- ecological degradation and habitat loss, resulting from overgrazing by stock, rabbits and kangaroos; and
- urban development and associated impacts of an increased human population, including loss and fragmentation of habitat and predation by domestic pets.

Response indicators

Threatened species conservation

Listed species

Legal protection is an important component in species conservation. In May 2011, the Nature Conservation (Special Protection Status) Declaration (ACT Government 2011b) was added to the ACT Nature Conservation Act. This ensures that species

listed nationally as threatened under the EPBC Act automatically receive special protection status in the ACT.

Such species, although given legal protection in the ACT, are not always included in the ACT Action Plans that provide direction for the conservation of fauna in the ACT. However, national recovery plans are generally prepared for EPBC-listed species and the ACT is guided by those.

The process for declaring a threatened species in the ACT (and subsequent preparation of an Action Plan for that species) requires a nomination to be made to the ACT Flora and Fauna Committee by a person or organisation. The Flora and Fauna Committee considers new nationally listed species and NSW listed species at each of its quarterly meetings, to determine whether consideration should be given to nominating the species under ACT legislation.

Species that do not yet justify nomination but are considered close to meeting the criteria should be the subjects of monitoring, research and subsequent reporting.

Action Plans

Conservation of threatened animal species is guided by Action Plans that outline conservation goals, objectives and actions for the conservation of relevant ecological communities or habitat, and the threatened species that inhabit them (TAMS 2006).

Assessing the implementation and effectiveness of these Action Plans in terms of threatened fauna recovery is, in many cases, hampered by a lack of data. As one example, already mentioned, data collected in the woodland-bird monitoring program are not sufficient for accurate assessment of the status of threatened woodland birds covered by ACT Lowland Woodland Conservation Strategy: Action Plan 27 (Bounds et al. 2010). It is acknowledged that monitoring can be costly, and in some cases no feasible monitoring method has been developed, but data management is not helped when data gathered for other purposes are not pooled. For example, data from surveys by consultants before urban development are often held in planning and development units of the ACT administration rather than being shared with the teams managing biodiversity across the ACT.

Implementation of a number of the Action Plans has been reviewed by the ACT Flora and Fauna Committee during the reporting period:

- *ACT Lowland Woodland Conservation Strategy: Action Plan 27* (for the period 2004-2010); and
- *ACT Lowland Grassland Conservation Strategy: Action Plan 28* (for the period 2004-2008);
- *ACT Aquatic Species and Riparian Zone Conservation Strategy: Action Plan 29* (for the period 2007-2010).

The reviews found that many of the performance indicators relating to fauna recovery have been addressed to some extent. However, there is a lack of population trend data in these review reports, and therefore it is unclear if the

actions undertaken have been effective in terms of species recovery. The reports of Action Plan reviews should be made publicly available.

The three ecosystem-based Action Plans listed above are comprehensive and provide a strategic approach to biological conservation in the ACT. If the specific actions for species recovery were to be put into an order of priority, then a ranking could be developed for conservation actions, including monitoring of population trends, for particular threatened species and ecosystems, based on their cost-effectiveness. This approach has been used in New Zealand (Joseph et al. 2009a), and in NSW in the preparation of threatened-species priority action statements (Joseph et al. 2009b). It is also recommended in the review of the EPBC Act (Hawke 2009) for prioritising the various aspects of recovery management in Australia.

Monitoring

It is important that trends in the populations of threatened species be monitored to support the successful management of the species (Joseph et al. 2009b, Diamond et al. unpublished). Monitoring is often a costly and difficult task because populations can be small and individuals may be cryptic. For some threatened ACT species, such as the Perunga Grasshopper, no practical survey methods exist.

The ACT Government and associated research teams have been actively addressing the problem of surveying cryptic threatened species: for example, a method for assessing the abundance of the Grassland Earless Dragon uses artificial burrows. This technique is now accepted nationally for best practice monitoring of the species (TAMS 2010a). Different artificial shelters using tiles are being trialled for monitoring the Striped Legless Lizard (TAMS 2010a).

In 2010 the ACT Government released guidelines on monitoring the Golden Sun Moth, with the aim of promoting a consistent and reliable method for determining the species distribution and/or its abundance at sites in the ACT. The guidelines are consistent with survey guidelines for the species under the EPBC Act (Australian Government 2011).

Research

Research during the reporting period has added to knowledge about the threatened fauna species in the ACT (Table 1). Many of the research projects are collaborations between the ACT Government and tertiary institutions such as University of Canberra (UC) and the Australian National University (ANU). A significant proportion of the threatened species research has been associated in some way with infrastructure developments such as the Enlarged Cotter Dam and urban expansion projects. Given the challenges posed by monitoring and data management, it is essential that the research findings are made accessible to all those who are responsible for managing biodiversity and conservation in the ACT, and in as timely a manner as possible.

Table 1. Examples of research projects with a focus on threatened fauna (ECD = Enlarged Cotter Dam)

Project	Undertaken by	Outcomes/description
Large biota project	ACT Government (pre-development study)	Radio-tracking methods for 4 fish species, 1 crayfish, 1 reptile species and 1 mammal trialled in the laboratory and field situations. Diet movements and habitat preferences of Macquarie Perch in Cotter Reservoir determined. Research recommendations used to guide reservoir, river management and construction of the ECD.
Constructed homes project, Murray Crayfish and other projects for Enlarged Cotter Dam (ECD) management	UC, ANU, ACT Government (pre-development study)	Artificial habitat use by Macquarie Perch assessed and ECD construction activities guided by recommendations. Movement patterns of Two-spined Blackfish in Bendora determined. Murray Cray survey techniques and densities determined; swimming speeds of Macquarie Perch and alien fish species in the Cotter determined to help understand and manage fish passage.
Pink-tailed Worm Lizard habitat mapping project	ACT Government and UC	On-ground mapping and modelling
Pink-tailed Worm Lizard habitat mapping project (Molonglo)	ACT Government and UC (pre-development study)	Detailed mapping of Pink-tailed Worm Lizard habitat and ground truthing, including rock-rolling surveys along the Molonglo Valley
Local genetic population structure of Macquarie Perch	The University of Adelaide, ACT Government and ECD Construction	Macquarie Perch population in ACT Region distinct at a local level. Cotter population secure; Queanbeyan River population in genetic stress and Upper Murrumbidgee population showing potential structuring. Project helps to understand genetic population size and distinctiveness to guide potential re-introductions.
PhD research study on Golden Sun Moth	ACT Government and UC	Study of ecology, habitat requirements and genetics
PhD and Honours research studies on Grassland Earless Dragon	ACT Government and UC	Studies of ecology, population modelling, habitat requirements and genetics
Captive breeding of Northern Corroboree Frog	ACT Government	The species was successfully bred in captivity for the first time in 2008 and now there are over 1000 individuals in captivity
Striped Legless Lizard survey method development	ACT Government	The use of artificial shelters (concrete tiles of various reflective properties and wooden blocks) has been trialled as an alternative survey method to the usual pitfall trapping method
Calcein marking	ACT Government	A marking method for Macquarie Perch was successfully

Project	Undertaken by	Outcomes/description
trial of Macquarie Perch	and ECD Construction	developed and over 400 juvenile Macquarie Perch were marked and released into Cotter Reservoir with the assistance of University of Canberra.
Goorooyarroo	ANU, ACT Government	Small mammal diversity and abundance in Goorooyarroo Bird diversity and abundance in Goorooyarroo
PhD research on threatened woodland birds	ANU, ACT Government	Conservation of woodland birds in the ACT and in Molonglo/urban areas (including boundaries with nature reserves)
PhD research in Mulligans Flat – Goorooyarroo	ANU, ACT Government	Brown Treecreeper reintroductions, and bird-banding project

Source: Compiled from TAMS 2008, n.d; OCSE 2011

Key actions

Mulligans Flat Woodland Sanctuary

In 2009 a 450 ha woodland sanctuary was established in the Mulligans Flat Nature Reserve by the construction of an 11.5 km predator-proof fence. The project aims to restore the woodland ecosystem that was present before European settlement, and reintroduce locally extinct fauna.

A strong emphasis is placed on supporting research into the ecology and restoration of woodlands. The ACT Government and researchers from ANU are using the site to investigate management manipulations, with the aim of improving woodlands for biodiversity.

Captive breeding programs

The previous *State of the Environment Report* highlighted the plight of the Northern Corroboree Frog and reported on the initiation of a captive-breeding program by the ACT Government at Tidbinbilla Nature Reserve. During the current reporting period significant breakthroughs have been made. The species was successfully bred in captivity for the first time in 2008, and subsequently breeding was successful in 2009 and 2010. There are currently around 1000 individuals held in captivity.

Decline in the wild populations is thought to be caused by a species of chytrid fungus (*Batrachochytrium dendrobatidis*) which is now widespread in the environment and all over the world, and is unlikely ever to be eradicated. However, there is some evidence that frog species in northern Australia are able to survive with the fungus at endemic levels (e.g. Retallick et al. 2004), and in frog populations elsewhere in Australia there is evidence that some individuals are resistant to the fungus (DECCW 2009).

The captive breeding program has two aims: first, to breed a population to ensure the species' survival in the event of the wild population becoming extinct; and also, to release frogs into the wild to bolster wild populations and enable natural disease resistance to develop. The National Corroboree Frogs Recovery Team and other experts in amphibian species recommended these actions, to support development of natural disease resistance in the wild populations.

For the Grassland Earless Dragon, similarly, the possibility of establishing a captive breeding program is being investigated (TAMS 2011b). Such a program, along with protection of its habitat could help to prevent extinction of the species.

Further actions undertaken to conserve threatened animal species during the reporting period are included in Tables A1-A7 in the Annex.

Native species conservation

The preservation both of habitat and of connectivity between reserves is paramount to the conservation of native species. The ACT Government currently maintains a comprehensive reserve system that covers over 50% of the Territory. Its ecosystem management approach aims to conserve habitat for a range of native animal species (see the *Ecological communities* indicator cluster for more information on connectivity).

Effective conservation activity needs data. As already mentioned, monitoring data for frog and bird species are collected by community groups and made available through individual reports. However, to improve the accessibility and usability of fauna distribution and abundance data collected in the ACT, they could be added to the Atlas of Living Australia[1], along with other research data. Entering ACT data in the Atlas of Living Australia database would also mean that ACT data could contribute to other large databases such as the NSW Wildlife Atlas and Birds Australia database.

Research

During the reporting period the ACT Government's Nature Conservation Policy Section (NCPS) has been involved in the establishment and operation of several significant research projects relevant to native fauna and their habitat within the ACT. Key research areas have included woodland restoration and kangaroo management.

Upper Murrumbidgee Demonstration Reach Project

The concept of a demonstration reach is an initiative under the Murray-Darling Basin Authority Native Fish Strategy, with the aim of improving fish habitat in the river. The Upper Murrumbidgee Demonstration Reach project began in 2009 after a cooperative of government and community groups successfully applied for funding from the Australian Government Caring for Our Country fund (ACT Government 2010b). The demonstration reach is 100 km long and the project aims to improve native fish habitat and showcase the cumulative benefits of many management

[1] The Atlas of Living Australia is a national initiative focused on making Australia's biodiversity information more accessible and useable online. It is a partnership between CSIRO, Australian museums, herbaria and other biological collections, and the Australian Government. http://www.ala.org.au/

interventions along this single river reach between Bredbo (NSW) and Casuarina Sands Reserve (ACT). Further information can be found in Sustainability Stories.

Woodland restoration

The Mulligans Flat Woodland Sanctuary is the setting for the Mulligans Flat - Goorooyarroo Woodland Experiment. This project is a partnership between researchers at the ANU, the ACT Government and CSIRO, which aims to assess ways of restoring Yellow Box-Red Gum Grassy Woodland to support biodiversity. Work completed so far by the researchers has generated over 10 publications in national and international journals with several others in preparation.

Some of the findings from the experiment include: heavy grazing by kangaroos can have negative effects on beetle abundance and beetle species richness; addition of logs can have positive effects on beetle diversity by acting as refuges for the insects where grazing is heavy (Barton et al. 2011); beetles can act as an indicator of broader species richness in an ecosystem; and beetles are a food resource for insectivores. These findings and others have significant implications for the conservation of biodiversity in box-gum grassy woodlands.

Seven groups of Brown Treecreepers (*Climacteris picumnus*) were released in Mulligans Flat and Goorooyarroo nature reserves in November 2009 following woodland restoration. Monitoring of the success of the reintroduction and of the types of habitats used is expected to provide useful information on the habitat requirements of the species. It should help identify the reasons for the decline of the species from this area, which is useful information for management of these reserves.

Continued restoration of the Mulligans Flat Woodland Sanctuary, including the translocation of animal species such as the Eastern (or Tasmanian) Bettong (*Bettongia gaimardi*), is expected in the future (Manning 2011).

Kangaroo management

The ACT Government has prepared a Kangaroo Management Plan (TAMS 2010b) which considers the environmental impact of high densities of Eastern Grey Kangaroos, along with animal welfare and human welfare.

In 2009 the ACT Government began an annual kangaroo culling program in urban and periurban nature reserves that contain endangered ecological communities vulnerable to overgrazing. An average kangaroo population size has been calculated for each reserve based on new mapping of the forest, woodland and grassland extent in each reserve, and predictions from an interactive kangaroo-pasture model. This target population size is intended to be sufficient to provide enough grazing pressure and disturbance for the conservation of many plant species, while being low enough to enable relatively abundant ground layer vegetation to persist, as required by many small animals. The counted population of kangaroos is then reduced annually to achieve that target population, on average.

Research has also been improving understanding of the movements and home ranges of kangaroos in urban Canberra. Using GPS tracking collars, a pilot study has

recorded the movements of 25 individual kangaroos over two years. Preliminary results suggest that home ranges in the suburbs are similar to those occupied by non-urban kangaroos, and they are surprisingly small for such a large species capable of rapid and sustained travel. A novel finding is evidence of road sense, with the kangaroos being more wary of roads with higher speed. Interestingly the study shows that while kangaroos generally stay within a defined home range some of the kangaroos monitored occasionally undertook apparently purposeful excursions of up to several kilometres, returning the same day or after a few days. Further research into the movement of urban kangaroos will help inform management and planning decisions to minimise the incidence of kangaroo vehicle collisions in the ACT (TAMS 2010b, 2010c).

Grazing by kangaroos is among threats to grassy ecosystems identified in Action Plans 27 and 28. The plans include actions for identifying and monitoring threats (including grazing) to ensure the recovery of the grassy ecosystems. The Office of the Commissioner for Sustainability and the Environment identified a number of grassy ecosystems as being overgrazed and approaching a threshold from which they will be difficult to rehabilitate. In 2009 a monitoring program was begun to measure the condition of vegetation and the density and off-take of vegetation by kangaroos at a number of grassland and woodland Nature Reserves. No comparisons between the vegetation parameters and the abundance of kangaroos have been undertaken, because additional annual records are required to allow for a comprehensive analysis (TAMS 2010a).

In relation to kangaroo fertility, the ACT Government has been supporting two research projects - one in partnership with the Marsupial Research Laboratory (at the University of Newcastle), and one with a group in CSIRO funded by the Invasive Animals Cooperative Research Centre. Both are developing immunocontraceptive vaccines that are expected to cause infertility in macropods several years after inoculation. The vaccines have the potential to be developed for delivery in food such as pellets, meaning there is the possibility of using them to control wild kangaroo populations. See the *Threatening processes* indicator cluster for additional information.

Community engagement

Community groups make an important contribution to biodiversity conservation and management in the ACT. Volunteers from organisations such as Frogwatch, Parkcare, Landcare, Greening Australia and the Canberra Ornithologists Group are active in monitoring and managing biodiversity in ACT nature reserves.

For more information on the role of community groups in conservation see the *Community engagement* indicator cluster in the *People* theme.

Glossary

Biodiversity: the variability among living organisms from all sources (including terrestrial, aquatic, marine and other ecosystems and the ecological complexes of which they are part), at all levels of organisation, including genetic diversity, species diversity and ecosystem diversity

Chytrid fungus: The chytrid fungus *Batrachochytrium dendrobatidis* (itself commonly known as Chytrid) is responsible for a recently discovered disease of amphibians, chytridiomycosis. Discovered in 1998 in Australia and Panama this disease is known to kill amphibians in large numbers, and has been suggested as a principal cause for the worldwide amphibian decline. The actual process leading to mortality is, however, unknown. A popular theory is the fungus hardens the skin of amphibians which hinders respiration.

Connectivity: habitat connectivity is the degree to which an organism can move around the landscape using adequately spaced patches or bands of habitat. For fauna, connectivity has been defined as the degree to which the landscape facilitates or impedes movement among patches

Ecological community: naturally occurring groups of plants and animals. Their species composition can be determined by factors such as soil type, position in the landscape, climate and water availability

Ecosystem: a dynamic combination of plant, animal and micro-organism communities and their non-living environment (e.g. soil, water and the climatic regime) interacting as a functional unit. Examples of types of ecosystems include forests, wetlands, grasslands and tundra.

Habitat fragmentation: the result of removal (usually by clearing) of large parts of a natural area, resulting in the retention of only small parts (fragments or remnants) of habitat.

Species: a level of biological classification comprising one or more populations of individuals capable of interbreeding to produce fertile offspring

Threatened species: species categorised as, in order of increasing threat, *vulnerable*, *endangered*, or *critically endangered*. Although *threatened* is the term generally used to refer to species in any of the three categories, the term *vulnerable* can be used interchangeably with it, because those in the more at-risk categories of threatened species (namely *endangered* and *critically endangered*) must, by definition, also qualify as vulnerable.

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ACT Department of the Environment, Climate Change Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

NSW Department of Environment, Climate Change and Water - now the Office of Environment and Heritage within the Department of Premier and Cabinet

Canberra Ornithologists Group (COG)

Parks, Conservation and Lands (PCL) - now part of the Environment and Sustainable Development Directorate (ESDD)

ACT State of the Environment Report 2011

Annex A: Status of Animal Species listed under the *Nature Conservation Act 1980* in the ACT

(NC Act = ACT *Nature Conservation Act 1980*; EPBC Act = national *Environment Protection and Biodiversity Conservation Act 1999*)
CPR stands for the ACT Conservation Planning and Research team)

Table A1. Status of Birds

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Swift Parrot (*Lathamus discolor*) NC Act - Vulnerable	Reported in ACT every second or third year; 5 sightings recorded in the ACT in 2008-09 compared with 8 in 2007-08; only 1 record in 2009-10.	Main pressure is clearing of critical over-wintering habitat features (winter flowering eucalypts and eucalypts carrying lerps).	The migratory nature of this species means that it cannot be conserved in the ACT, but protection of known and potential Swift Parrot habitat on rural leases and federal land has been pursued through Land Management Agreements and a memorandum of understanding with federal agencies. See ACT Action Plan 27 (2004) for proposed conservation actions.	Woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010). Small numbers and migratory nature make assessment difficult.
Superb Parrot (*Polytelis swainsonii*) NC Act - Vulnerable EPBC Act - vulnerable	In the ACT the species is regarded as a non-breeding summer migrant restricted to the north western area of the ACT. However in recent years the number of sightings in the ACT have increased. Breeding has been confirmed in the Gungahlin area and is suspected in the central	Main pressure on this species is loss and fragmentation of habitat, and lack of large living and dead trees with hollows for nesting sites. Urban expansion has the potential to impact on this species in the ACT. Species commonly feeds on ground on spilt grain and many are struck by motor vehicles. Trapping for aviary trade occurred in past, but	See ACT Action Plan 27 (2004) for proposed conservation actions. Surveys for breeding sites in areas proposed for urban expansion in Gungahlin have been undertaken. Results will inform the development layout to conserve important habitat.	General woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010). Threat of habitat loss through urban expansion. Further research, surveys and careful planning will be required to ensure the continued use of

Species and Declared Status	Condition	Pressure	Response	Status/outlook
	Molonglo Valley.	present extent is unknown and is likely to be a far less significant threat than habitat loss.		habitats within and adjacent to proposed urban expansion. Opportunities exist to restore degraded woodland and improve habitat for the species.
Regent Honeyeater (*Xanthomyza phrygia*) NC Act - Endangered EPBC Act - Endangered	ACT reports show a decline from the 1960s with sightings now single birds, pairs or small flocks. Considered a rare breeding visitor in the ACT. There was 1 record of this species in both the 2008-09 and 2009-10 seasons; the last records for this species before that were in 2005.	The main pressure is loss of rich flowering eucalypts from fertile river flats and lower slopes.	While the species requires conservation at a landscape scale, within the ACT the species will benefit from the protection of woodland areas with large Yellow Box and mistletoe (e.g. Mulligans Flat Nature Reserve). The species is included in the ACT Action Plan 27 (2004).	Woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010). The long-term future of the species remains uncertain in the ACT and is largely dependent on conservation efforts outside the ACT within the remainder of the species range.
Painted Honeyeater (*Grantiella picta*) NC Act - Vulnerable	The species is considered a very rare vagrant to the ACT. An influx of the species occurred in 2002-03 with reports of breeding (Lenz and Dabb 2003). There were no ACT records for the species in the 2007-08 season and only 2 records in the 2008-09 season. During the 2009-10 season 2 birds were reported 5 times including a record of a breeding attempt.	The main pressure appears to be loss of habitat - woodland with older trees and Mistletoe (*Amyema* spp.).	Habitat along the Murrumbidgee River corridor and within woodland has been protected in reserves, but because of its general scarcity, specialised diet and nomadic habits, the species cannot be effectively protected in reserves alone. For proposed conservation actions refer to ACT Action Plan 27 (2004).	Woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010). Conservation efforts outside the ACT in the remainder of the species range will determine the levels of habitat usage within the ACT.
White-winged	Relatively high numbers of	Degradation of woodland habitat	For proposed conservation	Woodland bird monitoring is

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Triller (*Lalage sueurii*) NC Act - Vulnerable	sightings (101, 124, 124) were recorded by COG in the 2007-08, 2008-09 and 2009-10 seasons respectively. These numbers are up on the previous years' results (<85)	including removal of fallen timber and litter, weed invasion, overgrazing, rural tree dieback. An additional threat comes from predation by feral and or domestic animals.	actions refer to ACT Action Plan 27 (2004).	inadequate to determine the population trends of threatened species (Bounds et al. 2010), but there is evidence that numbers of this species fluctuate from year to year.
Glossy Black-cockatoo (*Calyptorhynchus lathami*) NC Act - Vulnerable	This species is considered a rare visitor. There were 20 records in 2006-07, 1 record in 2007-08, 7 records in 2008-09 and 6 records in 2009-10; 2 records of breeding were made during the reporting period. Most records come from Mt Ainslie/Mt Majura where significant stands of cone bearing *Allocasuarina verticillata* feed trees occur.	The major threat to this species is habitat loss, degradation and fragmentation. Loss of casuarina food trees and large hollow-bearing nest trees due to changed fire regimes and clearing are implicated in the species decline. Nest predation by possums and feral cats and competition for nest hollows by galahs and introduced honey bees are additional factors that threaten the species.	An Action Plan for this species is in production. Surveys of feed trees (*Allocasuarina verticillata*) in the northern ACT has been undertaken by CPR. Data on habitat characteristics of feed trees has led to the development of recommendations for the establishment of new stands of feed trees.	This species has been listed as vulnerable under the ACT Nature Conservation Act during the reporting period. A recovery plan is to be completed. Continue observation of the species and habitat usage within the ACT. Continue habitat mapping in the southern ACT. Trial plantings of *Allocasuarina verticillata*) using information gathered from habitat characteristics of existing stands. Protect young (<25 year-old) stands from fire, and trial burns in older stands.
Little Eagle (*Hieraaetus morphnoides*)	In spite of reasonably high numbers of Little Eagles recorded by COG surveys, the species appears to be in	Increased human disturbance is implicated in the decline of this species in the ACT. Urbanisation of habitat is likely to increase the	An Action Plan is in production for this species. University of Canberra has led several surveys monitoring.	This species has been listed as vulnerable under the ACT Nature Conservation Act 1980 during the

Species and Declared Status	Condition	Pressure	Response	Status/outlook
NC Act - Vulnerable	significant decline in the ACT. A nest survey found only 4 of the 11 nests active in 1990-1992 were still active in 2008.	pressure on this species.	nesting attempts	reporting period. The Action Plan for this species is to be completed. Species is likely to decline further and breeding pairs may be lost from the ACT in the face of increased urbanisation (Olsen et al. 2010). Investigations into the potential impacts of rabbit pindone baiting on raptors is recommended, along with radio tracking studies to determine habitat usage and home ranges for the species (Olsen et al. 2010).
Brown Treecreeper (*Climacteris picumnus*) NC Act - Vulnerable	Large reductions in density have been reported over most of the range of the species. Considered an uncommon breeding resident in the ACT. While not necessarily reflective of population trends there was an increase in COG records in the 2008-09 season (101) compared with 81 records in 2007-08, but the 2009-2010 results were back to 74.	Main pressure is loss of habitat. Species appears to need large woodland/forest patches (300 ha) with native understorey, especially grasses and fallen dead timber but without a dense, woody shrub layer.	A reintroduction project has been undertaken by the ANU, CSIRO and the ACT Government (CPR) to reintroduce the species into two woodland reserves in the ACT. Seven groups of Brown Treecreepers have been released into Mulligans Flat and Goorooyarroo Nature Reserves. For other proposed conservation actions for this species see ACT Action Plan 27 (2004).	Woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010).
Varied Sitella	The COG Woodland Bird survey	Loss and simplification of habitat	This species is covered in the	Woodland bird monitoring is

Species and Declared Status	Condition	Pressure	Response	Status/outlook
(*Daphoenositta chrysoptera*) NC Act - Vulnerable	10 year results (1998-2008) indicate there is weak evidence of an increase in numbers but few records were collected for this species	through clearing, loss of paddock trees and collection of firewood are implicated in the decline of this species. The sedentary nature of the Varied Sitella makes it prone to fragmentation impacts. The species is also affected by the dominance of Noisy Miners which are increasing in their habitat.	ACT Action Plan 27 (2004).	inadequate to determine the population trends of threatened species (Bounds et al. 2010).
Hooded Robin (*Melanodryas cucullata*) NC Act - Vulnerable	Considered an uncommon breeding resident in the ACT. Local disappearances are documented in the ACT especially adjacent to the urban area. Woodland bird surveys conducted by COG indicate that the Hooded Robin has been in decline in the ACT, but numbers have dropped too low for data analysis by the project.	Main pressure is loss of suitable habitat (woodland/native grassland with retention of understorey). The species tends not to be found in or near urban areas.	Protection of known and potential Hooded Robin habitat on rural leases has been pursued through Land Management Agreements. See ACT Action Plan 27 (2004) for proposed conservation actions.	Woodland bird monitoring is inadequate to determine the population trends of threatened species (Bounds et al. 2010). Urban development has impacted on this species in the northern parts of the ACT and its long-term future in this area is uncertain despite the presence of two large woodland reserves, Mulligan's Flat and Goorooyarroo.

Table A2. Status of Crayfish

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Murray River Crayfish (Euastacus armatus) NC Act - Vulnerable	In the ACT, mainly in the Murrumbidgee River, also the lower Cotter and Paddys rivers. Populations and sizes of individuals greatly reduced. Research into the ecology of crayfish in these rivers indicated the species continues to have a patchy distribution in the Murrumbidgee River and lower Cotter River, largely being found where public access was difficult. Most catches were of individuals that had not yet reached sexual maturity.	Habitat destruction and modification especially sedimentation, overfishing (considered a major factor in decline in Murrumbidgee River in the ACT), heavy metal pollution (Molonglo River), possible effects of introduced fish. Illegal taking of crayfish previously widespread in NSW, and overfishing in ACT prior to legislation; illegal removal is still likely to be occurring.	Conservation actions for the species are outlined in ACT Action Plan 29 (2007) Research has been undertaken as part of the Enlarged Cotter Dam Fish Management Plan. The study identified preferred habitat for the species, and suitable monitoring methods.	Data suggest the species continues to have a patchy distribution; the lack of breeding-age individuals recorded by monitoring is of concern. Potential threats to be mitigated include illegal fishing and instream developments. Research as part of the Enlarged Cotter Dam recommends the preservation or remediation of habitat critical to the survival of the species as identified by the research, and the development of a management plan encompassing populations in the lower Cotter, Paddys and Murrumbidgee rivers.

Table A3. Status of Fish

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Macquarie Perch (*Macquaria australasica*) NC Act - Endangered EPBC Act - Endangered	In the ACT, populations exist in the Murrumbidgee, Paddys and Cotter rivers. The Cotter River population is considered one of the most viable populations in Australia. Macquarie Perch have been translocated into Molonglo River at Kowen Forest, Upper Cotter River and Paddys River (2005-2008). Monitoring indicates the species is becoming well established in the Cotter River above Cotter Dam. The population of Macquarie Perch in the Queanbeyan River above Googong Dam has reduced below detectable levels. In 2009-10 Macquarie Perch were recorded at Angle Crossing on the Murrumbidgee River for first time in 5 years.	Habitat alteration, overfishing, effects of introduced fish and potentially habitat alteration by developments such as the Enlarged Cotter Dam.	Conservation actions for the species are outlined in ACT Action Plan 29 (2007). A Calcein marking trial of juvenile Macquarie Perch was successful and will assist in monitoring impacts of the Enlarged Cotter Dam on the species. A Fish Management plan has been produced for the Enlarged Cotter Dam development and includes 9 research projects; 8 of the projects are directly relevant to the conservation of Macquarie Perch. As part of the mitigation measures, 2 road crossings will be made fish friendly extending the available range of Macquarie Perch.	The construction of the Enlarged Cotter Dam is expected to significantly affect the 2010-2011 spawning season. Monitoring of the response of Macquarie Perch to the Enlarged Cotter Dam development will determine the success of the mitigation measures developed to minimise impacts to the species - refer to the ECD Fish Management Plan 2010 (ACTEW 2010).
Trout Cod (*Maccullochella macquariensis*)	Only two self-supporting populations remain: River Murray below Yarrawonga, and streams near Euroa, Victoria. Last recorded capture in the	Habitat destruction and modification especially sedimentation, previous overfishing (species was	Conservation actions for the species are outlined in ACT Action Plan 29 (2007).	Stocked population in Murrumbidgee River is surviving but no evidence of breeding. Bendora

Species and Declared Status	Condition	Pressure	Response	Status/outlook
NC Act – Endangered EPBC Act - Endangered	ACT from Gigerline Gorge, Murrumbidgee River, late 1970s. Stocking has occurred in the Murrumbidgee River at Angle Crossing (1996-2005) and Kambah Pool (2006-2008) and at Bendora Dam. Natural recruitment has been recorded at Bendora Dam on isolated occasions since 2004.	not distinguished from Murray Cod), effects of exotic species including fish diseases.	Monitoring following stocking continues in the Murrumbidgee River and at Bendora Dam.	population likely to occasionally breed but the general trend is fewer larger specimens following stocking.
Silver Perch (*Bidyanus bidyanus*) NC Act - Endangered	Silver Perch have not been captured in the Murrumbidgee River for 20 years in the ACT.	River regulation severely affected this species through disruption of migration and reproduction. Thermal pollution and interactions with pest species (Carp and Redfin Perch) are also suspected to be a threat.	Conservation actions for the species are outlined in ACT Action Plan 29 (2007). Silver Perch are looked for in the bi-annual Murrumbidgee River Survey.	No evidence for change in status of the Silver Perch in the ACT 2007-2010. No targeted actions are proposed for this species.
Two-spined Blackfish (*Gadopsis bispinosus*) NC Act - Vulnerable	Last record from the Murrumbidgee River in the ACT in the mid-1970s. Now found only in the Cotter River catchment upstream of Cotter Dam. Monitoring of regulated sites (where an artificial flow was maintained through the drought) has detected higher numbers of juveniles than at unregulated sites suggesting drought is	Habitat destruction and modification especially sedimentation; effects of exotic species including fish diseases (the species appears to be able to coexist with Trout in preferred habitat); not sought as angling fish	Conservation actions for the species are outlined in ACT Action Plan 29 (2007). Monitoring of populations continues. Studies as part of the Enlarged Cotter Dam have been undertaken and have increased the knowledge of the species ecology, movements and habitat usage,	No evidence of change in status in the ACT 2007–10. Continue monitoring recovery and recruitment following the 2003 fire. Continue sediment control works in the lower Cotter catchment to improve

Species and Declared Status	Condition	Pressure	Response	Status/outlook
	limiting recruitment. Overall records at unregulated sites have increased since 2005.	though accidentally caught.	particularly within Bendora Reservoir.	spawning habitat.

Table A4. Status of Reptiles

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Grassland Earless Dragon (*Tympanocryptis pinguicolla*) NC Act – Endangered EPBC Act - Endangered	Now restricted almost entirely to a few remnant patches of natural temperate grassland in the ACT and nearby NSW. In the ACT, the species is found in two disjunct populations, one in the Majura Valley and one in the Jerrabomberra Valley. Monitoring results show a population crash in 2005-06 from which the species has not recovered. The population trends show a steady decline and the species is at serious risk of extinction.	Loss and fragmentation of habitat (rural, urban, infrastructure, industrial development); weed invasion; predation.	Conservation actions for the species are outlined in ACT Action Plan 28 (2005). Regular monitoring occurs, the Majura Training Area (monitored by CPR) and the Jerrabomberra West Grasslands Reserve (monitored by University of Canberra (UC)). A UC project is currently studying the Monaro populations.	The populations in the ACT remain critically small and there are fears that some populations of the species may be lost within the next five to ten years (TAMS 2010a), or become extinct (Diamond et al. unpublished data). The ACT Government has committed significant funds to research aiming to conserve this species including the establishment of a captive breeding program.
Striped Legless Lizard (*Delma impar*) NC Act - Vulnerable EPBC Act - Vulnerable	The species occurs in three reserves set aside for its conservation in the north of the ACT as well as the Jerrabomberra valley. Monitoring results were not available for the reporting period	Loss and fragmentation of habitat (rural, urban, infrastructure, industrial development) weed invasion; predation; and pressures from encroaching development.	Natural temperate grassland and species such as Striped Legless Lizard now recognised in land use planning. Actions outlined in ACT Action Plan 28 (2005). The use of artificial shelter sites has been trialled as an alternative to pitfall trapping.	Using the recently developed shelter site survey technique many sites across the ACT are currently being surveyed for this species by the ACT Government. A remaining and increasing threat is urban encroachment on grassland areas resulting in urban/grassland edge effects including weeds, increased fire frequency and predation by cats and dogs.

Species and Declared Status	Condition	Pressure	Response	Status/outlook
				An education campaign building on community support for cat containment in the ACT would benefit this species.
Pink-Tailed Worm Lizard (*Aprasia parapulchella*) NC Act - Vulnerable EPBC Act - Vulnerable	This species occurs mainly in the Molonglo and Murrumbidgee Riparian Corridors, but significant populations also occur on Mt Taylor and Urambi Hills. Recent detailed habitat surveys and mapping within the Lower Molonglo Valley have confirmed that this area contains nationally significant populations in this area and has increased distribution upstream of Coppins Crossing.	The species is susceptible to degradation of its grassland habitat through weed invasion, inappropriate fire regimes, regrowth of native shrubs and trees, rock removal and stock impacts. Direct loss of habitat through urban expansion is a threat.	Conservation actions for this species are included in Action Plan 29 (2007). The ACT Government has provided $20,000 towards a current research project mapping habitat for this species. Detailed habitat mapping has been undertaken in the Molonglo Valley in relation to urban expansion plans in the area. An additional area outside the Molonglo urban development zone is proposed as a reserve dedicated to the protection of the Pink-tailed Worm Lizard. This area contains the highest densities of the species recorded in the ACT.	No regular monitoring of this species is undertaken in the ACT. Regular surveys for individuals at the same sites are likely to degrade habitat and should be avoided. The development of the land in the Molonglo Valley for urban expansion has the potential to impact nationally significant populations. Conducting research into the ecology and effective habitat management and restoring key areas of habitat thereby increasing connectivity of the existing populations. Careful consideration of the species will be required to ensure its continued existence down slope of the urban zone in the Lower Molonglo Valley.

Table A5. Status of Mammals

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Brush-tailed Rock Wallaby (*Petrogale penicillata*) NC Act - Endangered EPBC Act - Vulnerable	Species presumed extinct in the ACT with last confirmed sighting in 1959. Captive population at Tidbinbilla Nature Reserve (animals introduced from Kawau Island, New Zealand). Wild populations no longer exist.	Reintroduction within the ACT is not possible until fox control is feasible in the remote areas of Tidbinbilla and Namadgi National Park.	Actions outlined in Action Plan 22. The captive ACT population is being used for education and research. The population forms part of a reintroduction program in Victoria.	Until effective and sustained fox control is feasible in Namadgi National Park no reintroductions within the ACT are likely to occur.
Smoky Mouse (*Pseudomys fumeus*) NC Act – Endangered EPBC Act - Endangered	Records of Smoky Mouse in the ACT come from two males that were trapped in Namadgi National Park (Bulls Head 1986, Mt Kelly 1987) and one possible hair from Mt Namadgi in 1994. Repeated trapping and hair tube surveys to find the species since this time have not resulted in any additional records.	Difficult to interpret given long-term decline. Loss of habitat, inappropriate fire regimes and predation by foxes and cats.	Actions outlined in ACT Action Plan 23 include survey, ecological research and management actions to limit disturbance to likely habitat. No further surveys have been undertaken. Appropriate fire regimes for habitat have been incorporated into fire planning, and are stated in the Fuel and Fire suppression guidelines for ACT declared Threatened Species and Endangered Ecological Communities	No monitoring is undertaken for this species in the ACT. Further work is unlikely to be undertaken for this species considering the low probability of obtaining useful data. Habitat protection and control of pests continues as part of the management of Namadgi National Park.

Species and Declared Status	Condition	Pressure	Response	Status/outlook
			(2008).	
Spotted-tailed Quoll (*Dasyurus maculatus*) NC Act - Vulnerable EPBC Act - Endangered.	In spite of intensive searches from 1999 to 2004 there have been only twelve specimen records of the Spotted-tailed Quoll in the ACT since the 1950s, the most recent in 2009. In the past three years two Quolls have been captured in the suburbs and released into Namadgi National Park. No monitoring has been undertaken for this species since 2004.	Potential non-target impacts from increased wild dog and fox baiting in Namadgi National Park, but the removal of competition (foxes) and predation pressures (wild dogs) may benefit the Spotted-tailed Quoll. Potential road kill impacts.	ACT Action Plan 30 lists conservation actions for this species. 1080 wild dog baiting in Namadgi National Park complies with best practice prescriptions. No actions other than collating observations are currently being undertaken.	No monitoring is undertaken for this species in the ACT. A monitoring program, using infra-red cameras, would provide information on the potential impacts of increased wild dog baiting in Namadgi National Park and provide information on the status of the species.

Table A6. Status of Amphibians

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Northern Corroboree Frog (*Pseudophryne pengilleyi*) NC Act - Endangered EPBC - Vulnerable	Annual monitoring shows numbers of the Northern Corroboree Frog are critically low and continue to decline. In the ACT there are now estimated to be fewer than 100 Northern Corroboree Frogs left in the wild.	A chytrid fungus is now considered to be the primary cause of decline, with dry years further reducing breeding success.	Conservation actions are outlined in Action Plan 6. The ACT Government has facilitated research through direct assistance or provision of data. Studies include genetics, habitat distribution, impacts of UV light on tadpoles and captive breeding experiments. Annual monitoring and reporting continues, as does the protection of habitat, especially the Ginini Flats wetlands. Captive breeding program for the species at Tidbinbilla was successful for the first time in 2008 and subsequent breeding has occurred in 2009 and 2010. There are now over 1000 individuals in captivity at Tidbinbilla.	Captive breeding has been a success. Releases of captive bred individuals back into the wild are planned. A revised Action Plan reflecting current knowledge of the species is recommended. Wild populations are likely to become extinct in the ACT within the next 5-10 years unless their decline can be halted.

Table A7. Status of Insects

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Golden Sun Moth (*Synemon plana*) NC Act - Endangered EPBC - Critically Endangered	In the ACT the species occurs in natural temperate grassland dominated by *Austrodanthonia carphoides*. Currently recorded from 60 sites in the ACT including large grassland reserves and small unreserved areas. It is spread widely but generally in low to very low numbers in secondary grassland or native pasture throughout many of the undeveloped areas of Gungahlin. Evidence indicates that the species has increased in distribution and possibly in number within the ACT over the last 20 years. It was discovered in numerous secondary grasslands in 2009 (Hogg 2010). The species is listed as critically endangered nationally.	Loss or degradation of habitat (further fragmentation of grassland, weed invasion, changes to grazing regimes). A number of ACT sites are very small and potentially vulnerable to surrounding activities.	The species is covered in the strategic conservation document Action Plan 28 (2005). A report outlining a strategic approach to conservation in the ACT has recently been produced (Hogg 2010). Recommendations of the report include conserving and managing core conservation areas across the ACT with additional insurance populations.	In the ACT there is evidence that the species is relatively resilient having survived in several small sites in spite of continued disturbance. The habitat preferences of the species appear to be wider than originally thought and there is even circumstantial evidence that the invasive weed Chilean Needle Grass may be a host for this species (Hogg 2010), but this observation requires further investigation. Urbanisation is likely to impact on some Golden Sun Moth populations and others may be lost as woodland tree cover regenerates, particularly in the Gungahlin area. The reserves established by the ACT Government to protect natural temperate grassland conserve much of the quality Golden Sun Moth habitat in the ACT. Adoption of the recommendations in the *Strategic Approach To The Conservation and Environmental Assessment of Golden Sun Moth Sites in the Canberra Area* report would improve the resilience of the species by increasing the species distribution and ensuring conservation efforts targeted key populations.

Species and Declared Status	Condition	Pressure	Response	Status/outlook
Perunga Grasshopper (*Perunga ochracea*) NC Act - Vulnerable	Species is found in natural temperate grassland also native pasture and open grassy woodland. Recorded from Wagga Wagga (NSW) and areas north and east of the ACT. No population studies have been undertaken in the ACT.	Loss or degradation of habitat (further fragmentation of grassland, weed invasion).	Actions outlined in ACT Action Plan 28 (2005) include specific management arrangements for sites, survey, monitoring, research and education. Four areas are in reserves, and other known habitat areas are covered by a Memorandum of Understanding with federal agencies.	Lack of suitable survey method for species, low density and small cryptic appearance mean that population trends are difficult to determine, but there is no evidence for change in status of the Perunga Grasshopper in the ACT 2007-2010. Opportunistic observations are still occasionally reported for the species. Ecological studies needed to gain a better understanding of the species' habitat requirements, threats and distribution in the ACT. This will help to confirm that the ecosystem conservation approach adopted by the ACT Government is adequately protecting this species.

ACT State of the Environment Report 2011

THEME: Biodiversity

Indicator cluster: Ecological communities

The indicators for this cluster are:

- *Vegetation communities* (C) - extent and distribution of vegetation communities;
- *Vegetation condition* (C) - the quality and condition of vegetation including remnant areas and connectivity;
- *Protected areas* (C) - area and distribution of protected areas, and new areas;
- *Vegetation clearance* (P) - area, distribution, fragmentation of connectivity and loss of soil;
- *Conservation management* (R) - effectiveness of conservation management responses including biodiversity offsets and connectivity restoration; and
- *Protected area management* (R) - effectiveness of protected area management.

Condition indicators (C) present data on the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effects of environmental changes on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

Thirty vegetation communities have been recorded within the ACT, of which Yellow Box-Red Gum Grassy Woodland, Alpine Fens and Bogs, and Natural Temperate Grassland are listed as endangered ecological communities under both the ACT *Nature Conservation Act 1980* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Approximately 40% of the remaining area of these endangered ecological communities is now protected in nature reserves. A major threat to endangered ecological communities is urban development - a threat exacerbated by the strong economic position of the ACT because of the prevalence of large houses on separate blocks of land within the ACT and in neighbouring NSW.

Information is not available that would allow an accurate assessment of changes to the extent and condition of native vegetation in the ACT during the reporting period, but the ACT Woodland Assessment Project 2011 has determined that approximately 828 ha of lowland woodlands was cleared for urban development between 2003 and 2010. Natural temperate grasslands were mapped in the ACT in 2006. Since then

147 ha has been cleared, of which 145 ha has been on Commonwealth land. A mapping project is underway that will provide information on the extent of native vegetation, its condition and the connectivity of protected areas. No wildfires were identified during the reporting period that would contribute to vegetation modification. Since 2007, 3 new nature reserves have been gazetted and a further 2 are proposed. An ACT Biodiversity Offsets Policy is currently being developed as part of the review of the Nature Conservation Act.

Introduction

An ecological community is a naturally occurring assemblage of plant and animal species occupying the same geographical area. The species are functionally linked through direct or indirect influences on each other.

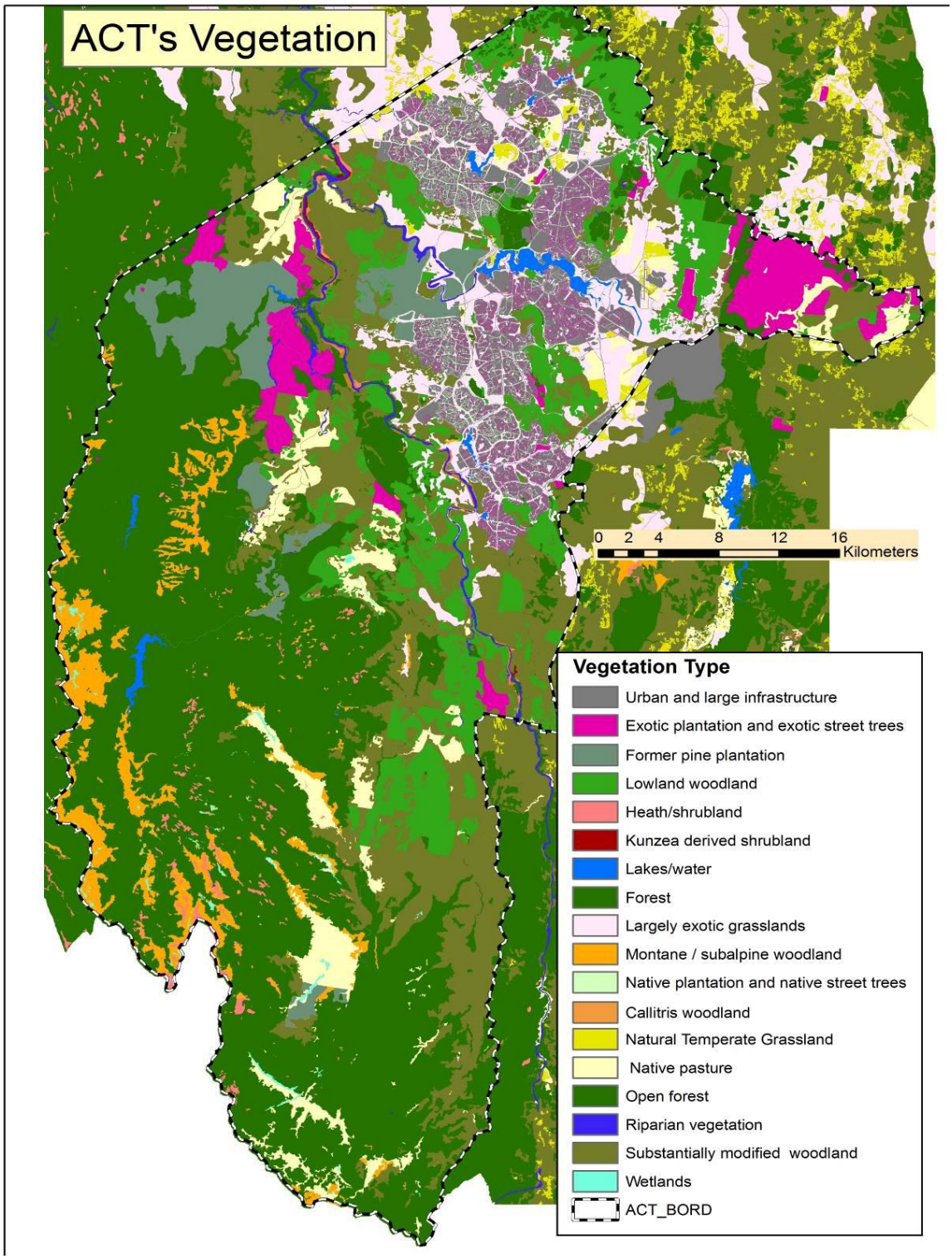
Reporting on the state of ecological communities in the ACT is important because they are an indicator of the condition of the natural environment, demonstrating the extent to which human activities have had an impact, and how well these impacts and other pressures have been moderated through management. Knowledge of the condition of ecological communities is also important for planning future development in the region and for identifying management strategies that could assist in improving the condition and extent of the native vegetation of the ACT.

Condition indicators

Vegetation types

In the ACT, 30 vegetation types are recognised. Of the 19 types mapped in Figure 1, forest occupies the largest area. Changes to the extent and distribution of these vegetation types since 2007 have not been recorded, but research is now classifying and mapping their current distribution.

Figure 1. Vegetation types in the ACT



Source: TAMS

Under the *ACT Nature Conservation Act 1980*, 2 of the 30 vegetation types are listed as endangered. These are:

- Yellow Box-Red Gum Grassy Woodland; and
- Natural Temperate Grassland.

Yellow Box/Red Gum Grassy Woodland

Yellow Box-Red Gum Grassy Woodland is an endangered ecological community primarily because of previous land-clearing activities. It is of high conservation value, typically having a species-rich understorey that includes native grasses, forbs and shrubs. This ecological community supports suitable habitat for a number of threatened flora and fauna, such as the Button Wrinklewort (*Rutidosis leptorrhyncoides*) and the Hooded Robin (*Melanodryas cucullata*).

Yellow Box-Red Gum Woodland is the primary focus of *Action Plan No. 27: ACT Lowland Woodland Conservation Strategy 2004* (TAMS 2004). The Action Plan outlines conservation and protection proposals for this ecological community, to minimise the effect of threatening processes.

Recent mapping has estimated that there are now approximately 12,034 ha of Yellow Box-Red Gum Grassy Woodland in the ACT - less than half of its original extent (Michael Mulvaney pers. comm. 2011). Urban development and agriculture in the Territory have destroyed or severely modified much of this ecological community. Currently 6160 ha of Yellow Box-Red Gum Grassy Woodland are protected in nature reserves (PCL), leaving more than 5500 ha unprotected. These areas are under continued threat from urban development expansion in particular, as well as from other land uses.

During the reporting period 322 ha of Yellow Box-Red Gum Grassy Woodland were added to the existing nature reserves while an additional 201 hectares are currently being managed for conservation in Kinlyside Reserve, near Hall in north-western ACT. Declaration of Kinlyside Reserve as a Nature Reserve is being considered.

Significant examples of Yellow Box-Red Gum Grassy Woodland previously protected in the ACT are in nature reserves at, for instance, Mulligans Flat, Goorooyarroo, Mount Ainslie, Mount Majura, Mugga Mugga, and Callum Brae.

Currently all areas of Yellow Box-Red Gum Woodland are being assessed for their potential for listing on the *A*CT Heritage Register as Natural Heritage Places. A draft nomination has been completed and forwarded to the ACT Heritage Council for consideration. The benefit of listing as a Natural Heritage Place is that such a listing

would provide an additional layer of protection against threats, particularly urban development.

Natural Temperate Grassland

Natural Temperate Grassland is an ecological community under considerable threat. It is estimated that there were 20,000 ha of Natural Temperate Grassland in the ACT area prior to European settlement. Approximately 5% (1000 ha) of this grassland currently remains, in remnants recorded at 39 locations. Most of them are very small: only 4 sites are larger than 100 ha. Nationally, less than 1% of the original (pre 1788) community remains. In the ACT, 147 ha of Natural Temperate Grassland have been cleared since 2006; 145 ha of this was at the Canberra airport on Commonwealth land under Commonwealth approval processes (PCL).

The Natural Temperate Grassland ecological community is included in *Action Plan No. 28: ACT Lowland Native Grassland Conservation Strategy* (TAMS 2005). *A* draft implementation review of Action Plan No. 28 was prepared in June 2008. High priorities for management are the major threats to Natural Temperate Grasslands: urban development, herbivore grazing including by kangaroos, and weed invasions. Among protection priorities is a requirement that all land development proposals take into account protection of conservation areas, and minimise impacts to other areas of Natural Temperate Grasslands.

Since 2008, all sites of Natural Temperate Grasslands have been nominated as Natural Heritage Items, and are being assessed by the ACT Heritage Council. Nomination for these sites is yet to be resolved (see *Heritage* indicator cluster for information on the heritage assessment backlog). During the reporting period, the *ACT Lowland Native Grassland Investigation* by the Office of the Commissioner for Sustainability and the Environment considered 49 lowland native grassland sites in the ACT, on both National and Territory land (OCSE 2009). The investigation found that the ACT is in a strong position to be able to advance the protection of lowland native grassland, in particular Natural Temperate Grassland communities and the species these grasslands support (OCSE 2009). However, management will be challenged by the fragmentation of the grassland sites and their proximity to urban areas (OCSE 2009).

Vegetation of Conservation Concern

In the *2007-08 ACT State of the Environment Report*, 5 vegetation communities were assessed as likely to have less than 30% of their former distribution remaining, and therefore to be of concern:

- Snow Gum-Candlebark Tableland Woodland;

- River She-oak Tableland Riparian Woodland;
- Ribbon Gum Tableland Riparian Woodland;
- Black Cypress Pine Tableland Woodland; and
- Tableland Wetlands.

Each community is conserved, to some extent, in the ACT's nature conservation areas, and relevant conservation strategies are outlined in *Action Plan No. 29: ACT Aquatic Species and Riparian Zone Conservation Strategy* (2007). Examples of these communities are protected in nature reserves, including those along the Murrumbidgee and Molonglo river corridors. Threats to these communities include inappropriate fire regimes, weed invasion, erosion and herbivore grazing, which results in a lack of natural regeneration. A review of the success of implementation of conservation activities outlined in Action Plan No. 29 was completed in June 2010.

Little else is known about the location and condition of remaining remnants of these vegetation communities, or of the status of monitoring or conservation activities that have been directed at them.

The ACT *2007-08 State of the Environment Report* identified a lack of knowledge and monitoring of the 5 ecological communities above. While a number of surveys and vegetation monitoring programs for riparian vegetation communities have commenced, specific monitoring and reporting of these ecological communities remain unavailable.

Snow Gum-Candlebark Tableland Woodland

Snow Gum-Candlebark Tableland Woodland is identified as a vegetation community of conservation concern in *Action Plan No. 27: ACT Lowland Woodland Conservation Strategy* (TAMS 2004). The plan identifies this vegetation community as Lowland Snow Gum Woodland, which occurs in low-lying frost-prone areas. A nomination for listing this community as endangered was considered, because there are so few localised sites of it in the ACT. However, in 2009 the ACT Flora and Fauna Committee rejected a nomination to list Lowland Snow Gum Woodland as threatened under the *Nature Conservation Act* because at that time there was insufficient information to make a determination. The *2007-08 ACT State of the Environment Report* recommended a full assessment and recording of the location and condition of remaining examples of Snow Gum–Candlebark Tableland Woodland. This does not appear to have been undertaken.

In April 2011, this vegetation community was listed as threatened in NSW. In that light, and on receipt of a further nomination, the ACT Flora and Fauna Committee will be reconsidering the listing of this community (PCL).

During the reporting period no new areas of Lowland Snow Gum Woodland have been added to conservation reserves in the ACT. Priority conservation actions for this vegetation community under Action Plan No. 27 are to protect examples of Lowland Snow Gum Woodlands, especially between woodland and grassland areas.

Alpine Sphagnum Bogs and Associated Fens - Endangered ecological community (EPBC)

The Alpine Sphagnum Bogs and Associated Fens ecological community is listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Ac*t). It occurs primarily within sub alpine and alpine areas. In the ACT this ecological community is found entirely within Namadgi National Park in areas more than 1000 m above sea level. The scattered bogs and fens have been mapped in detail. They were heavily damaged by the 2003 bushfire, but an extensive restoration program has already reversed much of the damage.

Natural Temperate Grassland and Box Gum Woodland - Endangered ecological community (EPBC)

Natural Temperate Grassland of the Southern Tablelands of NSW and the ACT, and White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grasses are also listed under the *EPBC Act* as endangered communities located in the ACT. These communities largely comprise the same species as are within the Natural Temperate Grassland endangered ecological community and Yellow Box-Red Gum Grassy Woodland, respectively, as described above.

Vegetation condition

A major threat to lowland grassland and woodland communities in the ACT is the continued encroachment of urban development which results in fragmentation of vegetation and a decline in connectivity between vegetation communities. In 2006, as part of the ACT's *Natural Resource Management Plan (2004-2014),* ecologists made an assessment of the extent of vegetation communities in the ACT. As discussed in the *2007-08 State of the Environment Report*, these studies identified important woodland corridors across the ACT

Lowland grassland

As mentioned above, only 5% remains of the estimated 20,000 ha of original Natural Temperate Grassland in the ACT, which has been fragmented into 49 separate areas.

The *Report on ACT Lowland Native Grassland Investigation* (OCSE 2009) assessed the 49 areas (1 of which is divided into 2, making 50 sites in total), and found that:

- 20 (40%) of the sites were in good condition;
- 20 (40%) were approaching a critical threshold; and
- 10 (20%) were in a critical condition.

Lower Cotter catchment regeneration

The catchment of the Cotter River is located almost wholly within the ACT. It occupies approximately 50,000 ha of land under a mixture of sub-alpine, wet and dry sclerophyll forests, perched swamps, valley floor grasslands and plantation forest. Recent vegetation condition assessments have been undertaken for the Cotter Reservoir catchment area by ACTEW and the ACT Government.

Satellite imagery studies following the 2003 fires have found that, within the native vegetation areas of the Lower Cotter catchment, much of the woody vegetation, shrubs and understorey has recovered significantly, either through epicormic regrowth (sprouting from the trunk), basal sprouting or seedlings (ACTEW 2011). Where forestry areas carried native vegetation, the cover has shown continual improvement over the period (ACTEW 2011), however natural regeneration in the pine-plantation forestry areas is poor and non-uniform. The limited natural regeneration can be attributed to the significant modification made to the site through clearing and site preparation during the previous operational forestry.

Generally, post-fire native vegetative regeneration has been dominated by *Acacia* species across the lower Cotter, with *Eucalyptus* seedling recovery occurring in many shrub and woodland areas. The predominance of acacias is not likely to be detrimental to the overall recovery of the vegetation community and its future diversity. Acacias are early-stage successional species, which are followed by mid- to long-term successional species that include eucalypts. Some acacia shrublands in areas that have been cleared of native vegetation for a long period of time contain poor biodiversity and are unlikely to recover to a diverse ecosystem without remedial plantings (ACTEW 2011).

Further information on riparian condition and catchment management can be found in the *Rivers, lakes and wetlands health* and *Land health* indicator cluster papers.

Lowland woodlands

The extent of lowland woodlands in the ACT is approximately 51,000 ha. About a third of the remaining lowland woodland in the ACT is now reserved (Table 1). Since the woodland mapping undertaken for preparation of the ACT Lowland Woodland

Conservation Strategy 2004, the condition of many areas has changed, either through restoration or through clearing (TAMS 2010a). In many cases, simply a change in management and land use, such as the removal of stock, has led to positive changes in woodland condition. These changes have generally not been incorporated into woodland mapping (TAMS 2010a).

Table 1. Area of remaining lowland woodland in the ACT

Vegetation type/condition	Area (ha) remaining in the ACT (as mapped in 2004)	Area (ha) reserved (up to mid 2010)
Partially modified lowland woodland	9335	2921
Moderately modified lowland woodland	13,664	3717
Moderately modified secondary grassland	3697	616
Substantially and severely modified lowland woodland	12,434	3390
Yellow Box-Blakely's Red Gum Grassy Woodland	12,034	6160

Source: PCL

Since the completion of the *Lowland Woodland Strategy* the extent of lowland woodland included in the ACT reserve system has increased by about 50%, from 4930 ha to around 7250 ha (TAMS 2010a).

In 2010 the Office of the Commissioner for Sustainability and the Environment commissioned a landscape function analysis for 34 existing nature reserves and one proposed nature reserve in the ACT in order to provide information for the *Investigations into Canberra Nature Park (nature reserves), Molonglo River Corridor (nature reserves), and Googong Foreshores*. Although a nature reserve can be given an overall condition classification, it is recognised that the conditions of areas within the reserve may differ.

The landscape functions of the forests, woodlands and grassy woodlands in the nature reserves were assessed and classified as being in the following conditions: satisfactory; approaching critical; or critical (Sharp 2011). Of the 35 areas (Sharp 2011):

- 28 nature reserves (80%) were in an overall satisfactory condition;
- within 6 nature reserves (17%), most of the reserve area was approaching a critical condition; and
- 1 reserve was assessed as in a critical condition.

See the *Land health* indicator cluster paper for more information.

Protected areas

The recent World Wildlife Fund assessment of Australia's protected areas identified the ACT reserve system as being "very close to adequate, with the chief remaining priority being the protection of Yellow Box-Red Gum grassy woodlands" (WWF 2011). Notwithstanding this general assessment, as Canberra expands and new suburbs and infrastructure such as major roads and service corridors are built, a significant consequence will be fragmentation of habitat at many scales (Manning et al. 2010). Fragmentation, modification and/or destruction of habitat are increasingly recognised as having potentially adverse impacts on biodiversity, as well as the integrity of protected areas.

The ACT's protected areas - the nature conservation estate - extend across more than 50% of the Territory and make an impressive contribution to national goals of establishing a comprehensive, adequate and representative national reserve system (Manning et al. 2010). The protected areas are managed as reserves and include Namadgi National Park, Tidbinbilla Nature Reserve, Murrumbidgee River Corridor and Canberra Nature Park.

Both Namadgi National Park (110,953 ha) and Tidbinbilla Nature Reserve (5936 ha) form part of the Australian Alps National Park. They support a range of vegetation communities including wetlands, grasslands, woodlands, wet and dry forests and sub-alpine and alpine areas.

The Murrumbidgee River flows through NSW and the ACT. The full length (66 km) of the ACT sector of the Murrumbidgee River is protected, being included in the Murrumbidgee River Corridor Reserve. All land and water up to a 4 km width along the 66 km length of the river is protected (ACT MRC 1998). Land uses in the corridor range from rural operations to low-impact recreation areas and nature reserves. Vegetation in the Murrumbidgee corridor includes riverine vegetation, grasslands and woodlands.

Canberra Nature Park is made up of 33 separate nature reserves including bushland hills, wetlands and lowland native grassland that cover approximately 10,305 ha. The Park also contains some of the best examples of Yellow Box-Red Gum Grassy Woodland left in Australia. Many of the areas within the Nature Park have previously been cleared for grazing, and many are now returning to native bushland, through management, revegetation and rehabilitation programs.

Table 2 lists the 33 reserves of the Canberra Nature Park, with approximate areas in hectares (OCSE 2011c). Significant proportions of these reserves are high quality

representatives of the listed endangered ecological community (EEC), and/or they are considered to be of very high importance for the threatened species shown. Conservation values are shown as high, medium, low: HCV, MCV, LCV, respectively.

Table 2. Nature reserves in Canberra Nature Park (EEC = endangered ecological community)

Park	Area (ha)	Threatened species and ecological communities	Other biodiversity values
Aranda Bushland	115	Small Purple Pea	HCV forest Snow Gum woodland Landscape connectivity
Black Mountain	460	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Pink-tailed Worm Lizard	HCV forest Landscape connectivity
Bruce Ridge	94	None listed	HCV forest Minor landscape connectivity
Callum Brae	143	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Perunga Grasshopper	HCV woodland Landscape connectivity
Cooleman Ridge	192	Yellow Box-Red Gum Grassy Woodland EEC; Pink-tailed Worm Lizard	LCV woodland Landscape connectivity
Dunlop Grasslands (woodland part only)	106	Natural Temperate Grassland EEC; Yellow Box-Red Gum Grassy Woodland EEC; Striped Legless Lizard	MCV woodland
Farrer Ridge	195	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Pink-tailed Worm Lizard; Small Purple Pea	HCV woodland Rare plants Landscape connectivity
Googong Foreshores (Western Foreshores)	19,482	Yellow Box-Red Gum Grassy Woodland EEC; Pink-tailed Worm Lizard; Button Wrinklewort	MCV woodland, grassland Landscape connectivity
Goorooyarroo	703	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Golden Sun Moth	HCV woodland Landscape connectivity
Gossan Hill	47	None listed	MCV woodland
Gungaderra Grasslands (woodland only)	281	Natural Temperate Grassland EEC; Yellow Box-Red Gum Grassy Woodland EEC; Declining birds; Striped Legless Lizard	HCV woodland Rare species Snow Gum woodland
Isaacs Ridge	325	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Pink-tailed Worm Lizard	MCV woodland Landscape connectivity
Jerrabomberra Wetlands	212	None listed	Waterbirds
Kama	155	Natural Temperate Grassland EEC; Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds	HCV woodland, grassland Landscape connectivity
Kinlyside	357	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds	HCV woodland, grassland Landscape connectivity
Lower Molonglo	570	Yellow Box-Red Gum Grassy Woodland EEC;	HCV woodland

Park	Area (ha)	Threatened species and ecological communities	Other biodiversity values
River Corridor		Pink-tailed Worm Lizard; Woodland birds[1]	Riparian vegetation associations Landscape connectivity
McQuoids Hill	63	Pink-tailed Worm Lizard	MCV woodland Minor landscape connectivity
Molonglo Gorge	994	None listed	HCV forest Landscape connectivity
Mt Ainslie	640	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Glossy Black-cockatoo; Canberra Spider Orchid	HCV woodland, forest Rare plants Landscape connectivity
Mt Majura	481	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Glossy Black-cockatoo; Canberra Spider Orchid	HCV woodland, forest Rare plants Landscape connectivity
Mt Mugga Mugga	151	Woodland birds, Pink-tailed Worm Lizard; Perunga Grasshopper	MCV woodland Landscape connectivity
Mt Painter	91	None listed	Landscape connectivity
Mt Pleasant	65	Yellow Box-Red Gum Grassy Woodland EEC	LCV woodland
Mt Taylor	297	Small Purple Pea; Pink-tailed Worm Lizard; Woodland birds	MCV woodland Rare plants Landscape connectivity
Mulligans Flat	791	Yellow Box-Red Gum Grassy Woodland EEC; Golden Sun Moth; Woodland birds	HCV woodland Rare plants Landscape connectivity
O'Connor Ridge	59	Yellow Box-Red Gum Grassy Woodland EEC	HCV forest
Oakey Hill	66	Pink-tailed Worm Lizard	LCV woodland
Percival Hill	79	None listed	LCV woodland
Red Hill	298	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Button Wrinklewort ; Pink-tailed Worm Lizard; Perunga Grasshopper	HCV woodland Rare plants Landscape connectivity
Rob Roy Range	2017	Woodland birds	HCV forest Landscape connectivity
The Pinnacle	135	Woodland birds; Pink-tailed Worm Lizard	HCV forest Landscape connectivity
Tuggeranong Hill	372	Yellow Box-Red Gum Grassy Woodland EEC; Woodland birds; Pink-tailed Worm Lizard;	HCV grassland Landscape connectivity
Urambi Hills	249	Yellow Box-Red Gum Grassy Woodland EEC; Pink-tailed Worm Lizard	HCV woodland Landscape connectivity
Wanniassa Hills	286	Yellow Box-Red Gum Grassy Woodland EEC;	HCV woodland Landscape connectivity
West	272	Natural Temperate Grassland EEC; Yellow	HCV woodland

[1] Pers. Comm. (email), Ms Heather Tomlinson, ESDD, to Mrs Narelle Sargent, OCSE, 22 July 2011

Park	Area (ha)	Threatened species and ecological communities	Other biodiversity values
Jerrabomberra (woodland part only)		Box-Red Gum Grassy Woodland EEC; Woodland birds; Grassland Earless Dragon; Pink-tailed Worm Lizard	Landscape connectivity
Total area (ha)	13,307	None listed	

Source: OCSE 2011c

Note: Yellow Box-Red Gum Grassy Woodland is shorthand for Yellow Box-Blakely's Red Gum Grassy Woodland Endangered Ecological Community. For Googong Foreshores, the area is for the western shore only.

Pressure indicators

Vegetation clearance

Vegetation clearing, overgrazing and urban development result in at least partial loss of vegetation communities, leading to changes in available habitat and connectivity in landscapes. Vegetation clearing makes the natural environment more susceptible to a range of impacts such as soil erosion, water quality, weed invasion and climate change. Information on the total area of vegetation cleared for development in the ACT is not complete. An indication could be gained from the development applications approved but these data are not combined to determine clearance of total vegetation or vegetation types. Such information would be valuable in assessing urban impacts and potentially monitoring thresholds for ecological communities across the ACT.

In collaboration with the NSW Office of Environment and Heritage (formerly the NSW Department of Environment, Climate Change and Water) the ACT Government is undertaking a project to map the extent and distribution of vegetation communities in the ACT. Once the vegetation communities for the ACT are mapped it will be possible to assess subsequent changes to the extent and condition of vegetation types. In 2007, the approximate extent of 30 vegetation communities was determined by amalgamating data from vegetation community surveys between 1972 and 2005 and ground-truthing surveys in 2006 (Sharp et al. 2007).

Overgrazing by herbivores including kangaroos and rabbits can also have a negative impact on groundcover, and therefore affect species composition. See the *Threatening processes* indicator cluster paper for more information. ACT Action Plans No. 27 and No. 28 both include an action for identifying and monitoring threats (including grazing) to the recovery of the ACT lowland grassland and grassy woodland endangered ecological communities.

In the aforementioned investigation of lowland grasslands it was recommended that the ACT Government prioritise reduction of the key threatening processes of weed invasion, inappropriate mowing and overgrazing by stock, rabbits and kangaroos as a matter of urgency (OCSE 2009). In 2009 a monitoring program began measuring the condition of vegetation, and the density and off-take of vegetation by kangaroos, at a number of grassland and woodland nature reserves. No comparisons between the vegetation parameters and the abundance of kangaroos have been made, because additional annual records are required to allow for a comprehensive analysis (CPR 2010).

Impact indicators

There are no impact indicators for this indicator cluster. However, as new urban areas are developed within or adjacent to native vegetation, the extent, and potentially the condition, of ecological communities in the ACT is inevitably affected. During the reporting period the area of land zoned for urban use in the ACT increased by about 9%.

The *2003 ACT State of the Environment Report* identified that bushfires in 2003 burnt 70% of the ACT. Fire events, including operational burns and wildfire, have impacts on ecological communities. The predicted effects of climate change will also affect the species that together form ecological communities. For more information see the *Threatening processes* indicator cluster.

Response indicators

Connecting fragmented landscapes

Canberra is growing, and in that light the protection and conservation of the lowland woodland and grassland communities of the ACT is a particular challenge.

Innovative ways of simultaneously addressing urban expansion and conservation or protection of ecological communities will need to be considered within the framework of the ACT's objectives for both conservation and development. These could include identifying, protecting and enhancing areas of importance to ecological connectivity, increased options for off-reserve or private conservation, and introducing a biodiversity offsets policy.

The Nature Conservation Act provides for the declaration of threatened species and ecological communities, but protection focuses on threatened plants and animals and their nests rather than endangered communities. Where individual components of the ecological community are not themselves endangered or protected, interference can occur without committing an offence under the Nature

Conservation Act (DECCEW 2010). It is increasingly recognised that nature conservation requires a whole-of-landscape and ecosystem approach. It is expected that the current single entity focus of the *Act* will be addressed in the review that is currently underway (DECCEW 2010).

The NSW Office of Environment and Heritage has recently finished describing and classifying the vegetation communities in the ACT and its surrounds. Within the next year, the ACT Government plans to build on this work by developing a vegetation map of the ACT which will provide extent and distributional information for the communities described. Once that is complete, the compiled information about the vegetation communities of the ACT should be reviewed to determine:

- the identification of vegetation communities that comply with criteria in the Nature Conservation Act or the EPBC Act for listing as Endangered Ecological Communities;
- the extent and distribution of listed Endangered Ecological Communities; and
- the extent and distribution of non-listed vegetation communities.

Such an assessment would show if there are additional ecological communities that should be considered for nomination as threatened under the Native Conservation Act.

Biodiversity or environmental offsets

Offsets are a mechanism to compensate for the adverse environmental impacts of a development on a site by enhancing the environmental values of another site. Biodiversity or environmental offsets are generally understood to be actions taken by developers to compensate for the adverse environmental impacts of a particular development (DECCEW 2007). It is important that offsets deliver a tangible conservation benefit; but they should be considered as a last resort after all avenues for mitigating potential impacts have been exhausted.

Currently there are no biodiversity offset guidelines for the ACT, but a draft ACT Biodiversity Offsets Policy is being developed. Ideally this new policy will avoid perverse results, protect areas with high ecological values, suit ACT context and administrative arrangements, and be based on sound land use planning practice (OCSE 2011a). At present, biodiversity offsets in the ACT are only implemented via the Commonwealth EPBC Act. The Australian Government uses biodiversity offsets in an attempt to achieve either no net loss, or a net gain in biodiversity outcomes while allowing for the development of areas containing matters of national environmental significance (this includes endangered ecological communities). There are no current programs that measure the outcomes of implementing biodiversity offsets for the

ACT. As such, the draft ACT Biodiversity Offsets Policy should include a requirement to prepare a program that includes monitoring and independent auditing of the success of any biodiversity offsets implemented.

Four offset packages for endangered ecological communities have been developed as a Commonwealth requirement (Table 3).

Table 3. Commonwealth-required offset packages for the ACT.

Biodiversity impact	Development	Offset actions
Loss of Golden Sun Moth (grassland) habitat	West Macgregor - residential development area	Developer is investing $200,000 in grassland restoration on an adjacent rural lease where dense populations of Golden Sun Moth have been recorded. University of Canberra will lead research into restoration methods.
Loss of Golden Sun Moth (grassland) habitat	Forde North - residential development area	Forde North developers are investing $100,000 on Golden Sun Moth research, including translocation studies. $10,000 in weed control for adjoining nature reserve. Construction of a dog-proof boundary fence between the suburb and the nature reserve and construction of a walking track into the reserve.
Loss of 2.5 ha of Box-Gum woodland	Clarrie Hermes Drive connection to Barton Highway	The Commonwealth requested an offset that would benefit woodlands across the region. The accepted proposal is to investigate methods for restoring ground-layer vegetation of Box-Gum woodland. $140,000 will be invested in a PhD and a further $50,000 in supporting Honours or Masters research project(s). A further $50,000 will be spent on on-ground work in Kama Nature Reserve.
Loss of 2.4 ha of Tablelands Grassy Box-Gum woodlands	Kings Highway Upgrade	The agreed offset strategy includes investment of $60,000 in studies by the Australian National University to identify connectivity corridors. A further $140,000 will be contributed to woodland restoration in the ACT. The location of restoration activity will be identified from the connectivity study.

Source: TAMS

Connectivity

Wildlife corridors are increasingly regarded as particularly important as a way of providing added protection to the ecological systems in Canberra's reserves. However, it must be acknowledged that there is no one-size-fits-all approach to connectivity. Different species have different requirements for habitat and movement. It is important that these are recognised and incorporated into connectivity planning. Reduced connectivity can isolate remnant native vegetation, and this combined with climate change is likely to compound the fragmentation and hence isolation of ecological communities of the ACT Nature Reserves (Manning et al. 2010). Disrupting connectivity can inhibit movement between populations of flora and fauna, and prevent genetic migration between reserves. It can also lead to the permanent loss of local populations after catastrophic events, such as bushfire, habitat loss through pest invasion and diseases (Webb 2011).

During the reporting period, the ACT Government commissioned specific modelling of the connectivity-needs of 6 types of fauna. The report, *Ecological Connectivity for Climate Change in the ACT and Surrounding Region* (Manning et al. 2010), makes recommendations for incorporating connectivity into the ACT planning framework. The study was not intended to be comprehensive, and it is a starting point for additional, more detailed application of whole-of-landscape connectivity approaches in planning the ACT. For example, results from modelling indicate several locations where high priority should be given to maintaining or improving connectivity in the ACT. These include (Manning et al. 2010):

- Black Mountain to Belconnen Hills and the lower Molonglo River;
- Callum Brae/Jerrabomberra to NSW (via Hume);
- Hall to Mulligans Flat and Goorooyarroo nature reserves and then with Mt Ainslie and Mt Majura nature reserves and the Majura Valley (including land occupied by the Department of Defence);
- Mulligans Flat and Goorooyarroo nature reserves to NSW (Greater Goorooyarroo);
- East Jerrabomberra nature reserve to Queanbeyan Nature Reserve (NSW) (across railway line and Lanyon Drive).

Also:

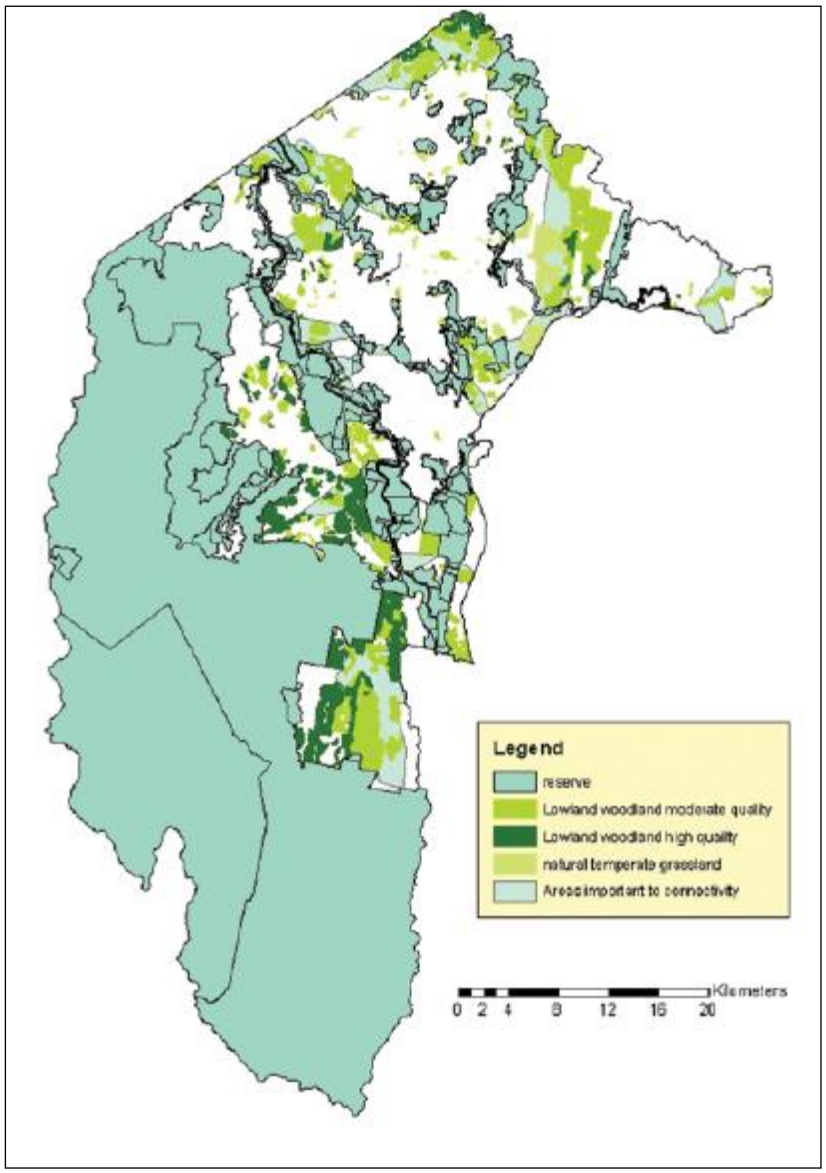
- action to strengthen the links between Mulligans Flat and Goorooyarroo nature reserves with the Majura hills and adjacent NSW land (Greater

Goorooyarroo) needs to be considered soon, before woodland habitat areas become more isolated and/or fragmented.

Building on that modelling, the ACT Government has commissioned further connectivity analysis, to:

- develop and deliver an ecosystem connectivity map for the ACT and surrounding area;
- provide the means where the relative connectivity value of a particular site can be assessed before and after clearing or restoration activities;
- identify priority areas for restoration activities, including woodland restoration;
- provide the means by which connectivity value can be identified and incorporated into a biodiversity layer being produced as part of the Canberra Spatial Plan Evaluation;
- assist in identifying those parts of the ACT that are of greatest importance to the capacity of ACT's wildlife to adapt to expected climate change impacts; and
- be useful in the consideration of biodiversity offsets.

Figure 2: Significant areas for ecological connectivity.



Source: DECCEW 2010.

Future work is required to improve connectivity between ecological communities through corridors and 'stepping stones' of habitat, including integration with conservation outside of reserves. The 2010 review of Action Plan No. 27 has identified that the results of the connectivity work will be integrated into the ACT planning process and used in assessment of current development options. It is important to ensure that this happens and is updated on an ongoing basis as new information becomes available.

Protected Area management

The Nature Conservation Act provides for the protection and conservation of native plants and animals, declaration of threatened species and ecological communities. Over 50% of the ACT is protected within conservation areas. However, protected

areas in themselves cannot guarantee the ongoing survival of threatened species or ecological communities. Effective adaptive management through monitoring and assessment is needed to ensure protected areas are restored or maintained in a good condition.

The large areas of reserves in the ACT are a major management challenge. In 2010-11, the ACT Government's budget for the environment was $40.8 million, which represents just over 1% of the ACT Government's total budget (OCSE 2011b). Of this, $8 million is spent on the management of Canberra Nature Park, and half of that is committed to implementing the Bushfire Operational Plan on reserves, restricting funds available per hectare for conservation and visitor programs (OCSE 2011b). A recent comparison of population, area of nature/conservation reserves (hectares), funding in Hobart City Council, Brisbane City Council and Canberra found that while overall more funds are invested in nature reserves in the ACT, the ACT has four times the area of the reserves that are managed in Hobart, and the ACT has only around one-third of the population (and therefore a far smaller income from rates) of Brisbane (OCSE 2011b). With increasing demand and pressure on the ACT's protected areas, management will continue to be a significant challenge.

Recently a new Plan of Management has been gazetted for Namadgi National Park, which replaces the 1986 Plan of Management. Since the development of the 1986 *Namadgi National Park Management Plan* there have been a number of significant changes to political, social and environmental settings relevant to the management of the park, including:

- expansion of the area of Namadgi National Park in 1991 (extending the park in the north-west from Mt Aggie to Mt Coree and Mt Blundell); and
- inclusion on the Australian Government National Heritage List as part of the Australian Alps national parks (TAMS 2010b).

No expansions of boundaries or additions have been made during the current reporting period.

A new Plan of Management for Tidbinbilla is expected to be gazetted in 2011. When finalised, it will replace the existing 1999 Plan. The Tidbinbilla Nature Reserve has been increased to include Jedbinbilla, a former pine plantation, and Birrigai, a special purpose reserve for recreation and education. In addition, the Tidbinbilla Plan of Management is expected to address the proposed inclusion of part of the Gibraltar Pine Forest, which was destroyed during the 2003 bushfire and is no longer used as a pine plantation. Since the 2003 bushfire, extensive forest regeneration has occurred using native forest species. The proposed incorporation of this area into Tidbinbilla would connect this reserve with Namadgi National Park.

During the reporting period three new nature reserves (Callum Brae, Jerrabomberra West and Kama) have been added as Canberra Nature Park conservation reserves. In addition, approximately 80 ha have been added to existing reserves (TAMS). Two additional nature reserves (Kinlyside and Jerrabomberra East) have also been proposed for inclusion into the Canberra Nature Park. The boundaries of the proposed nature reserves have been established and are currently managed for conservation values by the ACT Territory and Municipal Services (TAMS).

The new Canberra Nature Park inclusions largely consist of Natural Temperate Grassland and Yellow Box-Red Gum Grassy Woodland. The areas of vegetation in each reserve are shown in Table 4. These areas are approximate only and are derived from ACT-wide mapping of these communities (TAMS).

Table 4. New reserve inclusions for the Canberra Nature Park since 2007

Reserve name	Total area (ha)	Area of Grassland	Area of Box - Gum Woodland	Area of other lowland woodland, including secondary grassland
Callum Brae	143	-	122	-
Jerrabomberra West	261	181	65	8
Kama	155	39	98	19
Kinylside (proposed)	226	-	117	95
Jerrabomberra East (proposed)	99	78	-	-

Source: TAMS

There is a need to update the *Canberra Nature Park Management Plan* (ACT Government 1999) to incorporate the new reserves. Many of the ACT's woodland reserves were established to preserve hilltop vegetation rather than woodland conservation values; thus many reserves incorporate heavily degraded areas. It is estimated that 10-20% of the Canberra Nature Park supports highly degraded woodland in need of restoration (TAMS 2010a).

Currently a research and restoration experiment is underway in the Mulligans Flat - Goorooyarroo Woodland. This site includes the largest and most intact example of this type of Yellow Box-Red Gum Grassy Woodland in the ACT. The experiment aims to identify methods to restore the structure and function of temperate woodlands and increase biodiversity, and the intention is to support park managers in their work to conserve woodlands (Manning 2011). The experiment is a partnership between teams from the ANU, the ACT Government and CSIRO. See the *Native species - fauna* indicator cluster paper for more information.

The conservation of Endangered Ecological Communities in the ACT is an important part of protecting natural values and maintaining healthy ecosystems. Ensuring these ecological communities are retained in the ACT largely depends on eliminating or mitigating processes that result in habitat loss through urban development, fire regimes and climate change. These processes are largely identified through research and are currently managed by the ACT Government through the implementation of recovery actions, strategies and Action Plans. The Nature Conservation Act does not specify that Action Plans should include monitoring provisions to gauge their success; however, the plans generally include such a provision. Similarly the *Act* does not include a requirement or process to monitor and report progress on implementing Action Plans at periodic intervals. Existing ACT Action Plans for Endangered Ecological Communities include:

- *Action Plan No. 27 - ACT Lowland Woodland Conservation Strategy* - this strategy is focused on the protection of the remaining lowland grassy woodlands; it is also the statutory Action Plan for 11 species of plants and animals declared threatened under the Nature Conservation Act;

- *Action Plan No. 28 - ACT Lowland Native Grassland Conservation Strategy* - this strategy seeks to maintain and improve the natural integrity of the remaining lowland native grassland ecosystems; it also supersedes 7 separate Action Plans for ecological communities and species declared threatened under the Nature Conservation Act; and

- *Action Plan No. 29 - ACT Aquatic Species and Riparian Zone Conservation Strategy* - this strategy is focused on the protection and management of the rivers and riparian areas in the ACT that support threatened species and ecological communities; it is also the statutory Action Plan for 6 species of plants and animals declared threatened under the Nature Conservation Act.

The 3 Action Plans are complementary and recognise that ecological communities are dynamic; they change over time and integrate with each other. Each of these Action Plans has 5-year periods of action. Progress has been made on implementing the priority actions in the three comprehensive Action Plans released between 2004 and 2007. Action Plan No. 27 and Action Plan No. 29 were reviewed in 2010, and Action Plan No. 28 was reviewed in 2008, and the reviews indicate that the majority of the actions in the plans have been implemented or are ongoing. As such the plans are considered to be achieving their goals. For a summary of priority actions, progress and outcomes achieved during the review period see Table A1 in the Annex.

Lowland native grassland management

The *Report on the Investigation into the ACT Lowland Native Grassland Investigation* by the Office of the Commissioner for Sustainability and the Environment (OCSE 2009) made 32 recommendations to improve the protection and management of ACT Lowland Native Grasslands. The ACT Government agreed or agreed in principle with all recommendations. By the end of the reporting period, 14 of these recommendations had been fully implemented. The review of the Nature Conservation Act is expected to address a number of land-management matters recommended by the Commissioner's report. Other key actions that have advanced lowland native grassland protection and management include (OCSE 2011b):

- the Kama Woodland/Grassland (central Molonglo River Valley) was provisionally registered in 2009 under the Nature Conservation Act;
- the following grassland sites have been registration by the ACT Heritage Council: Tuggeranong Parkway Road Cutting, Small Purple Pea Habitat, Cotter Caves and Surrounds, and Button Wrinklewort Habitat; the Lower Molonglo Geological Site is provisionally registered; 2 nominations for Grassland Earless Dragon Habitat (Jerrabomberra Valley and Majura Valley) and Natural Temperate Grassland Ecological Community (Lawson and Majura Valley) are currently being assessed for provisional registration;
- during 2010-11 prescribed burns were undertaken for ecological reasons in a number of Lowland Native Grasslands sites; monitoring of these and other burns will provide information about the applicability of a wider program of ecological burning in Native Grasslands in the ACT;
- grazing on rural leases and licence areas containing high conservation grasslands is only permitted after consultation with grassland ecologists who review the proposals against conservation management strategies; their advice is included in the conditions attached to the grazing agreements;

Still to be implemented are: the development of an offsets policy and tool; making the location of sites publicly available; and ensuring assessment and adaptive management are implemented (OCSE 2011b). These would strengthen the management of Lowland Native Grassland in the ACT.

Independent Conservation Trust

Recently the ACT Government has undertaken a new approach to conservation management through the Capital Woodland and Wetlands Conservation Trust. This trust is a partnership between Government and the community and it aims to access private sector and community funding for projects located on public land, over and

above normal government-funded operations. The Trust is being established to support projects in the Jerrabomberra Wetlands Nature Reserve and Mulligans Flat Woodland Sanctuary. The Trust is intended to supplement, rather than replace, annual government support for normal, ongoing management of these areas (OCSE 2011b). For more information see the *Native species - fauna* indicator cluster paper.

Community engagement

Community groups make an important contribution conservation management in the ACT with activities ranging from biodiversity conservation and species surveys, to water-quality monitoring and pest and weed control. This voluntary work has financial value (OCSE 2011b):

- the number of hours of voluntary work undertaken in Canberra Nature Park, Molonglo River Corridor and Googong Foreshores in the 2009-10 financial year was approximately 14,530 hours; and
- multiplying by an indicative payment rate of $25 per hour, the value is $363,250 (OCSE 2011b:97-98).

For more information on the role of community groups in conservation see the *Community engagement* indicator cluster in the *People* theme.

Glossary

Ecological community naturally occurring assemblage of plant and animal species occupying the same geographical area

Forb: a herbaceous flowering plant that is not a graminoid (grasses, sedges and rushes)

Perverse: a behaviour that is a deviation from what is considered orthodox or normal.

Vegetation community: assemblage of plant species within a designated geographical area, which forms a relatively uniform patch of vegetation, distinguishable from neighbouring patches of different vegetation types

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

Department of Sustainability, Environment, Water, Population (DSEWPaC)

ACT Department of Territory and Municipal Service (TAMS) - now Territory and Municipal Service Directorate (TAMSD)

ACT Department of the Environment, Climate Change Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

Parks, Conservation and Lands (PCL) - now part of the Environment and Sustainable Development Directorate (ESDD)

Annex

Table A1. Summary of Action Plan implementation reviews

Action Plan No. 27 - ACT Lowland Woodland Conservation Strategy 2007-2009	
Monitoring Priority Actions	**Progress and/or Outcomes of the Action**
Completing surveys of woodlands including data collection on groundlayer and understorey vegetation and habitat characteristics.	2924 woodland polygons mapped spatially and entered into a data base.
Protecting key habitat areas in Hall – Kinlyside, Gooroo, East Majura Valley and Callum Brae, and off-reserve areas such as Castle Hill (Tuggeranong – Naas complex).	Since 2003, reserves have been established at Callum Brae (414 ha) and Goorooyarroo (701 ha). Kinlyside (201 ha) is being managed for conservation.
Establishing mechanisms to assist in the application of best practice management (CMNs, voluntary management agreements, guidelines) to facilitate conservation outcomes on reserve and off-reserve land.	CPR monitoring of 15 Natural Temperate Grassland and Lowland Woodland reserves is measuring species richness, abundance and cover.
Threat Priority Actions	**Progress and/or Outcomes of the Action**
Reviewing management of lowland woodland areas in government horse paddocks and agisted land to ensure ecological condition is improved.	Woodland condition and distribution on horse paddocks and agistment land has been assessed and mapped. Future work is required to assess the extent and nature of changed management practices to enhance ecological condition in government horse paddocks.
Protection Priority Actions	**Progress and/or Outcomes of the Action**
Protecting key habitat areas in Hall (Kinlyside), Goorooyarroo, East Majura Valley and Callum Brae, and off-reserve areas such as Castle Hill (Tuggeranong – Naas complex).	Since 2003 reserves have been established at Callum Brae (414 ha) and Goorooyarroo (701 ha). Kinlyside (201 ha) is being managed for conservation.
Protecting examples of Snow Gum lowland woodland, especially ecotones between woodland and grassland.	This priority has been applied in planning decisions (e.g. Kings Highway deviation) but no new Snow Gum lowland woodland has been added to the reserves system. Nomination to list Snow Gum Woodland as an Endangered Ecological Community was rejected by the ACT Flora and Fauna Committee: at the time of nomination not enough information was available to make an assessment.
Assessing woodlands for their potential for listing on the ACT Heritage Places Register as natural heritage places.	A draft nomination has been completed; stakeholder consultation is occurring.

Action Plan No. 28 - ACT Lowland Native Grassland Conservation Strategy 2005-2008	
Monitoring Priority Actions	**Progress and/or Outcomes of the Action**
The location, type and ecological condition of all Natural Temperate Grassland and habitat for threatened species in the ACT are described and the information kept current.	Vegetation surveys of all known Natural Temperate Grassland sites have been undertaken and data are maintained in the ACT Vegetation Database. Quantitative vegetation surveys using the same methods that are used in NSW and for other ACT ecosystems have been undertaken for selected sites. Data have been supplied to the relevant land managers. Extensive surveys have been undertaken in grasslands in the Southern Tablelands in NSW.
A comprehensive database of Natural Temperate Grassland and component species in the ACT is maintained. ACT data are included in national, state and community databases.	The ACT checklist of vascular plants has been prepared by the Australian National Herbarium (ANH) and will be maintained on the ANH website. This will be an important reference for managers and researchers.
Threat Priority Actions	**Progress and/or Outcomes of the Action**
Substantially reduce or eliminate threats to natural temperate grassland through appropriate planning and management actions.	Fire suppression guidelines have been developed for ACT declared threatened species and communities. The guidelines will be used in fire management and fire suppression operations to ensure fire managers are aware of appropriate techniques to apply to prevent damage to threatened species and communities. Data on threatened species locations have been updated and generalised maps prepared for use in fire management. An ACT Kangaroo Management Plan is being prepared and it will address conservation issues associated with kangaroo grazing pressures.
Reduce the impact and occurrence in grasslands of weeds of concern.	Annual weed programs of all Territory and Commonwealth land managers include, as a priority, weed control in areas of Natural Temperate Grassland and threatened species habitat.
Protection Priority Actions	**Progress and/or Outcomes of the Action**
A comprehensive, adequate and representative system of Natural Temperate Grassland areas in the ACT is protected by reservation, or other measures where reservation is not practical or desirable.	About 400 ha of grasslands in the Jerrabomberra valley have been identified for reservation. The Territory Plan has been amended to include these areas in nature reserves, except for Jerrabomberra East (about 125 ha) which is currently being surveyed to prepare a Draft Variation to the Territory Plan.
The ACT Heritage Places Register includes natural temperate grassland and key habitats for threatened grassland species.	All Natural Temperate Grassland sites have been nominated for heritage listing and are being considered by the ACT Heritage Council. Not finalised at time of writing.

Action Plan No. 29 - ACT Aquatic Species and Riparian Zone Conservation Strategy 2008-2010	
Monitoring Priority Actions	**Progress and/or Outcomes of the Action**
Comprehensive survey undertaken of riparian vegetation and habitat for high priority areas.	Riparian vegetation composition determined, condition assessed, and management needs assessed and mapped. A Murrumbidgee report and a major tributaries report has been produced, with included maps.
Vegetation monitoring program designed and commenced for priority species/ecological communities.	Method trialled, yet to be implemented.
Survey and other relevant data entered into ACT vegetation database within 6 months of collection.	Ongoing
Extent of recovery of fire affected riverine and riparian ecosystems and ecological communities reported.	Commentary provided in annual fish species reports. Follow-up fire response report to be completed. Riparian project determined and mapped extent of fire-affected vegetation communities. Post fire condition was also assessed.
Threat Priority Actions	**Progress and/or Outcomes of the Action**
Actions to address threats have been prepared and are being implemented.	Lower Cotter Catchment revegetation program (ACTEW 2011) to help address sedimentation.
Area of riparian zone occupied by weeds has been reduced. Incidence of high priority weeds has been reduced and their spread controlled.	Significant reduction in environmental weed cover at the locations mentioned.
Threats to rivers and riparian areas are substantially reduced or decreasing.	Ongoing
Protection Priority Actions	**Progress and/or Outcomes of the Action**
Conservation status of aquatic and riparian species and ecological communities assessed. Where appropriate, threatened species nominations prepared.	Reports prepared annually that include assessment of status of different species.
Key riverine and riparian habitats are protected by legislation, reservation, planning and management actions.	Murrumbidgee River Corridor largely protected in nature reserve. Cotter River entirely protect in national park and catchment area. Molonglo River protected in nature reserve or special purpose reserve.
Extent to which development proposals are assessed under applicable legislation.	Assessments under Planning and Development Act and EPBC Act undertaken and expert comments provided. Ongoing meetings conducted with developers to highlight environmental

	concerns. Molonglo River Assessment Strategy developed.
Rivers and riparian zones have been assessed for suitable entries to the ACT Heritage Places Register and nominations prepared (2010-2012).	No progress to date.

Source: ACT Government 2008, 2010a, 2010b

ACT State of the Environment Report 2011

THEME: Biodiversity

Indicator cluster: Threatening processes

The indicators for this cluster are:

- Weed status (C) - extent and distribution of weeds;
- Pest status (C) - extent and distribution of pests;
- Ecosystems and climate change (P) - impacts of climate change on ecosystems;
- Fire and fire regimes (P) - type, area, distribution and extent of fire (including ecological impacts of prescribed burning);
- Firewood gathering (P) - extent and distribution of firewood gathering;
- Road kill (P) - vehicle collision impacts on native species;
- Weed impacts (I) - nature of weed impacts on native species;
- Pest impacts (I) - nature of pest and overabundant native species impacts on native species;
- Ecological degradation (I) - broad measure of effects of urban and other development on ecological communities and species including urban expansion;
- Weed management (R) - effectiveness of weed management responses;
- Pest management (R) - effectiveness of pest and overabundant native species management.
- Fire management and ecology (R) - effectiveness of fire management responses in terms of ecology and native species and communities.

Condition indicators (C) present data on the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effects of environmental changes on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

The ACT has large areas of green space around and within the city. Changes at the local scale (such as human population increase and associated pressures) and at

global scale (such as global warming and climate change) are placing the ecosystems of the ACT under increasing pressure.

Processes that threaten or could threaten the survival of native species and populations or ecological communities in the ACT include: climate change impacts; changed fire regimes; pest and weed impacts; and development impacts such as urbanisation. There is a lack of ongoing monitoring, and therefore knowledge about specific impacts and the status of many threatening processes is very limited in the ACT. More information is required to guide effective management.

Introduction

Processes such as invasion by weeds and pest species, urban development, and climate change are placing ecosystems under increasing pressure. Much of Australia's flora and fauna has evolved alongside threatening processes such as fire and may rely on those processes for continued survival. However, changes to the processes (for example, fires of high or low intensity that are either too frequent or insufficiently frequent), or new processes such as loss of habitat through urban or infrastructure development, can lead to loss of native species and ecological communities. This paper reports on management responses to threatening processes in the ACT, and, where possible, the outcomes of these management responses during the reporting period. The paper also reports on identified potential factors resulting from threatening processes, which influence loss of biodiversity.

Condition indicators

The ACT the *Nature Conservation Act 1980* (ACT Government 2011a) defines a threatening process in relation to a species or ecological community, as:

... *a process that threatens, or may threaten, the survival, abundance or evolution of the species or community and includes the spreading of a pest animal or pest plant*.

Threats to the threatened species declared under the Nature Conservation Act (e.g. loss, fragmentation or alternation of habitat, and overgrazing) are identified in the Action Plans prepared for those species. (See also the Annex to the *Native species - fauna* indicator cluster paper for a summary of the major threats to each threatened fauna species listed under the Act.)

There are currently no threatening processes declared under the Act (ACT Government 2011a). The Flora and Fauna Committee has integrated threatening processes into Action Plans 27, 28 and 29 (TAMS 2006). It is important to assess

whether that integration puts enough focus on the individual threatening processes, and provides enough impetus to act on them.

Under the ACT *Pest Plants and Animals Act 2005* (ACT Government 2011b) a pest animal or plant can be declared a notifiable pest (i.e. its presence must be notified to the Director-General, previously the Chief Executive) or a prohibited pest (i.e. the supply or keeping of the pest animal is prohibited). Once a pest has been declared, the minister may prepare a plan for the management of that pest plant or animal.

Weed status

Weeds can be found across most of the ACT, including in remote areas of Namadgi National Park. Transported livestock and fodder, contaminated crop and pasture seeds, deliberate introductions of new species, and the movement of contaminated machinery including cars can spread weeds through agricultural areas and beyond. Once weeds establish in native plant communities they can change the structure and species composition of the original plant community by out-competing native plants, leading to flow-on effects to native animal species. Weeds such as Paterson's Curse (*Echium plantagineum*) and Capeweed (*Arctotheca calendula*) successfully spread and establish in new areas because of their capacity to quickly respond to changes in the landscape. Losses of native plant cover through fire and drought, and bare ground in introduced pasture or after harvest, give these and other weed species suitable opportunities to invade. Weeds such as Chilean Needle Grass (*Nassella neesiana*) and African Lovegrass (*Eragrostis curvula*) are also spreading in areas where land has been disturbed, particularly along fire trails, utility easements and adjacent to urban areas (ACT NRMC 2009). Between 2007 and 2009 the number of declared weeds included in the *Pest Plants and Animals (Pest Plants) Declaration 2009* increased from 76 to 78 (ACT Government 2011b). The two new pest plants declared are Mexican Feather Grass (*Nassella tenuissima*) and African Fountain Grass (*Pennisetum setaceum*) (Table 1).

Table 1. New pest plant inclusions in the ACT

Species	Condition	Pressure	Status
Mexican Feather Grass (*Nassella tenuissima*)	Planted in gardens across ACT. Identified plants have been seized, and there is an ongoing search for remaining plants. Small infestations near Bendora Dam and the Namadgi Visitor's Information Centre have been identified and contained. Monitoring for seedlings is ongoing.	Has the potential to invade pastures and native grasslands in the ACT. If uncontrolled, it could spread to other states of Australia. Importation into Australia is prohibited.	A notifiable and prohibited pest plant. Ongoing monitoring and education are necessary. Capable of dominating disturbed and un-disturbed areas due to its extreme rates of spread, smothering a wide range of native plants and/or pasture. Even small infestations are difficult to contain. Mono-cultures form rapidly.
African Fountain Grass (*Pennisetum setaceum*)	Has been found growing in the ACT. No locational information on this species has been provided.	An invasive weed, capable of dominating disturbed and un-disturbed areas with very high rates of spread, smothering a wide range of native plants and/or pasture. The species can form mono-cultures.	A notifiable and prohibited pest plant. Ongoing monitoring and education are necessary.

Source: TAMS 2008, 2009

There are currently 20 species recognised as Weeds of National Significance (WoNS) in the ACT, of which 9 (listed below) have been declared as pest plants under the provisions of the ACT Pest Plants and Animals Act.

Weeds of National Significance that are established in the ACT are:

- Blackberry (*Rubus fruticosus* agg.);
- Chilean Needle Grass (*Nassella neesiana*);
- Gorse (*Ulex europaeus*);
- Serrated Tussock (*Nassella trichotoma*);
- Willow (*Salix* spp.);

- Alligator Weed (*Alternanthera philoxeroides*).

Weeds of National Significance with the potential to establish in the ACT are:

- Bridal Creeper (*Asparagus asparagoides*);
- Cabomba (*Cabomba caroliniana*);
- Salvinia (*Salvinia molesta*).

The 2019 ACT target for weeds management is to eradicate a few species entirely (including Mexican Feather Grass and Madagascan Fireweed, *Senecio madagascariensis*), and either reduce the percent cover or reduce the infestations to occasional and localised for most other species and locations (see Table A1 in the Annex). A few species are targeted for occasional and widespread or common and localised cover on specific sites.

The ACT Government's weeds management team described 7 sites as having a 'common to dominant' coverage of targeted weeds in 2008-09 (PCL 2010a), indicating significant difficulties in achieving the targets of reduced weed coverage in well-established areas. In contrast, at 5 of the 7 sites that were reported as having 'common to uncommon' coverage the team successfully reduced the weed presence, in line with the *2019 ACT Weed Strategy* targets for the weed species (PCL 2010b). At all sites described as having 'rare' species coverage, either the weed species was eradicated or it was contained (PCL 2010b).

It is noted that weed cover has also increased in 8 of the 26 ACT locations (PCL 2010b). Further information is provided in Table A1 in the Annex.

Pest status

Pest species, including insects, birds, mammals and fish, are found throughout the ACT and surrounding region. Of these, 10 species are declared pests under the Pest Plants and Animals Act:

- Wild Rabbit (*Oryctolagus cuniculus* (wild));
- Wild Dingo/Wild Dog (*Canis lupus* (wild));
- Wild Deer species (*Cervus* spp. and *Dama* spp. (Wild));
- Wild Pig (*Sus scrofa* (wild));
- Wild Goat (*Capra hircus* (wild));
- European Red Fox (*Vulpes vulpes*);

- European Wasp (*Vespula germanica*);
- Weatherloach (*Misgurnus anguillicaudatus*);
- Carp (*Cyprinus carpio*);
- Gambusia (*Gambusia* spp.).

Data on the status of pest species, in terms of ACT-wide population trends, are not collected. Particular species are monitored at key sites. Data on the status of pest species monitored in the ACT are contained in Table 2.

Table 2. Current status and impact of selected pest species in the ACT

Pest	Current status in the ACT
European Red Fox	• Foxes are considered ubiquitous in the ACT. • In areas where targeted dog baiting occurs, fox numbers are likely to be greatly reduced because the foxes take the 1080 dog baits. Sand plot monitoring in southern Namadgi National Park confirms this assumption (0% plots showed fox prints). • Fox numbers are reported as being at medium levels in both Googong Nature Reserve and Rob Roy/Gigerline Nature Reserves (20% of sand plots showed fox prints) where monthly baiting occurs (winter and autumn baiting only in Gigerline). • Foxes have been eradicated from the Mulligans Flat Sanctuary using predator-proof fencing and trapping and shooting.
Carp	• Despite the good biodiversity of native fish species, European Carp (*Cyprinus carpio*) continue to make up 80-90% of fish biomass in the Murrumbidgee River within the ACT.
Wild Rabbit	• Rabbit numbers have been increasing in the ACT and in all other Australian jurisdictions over the last five years, probably because of a failure to use conventional methods of rabbit control to capitalise on low rabbit numbers following introduction of Rabbit Haemorrhagic Disease (Rabbit Calicivirus Disease) in 1995. • Results of regular spotlight monitoring within Namadgi National Park show a significant increase in numbers across all sites monitored.
Wild Pig	• Feral Pigs are widely distributed throughout the ACT in non-urban parks and reserves. • Former long-term performance monitoring in Namadgi National Park found a dramatic drop in signs of pigs (dung and rooting) following the initiation of a park-wide pig baiting program in the mid 1980s. The annual baiting program maintained pig signs at this level until the end of the study in 2000. • No more recent data are available.

Pest	Current status in the ACT
Feral Horse	• Feral Horses were eradicated from Namadgi National Park in 1987. By 2006, 18 horses had recolonised the park. Subsequent control has reduced the numbers of horses in Namadgi National Park to 4 animals.
Wild Deer Species	• Feral Deer sightings appear to have been increasing over the last 10 years. Herds of Fallow Deer are present along the Murrumbidgee, Naas, Paddy's and Molonglo rivers. Red Deer are present in the Naas Valley and adjoining areas of Namadgi National Park. Sambar Deer have recently been reported in the Brindabellas and upper Cotter catchment. • In response to the increased reports of incidental sightings a deer sightings register was established in 2008-09 for reports from staff of ACT Parks and Conservation Service, landholders and the public. In 2009-10 there were a total of 26 deer sightings reported, including 15 Fallow Deer sightings, 6 Red Deer sightings, 2 Sambar Deer sightings and 3 unidentified sightings. In 2009-10, 6 deer (4 Red Deer and 2 Fallow Deer) were reported shot by ACT Parks and Conservation Service.
Goat	• During 2009-10, 7 goats were shot at Googong Nature Reserve and 10 from Gigerline Nature Reserve and the lower Molonglo valley. About 60 goats were mustered from the Molonglo River corridor near Coppins Crossing to protect the nearby National Arboretum.

Source: DECCEW 2010, PCL 2010a

Pressure indicators

Ecosystems and climate change

In the coming decades impacts from climate change are likely to become increasingly prevalent in the ACT. The most likely future climate scenario for the ACT includes (Webb 2011):

- the strong likelihood of mean temperatures continuing to increase, along with more frequent and severe heatwaves for the ACT and region; and
- a high probability of changes in the pattern of rainfall from that observed during the period of instrumental records, with some risk of a decline in long-term average rainfall; and in addition, the likelihood of an increase in rainfall intensity with more extreme rainfall events.

Climate change is likely to affect ecosystems in the region by altering their structure, composition and function. The distributions of individual species may change, as may invertebrate populations. Climate change may cause high-altitude ecosystems to contract (NSW Government 2010). Change is expected to be driven by bushfire frequency and intensity, reduced primary productivity in plants, interaction with existing pressures, changes in rainfall patterns involving more intense seasonality,

increased grazing pressure from native herbivores and increased weed incursion (NSW Government 2010). The potential rate, scale and geographic extent predicted as possible under climate change make it potentially even more significant than other threats (Webb 2011).

Organisms are responding individually to climate change and will not move as complete ecological communities (Peters 1990). This may result in the formation of novel ecosystems with new species compositions and relative abundances (Hobbs et al. 2006, Lindenmayer 2008).

Impacts on native species

Climate change is predicted to affect species directly through: heat stress and changes to growth and water use in plants; concentration of nutrients and toxins in leaves; timing of seed germination and flowering in plants; and egg laying and hatching in birds, reptiles and insects (Webb 2011). Some sensitive species are expected to be lost while invasive species are expected to persist and spread. Species at most risk from climate change include those with limited ability to move, those with limited habitat range, and those with specialised habitats or dependent on other species (DECCW 2010).

Some of these potential impacts have already begun to occur, as indicated by a number of extinctions, functional extinctions and threatened species; and changes in relative abundance, diversity, distribution and range of species (Webb 2011). Globally, observed changes in biodiversity have predominantly been at the species level, with the clearest evidence coming from changes in life-cycle events and shifts in geographic ranges (Hughes et al. 2010).

Observed changes include reductions in communities of freshwater invertebrates that prefer cool fast-flowing water bodies (Chessman 2009), and fauna such as Kookaburras colonising sites at higher altitudes than normal, such as alpine ecosystems in the Australian Alps where they are preying on alpine skinks that do not recognise them as predators (Green 2003, Pickering et al. 2004, Low 2007, DECCW 2010). Climate change now affects bird species' behaviour, ranges and population dynamics. Birds are highly sensitive to weather and are the 'canaries in the coal mine' in relation to climate change (Wormworth and Mallon 2006).

Ecological communities and biomes

Impacts of climate change on grassy woodlands in the ACT could include death of trees from moisture stress, altered shrub-grass balance potentially in favour of shrubs, and changes in groundcover composition, with consequent impacts on fauna. Potentially higher stress is predicted for reptiles, snails and plants, and relatively

lower stress for mammals, birds and frogs. However, species such as the Northern Corroboree Frog, which lives in high-altitude habitats, are likely to experience greater pressure. Fauna impacts may be very complex and involve 'cascading changes' affecting invertebrate dynamics, species-species interdependencies and disease patterns (Prober et al. 2010). Grassy woodlands are no longer as well buffered against the impacts of change as they would have been when they had naturally high species-richness and environmental heterogeneity, were widely distributed and well connected (Webb 2011).

Natural Temperate Grassland and Snow Gum-Candlebark Tableland Woodland are dependent on low temperature conditions for their distribution; higher temperatures could result in invasion by other species.

In freshwater ecosysystems, reduced water availability will affect fish migration and spawning, other aquatic vertebrates, macroinvertebrates (such as insect larvae and crayfish), water plants and adjacent riparian systems, and it will make sites more vulnerable to weed invasions (Sharp et al. 2008).

Increased concentrations of atmospheric carbon dioxide have been shown to increase plant productivity and water use efficiency, but soils beneath Australian forests are typically poor in nutrients and that may restrict this benefit (Medlyn et al. 2010). Reduced water availability and more frequent droughts may threaten forest functioning. However, the limited evidence available suggests that flowering and reproduction in Australian forests are relatively robust under climatic variability. Also, the overall impacts of pathogens and invasive weeds as stressors on native forests are unlikely to worsen with the projected changes in climate (Medlyn et al. 2010).

Invasive species

Climate change is likely to aggravate Australia's invasive species problems. Native plant communities can be displaced by weeds because weeds tend to have greater capacity to adapt to changing climatic conditions (Low 2008). Predicted extreme events, such as floods, droughts and fires, will facilitate invasions by introduced species (Low, 2008), with weed species such as short-lived annuals quickly colonising grassy woodland areas following the breaking of drought (Sharp 2011). Invasion by weeds can weaken ecosystems in advance of direct impacts from climate change, making weed control and improvement of ecosystem resilience important lines of defence against both these threatening processes (Low 2008).

Pest animal problems may be exacerbated by climate change. For example, feral pigs may stay in high-altitude areas for longer if winters become warmer, rather than retreating to lower altitudes. That could result in more rooting damage to subalpine

areas during the colder months. It could also affect pig control in Namadgi National Park where rangers conduct effective baiting programs in winter when pigs congregate there.

Climate change may also result in native species from around the ACT expanding their geographic ranges and threatening local native species. For example the Broad Tooth Rat (*Mastacomys fuscus*), which is found in the ACT but is listed as threatened in NSW, may suffer increased competition from the Native Swamp Rat (*Rattus lutreolus*) (Low 2008).

Landscape function

Some Canberra reserves already have reduced or severely reduced landscape function (Sharp 2011). In addition to direct effects of climate change on species, there is a significant risk that climate change will affect natural ecosystem function and processes through increased erosion, drier soils, reduced vegetation growth and renewal, and effects on biological or nutrient processes (Webb 2011).

Drought and drier conditions in general reduce landscape function because they restrict soil moisture, vegetative growth and the maintenance of biological processes. On the other hand, extreme rainfall events result in excessive run off and erosion. More frequent fires and prescribed burning may decrease landscape function by removing natural litter layers and destroying the soil crust (Webb 2011).

Fire and fire regimes

A fire regime is defined as the history of fire events at a point in the landscape. The region is prone to bushfires, because although the ACT is in a zone of seasonally uniform rainfall (BoM 2011) the summers can be relatively dry, periodically there are droughts, and the native vegetation is flammable. While natural ecosystems of the ACT are adapted to fire, changes in the fire regimes - whether from suppression of fires or from more frequent fire - can have serious consequences for species that have evolved to survive different fire frequencies and intensities. Changed fire regimes can have ecosystem-scale impacts that may take years to disappear or that permanently change vegetation communities. Changes in vegetation communities can in turn affect the fire regime because fuel loads are influenced by vegetation type.

Even prescribed burns can have an ecological impact. The ACT Strategic Bushfire Management Plan (ACT Government 2009) does not focus on potential ecological impacts, but it acknowledges there may be a difference between the planned fire regimes and the natural fire regime resulting in changes to natural ecosystems.

Climate change will also affect fire regimes through impacts on both fire weather and fuel availability. Modelling for a 2°C increase in mean annual temperature suggests an increase in the landscape measure of fire intensity by 25%, increasing the area burnt and reducing intervals between fires (Cary 2002). More research is needed to clarify the net impact of climate and fire regime change on ecosystems in the region (Webb 2011). For more information on the impacts of climate change on fire see the *Climate vulnerability* and *Natural hazards* indicator clusters.

The *2007-08 State of the Environment Report* proposed "improving the scientific knowledge of managers and custodians of the ACT nature conservation estate about fire fuel management through research, monitoring and evaluation". Currently only around 10% of prescribed burns are monitored for ecological effects, and only for a 5-year period (OCSE 2011). Considering the complexities of ecosystems, the knowledge gaps about the responses of threatened species to different fire regimes, and the risks that modified fire regimes pose for natural ecosystems, monitoring of fire management activities should be a high priority.

Fuel reduction

Balancing the protection of life and infrastructure against the maintenance of biologically appropriate fire regimes is a challenge in the ACT. The Canberra Nature Park reserve system comprises 33 areas located within or adjacent to the suburbs of Canberra. The nearness of houses to the Canberra Nature Park system means that fuel loads within the reserves need to be keep relatively small in order to protect property. If the fuel loads are controlled by relatively frequent prescribed burning, there is a risk of loss of the parks' native species that need relatively infrequent fires to survive. For more information on fire management and fuel reduction practices, see the *Natural hazards* indicator cluster.

Areas where fuel reduction activities are proposed, and the methods to be used, are identified in the ACT Government's Regional Fire Management Plans and annual Bushfire Operational Plan. Activities to reduce fuel loads can include prescribed burning, slashing, grazing and physical or chemical removal of vegetation. These activities all have the potential to cause environmental damage and associated loss of biodiversity if applied inappropriately.

At the time of reporting, no data were available on the locations or numbers of prescribed burns or other fuel reduction operations during the reporting period. The 2010-11 Bushfire Operational Plan for the ACT lists a total of 49 prescribed burns planned for the financial year. Of these, 9 were planned for ecological reasons.

Firewood gathering

Collection of firewood for commercial purposes is not permitted in the ACT. Firewood sales in the ACT are regulated, and firewood merchants must be licensed and are required to report annual sales.

Dead trees and fallen timber in nature reserves, local forests, woodland occurring on private property or roadsides may look like potential pieces of firewood but should not be collected because they offer essential habitat for native fauna for nesting, roosting and foraging.

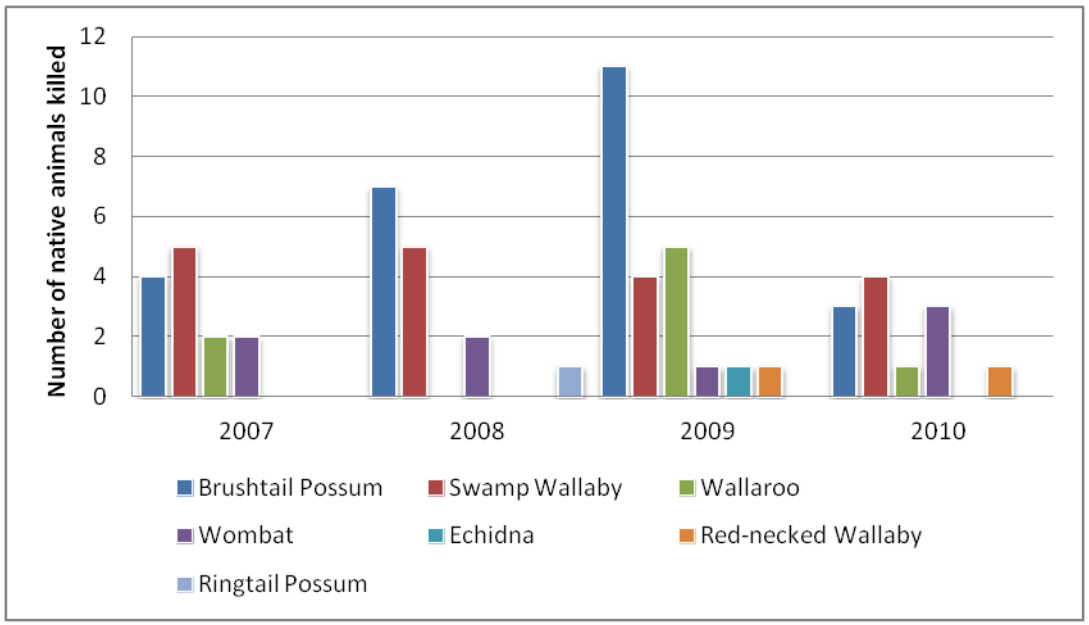
There is currently no provision to issue an infringement notice for the offence of removing fallen native timber under section 52(3) of the ACT Nature Conservation Act 1980 (ACT Government 2011a). If a ranger observes somebody collecting fallen timber for firewood the ranger's only option is to issue a warning of prosecution or undertake prosecution (DECCEW 2010).

Road deaths

Vehicle collisions with wildlife are of significant concern, both for human safety and for conservation reasons. Roads fragment areas of native habitat, and pose hazards to native fauna crossing the roads. These add to other existing pressures on biodiversity, such as from habitat loss and degradation and invasions by pests and weeds. The gains to fauna conservation from reserving land in an urban setting can be eroded through native species' road fatalities within and adjacent to these patches of land.

There are known collision 'hot spot' locations for large wildlife species in the ACT (TAMS 2010a). During the reporting period, 15 native species have been killed on ACT roads (Figure 1), with brushtail possums the most numerous apart from kangaroos, followed by swamp wallabies and then wombats and wallaroos. However, not all road deaths are reported to TAMS and the data should be considered to show only minimum numbers. Many smaller native species killed in vehicle collisions cannot be identified.

Figure 1. Native fauna reported killed on ACT roads, 2007-2011 (excluding kangaroos)



Source: TAMS

Kangaroos are by far the most commonly reported victims of collisions on roads, because of their large population within the urban area, the intersection of their natural movement corridors with roads, and the combined pressures of drought and abundant roadside vegetation. Over the reporting period more than 200 kangaroos were killed annually, except in 2010 when approximately 140 kangaroo road-deaths were recorded.

Impact indicators

Weed impacts

Weeds reduce natural diversity by smothering native plants or preventing their seedlings from establishing. Weeds also reduce the productivity of agricultural lands, and some weeds are toxic to stock. For information on the status of weeds in the ACT in 2009, see Table A1 in the Annex.

The impacts of weeds on native species and agriculture in the ACT are not comprehensively understood. The ACT lacks standardised procedures and databases for collecting and maintaining consistent information on weeds, and that limits the capacity to identify priorities and manage the impacts of weed species on biodiversity and agriculture at the Territory level. Work has begun to map species and density of weeds in priority areas, including locations of rare or threatened plant species that may be at threat from weed invasion. This will help with setting priorities for control work.

There need to be quantitative studies on the impact of the 78 declared pest plant species on native species in the ACT. The studies need to identify the native species that are most at risk from weed invasions, and also the capacity of native species and ecosystems to tolerate each relevant weed species. Weeds are also having broader impacts, at the landscape level, in relation to soil degradation, habitat disturbance and water quality. These need to be understood to help in effective management of weed impacts.

Pest impacts

Pest animals have negative impacts on native biodiversity through habitat competition and degradation, predation, and by harbouring parasites and diseases. Pest animals can also damage crops, pastures and agricultural assets, and reduce the safety and aesthetic value of urban open spaces.

Rabbits are a major cause of degradation in the Canberra Nature Park. Besides the obvious impacts of their warrens there are more subtle impacts, such as interactions with grazing by other herbivores and the stringencies resulting from drought and burning and sustaining populations of predatory foxes and cats. The long-term outcome is loss of perennial vegetation, trees and shrubs, native species and their ecosystem services, loss of nutrients, denudation and erosion of soil, and increase in weedy annual forbs and grasses (Williams 2011).

Some examples of pests listed in the ACT Vertebrate Pest Management Strategy (2002) and their impacts are shown in Table 3.

Table 3. Current impacts of selected pest species in the ACT

Pest	Potential impacts	Monitored impacts
European Red Fox	• Reduced abundance of medium-size native mammals, especially wallabies and possums, and likely impacts on invertebrates, small mammals and reptiles. • Possible impacts on bird populations and some threatened species. • Occasional urban nuisance. • Potential reservoir for rabies. • Agent for the spread of weed seeds.	No performance monitoring reported.
Wild Rabbit	• Reduced seedling recruitment by browsing. • Warrens promote soil erosion and weed invasion. • Grazing competition with native herbivores. • Overgrazing can lead to habitat degradation, affecting fauna species that rely on groundcover plants for food and shelter. • Food source for populations of feral cats and foxes that in turn can pose a threat to native species of concern.	No performance monitoring reported. Rabbit abundance from spotlight counts is used as a guide to the likely level of damage caused by rabbits.
Wild Pig	• 'Ploughing' of treeless flats and bogs in sub-alpine areas, with presumed impacts on wetland hydrology and abundance of plants and animals, including threatened species. • Reduced distribution of favoured tuberous native plants. • Pig-ripped ground and sightings of mobs of pigs impact negatively on experience of park visitors. • Degradation of water quality in catchments and wetlands.	Long-term monitoring of 700 plots in Namadgi National Park shows pig rooting has been recorded on 5-10% of plots since the 1980s, down from 30% of plots pre-control. (Data since 2000 were not available at the time of reporting.)
Feral Horse	• Alteration of subalpine habitat and other non-treed vegetation. • Restructuring of habitat critical to sub-alpine species of very limited distribution, particularly wetlands.	No performance monitoring reported.
Wild Deer	• Some evidence of tracking and browsing; significance of impact unknown. • Reservoir for diseases of livestock.	No performance monitoring reported.
Goat	• Vegetation structure altered by selective browsing of native shrubs, with implications for dependent species that are of conservation concern.	No performance monitoring reported.

Source: Environment ACT 2002, PCL 2010b

Ecological degradation

Ecological degradation is defined as any change or disturbance to the environment perceived to be deleterious or undesirable.

In addition to the impacts of climate change, weed and pest invasion, and changes in fire regimes discussed above, the most significant threat of ecological degradation in the ACT comes from the growing human population of the Territory and associated urban expansion. Urban developments can potentially have significant negative impact on the habitats of some key native species. However, developers are also financing targeted ecological research to be done as part of the impact assessment process. The findings of these studies are often equally applicable to the species or community of interest at other locations in the ACT.

Urban development

Urban development and expansion can lead to loss, fragmentation and alteration of habitats and ecosystems. Of the lowland area of the ACT, 60% has been cleared for agricultural and urban land use, and further urban expansion is planned.

Yellow Box-Red Gum Grassy Woodland and Natural Temperate Grasslands occur on the lowlands and are at increasing risk from the continued urban expansion. Key remnants of these ecosystems are conserved in the Canberra Nature Park reserve system, but less than 15% of the former lowland vegetation is protected and the fragmented nature of the reserves makes maintaining connectivity particularly important. This connectivity is likely to become even more important for maintaining biodiversity as the effects of climate change increase.

Future urban development in the Gungahlin area in North Canberra could potentially affect the Superb Parrot (*Polytelis swainsonii*) a nationally and locally vulnerable species that has been recorded in increasing numbers in north-west Canberra by the Canberra Ornithologists Group (COG) over recent years (see Table A1, Annex, *Native species - fauna* indicator cluster). A recent survey has confirmed breeding attempts and mapped potential habitat (Davey 2010). Currently 40 nesting trees used by the Superb Parrot have been identified in the ACT, and of these 22 are located in the proposed future suburb of Throsby.

Urban expansion into the Molonglo Valley in Canberra's south-west will have an impact on areas of habitat used by the Pink-tailed Worm Lizard, *Aprasia parapulchella*, a species listed as vulnerable in the ACT and nationally (see Table A4, Annex, *Native species - fauna* indicator cluster). Detailed habitat mapping and surveys have been undertaken as part of the urban development process in this valley. These studies have confirmed that nationally significant populations of Pink-tailed Worm

Lizard still exist along the Molonglo River. The maps have enabled the areas of habitat supporting key populations to be incorporated into the design of a large river park that is proposed as part of an offset strategy for the development. An additional conservation area, protecting habitat containing the largest and highest-density population of the species, to the west of the proposed urban development, is also proposed as part of the offset strategy.

One of the impacts commonly associated with urban development is an increase in domestic pets. Cats in particular can have a devastating impact on native wildlife. In recognition of this the ACT Government has required cats in new suburbs, for example Forde and Bonner in the Gungahlin area, to be contained within property boundaries at all times. These measures protect threatened native species in nearby nature reserves such as Mulligans Flat and Goorooyarroo as well as the cats themselves. A recent survey on the public perception of cat containment conducted on behalf of the ACT Government showed strong community support for cat containment in the ACT. An education campaign about the benefits of cat containment, both for the cats and for native wildlife, could build on this support and help increase cat containment in the ACT.

Other developments

The Enlarged Cotter Dam is a major project currently being undertaken by ACTEW Corporation and partners, to secure the future water supply of the growing ACT population. The project involves the construction of a new dam wall that will increase the area of Cotter Reservoir by 232 ha. The Cotter River is home to 5 threatened native aquatic species listed under the Nature Conservation Act 1980 (see Tables A2 and A3, Annex, *Native species - fauna* indicator cluster):

- Macquarie Perch (*Macquaria australasica*);
- Trout Cod (*Maccullochella macquariensis*);
- Silver Perch (Bidyanus bidyanus);
- Two-spined Blackfish (*Gadopsis bispinosus*); and
- Murray River Crayfish (*Euastacus armatus*).

The proposed works have the potential to affect some or all of these species through changes to breeding, shelter and foraging habitat. Research, via 9 separate projects, has provided information to guide mitigation that should minimise impacts to the threatened species through the construction and operation of the Enlarged Cotter Dam. The results of the studies should help in managing the species in the rest of

their range and therefore have conservation implications beyond the direct impact areas of the development.

Overgrazing

The remaining native grassy ecosystems of the ACT are of high conservation value for ecological communities because large areas of these lowland ecosystems elsewhere in the region have been cleared for agriculture and urban development. Overgrazing by rabbits, kangaroos and livestock are key threatening processes to the Territory's lowland native grassland sites (OCSE 2009). Kangaroos are a natural part of the native grassy ecosystems, but with the removal of natural controls such as dingoes and the provision of new areas of habitat through clearing, numbers of kangaroos have risen to a point where their grazing pressure puts other native species at risk (TAMS 2010b).

Response indicators

The *Nature Conservation Act 1980* (ACT Government 2011a) establishes the ACT Flora and Fauna Committee, and assigns it responsibility for assessing the conservation status of the native flora and fauna of the ACT and the ecological significance of potentially threatening processes. As previously stated, there are currently no threatening processes declared under the Act.

If a threatening process were to be declared under the Nature Conservation Act, then an Action Plan would be developed to minimise the effect of that process threatening any species or ecological community. Identification and subsequent nomination of the most significant threatening processes in the ACT might therefore help the formation of strategic approaches to address them.

Threatening processes have been declared under both Commonwealth and NSW legislation. The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government 2011) lists 19 key threatening processes of which 9 have been identified as threats within Action Plans for threatened species in the ACT (Table 4). The NSW *Threatened Species Conservation Act 1995* (NSW Government 2011) lists 36 key threatening processes, 19 of which are relevant to the biodiversity of the ACT. It may be appropriate for such threatening processes to be examined for nomination under the ACT Nature Conservation Act.

Table 4. EPBC Act threatening processes identified in ACT Action Plans

Key Threatening Processes declared under the EPBC Act
• Competition and land degradation by rabbits
• Infection of amphibians with chytrid fungus resulting in chytridiomycosis
• Land clearance
• Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
• Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases
• Predation by European Red Fox
• Predation by feral cats
• Predation, habitat degradation, competition and disease transmission by feral pigs
• Psittacine circoviral (beak and feather) disease affecting endangered psittacine species

Source: DSEWPaC 2009

Climate change and biodiversity

In 2009, the Office of the Commissioner for Sustainability and the Environment commissioned a report on the implications of climate variability and change for the Canberra nature reserves (Webb 2011). The report recommends a series of response strategies including:

- maintaining and enhancing ecosystems processes and services;
- enhancing ecosystem resilience through diversity, refugia and connectivity;
- facilitating ecosystems and species development (including 'novel ecosystems');
- land use planning;
- fire management;
- integrated governance; and
- adaptive management.

A study examining landscape function in the ACT's reserve system (Sharp 2011) has also made findings and recommendations that should be considered in future planning for Nature Park management.

In 2010 a workshop titled ACT Climate Change Vulnerability and Adaptation - Knowledge Needs for Natural Resource Management, was held[1] to identify knowledge gaps and priorities for improving natural resources management during climate change. The workshop developed options for knowledge management, and also fostered relations between the institutions. Outcomes of this workshop should be integrated into adaptive management for natural resources in the ACT.

Connectivity

The ACT Government commissioned the report *Ecological Connectivity for Climate Change in the ACT and Surrounding Region* (Manning et al. 2010), which provides a series of recommendations for enhancing connectivity in the ACT region. Specific locations in the ACT and region are identified where high priority should be given to maintaining or improving connectivity, and the report stresses the need to adopt whole-of-landscape connectivity as part of the planning process, irrespective of the tenure or use of the land. Other recommendations include the protection of scattered trees, anticipatory establishment or restoration of habitat, and assisted translocation in some cases. For more information see the *Ecological communities* indicator cluster paper.

Connectivity modelling is currently being conducted by researchers at the ANU for a range of planning purposes, including identifying connectivity corridors that could be included in the Canberra Spatial Plan, and conservation planning generally. Further work will contribute to woodland restoration in the ACT, and the location of restoration activity will be guided by the connectivity study. For more information on connectivity see the *Ecological communities* indicator cluster paper.

As discussed above, roads cut through the habitats of some native species and individuals are killed while crossing between habitat patches (TAMS 2010a). Mitigation measures such as the installation of underpasses with wing fences designed to funnel animals may help maintain connectivity and reduce the risk of native wildlife road deaths. Globally, this approach has been incorporated into many road systems, but the effectiveness of underpasses in the Australian context is yet to be proved (Rowden et al. 2008).

Underpasses and overpasses have been built into several new ACT road developments such as the Gungahlin Drive Extension and Majura Parkway. A

[1] co-hosted by the ACT Natural Resource Management Council (ACT NRMC), the Australian National University (ANU) Climate Change Institute, and the ACT Government Department of the Environment, Climate Change, Energy and Water (DECCEW)

drawback associated with better connectivity is that it can also facilitate pest and weed dispersal, but the potential benefits to native species would appear to outweigh the potential costs: most pest and weed species in the ACT are already widespread.

Firewood collection management

The *ACT Firewood Strategy 1999* promotes the use of fuelwood from mixed sources. Ideally, fuelwood should come from both hardwood plantations and softwood plantations, rather than native woodland outside ACT (collection within ACT not being permitted). Use of local plantation softwood and establishment of some fuelwood plantations could be part of a management strategy for woodland remnants, both in the ACT and in the region (ACT Government 1999). Potential air pollution and adverse health impacts from burning firewood should continue to be managed. See also the *Local air quality* indicator cluster paper.

Research into the location and characteristics of firewood source areas would improve understanding of the impacts of this process on both public and private lands. This research could be used to inform the community about the impacts of firewood collection on biodiversity, as well as the development of management strategies by government.

In addition it may be appropriate to decide whether on-the-spot fines should be issued for collecting fallen timber for use as firewood. The recent investigation into the ACT Government's tree management practices and the renewal of Canberra's urban forest (OCSE 2011) recommended developing a policy for sustainable reuse of timber, based on principles that include re-use of material from local urban trees, including for management and community purposes. Such a policy may help improve understanding of the use and management of wood collection in the ACT.

Weed management

Key policies and legislation relating to weed management in the ACT are:

- the *Planning and Development Act 2007* (ACT Government 2011c), which provides for agreements between the Government and rural lessees;
- the *Pest Plants and Animals Act 2005* (ACT Government 2011b), which provides for the declaration of pest plants, the preparation of pest plant management plans, the notification of a notifiable pest plant, and the creation of offences for the propagation of prohibited pest plants; and
- the *ACT Weeds Strategy 2009-2019* (DECCEW 2009), which, together with its annual implementation plans, provides a coordinated approach to weed management across rural leases and land managed by the ACT Government.

> Weed control targets specific weeds in specific locations via the Annual Weed Program. A class of plants may be declared to be pest plants, either generally or in a specified area. Once declared a pest, a plan for control of the propagation of the plants must be prepared.

The release and implementation of the *ACT Weeds Strategy 2009-2019* (DECCEW 2009) addresses one of the key recommendations of the *2007-08 ACT State of the Environment Report*. The Weeds Strategy gives priority to Weeds of National Significance (WoNS), and is guided both by the WoNS guidelines and the list of species declared under the ACT Pest Plants and Animals Act. Operational plans are currently being developed and updated.

Responsibility for managing pest plants in the ACT has been shared between ACT Parks and Conservation Service, Parks and City Services, ACT Planning and Land Authority and the Land Development Agency, with the Australian Government's National Capital Authority responsible for weeds on National Land. However, the recent restructure of the ACT management agencies into directorates under a single department may integrate the various ACT weeds management groups.

Effective implementation of weed control programs requires adequate support, coordination of action and ongoing resources. In recognition of this, the 2009-2019 strategy provided for the establishment of an ACT Land Managers Weeds Working Group (LMWWG) that is focused primarily on coordinating and implementing weed control programs across land management boundaries. To work with the LMWWG, a technical reference group has been established, which will give the LMWWG strategic direction and expert advice on weed matters.

Weed control programs are monitored using GPS-referenced photo points and mapping. The monitoring has shown a reduced cover of the priority weed species in targeted high conservation value areas. However, many other areas have shown an increase in weed cover (PCL 2009, 2010b). There has been some success in containing Mexican Feather Grass and African Fountain Grass. In high priority areas, the species and density of weeds since 2009 has been mapped and work is ongoing and expected to be included in future ACT Environmental Weed Control Operations Plans.

Pest management

The *ACT Vertebrate Pest Management Strategy* (Environment ACT 2002) is the principal planning and management tool for the management of fauna pest species. This document incorporates national developments in a strategic approach to pest management, based on reduction of damage caused rather than a reduction in pest numbers as an end in itself.

A review of the pest management strategy is currently underway: the *Draft Pest Animal Management Strategy 2011-2021* (ESDD 2011) identifies production of Pest Animal Management Plans, consistent with national threat abatement plans, as a key strategic action. Pest Animal Management Plans are most likely to be beneficial where a coordinated pest management response is required from multiple stakeholders across one or more land uses, and they are essential where management practices need to be enforced (ESDD 2011). The *2011-12 Vertebrate Pest Management Plan* is being developed.

In line with recommendations of the *2007-08 ACT State of the Environment Report*, the ACT Government has continued existing programs to manage known pest animals and is undertaking work to monitor and control emerging pests such as European wasps and deer.

Rabbits remain a challenge, as identified in a recent report, *Managing Rabbits in Canberra Nature Park* (Williams 2011). They are a prime cause of degradation of Canberra Nature Park, but strategic rabbit control has been implemented on only 6 of the Canberra Nature Parks because of inadequate resourcing that has also generated managerial and operational problems (Williams 2011). The report recommends focusing on resourcing, management, knowledge and research as well as operational issues in managing rabbit impacts.

Feral pig control used to be assessed annually in Namadgi National Park by performance monitoring to examine the relationship between pig rooting and reduced plant species richness. That work concluded in 2000, but ACT Parks and Conservation Service plans to establish follow-on monitoring to assess the effectiveness of the new 1080 baiting program (ESDD 2011).

Indian Myna birds are being successfully reduced in number in the ACT, largely through the efforts of the community-based Canberra Indian Myna Action Group (CIMAG). The group, operating in the ACT since 2006, aims to reduce the impact of the highly invasive Indian Myna through increasing public awareness of the problems caused by this species and by a humane trapping program. More than 37,000 Indian Mynas have been removed since the program started in 2006, and data indicate the species has dropped from the third (in 2005-06) to the thirteenth most commonly recorded species in 2010. CIMAG has inspired the formation of other groups in NSW, Victoria and Queensland, and the Canberra group provides support for these interstate Myna control activities. The group has assisted ANU research into the impacts of Mynas on native species.

Further information on current control of pest species in the ACT and the management outlook is in Table A2 in the Annex.

As was recommended in the *2007-08 ACT State of the Environment Report*, the effectiveness of pest animal and weed control programs should be evaluated on their success in achieving biodiversity and catchment-management aims. Best practice pest management assesses the response of the protected ecosystem or species, rather than the number of pests. Such performance or outcome monitoring is not generally undertaken in the ACT; for example, indices of rabbit abundance use spotlight transects or counts of active entrances to warrens. It is recognised that the ACT has relatively large conservation areas and limited resources. Therefore, a plan of robust performance monitoring should be developed for pest control programs (Clayton and Cowan 2010, Reddiex et al. 2006), which would allow management efforts and limited resources to be strategically focused.

Overabundant native species

Canberra is unusual in having large populations of free-ranging kangaroos in its urban areas. In the absence of natural predators such as dingoes, and with large areas of grazing habitat available because of land clearing for urbanisation and agriculture, kangaroo populations in some areas of the ACT have grown very large and caused ecological damage through overgrazing. Management needs to reduce the sizes of these populations and the impacts that overgrazing causes to the lowland native grasslands and grassy woodlands.

In response to community and scientific concern about the overabundance of kangaroos and associated ecological, social and economic impacts the ACT Government prepared the *ACT Kangaroo Management Plan* which was released in 2010 (TAMS 2010a). The plan represents a significant advance in kangaroo management in the ACT. Its completion fulfils a recommendation of the *2007-08 ACT State of the Environment Report*.

The plan sets out the approach to be adopted in maintaining wild populations of eastern grey kangaroos in the ACT while managing their various impacts and ensuring their welfare. Particular consideration is given to managing kangaroo grazing pressure on native grassy ecosystems in the context of grazing pressure from all herbivores. The stated goals of kangaroo management in the ACT are to:

- maintain populations of kangaroos as a significant part of the fauna of the ‘bush capital’ and a component of the grassy ecosystems of the Territory; and
- manage and minimise the environmental, economic and social impacts of those kangaroo populations on other biota, grassy ecosystems, ACT residents and visitors.

It is important that monitoring is undertaken on the grassy ecosystems to determine the effect of managing kangaroo grazing. See the *Native species - fauna* indicator cluster paper for more information.

Fire management and ecology

Strategic planning

In 2009 a second version of the *Strategic Bushfire Management Plan for the ACT* was produced by the ACT Emergency Services Authority and ACT Territory and Municipal Services (ACT Government 2009). The plan provides a framework and lists actions to address the bushfire risk in the ACT, with this goal:

Through Government and the community working together, suppress bushfires and reduce their consequences on human life, property and the environment.

Bushfires are strategically managed or prevented in the ACT via bushfire management zoning. ACT-wide zoning maps are included in the Strategic Bushfire Management Plan, for all tenures. The plan allocates areas of land to particular zones with measurable treatment standards.

This approach makes it possible to clearly identify areas where the primary aim of fire management is to satisfy ecological requirements, so appropriate management strategies can be applied. Appropriate fire frequencies are determined using ecological thresholds.

Details of prescriptions and specific actions to be undertaken for particular areas of the ACT are contained in Regional Fire Management Plans developed by the ACT Government in consultation with the community. These plans are reviewed annually and identify target inter-fire intervals for ecological protection of different vegetation types following the initial planned burn. They also identify fire exclusion areas.

Monitoring

Annual surveys, which record potential changes in vegetation composition and structure as a consequence of prescribed burning, inform future management decisions and monitor biodiversity impacts of prescribed burns in the ACT. The ACT Government has been operating this program of surveys since 2005. In 2010, the team monitored 7 sites: 4 were prescribed burn sites where new survey sites were established, 2 were ongoing monitoring sites, and 1 was a long-term monitoring project.

Monitoring methods include Landscape Function Analysis and a rapid assessment survey. Landscape Function Analysis is a relatively new technique that focuses on soil characteristics. The rapid assessment includes photo monitoring sites.

A long-term monitoring project known as the Piccadilly Fire Ecology Project is looking at the interactions between fire and Snow Gum Woodland communities. The project spans 36 years and includes data from planned and unplanned fires. Results from the first 20 years of data indicate that the community is very resilient to repeated low intensity fires. Since 2008, monitoring undertaken by the ACT Government has collected data on the impacts of the devastating high-intensity fire of 2003. Trends emerging include some evidence of a decline in plant cover abundance under frequent fire regimes. The study indicates that this community may still decline under the 8-10 year fire frequency thought to be suitable for its recovery.

The impacts of other forms of hazard reduction in ecosystems, such as slashing or mowing, are not currently monitored to assess ecological outcomes and enable adaptive management, in the same way as prescribed burns are. Slashing and grazing are more likely to introduce or spread weeds than prescribed burns. Inappropriate mowing regimes have been identified as a key threatening process affecting lowland native grassland sites in the ACT (OCSE 2009). Information on the impacts of all forms of fuel reduction on the ecosystems of the ACT is required, to enable adaptive management and to develop appropriate annual site-operation plans for key sites such as lowland native grasslands. An ability to manage hazard-reduction activities in an ecologically sensitive manner is of increasing significance because of the predicted increase in fire frequency and intensity as a result of climate change.

Minimising risks to biodiversity

To minimise the risk of ecosystem impacts from fuel reduction activities, ecological guidelines have been prepared for the conduct of prescribed burns in the ACT. The guidelines include additional requirements to protect threatened and sensitive species (Table 5).

Table 5. Specified fuel reduction activities in the ACT

Flora/Vegetation		Fauna	
Species	**Requirements**	**Species**	**Requirements**
Black Cypress Pine (*Callitris endlicheri*)	As far as possible, this species must not be burnt.	Northern Corroboree Frog (*Pseudophryne pengeilleyi*)	Every practical measure is to be taken to protect this species and its habitat from burning.
Baeuerlen's Gentian (*Gentiana baeuerlenii*)	This species must not be burnt.	Smoky Mouse (*Pseudomys fumeus*)	Every practical measure is to be taken to protect this species and its habitat from burning.
Button Wrinklewort (*Rutidosis leptorrhynchoides*)	Restrict fires to December to March.	Grassland lizards (Grassland Earless Dragon *Tympanocryptis pinguicolla*, Striped Legless Lizard *Delmar impar*, Pink-tailed Worm Lizard *Aprasia parapulchella*)	Slashing is to be preferred to burning. Where burns are undertaken, they must be low-intensity and patchy. Preferably they should be undertaken in September-October (to avoid breeding season in summer) or March-April (to preserve winter vegetation cover).
Canberra Spider Orchid (*Arachnorchis actensis*)	As far as possible, burning of this species must be avoided.	Golden Sun Moth (*Synemon plana*)	Every practical measure is to be taken to protect mapped Golden Sun Moth areas. Surrounding areas must not be burnt between November and February.
Tarengo Leek Orchid (*Prasophyllum petilum*)	Every practical measure is to be taken to protect this species from burning.	Nesting birds	Areas with significant numbers of trees and/or shrubs must not be burnt during September-November.
Tuggeranong Lignum (*Muehlenbeckia tuggeranong*)	Every practical measure is to be taken to protect this species from burning.		
Showy Parrot-pea (*Dillwynia sericea*)	Burn with high-intensity fire to encourage seed germination. Minimise low-intensity prescribed burning.		

Flora/Vegetation		Fauna	
Riparian management zones (as defined in the Code of Forest Practice)	Every practical measure is to be taken to prevent burning. If burning occurs, fire retardant or fire fighting foam must not enter any stream and must not be used within 50 m of any stream containing threatened fish. Sediment and erosion controls should be assessed following burning to protect riparian areas. Where required, these should be in accordance with Environment Protection guidelines.		

Source: 2009-10 Burning Operational Plan - Ecological Guidelines Specified Conservation Actions

Post fire recovery

In partnership with NSW, a Burned Area Assessment Team (BAAT) has been development by TAMS in line with global best practice. This post-fire recovery team, including specialists in flora, fauna, flooding and erosion, assets and cultural heritage, was deployed during the 2010-11 fire season as a pilot project. The BAAT should facilitate rapid and strategic remediation activities following wildfires. There have been no significant fires since the establishment of the BAAT team.

Rapid response to a wildfire in southern Namadgi National Park in 2007-08 reduced the extent of the burn to 5 ha but the use of a bulldozer containment line created the need for post-fire rehabilitation work. Full track rehabilitation used a systematic approach, applied rapidly after the wildfire had been suppressed. In 2009, ACT Government staff revisited the site to assess the success of the rehabilitation works. The key findings were that the site was stable with very little evidence of soil loss and that vegetation of a similar composition to the original vegetation was re-establishing on the track. The recovery work is considered effective and the technique has been subsequently used to rehabilitate a post-fire site on Blundell's Road in Namadgi National Park.

Species recovery

Fire can be an important tool in the recovery of threatened species. In the *2010-11 Burning Operational Plan* a burn is planned at the site of a threatened annual herb Baeuerlen's Gentian (*Gentiana baeuerlenii)*. Despite monitoring the population of this plant since 1991, it has not been seen for over 12 years. If specimens are not detected

during the 2011 survey season a prescribed burn will take place with the objective of triggering germination of any seed that may persist at the site.

Prescribed burning is a proposed management action for the Small Purple Pea (*Swainsona recta*), listed as a threatened species in the ACT. Monitoring has failed to detect any recruitment of this species at one of the 5 sites that support this species in the ACT. A prescribed burn is thought likely to promote seedling recruitment, and may be undertaken in the future.

Glossary

Biodiversity: Biodiversity is the variability among living organisms from all sources (including terrestrial, aquatic, marine and other ecosystems and the ecological complexes of which they are part), at all levels of organisation, including genetic diversity, species diversity and ecosystem diversity

Ecological community: Ecological communities are naturally occurring groups of plants and animals. Their species composition can be determined by factors such as soil type, position in the landscape, climate and water availability.

Ecosystem: An ecosystem is a dynamic combination of plant, animal and micro-organism communities and their non-living environment (e.g. soil, water and the climatic regime) interacting as a functional unit. Examples of types of ecosystems include forests, wetlands, grasslands and tundra.

Environmental weed: Plant species not native to Australia and horticultural species that have escaped from cultivation

Habitat fragmentation: The result of removal (usually by clearing) of large parts of a natural area, resulting in the retention of only small parts (fragments or remnants) of habitat

Performance monitoring: Monitoring changes in pest or native animal impacts, or in their abundance or distribution, with the aim of evaluating management program success against established performance criteria and criteria for failure

Pest animal: an animal that causes more damage than good to a valued resource

Species: A level of biological classification comprising one or more populations of individuals capable of interbreeding to produce fertile offspring

Threatening Process: In relation to a species or ecological community, a process that threatens, or may threaten, the survival, abundance or evolution of the species or community and includes the spreading of a pest animal or pest plant

Weed: A terrestrial or aquatic species of non-native or native plant that is harmful to the natural environment (ecosystems/biodiversity), agriculture and other industries, or public amenity and health ACT

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ACT Natural Resource Management Council (ACT NRMC)

ACT Parks, Conservation and Land (PCL) - now part of the Environment and Sustainable Development Directorate (ESDD)

Australian Government Natural Resources Management Ministerial Council (NRMMC)

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)

Greening Australia

NSW Department of Energy, Climate Change and Water (DECCW)

Annex

Table A1. Summary of ACT Parks weed management moving towards the 2019 targets

Environmental weed species and 2019 target	Location	Snapshot of 2009 cover	2009-10 status or change since 2008-09	Comments
Mexican Feather Grass Target: Eradicate	Bendora Dam	Rare	Contained	
Spotted Knapweed, Madagascan Fireweed Target: Eradicate	Cotter Rd, Sulwood Dr	Rare	Eradicated	
Giant Willowherb Target: Eradicate	Gungahlin Pond	Uncommon	Contained	
Artichoke Thistle Target: Eradicate	Greenhills	Rare	Contained	
Madagascan Fireweed Target: Eradicate	Commonwealth Park	Rare	Eradicated	
Serrated Tussock, St John's Wort, African Lovegrass, Chilean Needlegrass Target: Reduce to isolated infestations	Canberra Nature Park, Namadgi National Park, Googong Foreshores, Tidbinbilla Nature Reserve	Uncommon	Reduced % cover	Exceptions: At Mt Pleasant Nature Reserve, Serrated Tussock and Chilean Needlegrass % cover have increased. African Lovegrass cover has increased at Tuggeranong Hill, Mt Taylor, Oakey Hill and Urambi Hills nature reserves.
Serrated Tussock, St John's Wort, African Lovegrass, Chilean Needlegrass Target: Reduce to isolated infestations	Agistments: Mugga-Mugga, Canberra Ave, Amtech, Molonglo-Coppins, Abattoir Holding Paddocks, Gungahlin 1 & 2 and One Tree Hill	Uncommon to Sub-dominant	Mixed results	Mixed results: % cover has increased at some agistments. For example African Lovegrass is sub-dominant at the Abattoir Holding Paddocks.

Environmental weed species and 2019 target	Location	Snapshot of 2009 cover	2009-10 status or change since 2008-09	Comments
Serrated Tussock, African Lovegrass, Chilean Needlegrass Target: Reduce to isolated infestations	Urban Open Space	Common to Dominant	Increased % cover	An example is the Watson powerlines corridor near Watson Woodlands and Mt Majura Nature Reserve.
Serrated Tussock, St John's Wort, African Lovegrass, Chilean Needlegrass: Target: Reduce to isolated infestations	Targeted rural roadsides	Uncommon to Sub-dominant	Reduced % cover	An exception is African Lovegrass. Its rapid rate of spread has been favoured by roadside mowing. Lack of resources for urban roadsides has allowed % cover to increase.
African Lovegrass, Chilean Needlegrass Target: Reduce % cover	Lower Molonglo River, Urban Waterways	Common to Dominant	Increased % cover	A very large increase in resources would be needed to contain the spread.
Alligator Weed Target: Reduce % cover	Yerabi Pond, Lake Ginninderra	Uncommon	Reduced % cover	
Serrated Tussock, St John's Wort, African Lovegrass, Chilean Needlegrass Target: Reduce % cover	Umbagong Districk Park, Non-reserve Priority 1-2 Urban Grasslands, Mt Rogers, Kowen Forest	Common	Reduced % cover	Kowen Forest will need an increase in control work in harvested areas - the loss of forest canopy leads to a increased % cover of Serrated Tussock.
Chilean Needlegrass, Serrated Tussock, African Lovegrass Target: Reduce % cover	Urban parks and open space	Common to Dominant	Increased % cover	

Environmental weed species and 2019 target	Location	Snapshot of 2009 cover	2009-10 status or change since 2008-09	Comments
Blackberry, Sweet Briar, Broom, Potentilla, Other Woody Weeds Target: Reduce % cover	Canberra Nature Park, Namadgi National Park, Tidbinbilla, Swamp Creek, Woodstock, Stony Creek, Bullen Range and Gigerline nature reserves, Lower Cotter Catchment	Rare to Common	Reduced % cover	Common in Canberra Nature Parks - Mt Pleasant and some former grazing properties on reserved land.
Sweet Briar, Bathurst Burr, Blackberry, Hawthorn, Crack Willow and Boxthorn Target: Reduce % cover	Agistments: Mugga-Mugga, Canberra Ave, Amtech, Molonglo-Coppins, Abattoir Holding Paddocks, Gungahlin 1 & 2 and One Tree Hill	Rare to Common	Reduced % cover	
Cotoneaster, Firethorn Target: Reduce % cover	Numerous urban parks, e.g. RSL Park Campbell	Uncommon to Common	Increased % cover	
Blackberry, Sweet Briar Target: Reduce % cover	Targeted rural roads	Uncommon to Common	Reduced % cover	
Blackberry, Cootamundra Wattle Target: Reduce % cover	Urban arterial rural roads	Common to Dominant	Increased % cover	Exception: Cootamundra Wattle spread on some urban arterial roadsides corridors is being contained by the Bushfire Operation Plan works program.

Environmental weed species and 2019 target	Location	Snapshot of 2009 cover	2009-10 status or change since 2008-09	Comments
Black Willow, Black Alder, Crack Willow, Blackberry Target: Reduce % cover	Molonglo Gorge Forest Reserve, Lower Molonglo Nature Reserve, Molonglo Reach, Westbourne Woods, Riparian sections of Swamp Creek, Woodstock, Stony Creek, Bullen Range and Gigerline nature reserves	Common to Dominant	Reduced % cover	Exceptions include the following sections of the Molonglo River: Oaks estate to Fyshwick, Pialligo, Scrivener Dam to Greenhills and Jerrabomberra Wetlands Nature Reserve (work will be done in 2010-11).
Blackberry, Broom, Cootamundra Wattle, Cotoneaster, Firethorn, Hawthorn Target: Reduce % cover	Urban open space areas, Pierces Creek Forest, Kowen Forest	Common to Dominant	Increased % cover	Blackberry control will need to increase in Pierces Creek and Kowen forests to keep up with the rapid rate of spread. Exceptions are where the Bushfire Operations Plan has targeted woody weeds in high fire risk areas. At these sites cover has been reduced.
Nodding Thistle, Paterson's Curse, Viper's Bugloss, Verbascum Target: Reduce % cover	Namadgi NP, Tidbinbilla Nature Reserve, Canberra Nature Park	Uncommon to Common	Mixed results	These broadleaf weeds have large fluctuations in % cover with seasonal conditions. Common on the former grazing properties in reserved land, and along disturbed areas such as roadsides and fire trails.

Environmental weed species and 2019 target	Location	Snapshot of 2009 cover	2009-10 status or change since 2008-09	Comments
Paterson's Curse, Thistles Target: Reduce % cover	Agistments: Mugga-Mugga, Canberra Ave, Amtech, Molonglo-Coppins, Abattoir Holding Paddocks, Gungahlin 1 & 2 and One Tree Hill	Uncommon to Common	Mixed results	
Caltrop, Khaki Weed Target: Reduce % cover	Open Space Areas eg. From Tuggeranong Open Space to Point Hut Crossing Car park	Uncommon to Dominant	Increased % cover	Exceptions are where City Parks - La-Trobe Depot staff have contained the spread of Caltrop.
Broadleaf weed species Target: Reduce % cover	Urban Arterial roadsides	Common to Dominant	Increased % cover	Highly disturbed sites - which favours spread of broadleaf weeds, eg. Thistles, Paterson's Curse, Capeweed, Caltrop.
Nodding Thistle, Viper's Bugloss Target: Reduce % cover	Boboyan Rd	Uncommon to Common	Reduced % cover	
Broadleaf weed species Target: Reduce % cover	Riparian areas	Common to Dominant	Mixed results	Thistles and Verbascum increase and decrease with seasonal flows and are not usually targeted for control work in these environments.

Source: ACT PCL 2010b

Table A2. Current pest control actions in the ACT

Species	Current management and monitoring practices	Outlook
European Rabbit	• Management programs are conducted at the landscape scale, involving all adjoining land managers. • Pre and post-management monitoring conducted to assess effectiveness of control programs. • Long-term spotlight monitoring of populations conducted in Namadgi National Park (Namadgi National Park), Tidbinbilla Nature Reserve (Tidbinbilla) and Googong Foreshores. • Cooperative, targeted community involvement in mapping and/or monitoring of rabbit populations. • Where terrain limits physical control actions the objective will be to reduce abundance to the 'low equilibrium range' where predators will tend to keep rabbit numbers low.	• Continuing participation in the national Rabbit Haemorrhagic Disease (RHD) program by supply of RHD-infected carcasses and testing of new RHD strains as they are developed. • Maintain community participation in mapping/monitoring of rabbit populations. • Stay aware of new and emerging technologies, e.g. carbon monoxide pressure fumigator being developed by the Invasive Animals CRC.
European Red Fox	• 1080 baiting programs undertaken in high-conservation, non-urban parks and reserves to reduce impacts on native species and neighbouring sheep-breeding enterprises. • Mulligans Flat Sanctuary maintained as fox-free area.	• Participate in site-based research programs on fox biology or new control methods. • Improved coordination of control programs across differing land tenures. • Implications for Brush-tailed Rock Wallabies need to be evaluated if their re-introduction is contemplated.
Dingo/Wild Dog	• 1080 baiting, 1080 ejectors and trapping occur in a control area of several kilometres between sheep-growing areas and parks and reserves. • Cooperative cross-border dog/fox management plans undertaken with NSW. • Sand-pad monitoring is used to assess effectiveness of management in buffer zone areas in southern Namadgi National Park. • Information signs about wild dog biology and behaviour erected at locations where park visitors are most likely to encounter wild	• Wider use of 1080 ejectors to improve cost effectiveness of baiting. • Seek further opportunities for collaborative research on movement patterns, the dingo's role in ecosystems, genetic integrity and control techniques. • Improve effectiveness of wild dog management by seeking further landholder participation in cooperative

Species	Current management and monitoring practices	Outlook
	dogs. • Australian Alps wild dog fact sheet available at visitor centres and on display boards at camp sites/toilets. • Promotion and education that wild dogs are performing function of top order predator in protected area landscapes.	wild dog management programs and on-farm stock protection via fencing and guardian animals. • Investigate use of remote cameras for monitoring of wild dogs • Interpretive pamphlets explaining presence and function of wild dogs in protected areas.
Feral Pig	• 1080 poisoned baiting has now replaced warfarin for the annual control program in southern parks and reserves, to keep impact to acceptable levels. • Targeted trapping is used to remove pigs that cause damage to specific sensitive or public areas, or where poisoned baiting is not possible. • Exploring options for alternative monitoring protocols following cessation of monitoring of pig abundance plots in Namadgi National Park. • Baiting of ACT parks and reserves is coordinated with parallel programs in neighbouring NSW parks. Free poisoned bait offered to rural landholders who participate in cooperative baiting programs.	• Continue to participate in trials of new feral pig toxins. • Continue to test new delivery systems for pig bait, particularly those suitable for use in remote areas. • Important to maintain some form of monitoring of feral pig abundance and impacts in Namadgi National Park to assess effectiveness of the annual program, new baiting regimes and toxins.
Feral Goat	• Populations currently at acceptable levels following aerial shooting and 2003 fires. • Continued monitoring of mob locations and size. • Ground-based shooting where practicable. • Mustering of goat mobs in collaboration with rural landholders. • Trial trapping on reserves, and rural land in collaboration with rural landholders.	• Joint control programs with NSW for border areas. • Re-visit radio-collaring 'Judas' goat technique when necessary.
Feral Horse	• Feral horses in remote areas of the Bimberi Range in Namadgi National Park managed by trapping, sedation and euthanasia. • Namadgi National Park Feral Horse Management Plan also allows for aerial	• Continual re-infestation likely from Kosciuszko National Park, requiring continuation of regional collaboration to facilitate cross-border control

Species	Current management and monitoring practices	Outlook
	shooting of trap-shy animals. • Photo-point monitoring of sub-alpine bogs impacted by feral horses.	programs. • Continue partnership with Australian Alps National Parks agencies to support feral horse research in the region.
Fallow Deer Red Deer Sambar Deer	• General monitoring of occurrence via a sightings database. • Rural lessees advised to shoot any deer that occur on rural land. Trials of attractants to improve the efficiency of ground shooting. • Education on deer impact and seasonal behaviour.	• Maintain regional liaison and surveillance. • Participate in research projects on deer ecology and management. • Management implications of further escapes/releases of animals from deer farms in the ACT region.
Feral Cat	• Targeted, intensive programs using trapping and shooting for sites of significance. • Continuing control and fence maintenance in sites of significance. • Cat containment requirement in new suburbs adjacent to high-value conservation areas.	• Maintenance of a watching brief on new management developments. • Participation in research on ecological significance of cat predation on native species.
Brown Hare	• Fencing, tree guards, chemical deterrents or shooting in response to damage.	• Likely to be continuation of current practices.
Indian Myna	• No cost-effective control method available for use on public land. • Protective measures undertaken on an individual basis by producers. • Public referred to Canberra Indian Myna Action Group for advice on trapping in backyard situations.	• Continue to support research on new control techniques and on quantification of impacts of Indian Mynas. • Community Indian Myna control has effectively reduced numbers in the ACT.
Common Starling	• No cost-effective control method available for use on public land. • Protective measures undertaken on an individual basis by producers.	• Continuing industry investigation of cost-effective and environmentally benign control measures.
Feral Pigeon (Rock Dove)	• No cost-effective method available for use on public land. • Licensed pest controllers may be authorised to use poisoned bait for specific, small-scale situations.	• Maintenance of a watching brief on new management developments.
Non-local aviary	• Maintenance of licensing system to reduce risk of escape of problem species.	• Community education regarding species of concern

Species	Current management and monitoring practices	Outlook
escapees		and responsible bird keeping.
Carp	• Participation in the Murray-Darling Basin Authority ACT Regional Carp Control Plan. • Programmed fish monitoring program. • Angler education. • Eradication of farm dam populations in otherwise un-infested catchments.	• Maintenance of a watching brief on emerging management and control measures. • Opportunistic continuing eradication of new farm dam populations. • Community education.
Feral Goldfish	• Programmed fish monitoring program. • Angler education.	• Community education. • Continuation of fish monitoring program.
Redfin Perch	• Programmed fish monitoring program. • Angler education.	• Community education. • Continuation of fish monitoring program.
Oriental Weather-loach	• Programmed fish monitoring program. • Angler education.	• Community education. • Continuation of fish monitoring program. • Maintenance of a watching brief on research to determine ecological impact of the species.
Brown Trout Rainbow Trout	• Programmed fish monitoring program. • Stocking of selected impoundments, i.e. at Googong. • Ban on stocking streams.	• Improved angler appreciation of issues involved. • Increased alignment with regional fish stocking policies.
Eastern Gambusia Fish	• Angler education.	• Community education. • Continuation of fish monitoring program. • Maintenance of a watching brief on research for impact and control of the species.
Discarded aquarium fish	• Education of aquarium keepers. • Participation in National Ornamental Fish Management Implementation Group (OFMIG).	• Community education. • Continuation of fish monitoring program. • Implementation of OFMIG pest lists. • Increase control on importation of pest species.
Over-	• Procedure in place for kangaroo culling on	• Continuing investigation of

Species	Current management and monitoring practices	Outlook
abundance of native species e.g. Eastern Grey Kangaroo	rural properties. • Response to other issues on a case-by-case basis. • 'Living with nature' ethos promoted.	management options in response to issues arising. • Community education regarding management alternatives. • Improved monitoring of population and distribution trends with support for related research.
Non-local crustaceans (Marron etc.)	• Surveillance of potential sources of introduction. • Education of aquarium keepers.	• Community education. • Continuation of fish monitoring program. • Compliance with National Policy for the Translocation of Live Aquatic Organisms.
European Wasp	• A contract consultant will provide an identification service and advice to the ACT community on European Wasps. • European Wasp Hotline. • All confirmed nests on Territory land will be treated within 24 hours. • In high-use barbecue/picnic areas where a nest cannot be located, a baiting program will be implemented during the breeding season when wasps are particularly aggressive.	• Adequate stocks of European Wasp brochures are to be available at Visitor Information Centres. • It is critical that media coverage is provided to remind residents to be aware of European Wasps and to encourage people to report nests.
Honey Bee	• Will only treat bee swarms if they pose a high risk to the public, e.g. a swarm in a high-use shopping centre or adjacent to a child-care centre or school.	• Will only treat bee swarms for nature conservation purposes if increasing numbers of bee swarms setting up in tree hollows become a key threatening process.
Termite	• Nests within 60 m of structures under attack must be destroyed within 14 days of Parks and Conservation being notified in writing by the pest control firm.	• Where a termite nest is not located, private leaseholders may consider the installation of a chemical soil barrier to prevent possible future termite attack of their residence from the soil.
Meat Ant and Sugar Ant	• Only treat Meat Ant nests if they occur at bus stops, barbecue areas or playgrounds • In exceptional circumstances, where ants are	• Residents are strongly urged to consider alternative ant control methods if ants are foraging in

Species	Current management and monitoring practices	Outlook
	genuinely invading a private property and making it uninhabitable to residents, i.e. residents or children are being bitten by ants.	backyards, e.g. removal of food sources which may attract ants.

Source: TAMS

ACT State of the Environment Report 2011

THEME: Air

Introduction to Theme

Air quality affects the condition of the environment and has an impact on human health and amenity. There is a legislative requirement for jurisdictions to monitor outdoor air quality in areas with large populations to ensure it meets the ambient air quality National Environment Protection Measure (NEPM).

Two Indicator clusters are drawn on for the Air theme, namely:

- *Local air quality*
- *Indoor air quality*

Context

Canberra's good outdoor air quality has not changed significantly during the last two State of the Environment reporting periods. As highlighted in the 2003 and 2007-08 State of the Environment Reports, bushfires and duststorms can occasionally create short-term increases in air pollutants, especially particulate matter.

On a day-to-day basis, emissions from motor vehicles and winter smoke from wood-burning fires have been highlighted in the two previous State of the Environment Reports as key sources of air pollution in the ACT. Action to reduce woodsmoke emissions has contributed to a reduction in particulate matter in the air.

Recommendations to encourage low-emission vehicles and publicly report air-quality data have been implemented. Expectations of extra nephelometers to be used for campaign or mobile monitoring of smoke pollution, related to ambient air quality, noted in the 2003 State of the Environment Report, have not been met because of calibration, set up and data gathering requirements. Their use for this purpose needs to be clarified.

Both the 2003 and 2007-08 State of the Environment Reports highlighted a lack of knowledge of indoor air quality with several recommendations to improve information. These recommendations have not been implemented and knowledge of indoor air quality in the ACT remains limited.

Many of these issues remain relevant in this reporting period and recommendations are provided at the end of this paper to assist progress.

Source: ACT Government

Theme summary: Key issues and outcomes

Local air quality

As in previous reporting periods, Canberra has relatively clean air with few exceedances of standards.

Motor vehicles are still the dominant source of outdoor air pollution in the ACT. The good air quality enjoyed in the ACT is, in large part, due to the lack of other common sources such as heavy industry and concentrated high-density urban development, and the ACT still has a relatively small population.

As noted in previous reporting periods, monitoring indicates that particulate matter is the only outdoor ambient air quality pollutant of concern in Canberra's air. Particulate matter exceedances are generally caused by woodsmoke from point sources in an area, and do not affect the whole ACT airshed. However, the whole airshed can be affected by events such as bushfires and duststorms.

In 2009, particulate matter (PM10) measured at the Monash performance monitoring station in the southern part of Canberra exceeded the NEPM standard. Compliance with the NEPM goal is achieved if there are 5 or fewer days per year when PM10 exceeds the NEPM standard. This goal was not met in 2009, with 9 exceedances recorded at the Monash site.

During the reporting period, the ACT population increased, triggering the requirement for a second outdoor air performance monitoring station for reporting under the NEPM (EPA 2010). A performance monitoring station at Civic (in central Canberra), whilst not NEPM compliant is currently providing limited data until a more suitable performance monitoring station can be established, possibly in the north of the ACT.

Air quality depends not only on rates of emission but also on prevailing weather conditions and local topography. On a windy day, contaminants can be dispersed quickly and concentrations near a given emission source can be lower than on days when there is little wind to move them. In the ACT, atmospheric inversions such as can occur on a calm still night may cause contaminants to be trapped by the landscape and consequently reach higher concentrations.

While there are no specific data on direct health impacts of air pollution in the ACT, a number of national and international studies have identified key health impacts of air pollutants. The most common of these are respiratory and cardiovascular disorders (both chronic and acute). However, understanding the health effects of air pollutants is complex because individuals vary greatly in their sensitivity to air quality. A concentration which may cause symptoms in one person may have no discernible effect on another.

The NEPM aims to reduce the health impact of airborne pollutants by setting standards to protect the community from adverse health impacts. Continuing to meet outdoor air quality standards in the ACT should help in managing the risk of health impacts associated with *local air quality.*

Indoor air quality

Little information is available on the quality or impacts of pollutants in indoor air. There is no specific information on indoor air quality publicly available in the ACT, although some private organisations may have data from years of monitoring. As with outdoor air quality, the quality of indoor air will depend on the sources of and nature of contaminants, the air flow in the area and the rate at which the contaminant is emitted.

Indoor air quality can be affected by:

- outdoor air entering and being distributed around the building;
- emissions from processes and equipment in the building (e.g. cleaning substances, furniture, printers);
- emissions from occupants (e.g. environmental tobacco smoke); and
- emissions from construction and finishing materials (e.g. foam insulation, asbestos).

A number of potential health impacts are associated with indoor air pollution, particularly respiratory disorders. However, as with outdoor air pollution, the linkages between indoor air pollution and human health are complex. Despite recommendations in several previous ACT State of the Environment Reports, there remains a lack of knowledge and data on indoor air pollution in the ACT.

Source: ACT Government

Responses and effectiveness

Following a recommendation in the *2007-08 ACT State of the Environment Report*, the ACT Environment Protection Authority released the first annual outdoor ambient ACT Air Quality Report in July 2010 (EPA 2010). That report provides information on air quality monitoring in the ACT, and the Territory's compliance with the NEPM for ambient air quality.

Mobile monitoring of ambient air quality has been recommended in several previous ACT State of the Environment Reports, for hotspots such as road intersections. However, as yet that recommendation has not been implemented.

There are national and ACT programs aimed at improving air quality. National work currently focuses on emissions of particles and the reagents that form ozone, from sources including wood heaters, small engines, surface coatings and non-road engines. National legislation governs standards for emissions from car exhausts. The introduction of the Green Vehicle Guide website (Commonwealth of Australia 2010) gives consumers information on cars' air contaminant emissions as well as their 'greenhouse gas' impacts.

In the ACT, education and enforcement programs are in place to address the emissions of air pollutants from motor vehicles and wood heaters including:

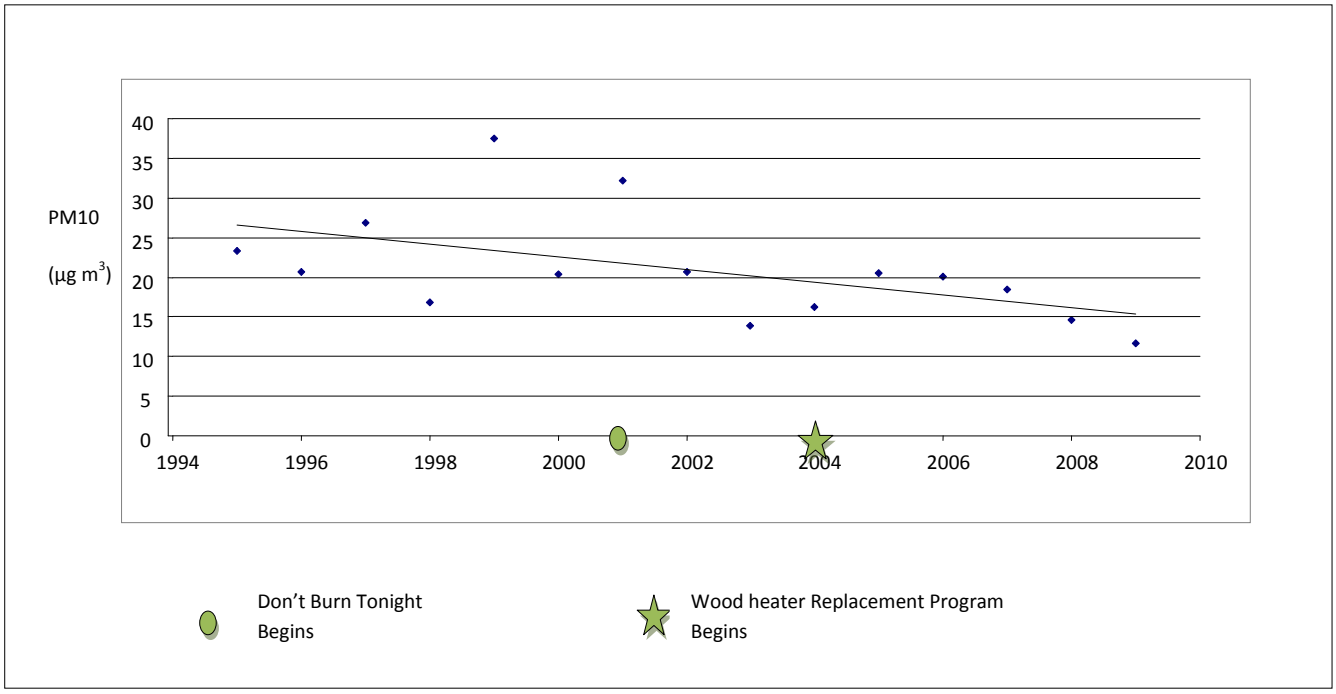
- ACT Green Vehicles Duty Scheme - offers differential stamp duty costs for new vehicles based on their performance in relation to air pollution (and greenhouse gas emissions) (ACT Government 2008);

- Don't Burn Tonight - a campaign that encourages Canberrans to use alternative heating on cold still nights when smoke from household wood fires is unlikely to clear quickly;
- Wood Heater Replacement Program - a subsidy offered to eligible householders for replacing wood heaters with new mains-supplied gas heating.

Small reductions in carbon monoxide emissions over the reporting period are likely to be a result of the focus on lowering emissions from individual cars. However, total emissions are dependent on the number of vehicles on the road and the total distances travelled. Actions to reduce reliance on motor vehicles (see *Transport* indicator cluster for more information) are also likely to help improve outdoor air quality in the ACT.

Reduced particulate matter (PM10) has been noted in the long-term trend for the Tuggeranong Valley beginning in 2002 (Bridgman 2009).

Figure 1. Average daily particulate matter (PM10) emissions during winter, 1995–2009 (micrograms per cubic metre of air)



Source: Adapted from Bridgman 2009

The ACT Environment Protection Authority (EPA) recently reviewed existing programs aimed at reducing wood smoke in the ambient air of the Tuggeranong Valley. The review found that more could be done to reduce total emissions of smoke from household wood heaters. There is an Australian and New Zealand standard for particle emissions factors (AS/NZS 4013 - Determination of particle emissions factors), currently enforced in Tasmania, which makes it illegal under the Building Regulations for a dwelling to operate a non-certified wood heater. Implementation of such a

regulation in ACT would expedite the removal of non-certified wood heaters and reduce the emission of wood smoke.

Air quality measurements for all new greenfield developments in the ACT can help ensure that potential future air pollutant issues can be identified and managed proactively. In some instances where this has been implemented, air quality management initiatives have been integrated with planning and development. For instance, crown leases in East O'Malley and Dunlop require written approval by the ACT Government for installation or use of solid fuel heating systems.

For *Indoor air quality*, a continuing lack of data for the ACT is limiting potential management of contaminants in workplaces and homes. ACT legislation now in place, banning cigarette-smoking in public buildings and licensed premises, can be assumed to have reduced environmental cigarette smoke concentrations and improved indoor air quality for many people. Contamination of indoor air in the workplace is managed under occupational health and safety legislation, but there is no equivalent legislation to address indoor air pollution in non-workplace environments. Structural elements and materials used in buildings in the ACT will also play a role in indoor air quality.

Emerging issues

The recent *Review of the National Environment Protection (Ambient Air Quality) Measure Discussion Paper Air Quality Standards* (NEPC 2010) improves the amount of information available on health effects of outdoor air pollution. Of concern are Australian studies identified in that report which indicate that health effects can occur when carbon monoxide, oxides of nitrogen, and ozone are at concentrations lower than the current NEPM Ambient Air Quality standards. For health effects in relation to particulate matter also, the report identifies that there is no threshold below which various health effects are not observed. This poses a significant challenge for proposing standards for particulate matter which would protect the community from potential health effects. That Report is soon to be reviewed by the Environment Protection and Heritage Council, and the review's recommendations will be prioritised and responded to through the development of the National Plan for Clean Air.

The good air quality enjoyed in the ACT is, in large part, because of the lack of heavy industry and concentrated high-density urban development, the relatively small population, and wind factors. Future increases in population and housing density have the potential to impact on the air quality in the ACT. Future climate scenarios with increased risk of fire and drought will also potentially affect the air quality of the ACT (see *Climate vulnerability* indicator cluster paper).

For *Indoor air quality,* the design and construction of modern buildings often make them better sealed than older buildings, with less air exchange between indoors and outdoors. Air or heat exchanges can improve indoor air quality, but there are currently no minimum air-flow standards.

Recommendations

1. To improve knowledge of our indoor air quality, the Chief Health Officer should consider the health impact of indoor air quality in the ACT in the 2014 Chief Health Officer Report.

2. Improve local air quality outdoors through:
   a. requiring air quality assessments in all new greenfield developments, to identify and manage air emissions, potentially detrimental to human health and the environment;

   b. installing and operating a second performance air monitoring station to ensure that the ACT is compliant with NEPM standards; and

   c. determining the feasibility, including costs, of mobile monitoring of appropriate ambient air quality NEPM standards at locations in and around Canberra.

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

Environment Protection Authority, ACT Department of the Environment, Climate Change, Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

ACT State of the Environment Report 2011

THEME: Air

Indicator cluster: Local air quality

- Local air quality (C) - includes carbon monoxide, nitrogen dioxide, photochemical oxidants (such as ozone), sulfur dioxide, lead, particles as PM10, particles as PM2.5 (NEPM requirements) and also volatile organic compounds;
- Vehicle emissions (P) - type and volume of vehicle emissions;
- Other emissions (P) - type and volume of other emissions, including particulates and smoke from fires;
- Air emissions and health impacts (I) - health impacts from local air emissions; and
- Air quality management (R) - effectiveness of air quality management responses - also linked to *Natural hazards* indicator cluster in the *People* theme.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data for the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

Local air quality refers to the air quality outdoors over the ACT - that is, in the ACT airshed. Local air quality has met the National Environment Protection Measure (NEPM) standards for carbon monoxide, nitrogen dioxide and ozone during the reporting period, 2007-2011. Carbon monoxide emissions have decreased slightly from the levels reported in the *2007-08 ACT State of the Environment Report*. Particulate matter continues to be a concern because the NEPM standard for particulates smaller than 10 micrometres was not met in 2009.

Motor vehicles remain the dominant source of air pollutant emissions in the ACT. Particulate matter exceedances are generally caused by woodsmoke from point sources in an area, and do not affect the whole ACT airshed. However, the whole airshed can be affected by events such as bushfires and duststorms.

No quantitative data are available on health impacts of outdoor air emissions in the ACT, but studies across Australia and the world have found that the most common health impacts of local air pollution are respiratory and cardiovascular disorders (both chronic and acute). A recent report identified negative health effects occurring below the current NEPM Ambient Air Quality standards for carbon monoxide, oxides of nitrogen and ozone.

ACT State of the Environment Report 2011

During the reporting period the ACT Government continued to implement programs focused on reducing air pollution emitted from vehicles and wood heaters. These are likely to have contributed to the continuing small reductions in carbon monoxide emissions and long-term declines in some particulate matter (PM10) concentrations.

Introduction

The emission of pollutants into the atmosphere can lead to concentrations of gases and particulate matter that can have adverse impacts on some ecosystems and human health. The ACT Government has been monitoring ambient air quality in Canberra since the early 1990s. Compliance with the National Environment Protection Measures (NEPM) (EPHC 2011) requires the ACT Government to monitor carbon monoxide, nitrogen dioxide, ozone and airborne particles. Two sizes of airborne particles are measured: less than 10 micrometres (microns) and less than 2.5 microns in diameter, known as PM10 and PM2.5 respectively. The monitoring of lead ceased in July 2002 following the phase-out of leaded fuel by 1 January 2002, with ambient air lead concentrations being less than 2% of the standard. The ACT Government has never monitored sulfur dioxide because of the absence of heavy industry in ACT (EPA 2009).

Condition indicators

Air quality in the ACT is measured and monitored by the ACT Government and assessed against NEPM standards[1] (Table 1).

[1] Air quality complies with standards if the number of exceedances of the standard is no more than the number specified in Schedule 2 of the NEPM, and data availability was at least 75% in each quarter of the year. Air quality is assessed as 'not demonstrated' if the data collected have been insufficient to demonstrate that the standards and goal have been met or not met.

Table 1. NEPM standards and goals to be achieved by 2008

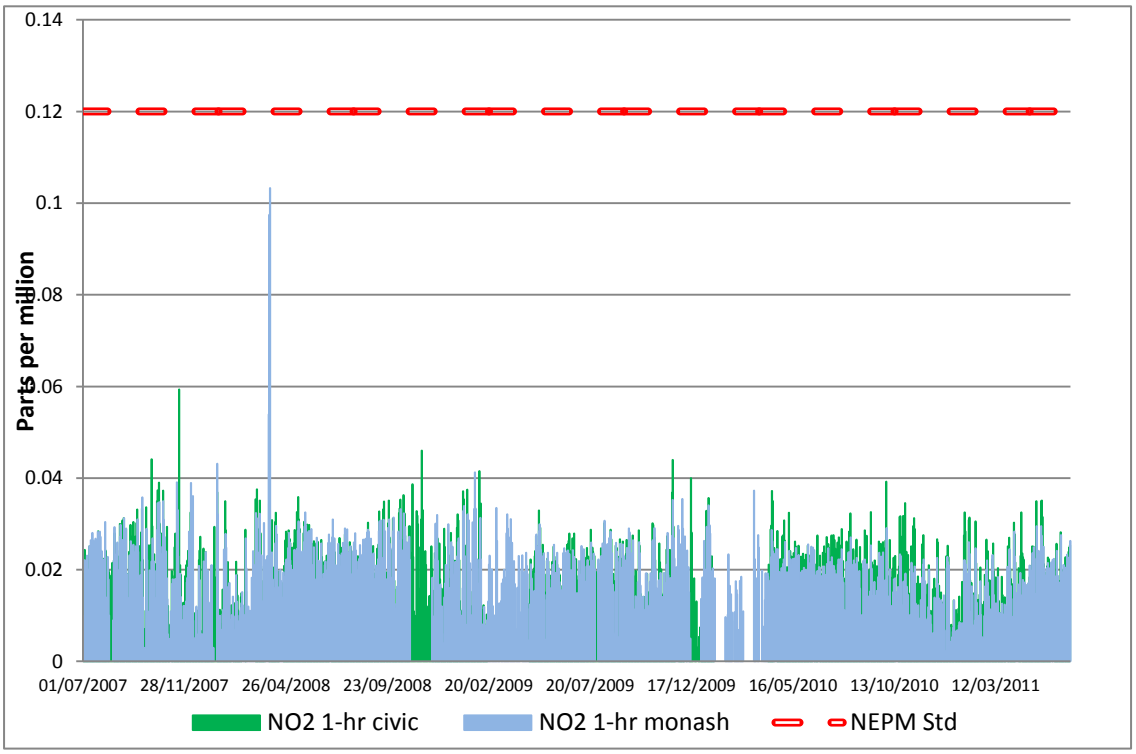
Pollutant	Averaging period	Maximum concentration relative to volume of air	Maximum allowable exceedances
Airborne particles (as PM10)	1 day	50 µg/m^3	5 days per year
Airborne particles (as PM2.5) - reporting standard only	1 day	25 µg/m^3	Gather sufficient data nationally to facilitate a review of Advisory Reporting Standard.
	1 year	8 µg/m^3	
Carbon monoxide	8 hours	9.0 ppm	1 day per year
Nitrogen dioxide	1 hour	0.12 ppm	1 day per year
	1 year	0.03 ppm	None
Ozone (photochemical oxidants)	1 hour	0.10 ppm	1 day per year
	4 hours	0.08 ppm	1 day per year

Source: NEPC 2010

ACT Government Health Directorate staff measure air quality at the performance monitoring station at Monash in the Tuggeranong Valley, southern ACT, which has been operational since 1996. During the reporting period the population of Canberra increased so that the ACT now requires a second outdoor air performance monitoring station for reporting relative to the NEPM (EPA 2010a). A monitoring station at Civic, in central Canberra, is currently providing data until a more suitable performance monitoring station can be established, possibly in the north of the ACT. Until a second ambient air quality NEPM performance monitoring station can be established, data from the Civic performance monitoring station, through not ideally located, will be used for annual report purposes.

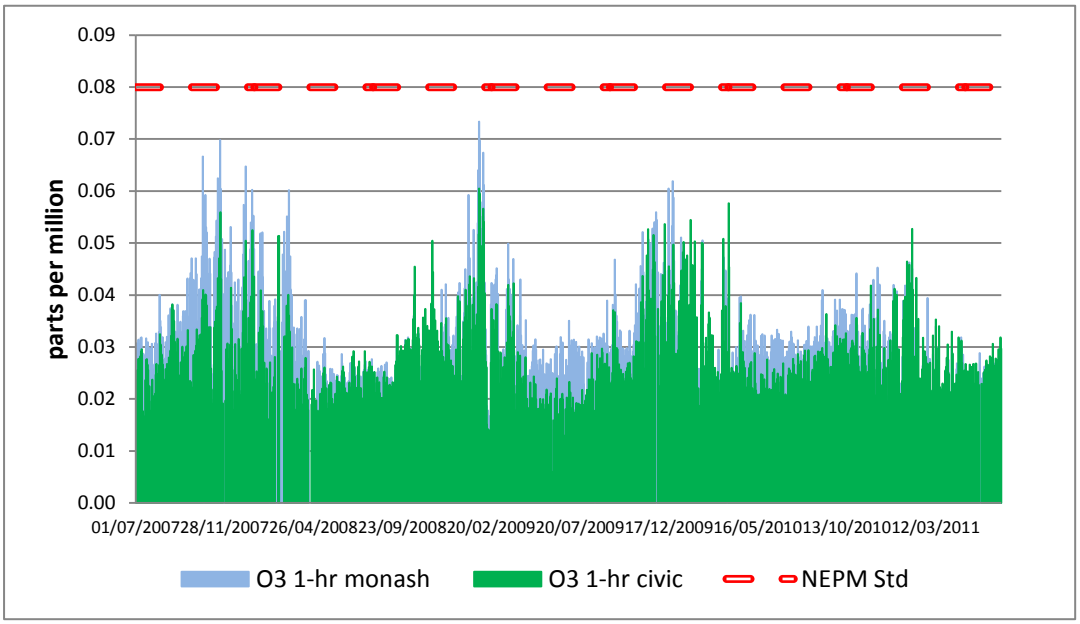
Air quality in the ACT met NEPM standards for carbon monoxide, nitrogen dioxide and ozone during the reporting period. Long-term nitrogen dioxide data (Figure 1) and ozone data (Figures 2 and 3) show no discernible trend, and are all below the thresholds set by the NEPM standards. Gaps in the record for nitrogen dioxide were caused by failure of equipment at both stations in 2010.

Figure 1: Nitrogen dioxide concentrations measured at Monash and Civic monitoring stations



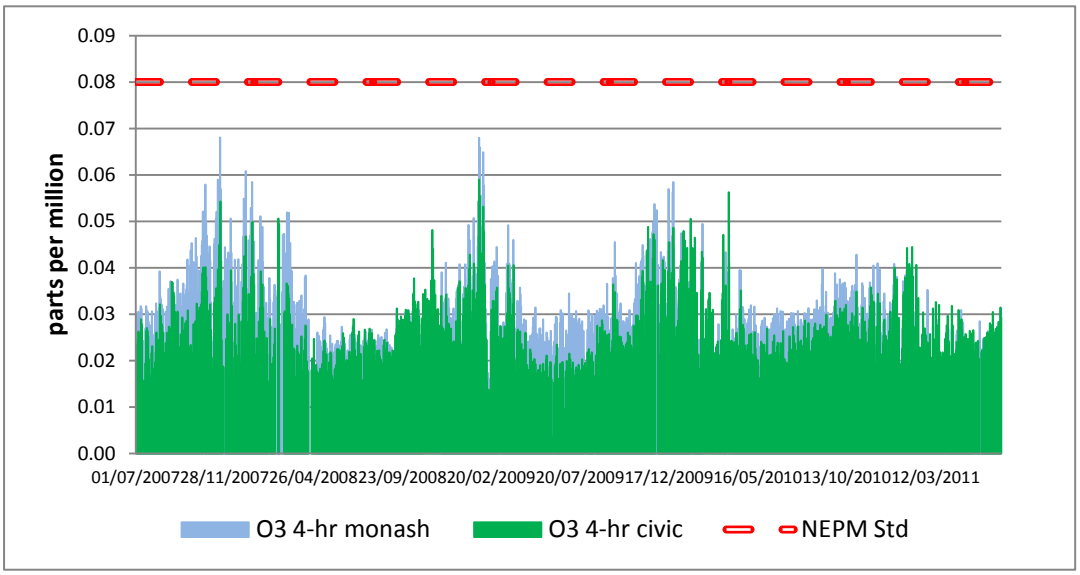
Source: Environment Protection Authority

Figure 2: Ozone - 1-hour concentrations measured at Monash and Civic monitoring stations



Source: Environment Protection Authority

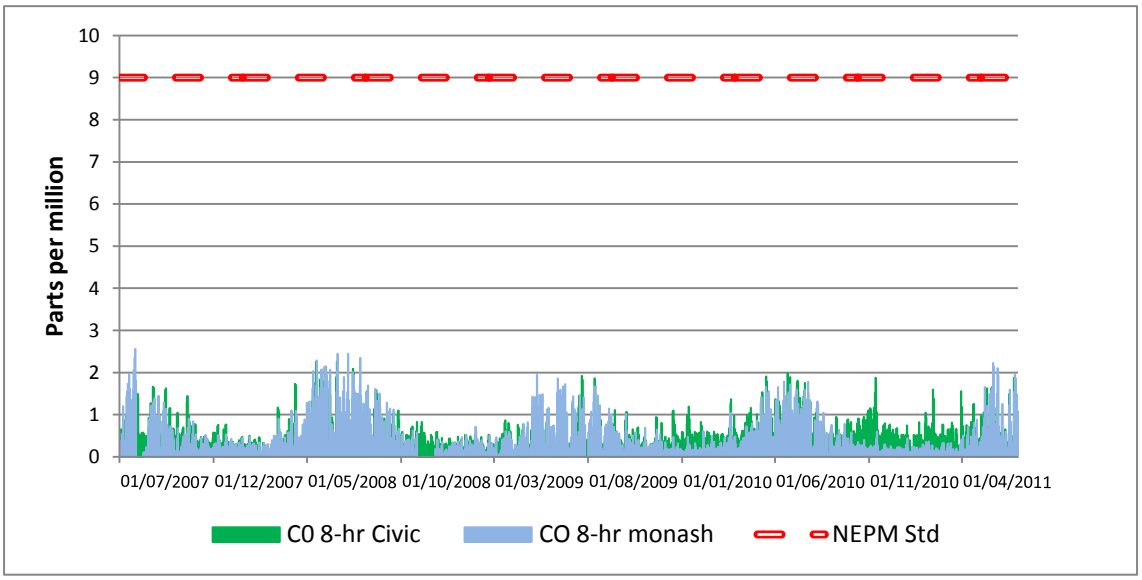
Figure 3: Ozone - 4-hour concentrations measured at Monash and Civic monitoring stations



Source: Environment Protection Authority

There are seasonal fluctuations in carbon monoxide concentrations (Figure 4), with higher values in the winter. Carbon monoxide concentrations have fallen slightly since July 2007, continuing a trend reported in the *2007-08 ACT State of the Environment Report*.

Figure 4: Carbon monoxide concentrations measured at Monash and Civic monitoring stations



Source: Environment Protection Authority

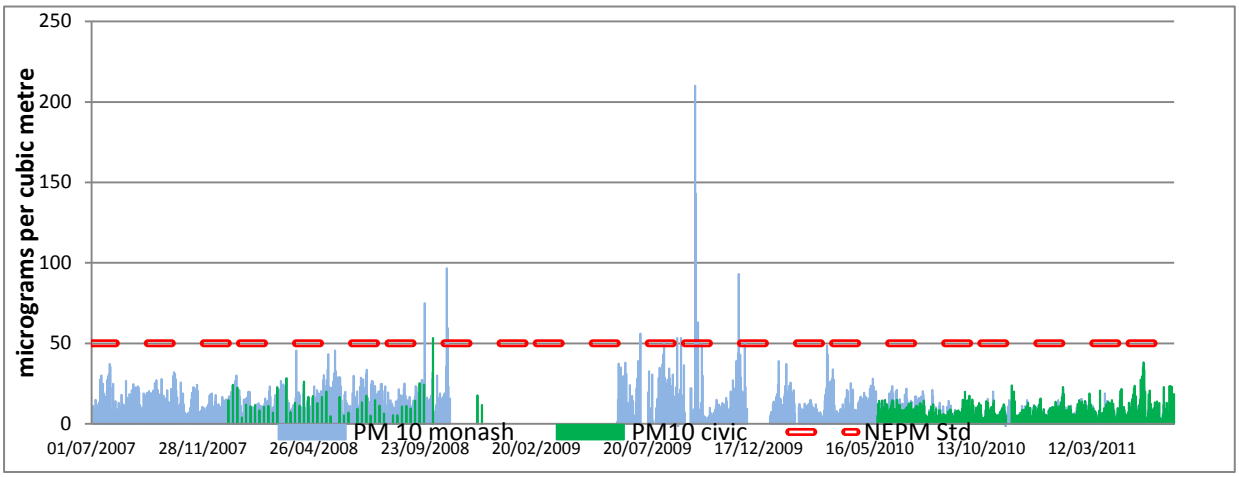
As noted in previous reporting periods, monitoring indicates that particulate matter is the only NEPM pollutant of concern in the Canberra airshed. Particulate matter is a product of point source pollution and does not necessarily affect the whole ACT airshed. Residential wood smoke during stable winter conditions causes air quality problems in many Australian cities and towns. In the Tuggeranong Valley, as in other areas with similar air quality issues,

topography, low temperatures, low wind speeds and higher atmospheric moisture content prevent the wood smoke from dispersing (Bridgman, 2009).

The available data for the current reporting period (2007-2011) record 17 exceedances[2] of the PM10 threshold. Compliance with the NEPM goal limits PM 10 exceedances to 5 days per year. This goal was not met in 2009, with 9 exceedances recorded at the Monash site (Figure 5). The available data for PM2.5 record 19 exceedances[3] of the threshold during the reporting period (Figure 6). The NEPM goal for PM2.5 is to collect sufficient data to facilitate a review of the PM2.5 standards (Table 1).

Monitoring data for PM10 and PM2.5 (Figures 5 and 6) are incomplete from early August 2008 up till early June 2009 (at Monash) or May 2010 (at Civic). At the Monash monitoring station, gaps in the record result both from a range of problems with the measuring equipment and from the station being closed for a short time in 2008 for relocation (EPA 2011). Monitoring of PM10 at the Civic monitoring station was affected by equipment failure from late 2008 to mid 2010 (EPA 2011).

Figure 5: PM10 concentrations measured at Monash and Civic monitoring stations

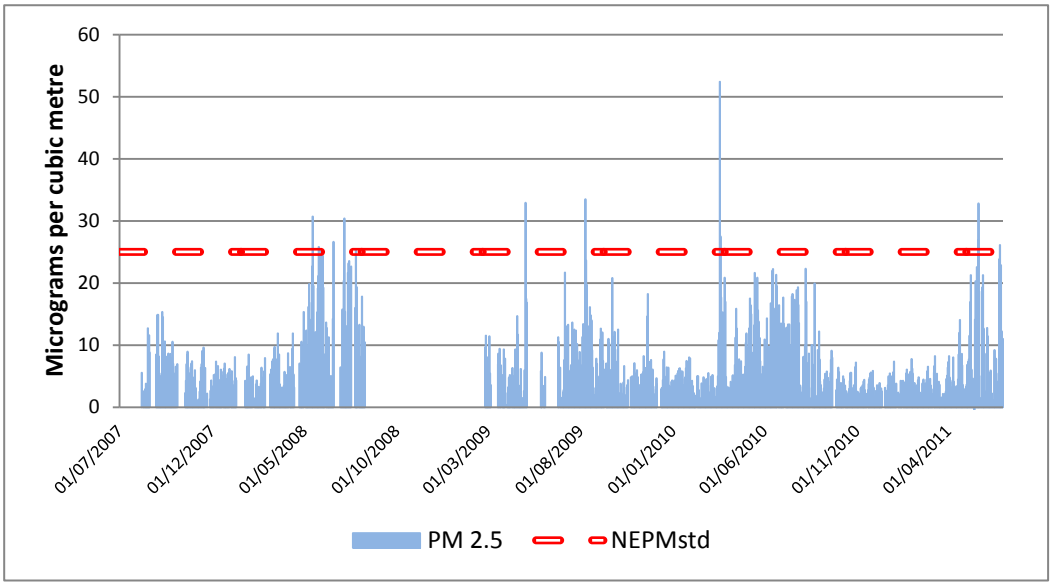


Source: Environment Protection Authority

[2] 5 exceedances in 2007; 3 in 2008 and 9 in 2009

[3] 8 exceedances in 2007; 6 in 2008 and 2 in 2009, 3 in 2011

Figure 6: PM2.5 concentrations measured at Monash monitoring station



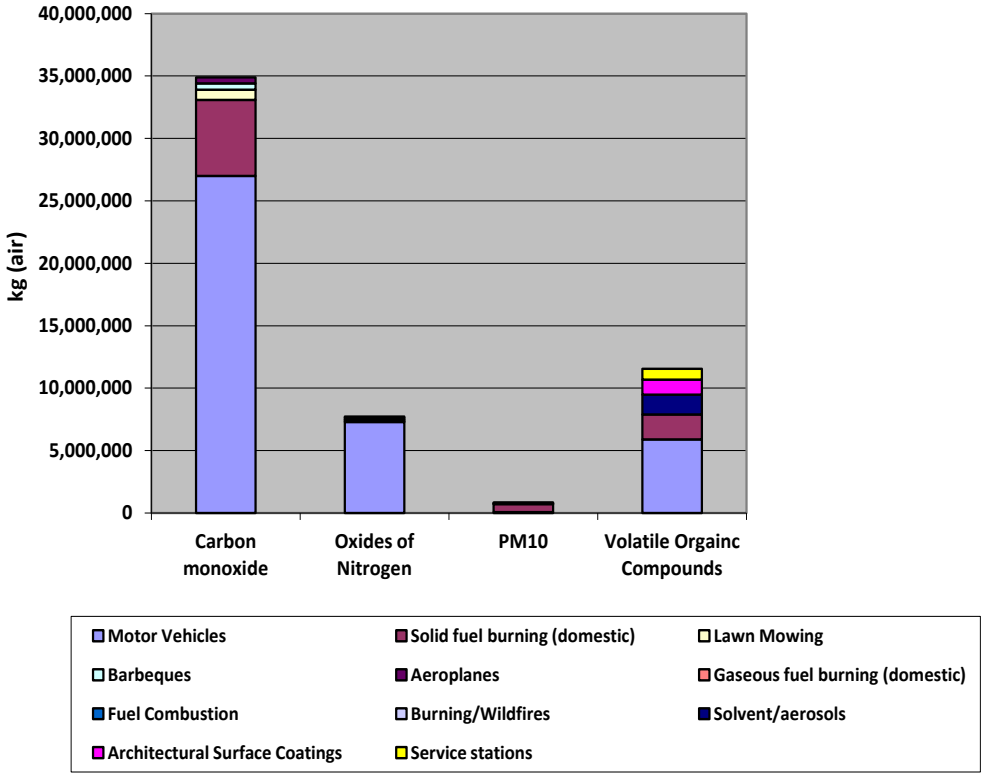
Source: Environment Protection Authority

Pressure indicators

The sources and volumes of emissions in ACT are assessed in comparison to the National Pollutant Inventory (NPI) (DSEWPaC 2010a), last updated in 1999. Updating this inventory may identify changes or improvements since then, which in turn may assist in managing air pollution.

According to the NPI, carbon monoxide is the largest component to air pollution in the ACT, and motor vehicles are the main source, contributing 75% of emissions (Figure 7). Wood heaters remain the largest source of PM10 (Figure 7).

Figure 7: Sources and volumes of ACT air contaminant emissions



Source: Data from DSWEPAC 2010a

Table 2. Sources of air emissions

Pollutant	Sources	ACT emission sources
Carbon monoxide	• The largest source in urban areas is the exhaust of internal combustion engines, e.g. motor vehicles, generators and lawnmowers. • Another significant source is combustion of fuels such as wood, coal, natural gas. • It is also a minor product of natural combustion processes such as bushfires.	• 75% from motor vehicles • 16.9% from domestic fuel burning (e.g. in wood heaters)
Oxides of nitrogen	• The largest source is combustion of fossil fuels, especially in motor vehicles.	• 91.3% from motor vehicles
Particulate matter	• There is a wide range of natural and man-made sources. • Natural sources include duststorms (clay particles), plants (pollen) and bushfires. • Manmade sources include fossil fuels and	• 71.1% from domestic fuel burning (e.g. in wood heaters) • Of the 17 exceedances of PM10 standards recorded in

Pollutant	Sources	ACT emission sources
	dust from industrial activities. • Particles can also be formed indirectly by precursors converting to particles through photochemical processes. • In Australia the main sources of particulate emissions are mining, electricity generation and woodsmoke from domestic heating.	the reporting period, only 6 exceedances[4] can be attributed to woodsmoke build-up. The remainder are attributed to bushfires or dust-storms in the area.
Ozone	• Ground-level ozone is not emitted directly from sources. Ozone is a gas that is formed when nitrogen oxides react with a group of air pollutants known as 'reactive organic substances' (volatile organic compounds) in the presence of sunlight. • Oxides of nitrogen and volatile organic compounds that can form ozone are emitted from natural sources such as bushfires, lightning and trees, as well as manmade source such as petrol and solvents and burning fossil fuels.	The major sources of volatile organic compounds in the ACT are: • motor vehicles (45.5%) • domestic burning of solid fuels (e.g. in wood heaters) (15.4%) • solvents and aerosols (12.3%)

Source: Compiled from DSEWPaC 2010a, 2010b

Concentrations of all contaminants in air, and hence air quality in general, depend not only on rates of emission but also on prevailing weather conditions and local topography. On a windy day contaminants can be dispersed quickly and concentrations from a given emission source can be lower than on days when there is little wind to move them, when they can be trapped by the landscape and consequently reach higher concentrations.

Future climate scenarios predict an increased risk of fire and drought; these are likely to have an impact on the air quality of the ACT (see *Climate vulnerability* indicator cluster paper).

Impact indicators

The most common health impacts of outdoor air pollution are respiratory and cardiovascular disorders (both chronic and acute) (NEPC 2010). While there are no specific data on direct health impacts of air pollution in the ACT, a number of national and international studies have identified health impacts of air pollutants (Table 3).

[4] 4 exceedances in 2009 and 2 exceedances in 2007

Table 3. Potential health impacts of air pollutants

Pollutant	Potential health effects	Groups at higher risk
Carbon monoxide	• Cardiovascular and neuro-behaviour effects • Birth outcomes such as low birth-weights	• People with cardiovascular disease, particularly elderly people with ischaemic heart disease
Oxides of nitrogen	• Damage to the lining of the smaller airways in the respiratory system	• Children • Asthmatics • People with existing respiratory disease • Elderly people
Particulate matter	• Increased risk of respiratory and cardiovascular diseases • Smaller particles (PM2.5) may be more important in causing cardiovascular illness; larger particles (PM10) may be more important in causing respiratory illness	• People with existing respiratory and cardiovascular disease Elderly people
Ozone	• Corrosive reaction with membranes lining the nose, throat and airways when breathed • Short-term exposure to moderate concentrations can lead to irritation of eyes and respiratory system • Longer-term exposure and higher concentrations may lead to bronchitis and pneumonia	• Children • Asthmatics • People with existing respiratory disease • Elderly people

Source: Compiled from AIHW 2011 and NEPC 2010

The recent *State of Australian Cities 2010* report (ADIT 2010) found that pollution of urban air is an underlying cause of 2.3% of all deaths and 1% of disability-adjusted life years in Australia. Respiratory conditions were the most commonly reported health problems for children and young adults (ADIT 2010).

While no data are available for Australia or the ACT, in New Zealand it was estimated that up to 85% of health costs related to air pollution were caused by long-term exposure to particulate matter (PM10) in the air. A European study by the World Health Organization also claimed that PM2.5 significantly increases mortality (AIHW 2011).

The National Environment Protection (Ambient Air Quality) Measure aims to reduce the potential health impacts of pollutants in the community by setting standards. However, the recent *Review of the National Environment Protection (Ambient Air Quality) Measure Discussion Paper Air Quality Standards* (NEPC 2010) identified Australian studies that indicated health effects are occurring below the current NEPM standards for carbon monoxide, oxides of nitrogen and ozone. In particular:

- nitrogen dioxide concentrations from 0.018 to 0.036 ppm (24-hour average) have been associated with increased hospital admissions and emergency department attendance; and
- significant health effects have been observed at ozone concentrations below the current 1-hour and 4-hour standards. Ozone that occurs near the earth's surface is not emitted directly from sources, but is formed when oxides of nitrogen react with volatile organic compounds in the presence of sunlight (Table 2). The health evidence suggests that health effects from ozone in ambient air are observed in relatively long averaging periods, such as over 8 hours.

The review report (NEPC 2010) also found that, for a number of health outcomes related to particulate matter[5], there is no lower threshold below which various adverse effects would not be observed. This poses a significant challenge for proposing standards for particulate matter that would protect the community from potential negative health effects.

Response indicators

In the ACT, air quality standards are legislated through the *Environment Protection Act 1997* (ACT Government 2011a). This Act aims to ensure national standards for air quality are met and environmental harm from local air pollutants is minimised, while still permitting some activities that potentially emit pollutants. Under the Act, actions that significantly contribute to air emissions are regulated or prohibited. This includes banning the burning of certain substances[6] and regulating activities that may generate dust, chemical spray or fumes[7]. The Act places the responsibility of care for the environment on all ACT residents and businesses, requiring them to take all practicable and reasonable steps to prevent or minimise environmental harm or environmental nuisance.

[5] The biological effects of particulate matter are determined by the physical and chemical nature of the particles, the physics of deposition and distribution in the respiratory tract and the physiological events that occur in response to the presence of the particle.

[6] Namely synthetic plastics or other synthetic polymers; wood that is painted, chemically treated or contaminated with chemicals; chemicals other than those recommended by the manufacturer as a fuel; unseasoned wood (more than 20% moisture content); and garden or other waste in urban areas.

[7] Including the use of spray paint and organic solvents and the idle running of motor cars.

The *Air Environment Protection Policy 1999* (ACT Government 1999) contains information and policies relating to the management of ambient air quality and pollutant emissions to the atmosphere in the ACT. The Policy covers activities in the following categories:

- industrial, including commercial;
- transportation; and
- domestic, social, rural and open space management.

Potential air emissions from significant developments (e.g. new suburbs or industrial projects) are assessed and approved by the ACT Environment Protection Authority (EPA) as part of the development application process. The EPA also monitors and assesses air quality from specific events (e.g. industrial fires, Summernats car festival). Previous State of the Environment Reports have recommended use of mobile monitoring to measure ambient air quality at hotspots such as intersections. The feasibility of mobile ambient air monitoring should be investigated. Given the recommendation of the 2004 Environment Protection Act Review (Environment ACT 2004) to consider whether regulation of air pollution should be expanded, it may also be appropriate to review the Air Environment Protection Policy (ACT Government 1999).

The ACT Government, with other jurisdictions, is working on national standards and approaches for reducing emissions of air pollutants, through the Air Quality Working Group of the national Environment Protection and Heritage Council (EPHC). These standards and approaches focus on emissions of particles and of precursors for ozone formation, particularly from the product and equipment sectors, including wood heaters, small engines, surface coatings and non-road engines. The recent *Review of the National Environment Protection (Ambient Air Quality) Measure Discussion Paper Air Quality Standards* (NEPC 2010) also identified that it may be useful to lower the thresholds for the standards for carbon monoxide, oxides of nitrogen, and ozone, because of reports of health effects occurring below the current NEPM Ambient Air Quality standards. This Report is soon to be reviewed by the EPHC, and the review's recommendations will be prioritised and responded to through the development of the *National Plan for Clean Air*.

Following the recommendation from the *2007-08 ACT State of the Environment Report*, the EPA released the first annual outdoor ambient ACT Air Quality Report in July 2010 (EPA 2010a), with information and data derived from air quality monitoring in the ACT, compared against the requirements of the NEPM. The report is available on the ACT EPA website.

Although data on sources and volumes of emissions for Australian jurisdictions (DSEWPaC 2010a) have not been updated since 1999, it is likely that motor vehicles and wood heaters remain the largest source of air pollutants in the ACT.

Woodsmoke emission reduction measures

The ACT Government acknowledges that woodsmoke can be problem in some areas, and continues to implement education and enforcement programs to address the issue (EPA 2010a). A campaign called Don't Burn Tonight has run from 1 June to 31 August every year since 2001, encouraging Canberrans to use alternative heating on cold still nights when smoke is unlikely to clear quickly.

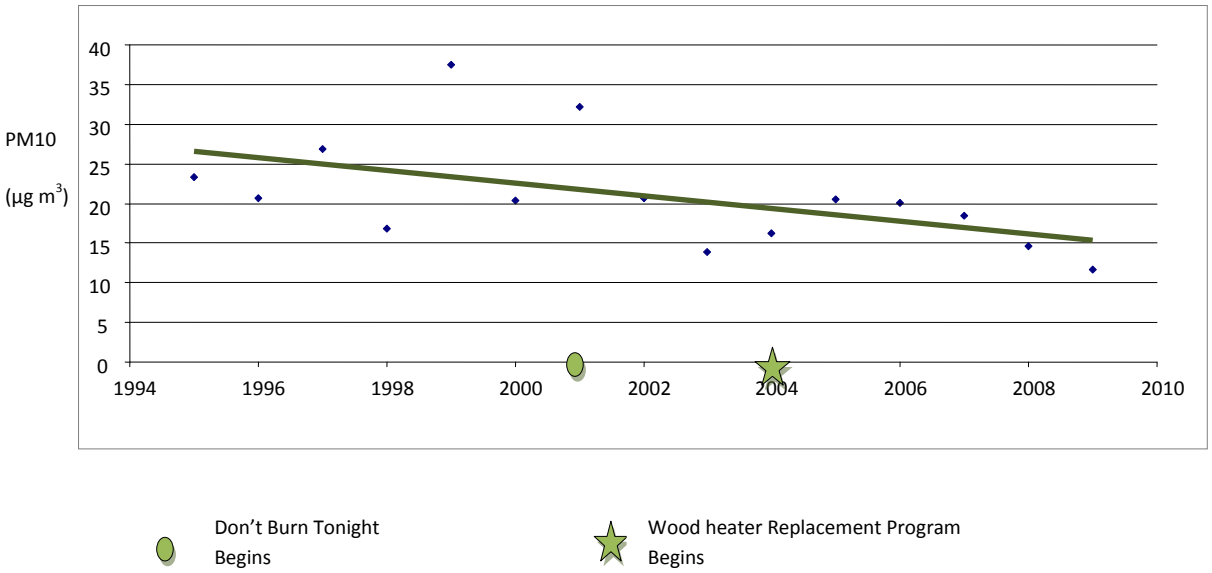
The Environment Protection Act 1997 sets out Canberrans' responsibility to minimise air pollution. *Guidelines for Acceptable Smoke Emissions* (outlined on EPA website) allow a house-chimney to smoke for up to 30 minutes when a wood-fire is first lit, and for up to 20 minutes after refuelling. At other times there should be little or no smoke from a properly operated wood heater. There are penalties set out under the Act for non-compliance.

The *Environment Protection Regulation 2005* (ACT Government, 2011b) regulates the sale and supply of firewood in the ACT. A list of authorised firewood merchants is available on the EPA website (EPA).

Since 2004 the ACT Government has run the Wood Heater Replacement Program, which offers a subsidy of between $600 and $800 to eligible householders for replacing wood heaters with a new mains-supplied gas heater. EPA data indicate that during the reporting period (2007-2011) more than 400 wood heaters have been removed, with nearly 900 wood heaters removed since 2004 (data from EPA). The rebate currently excludes replacement of wood heaters with electric heating systems. There is some discussion that electric heating can contribute more to emissions, particularly via sources related to coal-powered electricity-generation, than wood heaters. The situation needs to be clarified.

With the significant gaps in data for PM10 and PM2.5 emissions during the reporting period, it is not possible to determine whether there has been a reduction in air contamination by particulate matter over 2007-2011. However, long-term trends indicate a decrease in PM10 levels beginning in 2002 (Bridgman 2009), as shown in Figure 8. Between 1999 and 2008, the percentage of households in Canberra using wood heaters dropped from 5.7% to 3.0% (ABS 2008a). Further, the 95th percentile for PM10 at the Monash recording station has dropped from 56.5 $\mu g/m^3$ in 2001 to 23.5 $\mu g/m^3$ in 2010 (EPA 2011).

Figure 8. Daily PM10 - average winter concentrations, 1995-2009 at Monash recording station (micrograms per cubic metre of air)



Source: Adapted from Bridgman 2009

Emissions from woodsmoke have also been managed though planning guidelines. In some instances, air quality is measured in 'greenfield' sites as part of the development process to identify potential air pollutants. This has led to air quality management initiatives being integrated with planning and development. For instance, crown leases in East O'Malley and Dunlop require written approval by the ACT Government for installation or use of solid fuel heating systems. Such restrictions are also likely to be put in place in the new development of Molonglo. It would be valuable for air quality measurements to be required for all new 'greenfield' developments to ensure potential air emissions detrimental to human health and the environment can be identified and proactively managed. This approach also recognises the changing circumstances of higher urban density and increasing population. The *2003 State of Environment Report* noted good air quality was partly attributable to the absence of high-density urban development, and the relatively small population of the ACT.

The EPA recently reviewed existing programs aimed at reducing woodsmoke in the ambient air of the Tuggeranong Valley (EPA). The review found that more could be done to reduce emissions of woodsmoke from household wood heaters. If the ACT Government were to require the installation of wood heaters to be certified to meet Australian and New Zealand standards for particle emissions factors (AS/NZS 4013 - Determination of particle emissions factors), it would make installation of non-certified wood heaters illegal under the Building Regulations. That would also expedite the removal from service of non-certified wood heaters. This regulation is currently in force in Tasmania. It may be valuable for the ACT Government to examine implementing such a standard.

Motor vehicle emissions reduction measures

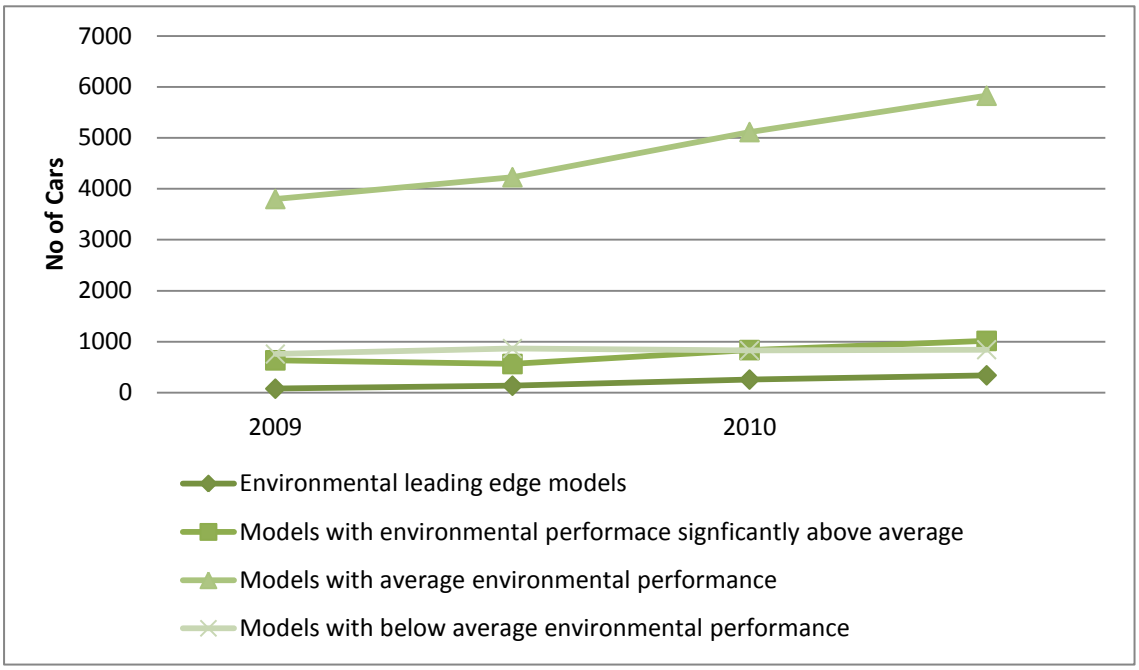
National legislation governs standards for car exhaust emissions. The first such pollution-control legislation, Australian Design Rule (ADR 37/00, came into force in 1986. Cars made in Australia from 1997 onwards must comply with increasingly strict controls (ADIT 2009). In 2008, the ADR 79/02 was introduced (to be fully implemented by July 2010), which limits exhaust emissions from petrol-fuelled vehicles to 1.0 g carbon monoxide/km, 0.08 g nitrogen oxides/km and 0.1 g hydrocarbons/km (ADIT 2008). National standards have also reduced carbon dioxide emissions by 2.7%, from 252.4 g/km in 2002 to 212.6 g/km in 2010 (NTC 2011).

The *Green Vehicle Guide* (Commonwealth of Australia 2010) is a national website developed to provide information about the environmental performance of new light vehicles[8] sold in Australia since mid-2004. It is updated regularly as new models come onto the market. A standard petrol engine passenger car meeting the current emission standard receives a mid-point air pollution rating (5/10) on the Green Vehicle Guide.

In September 2008, the ACT Government introduced the Green Vehicles Stamp Duty Scheme (TAMS) which offers differential stamp duty costs for new vehicles based on their performance in emitting greenhouse gases. The scheme uses a combination of two ratings from the Australian Government's Green Vehicle Guide: a star rating based on the car's greenhouse-gas performance and a rating out of 20 based on the car's air pollution emissions.

[8] up to 3.5 tonnes gross vehicle mass

Figure 9. ACT Green Vehicle trends 2009-2010



Source: Adapted from data from TAMS

More vehicles rated as 'environmentally leading edge' were sold in the year following the start of the Green Vehicle Duty scheme. That increase may be attributable to a range of factors, including better knowledge of performance and efficiency through the *Green Vehicle Guide*, greater availability of efficient vehicles, and higher fuel prices. Whatever the reasons, the outcome is likely to be benefiting the local air quality in the ACT. However, vehicles with above-average environmental performance still made up less than 20% of the total ACT fleet in 2009-2010 (Figure 9).

Concentrations of pollutants emitted by motor vehicles are affected not only by the emissions per vehicle but also by the number of vehicles, the total distance travelled and the age of vehicles. The total number of vehicles registered in the ACT rose by a further 15.6% between 2005 (219,552) and 2010 (253,848) (ABS 2011a). The total distance travelled had decreased during the last reporting period (to June 2007) but has increased during this reporting period, July 2007 to June 2011 (ABS 2011b).

Overall, the efforts of the Australian and ACT governments to reduce emissions are likely to have contributed to the small reduction in carbon monoxide emissions seen over the reporting period. However, as discussed, other factors have also contributed to this result.

ACT State of the Environment Report 2011

Glossary

Airshed: a volume of air confined to a distinct geographic region, and within which contaminants are contained

Atmospheric inversion: when air near the ground surface is cold and air temperature increases with distance above the ground

Contaminant: a substance or organism that degrades an environment by being potentially toxic to people, animals or plants

Pollutant: a contaminant that demonstrably causes a negative effect

ppm: parts per million parts

Precursor: an ingredient or reagent necessary for a reaction between air contaminants

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Other data sources

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Environment Protection Authority, ACT Department of Environment, Climate Change, Energy and Water, DECCEW - now Environment and Sustainable Development Directorate (ESDD)

Department of Territory and Municipal Services – now Territory and Municipal Services Directorate (TAMSD)

ACT State of the Environment Report 2011

THEME: Air

Indicator cluster: Indoor air quality

The indicators for this cluster are:

- Indoor air quality (C) - includes carbon monoxide, nitrogen dioxide, lead, particles, volatile organic compounds, formaldehyde and benzene;
- Indoor air quality health impacts (I) - health impacts from indoor air emissions; and
- Indoor air quality management (R) - effectiveness of indoor air quality management.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data for the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

There is a wide range of potential sources of indoor air pollution, but there are few quantitative data available on indoor air quality in the ACT.

Australians are estimated to spend 90% of their time indoors, yet the long-term health impacts of exposure to indoor air pollutants are not well understood.

With information about indoor air quality management in the ACT and Australia currently limited, it is difficult to determine the effectiveness of indoor air quality management, policy, legislation and education. Greater knowledge and management of indoor air pollution would be valuable.

Introduction

Indoor air can be polluted by a wide range of sources, including materials and activities indoors and also entry of outdoor air from the immediate surrounds. The main pollutants that have been studied are environmental tobacco smoke, nitrogen dioxide, carbon monoxide and volatile organic compounds. Bacteria, fungi and particulate matter[1] are also known pollutants of indoor air. A number of health effects, particularly respiratory, have been associated with indoor air pollutants.

[1] Two sizes of airborne particles are measured: less than 10 micrometres (microns), and less than 2.5 microns in diameter - known as PM10 and PM2.5 respectively.

Condition indicators

Indoor air quality

Indoor air quality can be affected by (AIHW 2011):

- outdoor air entering and being distributed around the building;
- emissions from processes and equipment in the building (e.g. cleaning substances, furniture, printers);
- emissions from occupants (e.g. environmental tobacco smoke); and
- emissions from construction and finishing materials (e.g. foam insulation, asbestos).

Whether a pollution source affects indoor air quality will depend on the nature of the pollutant, the ventilation of the area and the rate at which the pollutant is emitted (AIHW 2011). A wide range of potential indoor air pollutants have been identified, of which the main pollutants studied are (AIHW 2011):

- environmental tobacco smoke (ETS), sometimes called second-hand smoke - a mixture of around 3800 chemicals including carbon monoxide, nicotine, formaldehyde and ammonia, which results from tobacco smoking;
- nitrogen dioxide - produced during combustion, such as in gas stoves, ovens and heaters;
- carbon monoxide - produced during wood burning and in the exhaust of internal combustion engines such as idling cars; and
- volatile organic compounds (VOC) - a collective term for a range of chemicals from sources including paint, pesticides, building construction materials and office equipment. The most commonly studied VOC is formaldehyde which is found in a range of items including carpets, foam insulation, plywood and upholstery fabrics.

Bacteria, fungi and particulate matter[2] are also known pollutants of indoor air quality.

[2] Two sizes of airborne particles are measured: less than 10 micrometres (microns), and less than 2.5 microns in diameter - known as PM10 and PM2.5 respectively.

Table 1: Sources of some indoor air pollutants

Pollutant	Sources
Environmental tobacco smoke	Cigarette smoke
Carbon monoxide	The burning of kerosene, gas and solid fuel; car engines idling; cigarette smoke
Nitrogen dioxide	Gas combustion
Volatile organic compounds	New building products, cleaning products, office equipment, consumer products
Formaldehyde	Pressed wood products, laminates, consumer products (hobbies, crafts)
House dust mite allergens	Dust mites in bedding, carpets, furniture
Mould spores	Bathrooms, damp rooms, window sills, indoor plants, poorly ventilated areas

Source: DHA 2008

Data on indoor air quality in the ACT and elsewhere are limited. The Australian Government recently commissioned a study by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to provide information on the indoor air quality of the 'average' private dwelling in Australia. This study identified the following information (DEWHA 2010):

- carbon dioxide, carbon monoxide, nitrogen dioxide, formaldehyde, and some other chemicals[3] have higher concentrations indoors than outdoors;
- bacteria, fungi and particulate matter occur in similar concentrations both indoors and outdoors;
- ozone concentrations are lower indoors than outdoors (this was expected, because there are not large sources of ozone indoors in Australian dwellings, and indoor surface materials are very effective in removing ozone from the air);
- nitrogen dioxide was present in higher concentrations in dwellings near busy roads; its concentrations varied with season, being higher indoors in winter/spring and higher outdoors in summer/autumn, consistent with the use of heating through unflued chimneys;

[3] Other carbonyls, total volatile organic compounds, benzene, toluene, ethylbenzene and the three isomers of xylene.

- relatively old dwellings had increased air flow even when doors and windows were closed, tending to reduce the indoor concentrations of certain chemicals[4] that have indoor sources;
- garages attached to dwellings increased the concentrations of some chemicals associated with vehicle exhausts[5];
- opening of doors and windows during the week reduced carbon dioxide and formaldehyde (which have indoor sources) and increase ozone (which has outdoor sources);
- in houses that had renovations, painting, new flooring surfaces and new furniture, temperatures and concentrations of particulate matter were higher in winter/spring but not in summer/autumn - possibly because of reduced ventilation and more efficient heating and insulation during winter/spring;
- use of solvents increased the indoor concentrations of volatile organic compounds; and
- carbon dioxide, nitrogen dioxide and particulate matter all increased with more people in the dwelling. The major source of carbon dioxide in dwellings is human breath. Particles of size PM10 can be resuspended by human movements, and nitrogen dioxide is associated with unflued combustion.

There are some indoor air measurements undertaken by private organisations in the ACT. It is uncertain if these assessments are in response to specific issues (which is most likely) or broader assessments of overall indoor air quality.

Pressure indicators

There are no pressure indicators for the *Indoor air quality* indicator cluster. As identified above, indoor air can be polluted by a large range of sources, and it is affected by the flow of air in the building, the activities of the occupants and the materials within the building.

The design and construction materials used in buildings can affect the air quality of ACT indoor environments. Modern buildings are often better sealed than older buildings and therefore have less air exchange between indoors and outdoors. Air or heat exchanges can improve indoor air quality, but there are currently no minimum air-flow standards.

[4] Formaldehyde, other carbonyls, total volatile organic compounds and several of the aromatic compounds.
[5] PM10, benzene and m-xylene

Impact indicators

Health impacts

In 1998, the CSIRO estimated that the economic cost of poor indoor air quality amounted to $12 billion a year. This was mostly due to ill health and lost production (AIHW 2011).

However, the long-term health impacts of exposure to indoor air pollutants are not well understood: exposure is often subtle and the symptoms can be complex. Individuals vary greatly in their sensitivity to pollutants in air. A concentration that may cause symptoms in one person may have no discernible effect on another (AIHW 2011). Nonetheless, a number of health effects have been associated with indoor air pollutants (Table 2).

Table 2. Potential health impacts of some indoor air pollutants

Pollutant	Potential health impacts
Environmental tobacco smoke	• Developmental effects including low birth rate, sudden infant death syndrome and poor foetal growth • Respiratory effects including reduced lung function in children, asthma induction and exacerbation in children and adults, and chronic respiratory symptoms in children • Carcinogenic effects including lung cancer, nasal sinus cancer and breast cancer (in relatively young women) • Cardiovascular effects including altered vascular properties and acute and chronic heart disease
Carbon monoxide	• Aggravation of cardiovascular disease • Poor foetal development
Nitrogen dioxide	• Respiratory effects in children, including asthma and breathing difficulties
Volatile organic compounds	• Respiratory effects including inflammation and episodes of bronchial obstruction • An increased risk of pulmonary infections in infants aged six weeks has been observed in circumstances where painting (in restoration work) had occurred during pregnancy and where relatively high concentrations of styrene had been used (e.g. in flooring)
Formaldehyde	• In low concentrations, irritations of eyes, skin or airways • At higher concentrations, throat spasms and a build-up of fluid in the lungs, leading to death • In the long-term, workers with high exposure have shown an tendency to contract cancers, including nasopharyngeal cancer and leukaemia
House dust mite allergens	• Aggravation of asthma, nasal inflammation, eczema
Mould spores	• Aggravation of asthma, nasal irritation and inflammation

Source: Compiled from AIHW 2011 and DHA 2008

Response indicators

Indoor air quality management

It is estimated that Australians spend 90% of their time indoors, which makes it important to have an understanding of indoor air pollution and its implications (AIHW 2011).

Improved monitoring of indoor air quality has been recommended in several previous ACT State of the Environment Reports. However, there is still little information on indoor air quality or indoor air quality management in the ACT and Australia. It is therefore difficult to determine the effectiveness of indoor air quality management.

The *2007-08 ACT State of the Environment Report* reported that legislation banning smoking in public buildings and licensed premises in the ACT has greatly improved indoor air quality for many people. Smoking is now banned in any enclosed public place, which can be anywhere to which the public or a section of the public has access. In December 2010, the *Smoking (Prohibition in Enclosed Public Places) Amendment Regulation 2010* (ACT Government 2010) was finalised. This regulation extends the ban on smoking to all outdoor eating and drinking areas across the ACT.

To guide the management of asbestos in buildings in ACT, there is now policy, as well as legislation and education (ACT Government 2011).

Indoor air quality at workplaces is managed under occupational health and safety legislation, but there is no equivalent legislation to address indoor air pollution in private homes.

In 2008, the Australian Government Department of Health and Ageing published *Healthy Homes: A guide to indoor air quality in the home for buyers, builders and renovators* (DHA 2008). That booklet informs householders, home-buyers, builders and renovators about air pollutants that may be found inside the home. It also advises on actions that can be taken to protect health and make better-informed decisions about health and indoor air quality issues when undertaking maintenance or renovation activities.

As recommended in previous ACT State of the Environment Reports, given the number of sources of indoor air pollution and the amount of time spent inside, improved knowledge and management of indoor air pollution would be beneficial. Options could include a national focus on reducing emissions of potential air pollutants, either by removing the sources or by minimising emissions from sources. National standards may have to be developed to apply this option. Another option is to educate people to open windows and doors more often to increase ventilation - actions that are likely to result in improved indoor air quality.

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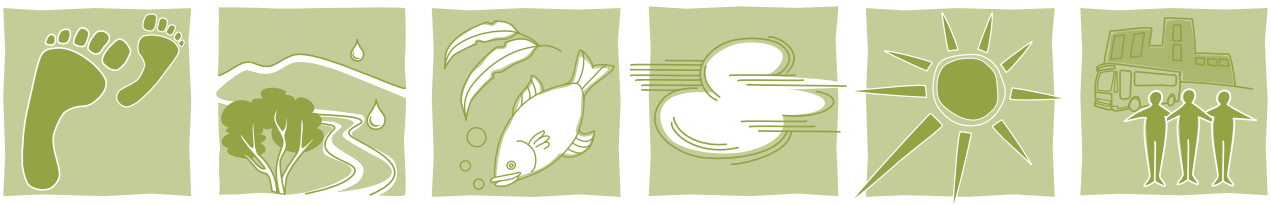
Other data sources

In addition to these published reports, data for this paper were also sourced from:

Environment Protection Authority, Department of the Environment, Climate Change, Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

"the future is not somewhere we are going, it is something we are creating."

Professor Ian Lowe

ACT Government

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