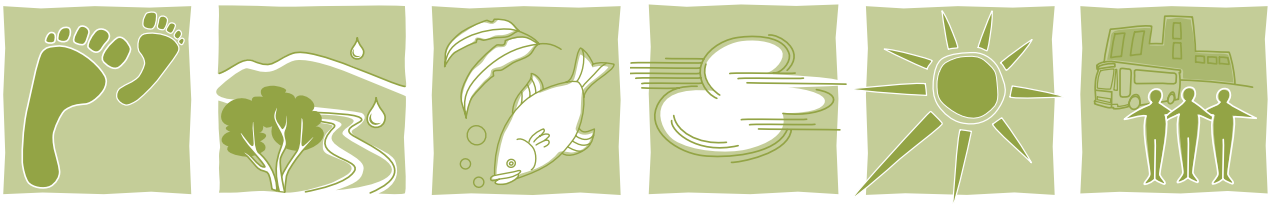
ACT State of the Environment Report 2011

Volume 1

Overarching papers

Office of the Commissioner for Sustainability and the Environment



ISBN 978 0 642 60575 7

ACT Government publication number: 11/1704

Published by the Office of the Commissioner for Sustainability and the Environment, Canberra

Office of the Commissioner for Sustainability and the Environment

PO Box 356 Dickson ACT 2602
Telephone: 02 6207 2626
Facsimile: 02 6207 2630
Email: envcomm@act.gov.au
Web: envcomm.act.gov.au

Citation
Commissioner for Sustainability and the Environment (2011), *ACT State of the Environment Report 2011*. ACT Government. Canberra.

ACT State of the Environment Report 2011

Contents

Volume 1

Overarching papers

Appendix: Expert papers

Volume 2

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

Land and Water Theme

ACT State of the Environment Report 2011

Biodiversity Theme

Air Theme

Volume 3

Climate and People Theme and Indicator Cluster papers

Climate Theme

People Theme

ACT State of the Environment Report 2011

Executive Summary

Introduction

State of the Environment reporting is an internationally recognised approach to assessing change in all aspects of the environment including atmosphere, biodiversity, land, water and human settlements. In the ACT, State of the Environment (SoE) reporting is a requirement of the ACT *Commissioner for the Environment Act 1993*. The Office has undertaken a SoE Report for the ACT, every four years beginning in 1994-95.

This SoE Report covers the period from 1 July 2007 to 30 June 2011.

The objectives of the ACT SoE Report are to:

- provide accurate, timely and accessible information to the community and government, regarding trends and the condition of the environment, underlying pressures and sustainability trends;
- evaluate the effectiveness of community and government actions, policies and initiatives in terms of progress towards sustainability;
- increase community and government understanding of environmental and sustainability trends and interactions;
- satisfy the obligations of the relevant ACT legislation; and
- develop recommendations for the Minister.

Framework

The ACT SoE report has adopted a framework of headline indicators, driving forces, themes, and indicators and indicator clusters to assess and report the environment (see Figure 1).

Headline indicators – These represent a small set of indicators that help provide simple and clear information to decision-makers and the general public about the overall condition of the environment and the changes that have taken place since the last reporting period.

Driving forces – These are indicators that provide data on demographic, social and economic developments, which, in turn, exert pressure on the environment. Four driving forces have been identified, namely, population, consumption, climate and landuse and transport.

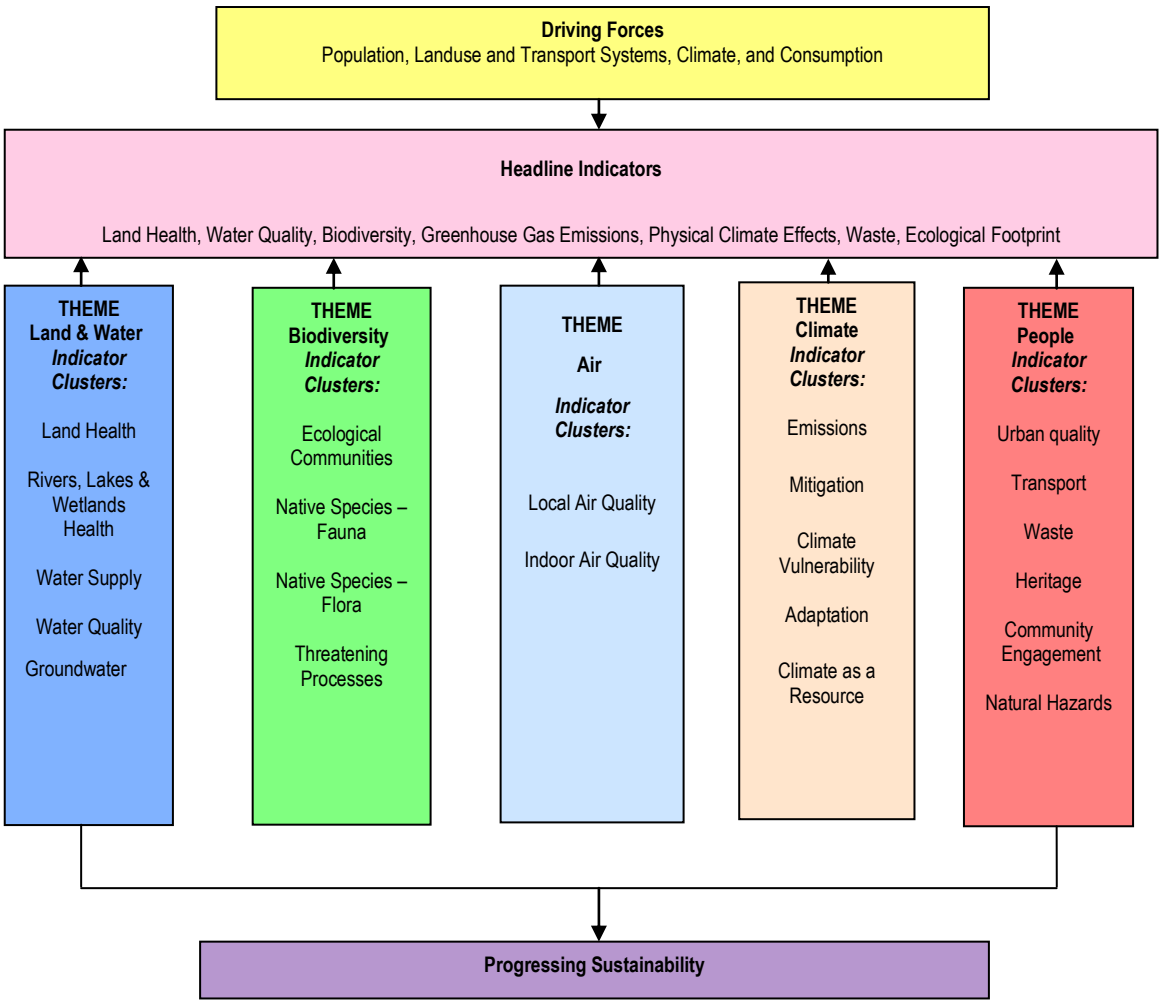
Themes –These are the main things one is likely to think of when thinking of the environment, land and water, air, biodiversity, climate and people. These papers provide an overview of the key findings, effectiveness of responses, emerging issues and recommendations in relation to different areas of the environment.

ACT State of the Environment Report 2011

Indicators and Indicator Cluster papers – These are the key measurement areas, which are analysed and interpreted in order to provide an assessment of each theme. Key indicators have been identified, defined and grouped within Indicator Cluster papers. The purpose of the Indicator Cluster papers is to group related condition, pressure, impact and response indicators and highlight interconnections and positive and negative relationships within and across themes.

Progressing Sustainability – This section places the findings of the SoE Report into a wider sustainability framework and provides information on the key challenges and opportunities for progressing sustainability in the ACT into the future.

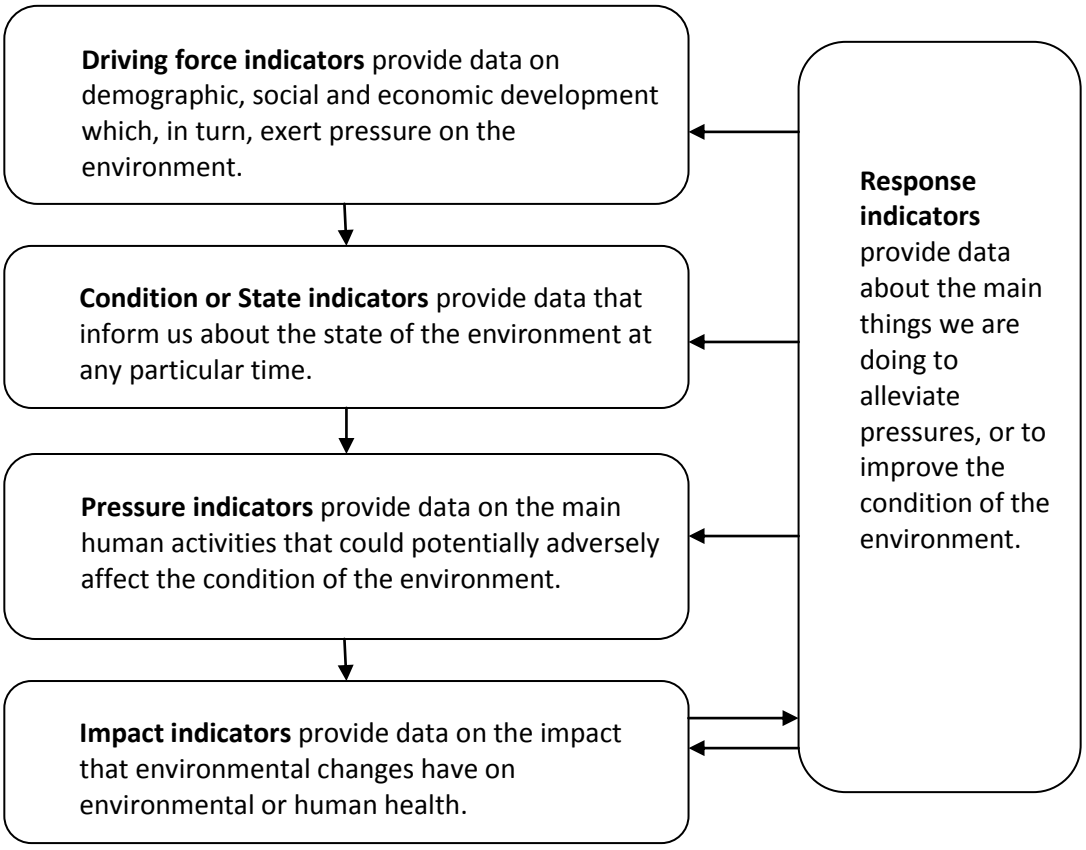
Figure 1. ACT SoE 2011 Framework



DPSIR model

This report uses the Driving Forces-Pressure-State (or condition)-Impacts-Responses (DPSIR) model to explore environmental issues in the ACT.

Figure 2. DPSIR model



Each theme in the report is made up of a number of indicator cluster papers, covering key issues related to each of the themes. The information in these papers is treated in the context of the DPSIR model, where possible. Where appropriate, the report shows the interconnections between the themes and issues.

Report preparation

This report was developed independently by the Office of the Commissioner for Sustainability and the Environment (OCSE). This report uses an evidence-based approach to assess the environment. Data and information were collected, analysed and interpreted by both the OCSE and subject area experts. The report was then developed by the OCSE, and reviewed by both experts and the ACT Government to further ensure accuracy. The OCSE acknowledges and thanks all the consultants and reviewers for their time, effort and expertise.

The information has been drawn from a wide range of sources, in particular the ACT Government, and represents the best information and data available at the time of collection for the report. References to sources are provided throughout the text and refer to a number of Directorates, which were formed in 2011 when the ACT Public Service was restructured into a single department. However, for publications prior to the formation of the current Directorates, previous agency titles have been used in referencing. The OCSE acknowledges the ACT Government for giving authorization to use the data, as well as organisations and individuals for this report.

Drivers of change

Our city, our economy and our society rely on the environment. However, the amount of resources we use is unsustainable and damaging our environment at both local and global levels. At the local level, the quality of our natural environment is comparatively high. In the ACT we have generally good air quality, large areas of green space and lack heavy industries, such as chemical plants or smelters. Further, Canberra has large expanses of open space and nature reserves, which, together with urban trees, form a major part of Canberra's green infrastructure. This provides essential ecosystem services and supports our economic and social systems, as well as the city's biodiversity. As a result, it may be difficult for us to find the link between our lifestyle and its potential to damage the environment.

Nonetheless, results of the extensive community consultation, *Time to Talk: Canberra 2030,* showed that Canberrans are conscious of the challenges they face. Discussions identified a need for change and for Canberra to become a more sustainable, accessible and an affordable city.

ACT population continues to increase; in 2011 it was 363,834 persons and it is projected to increase to 434,300 by 2030 and to 500,000 by 2050.

The zoned urban area of the ACT has increased by about 9%, during the reporting period.

The trend for higher than average temperatures continued, with 2007 being the hottest year recorded in Canberra and 2009 the second hottest.

The size of the average ACT resident's ecological footprint in 2008-09 was 9.2 global hectares.

In the ACT there are four key forces that drive significant change to our environment. These are further explored in the driving forces paper.

Population

The ACT population is growing and ageing and generally continues to have levels of disposable income above the national average (ABS 2011). On 31 March 2011, the estimated resident population of the ACT was 363,834 persons (CMCD 2011) and is projected to increase to 434,300 by 2030 and to 500,000 by 2050 (ACT Government 2011). The ACT's growing population and affluence will have significant impacts on both our urban quality and natural environment including:

- increasing demand for additional and diverse housing and associated infrastructure for transport, placing pressure on our green spaces;
- increasing demand for educational, medical, retail, recreational and other services, placing pressure on government and other resources; and
- increasing demand for water and energy supply and waste services.

However, while population growth and change can have significant negative impacts on the environment, it can also deliver professional and technical skills, knowledge and capacity to a community. As a result, this can bring about attitudinal change and result in practical outcomes in relation to environmental regeneration and protection. Further, communities can play a role as custodians of the natural environment. This is already evident in the ACT, with community groups playing a significant role in areas, such as biodiversity conversation and monitoring.

Landuse and transport systems

The area of land zoned for urban development in the ACT increased by about 9% during the reporting period (ESDD 2011). Urban development includes area for things such as housing, commercial, recreation and transport-related infrastructure such as roads, parking areas, cycle and footpaths. With around 49,000 additional residential dwellings expected to be needed in the ACT by 2031, the size and form of the urban area is likely to continue to undergo considerable change, with both infill and greenfield development planned. Greenfield development is expected to make up 55% of new residential development from 2011 to 2015 in the ACT (LAPS 2011). Such development can lead to vegetation clearing, reductions in the permeability of land, land degradation, water quality impacts, altered water flows, habitat loss and impediments to the movements of native animals.

Source: ACT Government

Canberra has large expanses of green space, which are not only important for biodiversity, but also contribute to the health, wellbeing, and sense of place of Canberra residents. Further, they increase the potential for human and ecosystem resilience in response to the impacts of climate change by sequestering carbon and ameliorating localised temperature extremes.

In the case of transport systems, motor vehicles are by far the most common mode of travel to work for Canberrans, well above the Australian average despite levels of walking and cycling above the national average (Mees et al. 2007). This creates a substantial problem, as road transport is a significant source of greenhouse gas emissions and air pollutants.

Climate

Having a relatively stable and predictable climate is important for many reasons, including human wellbeing, the health of ecosystems, maintenance of water resources, conservation of biodiversity and food security.

Climate variability during the reporting period reflected the impacts of El Nino Southern Oscillation events with hot summers in 2008/09 (due to El Nino events) and cooler summers in 2010/11 (due to La Nina events). The dry, warm conditions in the early part of the reporting period (due to extended drought conditions) had widespread impacts on native and exotic vegetation, river and catchment health and soil erosion, with two dust storms occurring in 2009 (Davis and Lindesay 2011). The end of this drought was marked by heavy rainfall in 2010 with a significant flooding event in Queanbeyan and ACT in December of that year (Davis and Lindesay 2011). As a result, sediment and contaminants brought by the high levels of runoff into waterways affected water quality and riparian and aquatic habitats (TAMS 2007).

Climate change will have a number of impacts on all of our society and our urban and natural environment. It is likely to lead to changes in the availability of water, an increase in drought severity due to higher temperatures and an increase in the frequency and intensity of weather events such as storms, floods and bushfires (Webb 2011). This in turn is likely to lead to additional pressure on the Territory's water resources and biodiversity, and may significantly change the patterns of bushfire and extreme weather events. This, along with increased population will place greater demand on our natural resources (such as water) and ecosystems. The impacts of climate change will also exert pressure on our infrastructure including health care systems, electricity infrastructure and green infrastructures (nature parks, urban trees and open spaces).

Consumption

The nature of and increase in our consumption per person is driving significant impacts on the environment. In affluent societies, such as the ACT, total environmental pressures tend to continue to grow with income as income drives consumption (Dey 2010). The greater the household income, the more disposable income there is available for activities such as travel, purchasing of retail goods and construction (Murray and Dey 2011) which in turn increases our ecological footprint. An ecological footprint is a calculation of the amount of land and water required to support our use of resources and disposal of our wastes. The size of the average ACT resident's ecological footprint in 2008-09 was 9.2 global hectares (gha) - we used 14 times the land area of the ACT to support our lifestyles. This is an increase of nearly 25% in 10 years and is 13% above the current Australian average (Dey 2010). To live within the current capacity of the world we would have to reduce our footprint to 1.8 gha per person. This figure includes the land needed to support only the human population, and not for other species. Consumption at this level is not sustainable in the long term and in a world with limited resources, as excess consumption by some, results in others living without sufficient resources to sustain life and health.

ACT State of the Environment Report 2011

Overall condition of the environment

The headline indicators for the SoE report indicate that Canberra is a very liveable city. However, as a largely urban population who import most of our consumer goods and services, we are increasing the impact on our local and global natural environment. In particular:

- the size of the average ACT resident's ecological footprint was 9.2 global hectares. This has increased by 8% in 5 years and nearly 25% in 10 years;
- waste generation per person has increased by 28% faster than the population growth of 5.5%, over the reporting period;
- greenhouse gas emissions continue to rise with ACT emissions increasing by 7% between 2005 and 2009;
- generally water quality is similar at Halls Crossing (as it exits the ACT) to that at Angle Crossing (as it enters the ACT). Urbanisation impacts are having an impact on a number of indicators of water quality; and
- during the reporting period, three new nature reserves were added to our conservation reserves, while three additional species were listed as vulnerable.

A summary of changes, challenges and improvements under each theme are presented below. Recommendations, for the ACT Government to consider, are provided in italics and numbered in this Executive Summary.

Land and Water

What has changed?

The effects of drought and fires dominated assessments of water and catchment health in the 2003 and 2007 ACT SoE Reports. Recommendations from previous SoE Reports focused on post-fire rehabilitation to protect catchments and significant steps in post-fire recovery have been made. Conditions have changed in this reporting period, and drought breaking rain and improved condition of riparian vegetation, following the 2003 bushfires, have led to an improvement in the overall river health (DECCEW 2010a). However, the summer incidence of blue green algae in Canberra lakes appears to be increasing.

Recovery from fire and drought and a number of catchment management projects are likely to have contributed to overall improved land health in the ACT, over the reporting period. However comprehensive data on land health are not available.

Generally water quality is similar at Halls Crossing (as it exits the ACT) to that at Angle Crossing (as it enters the ACT). Urbanisation impacts, including pollutants in stormwater run-off and treated sewerage, are having an impact on a number of indicators of water quality (pH, conductivity, total nitrogen and chlorophyll 'a').

Urban areas and land health continue to have a large impact on the health of water bodies and catchments in the ACT. Urban run-off, return of treated sewage and changes in geology, among other practices, affect water quality in the ACT. Despite several previous recommendations for improvement, there has been little change in our knowledge of the extent to which land clearing and urbanisation are impacting on our water quality. Waterways, which are less affected by urban pressures, appear to have also shown greater resilience to climatic events, such as drought, than those in peri-urban and urban areas (DECCEW 2009).

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.

Specific projects have been developed, which illustrate that cooperative catchment management activities and cross-boundary catchment management is possible. These projects have provided positive outcomes.

Challenges

Vegetation clearing, overgrazing and landuse change can significantly affect land health. This is because land with poor vegetation or ground cover is more at risk of wind and water erosion. However, currently there is limited information available about the extent of impacts of processes, such as erosion and soil acidity on the land in the ACT as well as how other factors, such as vegetation cover and quality, contribute to the ACT's land heath. The increasing urban footprint results in land degradation, vegetation clearing and habitat loss. This creates a significant challenge since land heath affects the riparian and aquatic ecosystems, biodiversity and green infrastructure of the ACT.

During the reporting period, a landscape function analysis of 34 nature reserves and one potential reserve was undertaken. Even though most of the ACT's nature reserves are in satisfactory condition, there are localised areas within these nature reserves that were assessed as being in critical condition or approaching critical condition (Sharp 2011).

Water will continue to be a significant issue in the ACT into the future. Land clearing and continuing urbanisation, is likely to have the largest impact on local water quality. Climate change and population growth will continue to place pressure on the ACT's water resources. Cross-boundary catchment management, including the impact of upstream land uses in NSW on the Murrumbidgee River, continues to be important, and will need to be improved into the future if our water supply is to remain secure.

There are indications of changing expectations for the function and use of water bodies in the ACT, integrating recreational, educational and environmental management objectives with urban infrastructure goals of flood mitigation and water treatment. Managing water bodies for multiple uses while balancing community expectations will be challenging for policy makers and regulators.

How are we responding?

Due to the continuing drought for much of the reporting period, there has been a strong focus on water security and efficiency measures. A number of water supply measures have been implemented. Of these measures, the three major projects initiated during the reporting period included enlarging the Cotter Dam, pumping of 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. With water restrictions in place, potable household water use within the ACT decreased by approximately 17 % in four years. However, with water restrictions now more relaxed following increased rainfall, it is yet to be determined whether water efficiency has been embedded in the behaviour of Canberrans, or if water use will once again increase.

A number of catchment management projects were implemented to improve the overall health of ACT's land and water resources, particularly in the Lower Cotter Catchment, where a major restoration project has been undertaken to rehabilitate and restore native vegetation. There has also been an increased focus on stormwater harvesting and Water Sensitive Urban Design (WSUD), with the construction of a number of urban wetlands, as well as rain gardens and constructed ponds. These initiatives aim to provide amenity to the urban landscape, whilst at the same time improving and enhancing water quality within the urban environment.

Catchment management in the ACT is still conducted by a number of different actors, creating challenges for an integrated and cross boundary approach. However some projects such as the restoration of the Lower Cotter and the Upper Murrumbidgee Demonstration Reach initiative have demonstrated the benefits of such an integrated approach.

Urban areas continue to have a large impact on the health of water bodies and catchments in the ACT. Recommendations from the previous SoE report that included monitoring the effects of urbanisation, the effectiveness of the Gross Pollutant Trap network and determining the sources and loads of salts entering the wastewater treatment networks, have not been fully implemented or integrated into water management. A better understanding of the impacts of urbanisation on catchments and the integration of this knowledge into improved management will be an ongoing challenge for the ACT.

How can we improve?

In improving land and water management into the future, it is important that we treat the resources, not as commodities but as part of the total ecosystem. The management of these resources should build resilience to expected climate change impacts. We are part of the wider Murray Darling Basin and catchment management should not stop at jurisdictional boundaries. Projects such as the Murrumbidgee Reach Demonstration Project illustrate the benefits of cross-jurisdictional and multi-partnered community engagement in catchment management.

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.*

Groundwater is an important localised water resource for the ACT, although it only contributes a small proportion of the overall water supply. Over-extraction affects

the health of groundwater dependent ecosystems, and the continuing availability of groundwater for human use. Under legislation, the amount of groundwater taken for use is limited to 10% of the historical groundwater resource. However, improved monitoring of groundwater is needed to provide greater knowledge and understanding of groundwater in the ACT.

2. *Complete assessment of the ACT's at risk groundwater resources.*

The previous two SoE Reports recommended monitoring the effects of urbanisation on ACT region's water catchments and using this information to respond to specific issues. The consequences of urban development, including vegetation clearing and increased run off, have significant impacts on water quality. While investigations have been undertaken on the ACT landscape, particularly around land uses and vegetation in different catchments, the effects of urbanisation remains a critical area for further action. Over recent years, significant effort has been put into Water Sensitive Urban Design. It is important that we monitor and report on the effectiveness of this work including construction and on-going maintenance requirements and changes in water quality, both local and downstream.

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.*

In contrast to other Australian states and territories, the ACT has a relatively small land area. However, as noted in previous SoE Reports, there is limited information on the extent and changes to land degradation. Given the effect of soil types and condition of land health, improving knowledge of soil conditions and the impact of land uses on soil is important for effective land management.

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 landuse changes, and 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.*

Co-ordination and ready access to existing and future research, and other data could help improve knowledge in areas with limited data, as noted above and elsewhere in the SoE Report. There is a rich but dispersed environmental research capacity of the ACT which could be capitalised on by facilitating access to and integration of environmental knowledge. This could be undertaken through building on existing government and non-government skills and programs that have the potential to reduce research overlap, identify knowledge gaps and promote a more holistic approach to research across the ACT.

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.*

Biodiversity

What has changed?

The focus on fire management since the 2003 reporting period has seen significant progress in balancing the at times competing objectives of protecting life and infrastructure and maintaining biologically appropriate fire regimes.

While over the last two reporting periods, progress has been made in continuing to protect key areas for conservation, pest plants and animals, climate change and urban development continue to put pressure on our biodiversity. Each new reporting period also sees a small increase in plant and animal species that are declared as threatened.

Three new species the Little Eagle, Glossy Black-Cockatoo and Pink-Tailed Worm Lizard have been listed as threatened during the reporting period.

The riparian shrub, *Bossiaea greyii* is currently being assessed for a nomination as a threatened species.

Three new nature reserves - Callum Brae, Jerrabomberra West and Kama were added in the reporting period. In addition, approximately 80 hectares have been added to existing reserves.

The 2007-08 SoE Report highlighted the impact of the overabundance of kangaroos in the ACT. The recommended Kangaroo Management Plan has been developed to inform management of this important native animal. Its efficacy is yet to be fully determined.

Many of the plans and strategies recommended in the 2003 and 2007-08 SoE reports have been completed and actions implemented to varying degrees. For example, the Jerrabomberra Wetlands Nature Reserve Management Plan, Namadgi National Park Plan of Management and ACT Weeds Strategy have all been finalised and some actions have been implemented. Overall, long-term research, monitoring and evaluation remain limited, with previous SoE recommendations to improve these areas only partially implemented.

Nonetheless, across all reporting periods, community involvement in biodiversity conservation has been valuable and significant.

Challenges

Changes at local and global scales are placing the ecosystems and therefore the biodiversity of the ACT under increasing pressures. Threatening processes currently putting pressure on the ACT include climate change impacts, changed fire regimes, pest impacts and development impacts such as urbanisation. Many of the endangered species in the ACT are located in protected areas; however this alone does not ensure their survival.

Despite the continued expansion of conservation land, urban expansion also continues and new suburbs and infrastructure such as major roads and service corridors continue to fragment habitat at many scales (Manning et al. 2010), placing pressure on our flora and fauna. Habitat fragmentation makes it difficult for many organisms to respond and adapt by moving across modified landscapes. The interaction of climate change and landuse change is having a far more detrimental effect on biodiversity than either factor in isolation (Lindenmayer and Hobbs 2007).

There is also the need to capture more relevant and timely data to assist in the better understanding of the condition of ecological communities and native species in the ACT, along with the pressures that are being placed on ecological communities and native fauna and flora species and the changes to their distribution and abundance. This should build on existing government and non-government skills and programs and focus on periodic reporting.

Source: ACT Government

Despite the pressures noted above, the recent report *Building Nature's Safety Net 2011 - The State of Protected Areas for Australia's Ecosystems and Wildlife* (WWF 2011) identified the ACT's reserve system being very close to adequate, with the key remaining priority being the protection of Yellow Box-Red Gum grassy woodlands.

How are we responding?

A number of innovative biodiversity conservation projects have been undertaken during the reporting period and include:

- a report, *Ecological Connectivity for Climate Change in the ACT and Surrounding Region* (Manning et al. 2010), which aims to better inform the ACT's planning process and future policy and strategies for connectivity. Building on this, the ACT Government has commissioned a connectivity analysis, including producing a biodiversity connectivity map for the ACT. It is important that the outcomes of the connectivity work are integrated into urban planning processes;

- the *Strategic Bushfire Management Plan,* developed over the reporting period, has established a framework aimed at balancing safety and ecological needs (through the ecological guidelines for burning); and

- a research and restoration experiment is underway in the Mulligans Flat - Goorooyarroo Woodland. The experiment is a partnership between the Australian National University, the ACT Government and CSIRO and aims to identify methods to restore the structure and function of temperate woodlands and increase biodiversity, with the intention to support park managers in their work to conserve woodlands (Manning et al. 2011).

In addition, changes to funding and management arrangements are being implemented. The Capital Woodland and Wetlands Conservation Trust is a partnership between Government and the community, which aims to access additional private sector and community funding for projects located on public land. The Trust is being established to support projects in Jerrabomberra Wetlands Nature Reserve and Mulligans Flat Woodland Sanctuary and is intended to supplement, rather than replace annual government support for normal, ongoing management of these areas (OCSE 2011).

How can we improve?

Accurate, current and detailed biodiversity data in the ACT is increasingly important, since governments, the community and industry need to access this data in order to better guide planning and development decisions. There are several areas of data management that need strengthening. Much biodiversity data and monitoring undertaken in the ACT is often focused on a specific location (through planning processes) or on threatened species. Strategic monitoring and data consolidation

across the ACT is limited, yet is important for determining key changes including habitat loss across the ACT as well as identifying species that may be at risk of becoming threatened or endangered.

Monitoring and tracking changes to ACT's biodiversity assets would involve the assessment of those assets that remain following planning and development decisions that affect individual species, populations and ecological communities. Public reporting about biodiversity matters is also needed in a way that clearly identifies and assesses the outcomes of decisions and activities that are related to individual species, populations and ecological communities in the ACT. Finally ensuring collaboration with the NSW Government and Regional Councils needs to continue to be effective to progress data and information gathering.

6. *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.*

Fragmentation of habitat and the removal of native vegetation through ongoing landuse changes exert key pressures on our biodiversity. While progress has been made over the last two reporting periods to increase conservation areas, threatened species and communities remain under pressure due to further clearing of the native vegetation primarily for urban development. Each new reporting period has also seen a small increase in the number of new plant and animal species that are declared as threatened. Finally, the existing high level of habitat fragmentation makes it difficult for many organisms to move between modified landscapes.

7. *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.*

Making biodiversity conservation an element of the landuse planning process in the ACT by integrating connectivity opportunities in all planning decisions and strengthening legislation would also assist in enhancing clarity and integration of biodiversity needs into the ACT planning framework.

8. *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 (NC) 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.*

ACT State of the Environment Report 2011

Air

What has changed?

Canberra's good outdoor air quality has not changed significantly during the last two SoE reporting periods. The ACT continues to enjoy good air quality in large part due to the lack of heavy industry, such as chemical plants or smelters, the absence of concentrated high-density urban development and the relatively small population. Recommendations to encourage low emission vehicles and publicly reported air quality data have been implemented and we have continued to see reductions in carbon monoxide emissions and particulate matter.

> The ACT continues to enjoy good outdoor air quality, with National Environment Protection Measures (NEPM) standards for carbon monoxide, nitrogen dioxide and ozone met during the reporting period.
>
> The NEPM goal for particulate matter to remain less than 10 micrometres was not met in 2009.

Previous recommendations to improve indoor air quality information have not been implemented and knowledge of indoor air quality in the ACT remains limited.

Challenges

We need to be proactive to ensure we maintain good air quality. The ACT continues to see increases in motor vehicles, population and urban development. Despite actions to reduce pollution from motor vehicles and reduced sources of particulate matter, such as woodheaters, these trends are likely to place pressure on air quality in the ACT. Recommendations in the 2003 and 2007-08 SoE Reports for using extra nephelometers for campaign or mobile monitoring of smoke pollution, related to ambient air quality, have not been implemented due to calibration, set up and data gathering requirements. Their use for this purpose needs to be clarified.

The recent review of Ambient Air Quality standards identified a number of studies that indicate negative health effects that occur below the current national Ambient Air Quality standards for carbon monoxide, oxides of nitrogen, ozone and particulate matter. This 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*.

How are we responding?

The ACT Government continues to be involved in a number of national and local programs aimed at improving air quality. The ACT Government has continued to implement education and enforcement programs to address wood smoke in order to reduce particulate matter in the air. Programs such as wood heater replacement, The *Don't Burn Tonight* campaign and changes to legislation and crown leases conditions in East O'Malley and Dunlop limiting solid fuel fires, have helped reduce particulate matter in the air. Further, despite an increase in vehicle numbers,

national pollution control legislation for car exhaust emissions is perhaps contributing to the reduction in carbon monoxide in the ACT air shed.

As identified in the previous SoE Report, limited action has been taken with regard to indoor air quality. For example, legislation has been put in place, banning smoking in public buildings and licensed premises. It is reasonable to assume that this has greatly improved indoor air quality for many people by reducing a source of pollution. Little else has been progressed to improve knowledge or management of indoor air quality.

How can we improve?

Given that we spend a significant amount of time indoors, better knowledge of our indoor air quality is needed.

9. *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.*

As our urban footprint increases, undertaking air assessments for all new greenfield developments and aligning planning, development and air quality measures would ensure the identification and management of potential future air pollutant issues. Mobile monitoring and measuring ambient air quality at hotspots such as intersections should be investigated. This has also been recommended in the previous SoE Reports.

During the reporting period, the ACT population increased, thus triggering the requirement for a second outdoor air performance monitoring station for reporting, under the NEPM (EPA 2010). Until a second ambient air quality NEPM performance monitoring station can be established, data from the Civic performance monitoring station, though not ideally located, will be used for annual report purposes.

10. *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.*

Source: ACT Government

Climate

What has changed?

Only greenhouse gas emission levels and energy use have been reported in the previous SoE Reports. Although previous recommendations regarding the completion of climate change strategies have been largely implemented, atmospheric levels of global greenhouse gases are continuing to increase, both globally and locally. This will directly impact our environment significantly and indirectly impact our economy and society.

> Long term trends indicate an increase in our greenhouse gas emissions of over 30% since 1990 and more than 5% since 2005.

Electricity produced by burning fossil fuels remains the largest contributor to greenhouse gas emissions in the ACT, followed by natural gas and transport fuels. It is clear that significant emission reduction efforts need to focus on these sectors. The total share of our electricity sourced from renewables has increased from 4.6% at the end of the last reporting period to 8.94% in 2009-10 (ORER 2011, ICRC 2011b). This includes renewable energy sourced as part of the Australian Government renewable energy targets requirements as well as GreenPower, which is purchased voluntarily by households, businesses and other organisations. Nonetheless, GreenPower continues to contribute less that 5% of ACT's energy use (ICRC 2011a).

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.

Challenges

ACT greenhouse gas emissions continue to rise and as of 2009-10, 91% of electricity sold in the ACT is still sourced from non-renewable energy sources (ORER 2011, ICRC 2011a). Without significant change in the way we use our resources, future predictions of a growing and ageing population in the ACT is likely to increase demand for the goods and services that produce greenhouse gases. Further, these population predictions will also place additional strain on our resources such as water, medical and other services, under the constraints brought about by climate change. There is therefore an urgent need for action at all levels – locally, nationally and globally – to manage greenhouse gas concentrations and their potential impacts.

Small changes in average values of climatic parameters, such as temperature and rainfall, can lead to large changes in the frequency and intensity of extreme events such as heatwaves, storms and fires. Further, climate change is likely to bring additional pressure to the Territory's water resources and biodiversity, and may significantly change the patterns of bushfire and extreme weather events. These in turn will have direct negative impacts on our health, biodiversity, food availability and other indirect impacts on our society such as higher prices for food, building damage, flood and fire.

How are we responding?

The ACT Government has legislated ambitious targets to reduce greenhouse gas emissions in the ACT and increase the use of renewable energy (ACT Government 2010). However, to date, no pathway for reaching these targets has been set out. The second action plan under *Weathering the Change* (the ACT Climate Change Strategy) is currently being developed and is expected to outline the path to meet these targets.

In addition, in 2007 the ACT Government committed to achieving carbon neutrality in its own buildings and services. It is of concern that the framework to achieve this target is not expected to be released until 2012, four years after the commitment was made.

The first action plan under *Weathering the Change* (the ACT Climate Change Strategy), focused primarily on actions to reduce emissions. However, reducing emissions cannot be done quickly; for example, it will take decades to achieve significant change in the energy efficiency of housing, infrastructure and building in the Territory.

While efforts to adapt to these potential changes are occurring in the ACT, these endeavours have mostly been focused on building knowledge and understanding the potential impacts. However, adaptation actions have been undertaken in response to other events, in particular in relation to water security and the natural environment.

Source: ACT Government

How can we improve?

It is acknowledged that work is being done to encourage emission reduction by government and the wider community and that business and community must play a role in reaching the ACT wide targets. However, there needs to be a framework to effectively measure and evaluate progress. This may include targets for key sectors contributing to emissions - transport, electricity, waste, with transport and older housing stock being a particular focus. Such targets, measures or actions will need to be integrated into relevant policies and plans.

11. *As a priority the ACT Government develop and implement pathways to achieve carbon neutrality in ACT Government buildings and services. These should be implemented through the second Action Plan of Weathering the Change and include monitoring, evaluation of actions and annual public reporting on progress.*

12. *The ACT Government develop and implement a pathway to achieve the legislated climate change emission reduction and renewable energy targets. This should be implemented through the second Action Plan of Weathering the Change and include:*
    a. *a focus on reducing emissions from transport and our buildings (especially improving energy efficiency of old building stock);*
    b. *responsive regulatory, governance and investment arrangements for renewable energy;*
    c. *continued engagement with ACT community; and*
    d. *regular monitoring, evaluation of actions and public reporting on progress against the targets.*

Future impacts from climate change and climate variability are likely to be more prevalent in the ACT. Much of the vulnerability work has been done in the water and emergency services sector and, more recently, in development planning and health areas. These areas remain important for further focus and additional areas may

include disaster and emergency management; natural resources; human settlements; infrastructure vulnerability and protection and tourism and recreation. Many climate change issues and responses have elements in common with the broader sustainability agenda and there is potential for climate change responses to align with, or leverage off, existing approaches (Rotstein and Webb 2009). Planned adaptation and government coordination are a significant challenge in implementing a response to climate change in the ACT.

13. *Develop a climate change adaptation planning and implementation response through:*
    a. *building on existing and undertaking additional sector vulnerability risk assessments;*
    b. *establishing a monitoring, evaluation, reporting and improvement methodology and framework as a consistent guide for Government, to develop, progress and report against adaptation planning;*
    c. *integrating adaptation planning outcomes into existing ACT planning and management frameworks.*

Climate change impacts are not limited by jurisdictional boundaries. Much will need to be done across the region to adapt to climate change. Climatic and environmental conditions of the Australian Capital Region are highly suited to a number of renewable energy industries. The ACT Government, working with the NSW Government, regional development authorities and local councils, could develop this region into a leader in renewable energy.

14. *Develop a regional approach to planning for climate change. This needs to be done in partnership with NSW Government, local councils and regional organisations. Key areas of focus should include opportunities for renewable energy development, water security, urban and regional planning, transport management and adaptation of ecosystem services to climate change.*

People

What has changed?

Our urban area continues to increase with both greenfield and infill development continuing to grow, although this increasing densification is not embraced by all Canberrans. While the implementation of the Housing Affordability Strategy continues as recommended in the 2003 SoE, housing affordability remains a challenge.

The modest shift away from private car use seen in the last reporting period has not continued. Despite high cycling and walking rates compared with that of the other Australian cities, the ACT continues to rely heavily on motor vehicles for transport with the public transport being under-utilised despite fleet, timetabling and route improvements. Recommendations from the 2007 SoE have only been partially implemented with, targets and plans relating to greenhouse gas emission from transport and delays in the development of the *Sustainable Transport Action Plan (2010-2016)* (recently re-titled *Transport for Canberra 2011-31*) being of particular concern.

Waste generation per person has increased by 28% over the reporting period and population by 5.5%.

Since 2007-08, the number of registered heritage places or objects has increased by nearly 27%.

Passenger vehicles accounted for 84% of all motor vehicle registrations in the ACT, which was the highest of any state or territory in Australia; although cycle rates continue to increase.

Canberra has been ranked as the 26th most liveable city by the 2010 Mercer Worldwide Quality of Living Survey.

Over the reporting period 72% of new development was in Greenfield sites.

While awareness of GreenPower in the ACT is 66%, the percentage of people who actually purchase GreenPower in the ACT is 4.9% indicating that awareness and action do not always correlate.

Between 1974 and 2003 Canberra experienced an average of 23 days of very high' or 'extreme' fire danger. This is predicted to increase to 36 by 2050.

We continue to generate waste at a faster rate than population growth. The decrease in waste to landfill seen in the 2003 and 2007 SoE Report has been reversed in this reporting period with the increase driven mainly by construction and demolition and commercial and industrial waste. As recommended in the 2007 SoE, public place recycling, business waste reduction programs and e-waste actions have been progressed. However, recommendations regarding organic waste collection, promoting waste minimisation and waste minimisation/avoidance action plan have not been implemented.

Progress has been made in heritage legislation noted in 2007, though it is yet to be finalised. Identification and management of Aboriginal heritage places and objects has improved since the 2003 SoE.

Government and community response to dealing with natural hazards in the wake of the 2003 bush fires has been significant.

Across all reporting periods, ACT residents continue to be concerned about the environment. However, this does not always translate into action, particularly around consumption and transport use.

Source: ACT Government

Challenges

One of the key management challenges for the ACT is improving the sustainability of the city of Canberra in the face of a growing population. A sustainable city is arguably one where residents have access to appropriate and affordable housing, proximity to work and recreational opportunities along with community facilities such as schools, shops, medical and other services. Integration of, and accessibility to, the natural environment is fundamental to improvement of the sustainability of the city's urban form, while also increasing environmental awareness and stewardship. Furthermore, a sustainable city offers an integrated transport network, allowing people to move between energy efficient residential and commercial buildings. Benefits of sustainability should be shared by all members of society, in particular those more vulnerable to the potential impacts of infrastructure costs and changes. Currently, Canberra's public transport remains under-utilised, with per capita usage rates barely half those of two decades ago, despite significant action and investment in public transport during the reporting period. Of particular concern is the recent work indicating that greenhouse gas emissions from the transport sector are still projected to increase to 50-60% above 1990 levels by 2020 (ICRC

2011a, Heuris Partners 2010)[1], even if the *Sustainable Transport Plan* targets are achieved.

The Government is struggling to meet the demand for affordable land and housing. In addition, increased land release and development has significant impacts on ecosystems and natural resource in the ACT and currently this is not effectively measured and monitored. A growing city and population requires the provision and maintenance of community services and facilities, public amenity, open space and recreation areas. This will be a challenge for government and community. Currently, our relative wealth and consumption continues to drive an increase in the ACT's urban growth and ecological footprints and waste generation. The co-location of employment, essential recreational and ancillary services, along with residential developments in town centres will need to be core components in efforts to increase the sustainability of the city while reducing carbon emissions and overall environmental impact. However, the share of development occurring within 7.5km of the city decreased steadily over the reporting period, to 28.5% in 2009-10; well below the 50% target set out in the *Canberra Spatial Plan* (ACT Government 2004).

The close proximity of bushland reserves to urban areas of ACT brings challenges, along with benefits. The health benefits provided by green spaces include positive physical, social, mental and spiritual health outcomes. However, managing this large area of open space with limited resources is challenging. Further, the close proximity of urban areas to bushland reserves and hilly terrain increases the risk of bushfire impacts on our urban area. Finally, extreme events such as storms and fires are also likely to increase in frequency and intensity in the future as a result of climate change impacts.

How are we responding?

The design and use of our urban areas and infrastructure, and our parks and open space, can significantly affect the quality of the environment. Community engagement and awareness in environmental issues can also have significant impacts on our overall level of resource use and waste generation. During the reporting period, the ACT Government has introduced or continued a number of frameworks, policies and initiatives including:

- release of the *Strategic Public Transport Network Plan*;
- five-year infrastructure program *Building the Future* which provides guidance and direction for the development of the first ACT *Infrastructure Plan*;

[1] Calculations based on ICRC transport emissions data from the 2009 Greenhouse Gas Emissions Inventory (ICRC 2011a) and ACT Government-commissioned research into existing policy baseline projections to 2050 (Heuris Partners 2010), as well as estimates of a 3% reduction based on changes in mode of work transport detailed in the *Draft Sustainable Energy Policy 2010-2020* (DECCEW 2009).

- water, waste and energy efficiencies programs for business and industry, schools and community as well as temporary initiatives at public events;
- free heritage and architectural guidance provided by the Heritage Advisory Service to owners and potential buyers of heritage buildings on renovating or extending a heritage home ; and
- The *Strategic Bushfire Management Plan for the ACT.*

While the interaction of resource use, urban design, and green infrastructure is complex, this complexity can be managed through a strategic, ongoing approach to sustainability that integrates the protection of our natural environment, the development of our city and the enhancement of our wellbeing. The *Spatial Plan* of the city is currently under review and will need to reflect the growing demands of ACT residents with the need for such sustainable development.

ACT residents also play a significant role in managing and protecting our environment with a high number of community groups involved in environmental programs in areas ranging from biodiversity conservation and water quality to renewable energy, climate change and sustainable food and gardening.

How can we improve?

A consolidated mix of greenfield and infill development is an important part of providing affordable and diverse housing options, and for increasing population densities in the ACT. As noted there is some concern voiced about altering the landscape character of the city through increasing height and plot ratios associated with densification. If we are to progress sustainability those concerns need be acknowledged and included in future decisions for the form of our city. There is an opportunity for the government to engage with the public through fora such as "Time to Talk" with the objective of improving sustainability through population densification

The city's environment, liveability and amenity depend in considerable measure on accessible open space and green infrastructure that provides passive ecosystem benefits. While Canberra's urban trees, parks, waterways and public open spaces are a major asset, they are also a management challenge.

15. *Finalise and implement the draft ACT Planning Strategy to provide an integrated approach to future landscape planning. Particular attention should be paid to:*
    a. *determining indicators and measures for urban quality in the ACT that includes the benefits provided by green infrastructure and access to open space; and*
    b. *developing greenfield and infill targets, which take into account both the need for public open space and the passive benefits of green infrastructure, as well as strengthening a sense of community and self containment.*

Future population growth and demographic changes will lead to an increased demand for housing, government and other services. More flexible options in various forms of housing will be needed to suit the diverse needs of young families, Canberra's large student population, older people and one-person households.

16. *Develop adaptable housing strategies to address the needs of changing population demographics into the future.*

Despite actions that have been undertaken by ACT Government and the large increases in operating costs, Canberra's public transport system has seen little improvement in patronage in the short-term, while comparisons with long-term trends indicate that usage per person remain barely half that observed two decades ago. The transport sector is the second largest contributor to the ACT's greenhouse gas emissions; a share that is expected to increase. A lack of current data, particularly regarding non-work travel, further restricts our capacity to understand travel behaviour in the ACT. Urgent, evidence-based actions and policies are therefore needed in order to encourage a shift to more sustainable transport options.

17. *Finalise and implement the draft Sustainable Transport Action Plan to provide an integrated approach to transport and urban planning. In doing so:*
    a. *obtain additional non-work related travel data, similar to the annual Sydney Household Travel Survey, to ensure a more complete understanding of Canberra's transport habits;*
    b. *focus on strategies and targets to improve access to sustainable forms of transport outside of transport corridors;*
    c. *develop targets for;*
        i. *reducing greenhouse gas emissions from transport;*
        ii. *increasing sustainable transport usage for non-work travel to complement the existing targets for work travel; and*
    d. *track progress towards Sustainable Transport targets on an annual basis.*

Waste generation and waste to landfill continue to increase. Construction and demolition as well as commercial and industrial wastes have been largely driving this increase and along with organic waste should be diverted from landfills. The link between our ecological footprint, consumption and waste generation is not well understood and further work and broader understanding of the issue is needed to help the Canberra community make more informed consumption choices.

18. *Finalise and implement a new ACT Waste Management Strategy with a focus on reducing waste generation; in particular:*

a. *examine and implement options for diverting wastes from landfill to higher order beneficial reuse opportunities. These actions should be measured, recorded and reported publicly.*
b. *focusing community education on the link between consumption and waste; and*
c. *targeting specific programs to reduce waste from the construction and demolition sector, and commercial and industrial sectors.*

There is a large backlog in processing relating to the ACT Heritage Register. Heritage places and objects in the ACT are at risk because of limited funding for registration and for management of the pressures of development. The Marshall Report (Marshall 2010) found that audit, compliance and enforcement are weak elements of the Heritage Act. In February 2012 the *Register of the National Estate* becomes obsolete potentially placing the protection of some ACT heritage sites at risk. Housing from the post-war boom period of Canberra's growth are common subjects of renovation and replacement. Some of these buildings, although worthy of nomination, are under threat.

19. *Strengthen heritage protection in the ACT by:*
    a. *developing an action plan for heritage which addresses the backlog of heritage nominations and recognises key future places for protection;*
    b. *strengthening audit, compliance and enforcement processes in line with recommendations of the Marshall report;*
    c. *developing a memorandum of understanding with the Australian Government to protect assets, subject to Australian Government planning approvals, on the ACT Heritage Register;*
    d. *promote ACT heritage values as a part of the Canberra 2013 Centenary celebrations.*

Many of Canberra's urban elements are close to, and inclusive of many of the natural features of our landscape such as bushlands, reserves and waterways that provide risks from fires, floods and storms.

20. *Align and integrate climate adaptation planning and disaster risk management where appropriate. This should include lessons learned from changes to fire management.*

21. *In collaboration with NSW Government and local councils, develop a regional approach to planning and risk management to address future challenges of population and climate change.*

ACT residents have a relatively high level of concern for and involvement in protecting the environment. They engage in regeneration, protection and research

activities, demonstrating their commitment over long periods of time and across multiple projects. However awareness in regards to sustainable transport, renewable energy and the impacts of consumption are not necessarily reflected in actions.

22. *Strengthen community engagement in sustainability by:*
    a. *undertaking research on attitudes to sustainability and consumption patterns and behaviours. This could be done through regular, comparable, community surveys similar to the annual NSW Who cares about the environment? with the outcomes informing focus areas for community engagement.*
    b. *foster behavioural change through community engagement to reduce our ecological footprint with a particular focus on:*
        i. *sustainable transport; and*
        ii. *impacts of consumption.*

Data

As has been identified in previous SoE reports, the lack and sometimes inadequacy of relevant data is an ongoing challenge for not only reporting but also for the effective monitoring and management of the ACT environment. Good environmental management requires good data in order to produce, and improve on, evidence-based strategies.

Currently key datasets are missing or incomplete, including indoor air quality sampling, assessments of the effectiveness of emissions reduction measures, data on land use changes including erosion, soil salinity and acidity, vegetation quality and cover changes, non-work related travel data, and consolidated habitat loss across ACT and thresholds for habitat loss.

Further, there is a lack of alignment between Australian Bureau of Statistics' *Census of Population and Housing* and ACT SoE Reporting cycles. For example, the Census provides valuable information on changes to the ACT community. The 2011 census data will not be available until mid 2012, resulting in this report relying on 2006 census data, pre-dating both the reporting period itself, and many of the current ACT government policies and management objectives. This problem is likely to be faced again in the next reporting cycle.

For its size, the ACT has an exceptionally high capacity to collect data and conduct research, with world-class research institutions, globally-recognised experts across national and local government institutions, numerous non-government organisations and a community highly-engaged in monitoring and environmental advocacy. Thus, in order to ensure efficient research and enhance planning and policy processes, there should be continued efforts to provide access to information, co-ordinate research and facilitate collaboration both between these institutions, and with

members of the wider community in order to raise public awareness of environmental issues.

A strategic monitoring, evaluation, reporting and improvement framework is needed to ensure that data from all parts of government are brought together to create a more holistic picture of environmental changes in the ACT. Such a strategy should co-ordinate and integrate the current knowledge and research, existing government and non-government skills and programs and focus on periodic reporting. Information-sharing mechanisms would also benefit from a centralised data repository, reducing repetition of monitoring, fragmented understandings of interconnected environmental issues and streamlining resourcing. This would require a dedicated position to consolidate and provide access to information and facilitate collaboration and integration between government and research/academic institutions across disparate fields to undertake research, teaching, planning and practical projects to enhance sustainability relevant to the ACT and Region.

References

ACT Government 2004. *Canberra Spatial Plan.* Canberra. http://apps.actpla.act.gov.au/spatialplan/introductory/index.htm (accessed 25/8/11)

ACT Government 2010. *Time to Talk. Canberra 2030 – Outcomes Report.* Canberra. http://timetotalk.act.gov.au/storage/78d10e40d957379825347909b6e2bfd9.Time%20to%20talk%20-%20web%20version.pdf (accessed 2/9/11)

ACT Government 2011. *Commissioner for the Environment Act 1993.* Republication No 12. Effective 1 July 2011. ACT Parliamentary Counsel. Canberra. http://www.legislation.act.gov.au/a/1993-37/current/pdf/1993-37.pdf (accessed 1/11/11)

ABS 2011. *6523.0 – Household Income and Income Distribution.* Australian Bureau of Statistics. Australian Government. Canberra. http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/DBE855896D8CA36DCA2578FB0018533C/$File/65230_2009-10.pdf (accessed 22/11/11)

CMCD 2011. *Australian Demographic Statistics — March Quarter 2011.* ACT Chief Minister and Cabinet Directorate. Policy and Cabinet Division. ACT Government. Canberra. http://www.cmd.act.gov.au/__data/assets/pdf_file/0020/245045/ERPMar10.pdf (accessed 8/11/11)

Davis, C. and Lindesay, J. 2011. *Weather and Climate of the ACT 2007-11 and Decadal Trends.* Office of the Commissioner for Sustainability and the Environment. Canberra. Unpublished.

DECCEW 2010a. *ACT Water Report 2009-10.* Department of the Environment, Climate Change, Energy and Water. ACT Government. http://www.environment.act.gov.au/__data/assets/pdf_file/0008/227978/DECCEW_Water_Report_WEB.pdf (accessed 22/11/11)

DECCEW 2009. *ACT Water Report 2008-09*. Department of the Environment, Climate Change, Energy and Water. ACT Government. Canberra. http://www.environment.act.gov.au/water/act_water_reports/act_water_report_2008-2009 (accessed 22/11/11)

Dey, C. 2010 *The 2008-09 Ecological Footprint of the Population of the ACT.* Integrated Sustainability Analysis (ISA). The University of Sydney. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0015/211182/ACT_Ecological_Footprint_08-09_final_report.pdf (accessed 11/8/11)

EPA 2010. *ACT Air Quality Report 2009.* Environmental Protection Authority. Department of Environment, Climate Change, Energy and Water. ACT Government. Canberra. http://www.environment.act.gov.au/pv_obj_cache/pv_obj_id_58A842886D03E5329562F66D685018FC51120A00/filename/ACTAirQualityReport2009.pdf (accessed 14/4/11)

ESDD 2011. *Population and Residential Density in Canberra*. Environment and Sustainable Development Directorate. ACT Government. Canberra. http://www.actpla.act.gov.au/__data/assets/pdf_file/0005/23648/Population_Density_2011.pdf (accessed 22/11/11)

Heuris Partners 2010. *ACT Greenhouse Gas Emissions: Existing policy baseline projections to 2050 - Research Report*. Heuris Partners. Canberra. http://www.environment.act.gov.au/__data/assets/pdf_file/0008/187217/ACT_Greenhouse_Gas_Emissions.pdf#ACT%20Greenhouse%20Gas%20Emissions (accessed 7/11/11)

ICRC 2011a. *ACT Greenhouse Gas Inventory Report for 2008-09*. Independent Competition and Regulatory Commission. Canberra. http://www.environment.act.gov.au/__data/assets/pdf_file/0003/235578/ACT_Greenhouse_Gas_Inventory_Report_2009_20110930.pdf (accessed 22/11/11)

ICRC 2011b. *ACT Electricity Feed-in Scheme Activity Summary: 1 March 2009 to 30 June 2011*. Independent Competition and Regulatory Commission. Canberra. http://www.icrc.act.gov.au/__data/assets/pdf_file/0015/230208/Electricity_Feed-in_Summary_Report_JuneQ11_Final.pdf (accessed 1/8/11)

LAPS 2011. *Australian Capital Territory Indicative Land Release Program 2011-2012 to 2014-15.* Land and Property Services. Economic Development Directorate. ACT Government. Canberra. http://www.economicdevelopment.act.gov.au/__data/assets/pdf_file/0010/205021/Final_Print_Ready_Land_Release_Text_6_May_2011.pdf (accessed 22/11/11)

Lindenmayer, D. and Hobbs, R. 2007. *Managing and Designing Landscapes for Conservation: Moving from Perspectives to Principles*. Wiley-Blackwell. London

Manning, A. 2011. *Mulligans Flat - Goorooyarroo Woodland Experiment*. Australian National University. Canberra. http://people.anu.edu.au/adrian.manning/bettong.html. (accessed 10/10/11)

Marshall, D. 2010. *ACT Heritage Act Review*. ACT Heritage. ACT Government. Canberra. http://www.cmd.act.gov.au/__data/assets/pdf_file/0019/154315/reduced_ACT_Heritage_Act_Review_4Aug10.pdf (accessed 3/5/11)

Mees. P. Sorupia. E. & Stone. J. 2007. *Travel to Work in Australian Capital Cities. 1976-2006: An Analysis of Census Data*. Australasian Centre for the Governance and Management of Urban Transport (GAMUT). http://www.abp.unimelb.edu.au/gamut/pdf/travel-to-work.pdf (accessed 18/11/11)

Murray, J. and Dey,C. 2011. *Canberra's Ecological Footprint: What does it mean?* Office of the Commissioner for the Environment and Sustainability. Canberra

OCSE 2011. *Report on Canberra Nature Park (nature reserves); Molonglo River Corridor (nature reserves) and Googong Foreshores Investigation.* Office of the Commissioner of Sustainability and the Envrionment. Canberra. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0009/234990/Summary_and_recommendations.pdf (accessed 19/10/11)

ORER 2011. *Renewable Power Percentage.* Office of the Renewable Energy Regulator. Australian Government. Canberra. http://www.orer.gov.au/For-Industry/Liable-Entities/Renewable-Power-Percentage/rpp#interim (accessed 11/11/11)

Rotstein, J. and Webb B. 2009. *Australian Capital Territory and Region Climate Change Vulnerability and Adaptation Project; Knowledge status and future issues report – Human Health*. Report to the Department of Environment, Climate Change, Energy and Water. Unpublished

Sharp, S. 2011. *Landscape Function in Canberra Nature Park and Impacts of Threatening Processes on Landscape Function*. Report to the Commissioner for Sustainability and the Environment. Unpublished

TAMS 2007. *Action Plan No. 29 - ACT Aquatic Species and Riparian Zone Conservation Strategy.* Territory and Municipal Services. ACT Government. Canberra. http://www.tams.act.gov.au/play/pcl/conservation_and_ecological_communities/aquatic_species_and_riparian_zone_conservation_strategy (accessed 17/9/11)

TAMS 2011. *Annual Report 2010-2011.* Territory and Municipal Services. ACT Government. Canberra. http://www.tams.act.gov.au/__data/assets/pdf_file/0007/233179/Volume_1_10-11.pdf (accessed 21/10/11)

Webb, B. 2011. *Impacts of Climate on the Canberra Nature Park: Risks and Responses.* Febuary 2011. Report for the ACT Office of the Commissioner for Sustainability and the Environment. ANU Climate Change Institute and Fenner School of Environment and Society. Australian National University.Canberra. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0004/220477/OCSE_ANU_paper_climate_CNP.pdf (accessed 2/11/11)

WWF 2011. *Building Nature's Safety Net 2011: The State of Protected Areas for Australia's Ecosystems and Wildlife*. World Wildlife Fund. http://assets.wwfau.panda.org/downloads/bi037_building_natures_safety_net_2011_6jul11.pdf (accessed 1/9/11)

Acknowledgements

This ACT State of the Environment Report (ACTSoER) has been developed independently by an in-house team of the Office of the Commissioner for Sustainability and the Environment assisted by a wide range of experts. It builds on work undertaken by the previous Commissioner, Dr Maxine Cooper. I am pleased to acknowledge the vital contributions of those involved in producing the Report.

Robert Neil

ACT Commissioner for Sustainability and the Environment

Office of the ACT Commissioner

I am grateful for the work of the State of Environment team within the Office of the Commissioner for Sustainability and the Environment (OCSE). I would particularly like to thank Ms Sarah Burrows – Senior Manager and ACT SoER 2011 Project Manager. Sarah's leadership and communication skills were a significant contribution to synthesising complex and multidimensional issues into an informative and readable report. Dr Aileen Power, as ACT SoER Project Coordinator, supplied invaluable planning and coordination skills and both she and Project Officer, Mr Alexei Trundle undertook essential research, writing and assessment of issues.

My thanks also to others in the OCSE team, Ms Bettina Holyman and Ms Sonya Hamley for their administrative and organisational assistance, Ms Joanna Temme, in particular for her work on the *Community Engagement* paper, and Mrs Narelle Sargent and Mr Warren Geeves, for their dedicated support.

ACT Government agencies

Special thanks go to ACT Government staff for their cooperation in providing data, information and advice on various parts of the Report.

Professional advice and expertise

The following consultants assisted in preparing the Indicator cluster and theme papers for the Report. Their expertise and willingness to work closely with staff helped ensure a comprehensive report:

Land and Water Theme - Halcrow Pacific Pty Ltd
Biodiversity theme - NGH Environmental Pty Ltd
Climate Theme – AECOM Australia Pty Ltd
People Theme - Beacon Hill Global Pty Ltd, Dr Paul Mees (RMIT) and SKM Pty Ltd

A number of people, with experience, knowledge and expertise in their fields have contributed input and advice during the development of the Report and recommendations. Their advice was particularly valuable in refining the Recommendations to Government. Their continued interest and commitment to the work of the Office is highly valued and appreciated: Dr Dianne Firth, Dr Sarah Ryan, Dr David Shorthouse, Prof Will Steffen and Mr Darro Stinson.

ACT State of the Environment Report 2011

Review of the Report papers

Many people, individually and as members of groups, participated in reviewing papers for the Report throughout its development.

ACT SoER reference group

Dr Joe Baker – previous OCSE Commissioner and current advisor to Queensland Government, Assoc. Director-General, Agriculture, Food, Tourism & Regional Services
Ms Maureen Cane – Cane & Gray Consulting Services
Mr Michael Mazengarb – Office of Renewable Energy and OCSE Youth Ambassador
Dr Geoff McAlpine – consultant and former CSIRO Principal Adviser Environment
Dr Sarah Ryan – ACT Natural Resource Management Council and CSIRO
Prof Will Steffen – The ANU Climate Change Institute, Executive Director

Peer review groups

Theme: Climate and Air quality

Dr Bob Webb - ANU Climate Change Institute
Mr Perry Wiles – Climate Policy and Coordination, Bureau of Meteorology
Professor Will Steffen – The ANU Climate Change Institute, Executive Director
Economic Development Directorate – Mr Rob Thorman
Environment and Sustainable Development Directorate – Ms Heather Tomlinson, Mr Mark Heckenberg, Mr Daniel Walters, Mr Dave Power
Health Directorate - Ms Linda Bower, Mr Richard Hopkins, Dr Ranil Appuhamy

Theme: Biodiversity

Dr Sarah Ryan - Natural Resource Management Council and CSIRO
Dr Joseph Baker - previous OCSE Commissioner and current advisor to Queensland Government, Assoc. Director-General, Agriculture, Food, Tourism & Regional Services
Prof Paul Downey - Faculty of Applied Science, University of Canberra
Mr Ian Fraser – ACT Natural Resources Management Advisory Committee
Dr Lyn Hinds - CSIRO Ecosystem Sciences
Dr David Shorthouse – Consultant & Visiting Fellow, Fenner School of Environment & Society, ANU
Economic Development Directorate – Mr Paul Lewis
Emergency Services Authority - Mr Nick Lhuede
Environment & Sustainable Development Directorate – Ms Sharon Lane, Dr Michael Mulvaney, Dr Murray Evans
Health Directorate - Ms Linda Bower, Mr Richard Hopkins, Dr Ranil Appuhamy

Theme: Land and Water

Prof Ian Falconer - Water Quality Consultant
Dr Joseph Baker - previous OCSE Commissioner and current advisor to Qld govt Associate Director-General, Agriculture, Food, Tourism and Regional Services
Dr Sarah Ryan - ACT Natural Resource Management Council and CSIRO
Dr Fiona Dyer - Institute for Applied Ecology, University of Canberra
Mr Chris Pulkkinen - ACTEW
Ms Bronwen Butterfield – ACTEWAGL
ACTPLA - Ms Kylie Carman-Brown

Health Directorate - Ms Linda Bower, Mr Richard Hopkins, Dr Ranil Appuhamy
Economic Development Directorate - Mr Rob Thorman
Environment and Sustainable Development Directorate – Dr Michael Mulvaney, Dr Murray Evans (Conservation, Planning and Research), Mr John Feint (Natural Resource Management), Mr Stewart Chapman (Water Policy) , Mr Daniel Walters, Mr Health Chester and Mr Mark Heckenberg

Theme: People

Prof Rachel Davey - Director, Centre for Research and Action in Public Health, University of Canberra
Dr Dianne Firth - Faculty of Arts & Design, University of Canberra
Professor Will Steffen - The ANU Climate Change Institute, Executive Director
Mr Alexei Trundle – Project Officer – Office of the Commissioner for Sustainability and the Environment
ACTPLA - Ms Kylie Carman-Brown
Chief Minister and Cabinet Directorate – Mr Richard Bontjer
Economic Development Directorate - Mr Paul Lewis
Health Directorate, Ms Linda Bower, Mr Richard Hopkins, Dr Ranil Appuhamy
TAMS, Transport - Mr Paul Peters (transport), Ms Joanne Clay (waste)
Emergency Services Authority - Mr Nick Lhuede

Supporting papers

Other subject experts prepared supporting papers which informed the Report:

Dr Steve Cork, Mr Clem Davis, Dr Chris Dey, Dr Janette Lindesay, Dr Joy Murray, Dr David Pearson, Dr Sarah Ryan, Dr Bob Webb

Sustainability stories

A number of organisations and ACT Government agencies contributed to the sustainability stories contained in this Report:

ACT Environment & Sustainable Development Directorate, in particular Dr Lisa Evans and Ms Anita Perkins
ACT Natural Resource Management Council
ACT Territory and Municipal Services Directorate, in particular Mr Geoff Virtue
Canberra Indian Myna Action Group
Canberra Organic Gardens Society
Dickson Motor Vehicle Registry Sustainability Working Group
OzHarvest Canberra
SEE-Change
Upper Murrumbidgee Waterwatch
University of Canberra
Yarralumla Nursery

Horizon Scanning

The following experts and community leaders participated in the Horizon Scanning consultation process:
Dr Joe Baker (former ACT Commissioner for the Environment)

Dr Greg Battye (University of Canberra)
Dr Matthew Brookhouse (Fenner School, Australian National University)
Ms Maureen Cane (Director, Cane and Grey)
Mr Robert de Castella (Managing Director, StartSmart)
Dr Keith Dear (Australian National University)
Prof Ian Falconer
Mr David Flannery (University of Canberra)
Mr Nectar Efkapides (Molonglo Group)
Ms Janet Jeffs (Director, Ginger Room)
Mr Dave Johnston
Dr Kuntala Lanhiri-Dutt (Australian National University)
Mr Geoff McAlpine
Mr Michael Mazengarb (OCSE Youth Ambassador)
Dr Warren Nicholls
Dr Sarah Ryan (CSIRO Sustainable Ecosystems)
Prof Will Steffen (ANU Climate Change Institute)
Ms Erika Strazdins (OCSE Youth Ambassador)
Ms Katie Taylor (OCSE Youth Ambassador)
Mr Peter Teggart (Bega Shire Council)
Dr Brian Walker (CSIRO)
Prof Jen Webb (University of Canberra)
Dr Su Wild-River (ANUgreen)

Communications group

A number of people have given advice and input on communication aspects of the Report:

Mr Simon Copland (Australian National University)
Dr William Grant (Australian National University)
Assistant Prof Joanna Henryks (University of Canberra)
Mr David Marshall (Talkforce Consultants & Trainers)
Ms Claudia Vannithone (Content Group)
Ms Penny Wilson (Australian National University)
Mr John Yanny (Voodoo Creative)

Editing

Ms Ann Milligan, ENRiT – Indicator Cluster and Theme Papers
Ms Sumaiya Ahmed – Driving Forces, Progressing Sustainability, Executive Summary and Headline Indicator Papers
Ms Penny Wilson – Sustainability Stories

Website Design and Graphic Design

Web Design - Voodoo Creative - Mr John Yanny, Ms Tegan Clarkson

Graphic Design of print versions - Paper Cut - Ms Kate Brennan, Ms Tamar Mavlian

ACT State of the Environment Report 2011

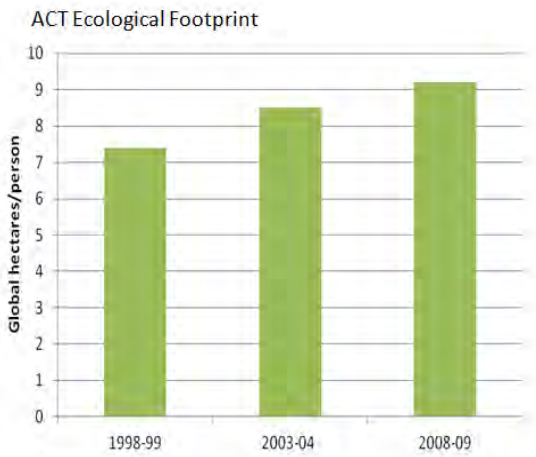
Headline Indicators

The impact that Canberra has on both local and global natural environment is continuing to increase. This section looks at the key indicators of the city's impact on the environment.

Canberra is a very liveable city. However, as a largely urban population with high levels of consumptions of goods and services, we are increasing the impact on the natural environment globally and locally.

Ecological Footprint

An ecological footprint is a calculation of the area of land and water required to support our use of resources and our disposal of wastes (expressed in 'global hectares'). This measure only accounts for the land needed to support the human population and not other species. In 2008-09 the size of the average ACT resident's ecological footprint was 9.2 global hectares. This has increased by 8% in 5 years and nearly 25% in 10 years.

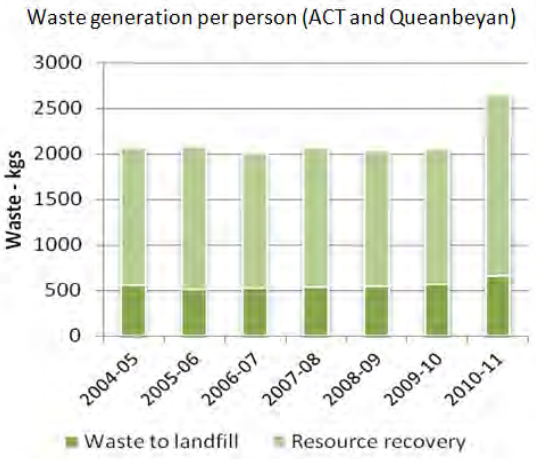


Source: Dey 2010

Our 2008-09 ecological footprint was 13% above the Australian average and nearly 3.5 times the global average. If everyone in the world lived in the same way as the average person in the ACT, we would need 5 Earths to give us enough land (and surface water) to provide our resources and absorb our wastes. Associated with this over-consumption is increasing waste generation and greenhouse gas emissions.

Waste

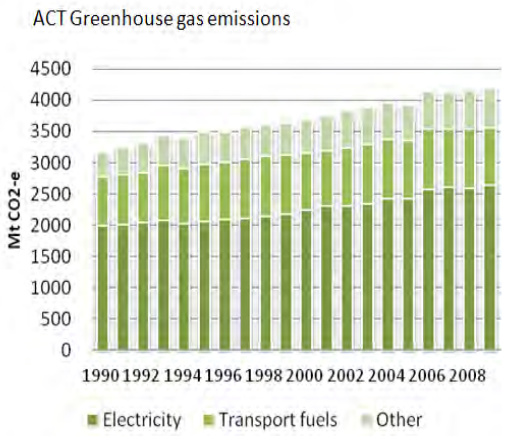
Total waste generation has increased by about 35% since the last reporting period. While we continue to recycle over 70% of our waste, we also continue to increase the amount of waste sent to landfill. Waste generation per person has increased by 28% since the previous reporting period, while population has increased by only 5.5%. This has implications for the environment through potential contamination of environmental assets and land used for landfill.



Source: TAMS

ACT State of the Environment Report 2011

Greenhouse gas emissions



Source: ICRC 2011

Globally, both anthropogenic emissions and atmospheric concentrations of greenhouse gases continue to increase. This increase has been reflected in the ACT with emissions rising by 7% between 2005 and 2009. Our lifestyles that demand a considerable use of resources are driving the increase of these emissions.

Electricity produced by burning fossil fuels remains the largest contributor to our greenhouse gas emissions, followed by natural gas and transport fuels. It is thus clear that efforts to reduce emissions need to focus on these sectors.

Physical Climate Effects

Having a relatively stable and predictable climate is important for many reasons including human wellbeing, the health of ecosystems, maintenance of water resources, conservation of biodiversity, and for food security. During the reporting period, the weather in the ACT was generally warmer than the long-term average (1961-1990), with drier conditions in 2008 and 2009 and wetter conditions for 2010. During the reporting period, the ACT region recorded below average rainfall for 7 of the last 10 years (2001-2010). Long-term trends indicate that temperatures have been increasing with more marked increases over the past 10 years, in line with overall trends for Australia (Davis and Lindesay 2011). These results tend to reflect the impacts of El Nino Southern Oscillation events. While climate variability has been evident over the reporting period, longer-term trends are consistent with the climate change predictions of hotter and drier conditions with more extreme climate events.

Changes in ACT weather phenomena

Year	1961-1990 Average	2008-2010 Average
Days 35 °C or more	5	11
Days 30 °C or more	30	43
No. Frosts	99	65
No. Thunderstorms	23	20
No. Fogs	44	39
No. Strong Wind Days	26	24
No. Rain Days	105	101
Mean Daily Pressure (isobars)	1016.7	1017.4

Source: Davis and Lindesay 2011

ACT State of the Environment Report 2011

Land and Water

Weather events and urban pressures impact the health of our natural environment. Recovery from fire and drought and a number of catchment management projects are likely to have contributed to overall improved land health in ACT over the reporting period. However comprehensive data on land health are not available. Generally, water flowing out of the ACT at Halls Crossing is of no less quality than that flowing into the Territory at Angle Crossing. Changes in geology, urban run-off and return of treated sewerage are impacting on a number of water quality indicators (pH, conductivity, total nitrogen and chlorophyll 'a').

Biodiversity

The area of land zoned for urban use in the ACT increased by about 9% during the reporting period (ACTPLA). This has grown at the expense of areas of native and modified vegetation. Three new nature reserves were added to Canberra Nature Park conservation reserves during the reporting period, namely, Callum Brae, Jerrabomberra West and Kama. In addition approximately 80 hectares have been added to the existing reserves. However, in 2010, 17 species and 2 communities were listed as endangered and 15 as vulnerable under the *Nature Conservation Act 1980* (ACT). During the reporting period 3 new species (the Little Eagle, Glossy Black-Cockatoo and Pink-Tailed Worm Lizard) were listed as vulnerable.

References

Davis, C. and Lindesay, J. 2011. *Weather and Climate of the ACT 2007-11 and decadal trends.* Office of the Commissioner for Sustainability and the Environment. Canberra

Dey, C. 2010. *The 2008-09 Ecological Footprint of the Population of the ACT*. Sydney. http://envcomm.act.gov.au/_data/assets/pdf_file/0015/211182/ACT_Ecological_Footprint_08-09_final_report.pdf (accessed 17/11/11)

ICRC 2011. *ACT Greenhouse Gas Inventory Report for 2008-09*. Independent Competition and Regulatory Commission. Canberra. http://www.icrc.act.gov.au/__data/assets/pdf_file/0009/235719/ACT_Greenhouse_Gas_Inventory_Report_2009_Final.pdf (accessed 11/10/11)

Other data sources

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

ACTPLA. ACT Planning and Land Authority (now Environment and Sustainable Development Directorate, ESDD)

Department of Territory and Municipal Services (now Territory and Municipal Services Directorate, TAMSD)

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

Progressing Sustainability

Concern for the environment and a desire to live more sustainably has become widespread internationally and is also evident locally in the ACT. Yet, considerable uncertainty exists regarding the meaning of these terms, the main challenges faced and the improvements that can be made to the current situation in order to move towards a more sustainable future.

Source: ACT Government

Much of the contemporary thinking about environmental sustainability is based on the landmark report, Our Common Future (WCED 1987:43), which describes sustainable development as that which would meet present needs without compromising the ability of future generations to meet theirs. Central to this view of sustainability is a concern for social justice and equity within and between generations. The inherent uncertainty around our ability to precisely predict future scenarios, the changing character of social organisation and technology, and the potential to meet our current and future needs are also central considerations.

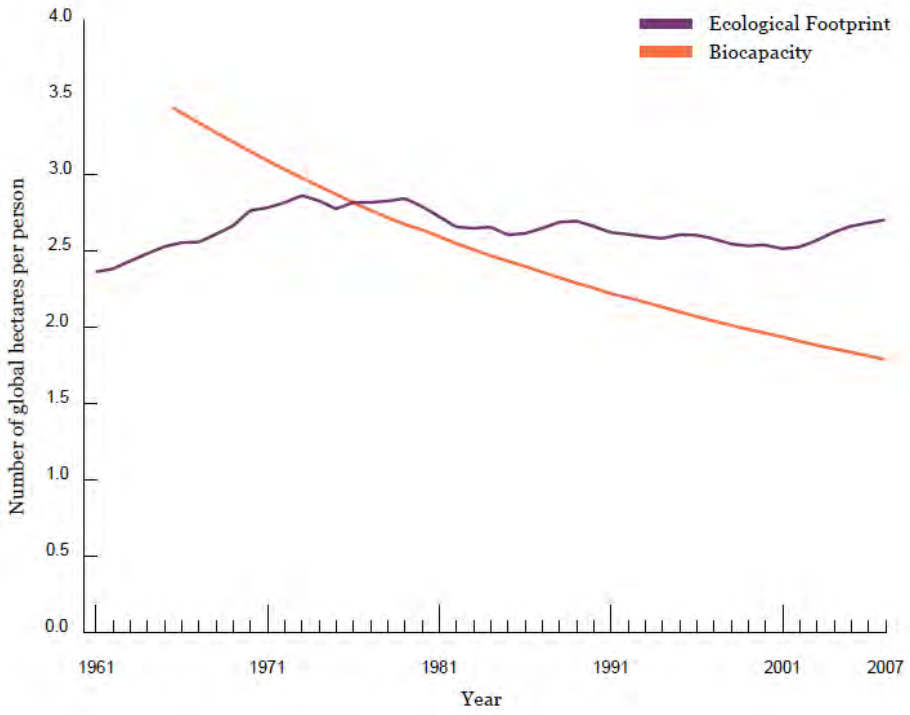
As in other situations where indications are clear but knowledge incomplete, applying the precautionary principle is necessary. Key aspects to consider, therefore, in assessing sustainability and taking actions for its enhancement are: resource depletion and degradation; pollution and wastes; ecological services that support all life; and a range of economic and socio-political issues (Dovers 2005:9).

This paper places the outcomes of the State of the Environment Report (SoER) into a wider sustainability framework and provides information for decision makers and the community on the key challenges and opportunities for progressing sustainability in the ACT.

Sustainability in the global context

We are part of an interconnected world and contribute to, and are affected by, emerging global trends. Globally, the area of land needed to support our lifestyles (ecological footprint) is exceeding the area of biologically productive land and water on earth available to meet the needs of human populations (biocapacity), which has continued to decline markedly over the past 50 years (Figure 1). The rate of consumption is not evenly spread across the globe, with high-income countries such as Australia having a footprint five times that of low-income countries (WWF 2010). The global carbon footprint (CO_2 emitted from fossil fuel consumption) has increased by over 30% since 1998, and now accounts for over half the ecological footprint (WWF 2010).

Figure 1. Changes in the global ecological footprint and the biocapacity available per person worldwide between 1961 and 2007



Source: WWF 2010

Commonly discussed pressures in recent times are the predicted changes that are likely to accompany climate change, the uncertainties of transitioning to alternative fuel supplies and sources of renewable energy, and global economic uncertainty. Other key global drivers that may impact on the ACT and Region include (Cork, 2011):

- changing international trade patterns and agreements;
- global power shifts in the Asia-Pacific region;
- shortages of water in many countries and associated shortages of food;
- a growing rich-poor divide and increasing inequity; and
- political change and unrest in many developed and developing countries, often arising from combinations of local and global change.

While these pressures may challenge efforts to achieve heightened sustainability, locally and nationally, other aspects of globalisation offer opportunities for progress. International and local actions are becoming increasingly interconnected through electronic media and the internet. Efforts are underway, using these technologies, to raise awareness, provide access to information, connect like-minded people and enable collaboration across disparate fields to undertake research, teaching, planning and practical projects to enhance sustainability in many different ways (see *Sustainability Stories*).

ACT State of the Environment Report 2011

The challenge we face – sustainability locally

The *Time to Talk: Canberra 2030* (ACT Government, 2010) community consultation found that most Canberrans want a green and sustainable city that limits urban sprawl. We are a highly urbanised population residing in a city, ranked as one of the top 30 cities worldwide for its liveability, water quality and availability, waste removal, air pollution and congestion (Mercer Worldwide Quality of Living Survey 2010), where we enjoy extensive green space within and around the city. Further, we experience very little industrial pollution as we import most of our consumer goods and services from interstate and overseas. Yet the ACT is facing many challenges in maintaining its urban quality and increasing its sustainability into the future. Ironically, it may be that the very liveability of the city is making it more difficult for Canberrans to associate their increasingly urban lifestyle with degradation of the natural environment, which determines our high quality of life and consumption.

The ACT's population and economy are continuing to grow with increasing levels of affluence, accompanied by urban expansion and an increased ecological footprint.

Source: ACT Government

Population demographics and the ways people interact in the ACT and Region are also changing and affecting how the region functions, particularly in transport patterns and housing and service requirements. All these changes have direct environmental impacts, resulting in land degradation, vegetation clearing, habitat loss, water quality impacts and increased run-off.

Many Canberrans are involved in addressing local impacts on the immediate environment (for example, in efforts to control pollution and protect ecosystems) but are less focused on addressing the Driving Forces, such as consumption, that create those impacts. This is reflected in the increasing size of our ecological footprint, which has grown by 8% in five years and nearly 25% in 10 years. It is now 9.2 global hectares - 13% above the Australian average and nearly 3.5 times the global average. If we were to have our fair share of the total global hectares (gha) available, we would have reduced our footprint to 1.8 gha per person.

This increase in our ecological footprint is linked to the growth in our urban footprint and our high levels of consumption. This in turn puts increased pressure on the local and wider environment. Our heavy reliance on motor vehicles is still trending upwards and, consequently, our greenhouse gas emissions are continuing to grow (by about 7% between

2005 and 2009). Waste generation increased by 34.7% (from 2007-08 to 2010-11) and the city boundary is further expanding as a result of the predominant share of greenfield development (72% over the reporting period).

Although local actions and policy measures are crucial for local environmental health and sustainability, the well-known adage of think globally/act locally needs reconsidering. The interconnectedness of every aspect of the environment at all scales from local to global, and our interdependence regionally, nationally and internationally, has become even more apparent. Achieving enhanced sustainability requires actions across all these scales. For the ACT, working with regional, NSW and national partners is particularly important. These 'cross-border' issues are diverse, existing in and across all the themes explored in this report. Some examples of such issues are:

- Over 98% of the ACT's stationary energy is generated in NSW, while much of the region's strongest potential for renewable energy, such as wind power, lies in surrounding areas outside the ACT.
- Free parking in the Parliamentary triangle, which provides a significant incentive for a large proportion of the 65,000 commonwealth public servants to drive and reduces the appeal of more sustainable public and active transport options. 20,000 NSW residents commute to work in the ACT daily (ACT Government 2010), the vast majority, by car.
- The ACT's water supplies feed into the Murray-Darling Basin, with large areas of our catchments located within NSW.

Emerging Issues

One of the challenges in planning and acting to progress sustainability is that change is constant, but our capacity to foresee the future is quite limited. In the ACT and Region, population growth and demographic and technological changes are affecting how and where we live. In particular, changes in household structure and expectations about the provision of services are modifying accommodation, recreation, consumption and employment needs, as well as travel options between the locations of these activities.

As a way of anticipating future directions, the Office of the Commissioner for Sustainability and the Environment (OCSE) undertook a series of horizon scanning workshops focusing on sustainability and environmental issues that are likely to have a significant impact on the ACT and Region. The workshops generated thoughtful dialogue by participants drawn from many different sectors of the community. Participant contributions were incorporated into a Report, Environmental Scan – Issues for Future Sustainability and Environmental Management in the ACT and Region (Cork, 2011). A wide array of ideas and questions about possible futures and issues were generated and included some ideas, such as moving the seat of government from Canberra, creating artificial meat, or needing to accommodate mass migrations of climate refugees, that seem unlikely to materialise. However being

prepared for some of the otherwise unexpected futures can help us, as a community, to take action now and into the future.

Resource limitations

Factors including population growth, changing demographics, lifestyles and the extent and nature of urban development have clear connections with our future use of water and energy. Responding to these factors as well as managing sources and limitations of energy and water supplies will shape future urban development and lifestyles in the ACT and Region in the next few decades (Cork 2011).

The ACT and Region face particular challenges due to their relatively high dependence on fossil fuels, both for the generation of our electricity and fuelling motor vehicles, on which we are so reliant. Further, with the breaking of the recent drought, the move to water conservation measures, rather than restrictions along with new water supply options, may lead the ACT and regional communities to become complacent about water use. In the face of population growth, there are major challenges in transitioning to new sources of energy, addressing water supply limitation, and taking action to mitigate and adapt to the impacts of climate change. However, with an already growing renewable energy sector in the Region, these challenges also present opportunities (Cork 2011). For instance, the emergence of local renewable energy businesses may positively affect the growth and distribution of urban populations and their impacts on the natural environment.

Health and wellbeing

Many emerging health issues are linked to our modern, largely urban, lifestyles. Increasing rates of obesity (ACT Government 2010), for instance, are in part associated with sedentary lifestyles and reliance on cars, while respiratory problems are being linked with urban air quality (AIHW 2011). Further, declining mental health, particularly in young people, results in growing social and economic costs (Cork, 2011) and raises the question of whether we are doing enough to consider the mental health in city and regional planning.

Source: ACT Government

Although these health issues present challenges for individuals and service providers, many of the solutions have co-benefits for both ecosystems and our personal and social wellbeing. Improving the sustainability of our city through initiatives that encourage locally-grown produce, active transport, recreational use of urban green space and good indoor and outdoor air quality will assist in offsetting a significant proportion of the perceived economic costs of related sustainability initiatives.

While local factors are currently the most immediate concerns for public health and wellbeing, global environmental issues, such as climate change, present another level of emergent health problems, which also have impact at a local level. Clear examples are an increased risk from heat waves, bushfire and other results of predicted extreme weather events (Webb 2011). Integrating preventative health management with environmental change will be a key social challenge over the next century. Even in this case, we find that environmental and health benefits are interconnected. For example, urban adaptation measures, such as the development of green-roofs to reduce the urban heat island effect, not only provide environmental benefits, but also bring health benefits. It is therefore important to recognise a healthy environment that builds into preventive medicine, now and into the future.

Biodiversity

Many leading scientists are concerned that we face dramatic ecological collapses that will have a cascading or domino effect leading to social as well as ecological problems (Tierney, J. 2011 and Brown P.R. et al. 2010 cited in Cork 2011). Thus, continuing efforts in preservation, monitoring and advocacy regarding our local biodiversity, are vital areas for action. Horizon scanning participants noted that little attention has been paid in the ACT to less visible

aspects of the natural environment, such as soils and insects, even though these areas are vital indicators of ecosystem change, in addition to their intrinsic value (Cork 2011). In addition to this, there is increasing evidence of a decline in general soil health, which in turn, is proving detrimental for overall biodiversity.

Source: ACT Government

However, we are fortunate to have a strong base of committed community environmental groups and research organisations active in the ACT region, and as a society our attitudes and understanding of biodiversity will remain key drivers of its protection. Nonetheless, protection and enhancement of biodiversity as a whole, rather than activism for specific species, localities, or ecological communities remain a challenge, both in terms of community attitudes and advocacy, and government planning and practice. The need for a strategic approach to biodiversity protection was highlighted by horizon scanning participants too. Additionally, there is uncertainty around the capacity of our governance and community structures to anticipate and cope with the ecological crises that may occur, if our biodiversity is not adequately protected. Integration of urban and biodiversity planning into both existing and future infrastructure will be increasingly important, for example through fauna sensitive road design and water sensitive urban design.

Urban design and transport

The way the city form is developed in response to population growth and changing demographics will have major implications for future sustainability. Policies and planning to encourage continuing efforts are central to shaping Canberra as a sustainable city into the future and enhancing community wellbeing. Well-planned urban densification, around city and town centres, that responds to changing community needs, is generally considered to be a more sustainable alternative to increasing our urban boundaries through greenfield development. Along with diverse housing forms, adequate open space and urban form that encourages reduced reliance on motor vehicles and provides easy access to essential services and recreational facilities are key elements of a sustainable city. This kind of development that values and protects remnant ecological communities at our urban fringe also offers health and wellbeing benefits to citizens. Further, it is a means to reducing the high-embodied energy levels that result from infrastructure and transport networks that are widely dispersed. As a result, if they are well designed, cities may be better for the environment than previously thought. Therefore, an important issue that arises is that whether the high level of green space can be capitalized upon by the ACT Government or whether it will be lost to meet the increasing demand for development.

Horizon scanning participants also discussed new forms of property ownership, which might emerge from the current challenge of housing affordability. Urban structure is important to how people meet and interact. In Canberra, as in many developed cities, there has been a major focus on retail places, which have become important meeting places (Cork 2011). This may become an issue in the future if there were a decline in consumerism and in the overall economy, as we would then need to provide alternative places for people to meet.

Technological change

Technological innovation and developments in communication are a source of emerging new information, which is likely to have far-reaching and unpredictable impacts. Horizon scanning participants highlighted the potential benefits of technology, including the flexibility it provides for people to live and work remotely and the opportunity to better engage the wider community in education, problem solving and decision making (Cork 2011). Such changes may affect the role Canberra plays in the region with a possible movement of people away from the ACT, which in turn may create infrastructure challenges, such as increased demand for better roads, water and internet access, for local councils. Therefore, a concern arises regarding changes that may need to take place in the ACT in response to the challenges posed by technological innovations.

Evidence indicates that the general community is adapting to change faster than governments. Developing technologies enables more efficient resource use, and more sustainable consumer choices, largely driven by community and the private sector. While such innovation often promises more efficient, market-driven solutions and information, it also presents a range of regulatory and social challenges that will have to be addressed, a process made more difficult by the uncertainty in and speed of the change occurring (Cork 2011).

Other emergent technologies such as hydrogen fuels and electric cars, may offer solutions to the environmental problems faced by the transport sector, but these options are likely to remain very expensive for a considerable time (Heuris Partners 2010). However, other innovative approaches are already being used to tackle food security issues with urban agriculture projects (such as growing food in abandoned buildings) and a new form of 'green revolution' including artificial foods is being discussed in a number of countries around the world (Cribb 2010 cited in Cork 2011). These technologies that are likely to arise in the future provide hope that humans may be able to change environmental processes, enabling 'improvements on nature'. However, potential outcomes of such actions bring with them another layer of uncertainty along with environmental and ethical questions, to name a few.

While technological innovation may offer ways of meeting future challenges, they also raise potential concerns such as new forms of pollution. For example, nano-silver which is used widely in the manufacture of air conditions, toys, vacuum cleaners, medical devices and the like, can enter the aquatic environment (Teuten et al. 2007 cited in Cork 2011). It can also affect the fertility of soil as well as impacting animal reproduction (Cork 2011). It is thus important to understand the impact that these and other pollutants will have on our environment in order to manage them.

Lifestyles and attitudes

Perhaps above all other factors, our natural and built environment will continue to be a product of our lifestyles and our attitudes to our environment. Our choices are influenced by our national political, economic, societal, technological and legal values and systems as well as our more personal family, friendship and other social connections (Pearson, 2011). One illustration is evident in our food choices where each decision about what is 'normal' is developed within this kind of network of connections. Therefore, this complexity needs to be taken into account when efforts to influence choices are being developed. For example if high priority is given to processed foods because of their convenience value, simply giving additional information that focuses on the high ecological impact of products, is unlikely to achieve the desired behavioural change (Pearson 2011).

To add to the complexity, attitudes and behaviours are reciprocally reinforcing; changes to lifestyles are influenced by attitudes but the reverse is also true. For example, changes in housing stock, energy sources and transport provision often have economic, behavioural and lifestyle impacts. These in turn can shape community attitudes and levels of concern about sustainability more generally.

The ACT population is relatively affluent and well educated (see the *Driving Forces* paper). We are also home to many tertiary educational facilities and research organisations, and therefore are very well placed to be well informed and have scope for making more sustainable buying choices. Accessing and coordinating the wealth of information generated in these disparate organisations and sectors, and applying this knowledge in positive ways to progress sustainability remain a challenge.

Source: ACT Government

The impact of these changes, whether negative or positive, will be central to our ongoing environmental, social and economic sustainability. Public interest, understanding, and concern about environmental issues more generally is another consideration. The importance given to any social issue can vary over time triggered by local, national and global events, and by media coverage. There is a danger that the mainstream use of the term 'sustainability', and in more extreme circumstances 'greenwashing', are having profound and often negative effects on public's understanding of environmental messages (Cork 2011).

Thus, while media attention can be highly influential in highlighting environmental issues, new information technologies are bringing global events and trends to bear more immediate and pervasive thinking at local levels. For example, community-driven international movements such as *Transition Towns*, are spreading to many different countries. Other initiatives such as *Less than 2 Degrees* are solely internet-based networks sharing information and ideas for action. The continuing re-assessment of national boundaries beyond militaristic and governance control to areas such as economic, cultural and even emotional well-being, is likely to continue to shape the global and Australian agenda (Cork 2011).

Relationships between the ACT and the region

Considering changed forms of governance was central to horizon scanning discussions. Participants broadly agreed that having appropriate governance systems that allow for a degree of experimentation and self-organisation when dealing with problems, would strengthen communities in the region (Cork 2011). How this can be developed in the region is a challenge for all levels of government and the community.

As a comparatively large population relative to our total land area, the ACT is more interconnected with its region than any other state or territory, presenting governance challenges for both sides of the border. Many of the emerging issues already identified, could change the shape of the region and the relationships between the region and the ACT. Decisions about accommodation of our growing population, technology, natural resources and landuse will together shape the future of the region.

The exacerbation of environmental stress is intensifying, with issues surrounding catchment and bushfire management, provision of infrastructure for a growing and changing population, and the management of energy resources. The cross-border nature of these challenges emphasises the increasing importance of effective intergovernmental arrangements.

Canberrans' vision for the future of our city

The sheer number and complexity of the challenges that we face can seem overwhelming. However, the *Time to Talk Canberra 2030* conversation was just one illustration of the willingness and capacity of Canberrans to engage with the Government and other sectors of the community in working to create a better future for the ACT. The picture that emerged of what Canberrans hoped for as a vision for a future included:

- enhancing Canberra's greenspaces;
- reducing carbon emissions, consumption and generally being more environmentally responsible;
- increasing housing diversity to meet the needs of all people and create vibrant neighbourhood centres and communities;
- employing a strategic approach to planning that brings together affordable and sustainable transport and housing;
- recognising and balancing the needs of younger and older Canberrans; and
- building employment opportunities though green knowledge and service industries.

Progressing sustainability in the ACT

The future is a product of our actions in the present, not a set destination that we are heading towards. Creating a sustainable community will involve addressing many diverse and interconnected issues, and require concerted and continuing action in the face of considerable uncertainty. This kind of complexity is a common characteristic of 'wicked problems' (Rittel and Webber 1973). Consequently, actions to address sustainability challenges are most likely to succeed when developed and implemented collaboratively with multiple stakeholders devising and implementing actions. Achieving positive change will also require developing different forms of living and governance (Brown et al. 2010:4). Community members, as well as government, subject specialists and business people, are key holders of expert knowledge and experience. Further, the relatively affluent, well educated and involved community, strong education and research institutions and multiple levels of government within the ACT position us well to take on sustainability challenges.

This SoE Report indicates that the two biggest challenges for sustainability in the ACT are:

- reducing our consumption; and
- balancing urban development with protection of ecosystem values and services.
- Taking strong action to address these two central issues is critical for achieving improved sustainability. However, we also need to find a balance which acknowledges the realities of an increasing population, our relative affluence, enviable quality of life and urban amenity, and our location within a market-based economy.

Reducing our consumption

Our continually increasing ecological footprint tells us that in Canberra, we are consuming at an unsustainable rate. While 'per capita' improvements to our energy and water-use sustainability are a step in the right direction, the finite nature of global resources means

that reductions in our ecological footprint, greenhouse gas emissions, energy and water consumption and waste generation must occur in the ACT at an aggregate level.

While this may seem daunting, there are many positive examples that we can build on. For example, retrofitting buildings is seeing significant reductions in energy use and waste generation (see story on improving office sustainability). Further, *OzHarvest* Canberra has been finding innovative ways to reduce waste by distributing excess food to charities and the University of Canberra has phased out the sale of bottled water on campus reducing waste, energy and pollution.

Source: ACT Government

Opportunities are widespread and actions can actually enhance our quality of life and result in cost savings. For example, promoting benefits such as the increased fitness associated with active transport can result in cost savings for health services provided for managing obesity. Further, new business ventures and jobs can be generated from investment in renewable energy industries and buying more sustainable products can result in localised social and economic benefits too. These are just some of the 'win-wins' that can take place as a result of actions taken to improve the sustainability of the ACT (Ryan 2011).

In other areas, government policy could also focus on consumption 'hotspots' within the control of the local community. For example, the drive down to the local shops can have a greater carbon footprint than the entire content of the shopping basket (Ryan 2011), while consumption of highly processed 'junk' food has been calculated to contribute one third of the food sector's climate emissions (Pearson 2011).

Research indicates that 80% of Australian supermarket consumers think about environmental issues when shopping (McKenzie-Mohr et al 1999 in Pearson 2011). Therefore, providing better information to consumers about the impacts of their buying choices is a vital part of progressing the ACT's sustainability. However we also know that there is a gap between our attitudes and values (what people think and feel), and our actions (Eckhardt et al. 2010). Drawing on social research that offers insights into how to address this gap will be vital if we are to convert current levels of environmental awareness into positive actions. Finally, working with business and harnessing technological innovation, particularly using new information technologies and educational tools, will be central to maintaining community engagement and changing consumer attitudes and patterns of behaviour.

ACT State of the Environment Report 2011

The Australian Capital Region has seen an increase in renewable energy generation and use, with a focus on solar technologies in the ACT and wind generation in the wider region. We are also seeing opportunities for water management, such as the Upper Murrumbidgee Demonstration Reach Project, that bring people together and act as a catalyst for new and more effective ways to approach environmental challenges.

Possibly the most cost-effective way to reduce stationary energy emissions is through energy-efficiency measures in both commercial and domestic sites. Reducing energy waste and purchasing energy efficient appliances can also generate significant cost-savings (Heuris 2010). While it is individuals that ultimately make the purchasing decisions, many opportunities for savings lie within the regulative control of the ACT Government, for example current draft amendments to the Territory Plan aim to improve the solar efficiency of houses by defining and limiting a building's envelope and by improving the design and orientation of new lots. Balancing urban development with protection of ecosystem values and services

A sustainable city is arguably one which balances environmental, social and economic needs. Residents should have access to appropriate, affordable housing, in proximity to work and recreational opportunities along with community facilities such as schools, shops, medical and other services. Finally, a sustainable city offers an integrated transport network that allows people to move between energy efficient residential and commercial buildings.

Much of our city's liveability, as well as our citizen's high environmental awareness, can be attributed to our proximity and easy access to national parks, nature reserves, and urban open space. Both expansion of the city and densification in response to population growth are major components in the growth of our ecological footprint, which consequently threatens the health and viability of ecosystems. Impacts include loss of native vegetation and particular ecological communities, such as grasslands, as well as increased run-off, disruption of water flows, pollution and reduced ecological connectivity. The resulting changes do not only have effects on the natural environment and its flora and fauna, but also on the capacity of the environment to meet our needs, especially for water.

We have a strong nature park and open space system, where residents and visitors alike, can enjoy the natural environment and the aesthetic, recreational and health benefits it offers. This rich resource is also a base for extending environmental awareness, education and engagement. Collaborative and innovative projects between community groups and government are already underway. For example, one program to revegetate and restore the Cotter River Catchment has improved water quality in the Cotter Reservoir. Research and restoration in the Mulligans Flat–Goorooyarroo Woodland is linking monitoring and data collection to conservation management. Another project, Platypus Count, is involving the community in environmental monitoring, advocacy and stewardship activities.

Source: ACT Government

In urban areas as well, greater concern and awareness of the impact of development is creating a desire and action among segments of the population, for more sustainable forms of construction in new developments. There are encouraging signs that retrofitting existing housing stock is gaining momentum. For example, retrofitting of houses was showcased at the annual Canberra *Sustainable House Day*. While still only small in impact, these efforts are providing models for moving towards greater sustainability in residential and commercial developments.

If we are to effectively manage our expanding built area, the value of our green infrastructure must be calculated, and then strategically assessed against the affordability and demand for housing. This assessment should move beyond incorporating costs of building to including long-term savings in terms of energy, water and transport efficiency, in order to have genuine social benefits. Additional consideration should be given to the existing urban form, where spatial distribution and ageing infrastructure present key challenges for allowing energy efficient movement, housing and access to employment.

Balancing our ability to respond to unknowns, with initiatives to enhance our resilience in specific areas will be a key challenge into the future. Although community-based actions are undoubtedly integral to improving our sustainability as a whole, there is also an important role for regulation, or top-down leadership and decision-making. A framework for sustainable action may be achieved with a combination of strategic infrastructure development, financial incentives, community education and regulation. However, to be effective, this needs to be based on sound long-term assessment and modelling of environmental indicators.

We have knowledge and other resources and we can, with goodwill and commitment, move as a community towards a more sustainable future. Residents of the ACT are relatively affluent and well educated and live in a city with generous amounts of greenspace surrounded by nature parks. Further, we have many strong education and research institutions and are the seat of both Commonwealth and Territory Governments. As such, we have a real opportunity to demonstrate leadership in becoming a centre of excellence as a sustainable city by using our resources and creativity.

References

ACT Government 2010. *Time to Talk. Canberra 2030.* Canberra. http://timetotalk.act.gov.au/storage/78d10e40d957379825347909b6e2bfd9.Time%20to%20talk%20-%20web%20version.pdf (accessed 17/9/11)

AIHW 2011. *Health and the Environment: A Compilation of Evidence*. cat. no. PHE 136. Australian Institute of Health and Welfare. Canberra. http://www.aihw.gov.au/publication-detail/?id=10737418534 (accessed 22/04/11).

Brown,V, Deane, P. Harris, A. and Russell, J. 2010. Towards a sustainable future. in V. Brown, J. Harris, and J.Russell .eds. *Tackling Wicked Problems: Through the Transdisciplinary Imagination*. Earthscan. London and Washington. 3-30

Cork, S. 2011. E*nvironmental Scan – Issues for Future Sustainability and Environmental Management in the ACT and Region.* Report prepared for the Office of the Commissioner for sustainability and the environment. Canberra

Dovers, S. 2005. *Environment and Sustainability Policy: Creation, Implementation, Evaluation*. Federation Press. Annandale. Sydney

Eckhardt, G., Belk, R., and Devinne, T. 2010. Why don't consumers consume ethically? *Journal of Consumer Behaviour*. 9: 426-436

Heuris Partners 2010. *ACT Net Zero Emissions Initiatives: Gap Analysis and Opportunity Identification.* http://www.environment.act.gov.au/__data/assets/pdf_file/0008/201212/Zero_emissions_gap_analysis.pdf (accessed 24/10/11)

Mercer, 2010. *Quality of Living Worldwide City Rankings 2010 – Mercer Survey Press Release.* http://www.mercer.com/press-releases/quality-of-living-report-2010#Ranking_Eco_Cities (accessed 21/8/11)

Pearson 2011. *Exploring Individual Values and Attitudes for a More Sustainable Canberra: the Example of Food.* Report for the Commissioner for Sustainability and the Environment. Canberra

Rittel and Webber. 1973. Dilemmas in a General theory of Planning. *Policy Science*. 4:155-169

Ryan S. 2011. *Buying Choices for a More Sustainable Canberra.* Report for the ACT Commissioner for Sustainability and the Environment. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0011/230312/BUYING_CHOICES.pdf (accessed 20/10/11)

Webb, B. 2011. *Impacts of Climate on the Canberra Nature Park: Risks and Responses.* Report for the ACT Office of the Commissioner for Sustainability and the Environment. ANU Climate Change Institute and Fenner School of Environment and Society. Australian National University. Canberra. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0004/220477/OCSE_ANU_paper_climate_CNP.pdf (accessed 7/8/11)

WECD 1987 *Our Common Future*. World Commission on Environment and Development. Oxford University Press. Oxford

WWF 2010. *Living Planet Report 2010.* World Wildlife Foundation in association with Zoological Society of London and Global Footprint Network http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/2010_lpr/ (accessed 7/10/11)

Other data sources

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

NSW Department of Planning and Infrastructure

ACT State of the Environment Report 2011

Sustainability Stories

12 Stories - illustrating action towards increased sustainability in the ACT

Mulligans Flat woodland sanctuary

Mulligans Flat Nature Reserve is just a short drive from the centre of Canberra and close to the growing suburb of Gungahlin in the north. It is now protects the largest remaining area of Yellow Box-Blakely's Red Gum Grassy Woodland anywhere in Australia. This particular grouping of eucalypts has largely disappeared from the Australian landscape.

Since European settlement over five million hectares, or 92% of its original range, have been cleared for grazing, cropping or urban development. Eastern Bettongs, small rabbit sized kangaroos, were once so widespread in the Canberra region that in the 1800s a bounty was paid for every skin.

A Bettong (Photo courtesy of Adrian Manning)

To protect the Reserve's flora and fauna, the ACT Government constructed a two metre high predator proof fence enclosing 470 hectares of Mulligans Flat, creating a secure Sanctuary. The fence protects the woodland, keeps out rabbits, cats, foxes and other feral pests, and allows for the re-introduction of animals that had long disappeared from the area.

Since the construction of the fence in 2009, the environment in the Sanctuary is rapidly being restored. Foxes and cats have been excluded and rabbit numbers have been reduced by over 90%. Work to re-introduce Eastern Bettongs is well-advanced while the Brown Treecreeper, an endangered woodland bird, can now be found in the Sanctuary.

The Mulligans Flat Nature Reserve was originally declared by the ACT Government in 1995. More recently a number of partnering arrangements have been established, initially with the Australian National University (ANU) and now other partners, including the CSIRO. A long term scientific study to investigate the best way to look after these woodland areas is underway. The study will develop better knowledge of the role of fire in woodlands, the importance of fallen timber in providing natural habitat, and the impact of grazing on woodland regeneration.

Mulligans Flat is a public reserve with unrestricted pedestrian access to the Sanctuary. A 'Friends Of Mulligans Flat' community group invites community participation in the care and management of the Reserve. A Board of Management now advises the Government on all facets of the Sanctuary's operation.

Mulligans Flat (Photo courtesy of ACT

In January 2011 the ACT Parks and Conservation Service entered into a two-year partnership with Forde Developments, who developed the nearby suburbs of Bonner and Forde. The agreement provides for the employment of an Aboriginal Ranger and two Aboriginal Trainee Rangers to work on land management, heritage and interpretation programs across the ACT, with a particular focus on Mulligans Flat Nature Reserve.

For more information see the ACT Government Territory and Municipal Services website, http://www.tams.act.gov.au/play

Yarralumla's historic seed bank

Almost 1700 different native plant species have been recorded in the ACT, including flowering grasses, herbs, shrubs and trees. Among these are a number of vulnerable and threatened species. Harvesting seed and storing it in seed banks is particularly important for the recovery of areas of high conservation value including endangered ecological communities. Seed harvesting helps conserve genetic diversity and enables the recovery of vulnerable species and assists in revegetating areas of land where large plant losses have occurred. With proper storage, many seeds will remain viable over very long periods making seed banks an optimal conservation strategy.

Germinated seedlings at Yarralumla Nursery
(Photo courtesy of ACT Government)

The Yarralumla seed bank is home to a living record of every seed collected, purchased and stored at the Yarralumla Nursery since 1948. It has an important role in preserving the biodiversity of ACT's flora.

With a collection of around 221 genus varieties and almost 2000 species of seed, the historic nursery asset contains recordings from as far back as January 1948 - a small sample packet of *Juniperus Californica* which was recorded by the Superintendent Institute of Forestry Genetics California USA.

Seed recording at the Yarralumla Nursery
(Photo courtesy of ACT Government)

The Yarralumla seed bank houses many varieties of *Acacia, Melaleuca, Callistemon* and *Leptospermum* and around 170 different types of Eucalyptus, some dating back to the 1960s. These species have been planted across Canberra and surrounding areas and remain viable for use today.

Contained in old lolly jars, the locally collected seeds, and those sourced from around the world, are kept in cool, dry and dark conditions and labelled with their species type, weight and a registration number. A portion of the seed is stored in a separate location in fire-proof barrels to further protect and safeguard them.

Seed stored in old lolly jars
(Photo courtesy of ACT Government)

With the support of an ACT Heritage Grant through the Australian Garden History Society, the Yarralumla Nursery seed ledgers are being digitised to preserve these valuable records. They will be made available on the Archives ACT website for future reference. Yarralumla Nursery's seed bank is an invaluable link to Canberra's past and a safeguard in protecting the Territory's native flora into the future.

Yarralumla Nursery is an ACT Government owned business within the Territory and Municipal Services Directorate. As one of its core businesses the Nursery grows and supplies plant material for ACT Government landscape development projects.

For more information on the seed banks go to the Yarralumla Nursery website, http://www.tams.act.gov.au/live/yarralumla_nursery

Water sensitive urban design

One of the challenges of urban development is dealing with storm water run-off. Sealed surfaces (buildings, roads, pathways, parking areas and the like) shed water rapidly into drains, channels and then into waterways taking with it, precious top soil and damaging pollutants. Water sensitive urban design (WSUD) is about reducing the extent of impervious surfaces and incorporating landscape features and built structures to temporarily store water where it falls and slow its flow into waterways. Good design also helps increases the use of stormwater and treated wastewater and reduces the volume of mains water used.

In WSUD terms garden rain water tank is a temporary water storage facility (Photo courtesy of ESDD)

Government, industry and the community have all played a role in the move to incorporate WSUD in the ACT. Water efficient buildings have become standard through the use of better fixtures and fittings, or by using different water sources. Most new developments in Canberra now use rainwater, via tank storage, for flushing toilets, in gardens and laundries. Rainwater tanks have become very popular and having them plumbed in appropriately, has increased their efficiency and led to a greater appreciation of water conservation.

Canberra's newest suburbs are now being built with wetlands, ponds, bio-retention facilities and rain-gardens, often integrated as a flood mitigation strategy. Some of these WSUD elements have also been introduced into our older suburbs. They improve urban amenity and, in some places, water for on-site gardens and local playing fields. They also enhance urban biodiversity by creating new aquatic habitats and protecting those downstream. Wetlands and ponds are valued by local residents for recreation and they facilitate educational and volunteering activities by providing a focal point for community life.

Examples of WSUD (From left to right) at the UC Innovation Centre, in Kingston and Childers Street, Acton. (Photos courtesy of Luke McPhail)

For more information contact Environment and Sustainable Development Directorate
http://www.environment.act.gov.au/

Bottled water free zone: first for an Australian university

The University of Canberra became Australia's first bottled water free university on World Water Day, 22 March 2011. The idea, from a student project in an innovation class, has led to the phasing out of bottled water on campus, effectively eliminating the 140,000 plastic bottles on campus each year.

Project contributors test out the UC bubbler water
(Photo courtesy of University of Canberra)

The initiative began when students Greg Stewart, Ellie Mortimer, Rachel Wooden and Diana Bannerman asked the question, "Could the University of Canberra go without bottled water for a day? How about for good?" They presented their plans to the campus and the University's sustainability planner, Beth Mitchell who came on board to assist.

To involve the whole university community in the project, students in marketing, industrial design and other disciplines planned aspects of the implementation as part of their university courses.

The project was supported by the ACT Chief Minister's Department and the action group *Do Something!* who helped the University in negotiations to install more bubblers and refilling stations for fresh, free drinking water on campus.

Filling up with fresh water
(Photo courtesy of University of Canberra)

One of the challenges of the project was getting the retailers onside. The project team arranged for alternative sources of income to be offered by the University vendors such as refillable aluminium SIGG water containers and water from energy-efficient water vending machines.

The initiative is a logical step in helping to reduce waste in the ACT. In Australia only 43% of plastic bottles are recycled so phasing out bottled water has meant a reduction in waste going to landfill, energy use and pollution. Now, with additional outlets for fresh water readily available on campus, students still have easy access to water as a healthy drink choice and they can save money at the same time.

A water bubbler on campus
(Photo courtesy of University of Canberra)

The University of Canberra hopes to become a role model in sustainability by influencing other Australian university campuses to take on the bottled water challenge.

For more information on sustainability at the University of Canberra, visit their website, http://www.canberra.edu.au/monitor/2011/feb/10-bottledwater.

OzHarvest Canberra: rescuing food and reducing waste

OzHarvest began when Ronni Kahn, founding Director, decided she was not prepared to be part of the waste cycle that is a usual outcome of the hospitality industry. When she found no available option in Sydney, she decided to set up a food rescue charity herself. Ozharvest has now expanded to Newcastle, Adelaide and Canberra.

OzHarvest Canberra has been operating since February 2008 and is managed and supported by Communities@Work, a community based not-for-profit organisation. It has delivered over 1,000,000 meals to more than 60 charities and refuges in Canberra, Queanbeyan and Yass. This helps charities focus more of their resources on other ways to help the community.

OzHarvest Canberra delivers to 'The Blue Door' (Photo courtesy of OzHarvest)

As well as helping vulnerable people in the community and providing a waste management solution for the hospitality and retail food industries, OzHarvest delivers sustainability and environmental benefits. To date over 370 tonnes of food have been saved meaning less food ending up in landfill. On average, every kilogram of food that OzHarvest rescues will save 2 kg of greenhouse (kg CO2-eq) emissions and avoid the use of 143 litres of water.


OzHarvest delivers the goods! (Photo courtesy of OzHarvest)

Food donors to OzHarvest Canberra include food retailers, supermarkets, clubs, caterers and local markets. However, some potential donors think that the easier option is to throw food away rather than risk being sued if anything goes wrong. Critical changes in legislation and the reliability of the OzHarvest pick-up and delivery service means that this fear is unfounded and that donating is a great option.

There are still challenges ahead for OzHarvest Canberra. Some charities have become dependent on OzHarvest as their main source of food, so establishing long term financial viability for the organisation is extremely important.

At present, OzHarvest Canberra has only limited food storage facilities so most food collected needs to be redistributed on the same day. Additionally not all charities have the facilities to store food so they can only accept food that can be used on the day of delivery. In the future, OzHarvest Canberra hopes to expand its storage facilities to create a small bank of food to assist charities to cope with peak demands.

For more information see the OzHarvest Canberra website, http://www.ozharvestcanberra.org/

Community gardens: growing sustainably

The *Canberra Organic Growers Society Inc* (COGS) is a non profit organisation that aims to provide a forum for sharing information and promoting organic growing methods. Since it began in 1977, the society has grown and now manages 11 gardens in the ACT. Anyone in the community can join COGS and get a plot at one of the community gardens.

The Dickson community garden, which includes a successful aquaculture project, is a good example of the work COGS is doing. The garden was developed jointly between COGS and Dickson College and is run by a garden convener and committee. It aims to involve students in organic food production and sustainable practices. COGS hopes to develop a teaching facility at the garden in the future.

Dickson Community garden (Photos courtesy of COGS)

The Dickson garden is located beside a popular cycle/footpath that runs towards the city. This high visibility helps spread community awareness of the garden and promote the value of the organic food production. When the garden is a lush green and rich with produce it attracts passers-by, who often inquire about getting a garden plot.

COGS is creating a movement away from industrial food production where vast amounts of energy and natural resources are consumed in the production, processing, packaging and transport of the food we eat. These food production methods are commonly associated with high carbon emissions, excess waste disposal to landfill, over-packaging, water pollution, soil depletion and erosion.

Small scale organic growing on the other hand reduces the environmental impact of our food supply. At the COGS Dickson community garden, food is grown using organic methods without artificial pesticides, herbicides and fertilisers. This helps to build soil fertility and save water while producing abundant crops. Since the food is consumed directly by the grower, the waste produced by transport, processing and packaging in the industrial system is drastically reduced.

The Dickson community garden has been very successful, especially in the support it has received from Dickson College and associated facilities. The challenge for the future is how to expand the garden sufficiently to satisfy the high demand for plots.

For more information on community gardens in Canberra see the COGS website, http://www.cogs.asn.au

Improving river health: Upper Murrumbidgee Demonstration Reach Project

Over the past decades the health of the Murrumbidgee River has suffered serious decline, largely as a result of human activities such as water extraction, altered flow regimes, vegetation clearing, catchment erosion, and placement of weirs and unsuitable river crossings.

Weeds have invaded riverbanks, river flows are low, sand has built up in parts of the river channel and water quality is often poor. As a result, there are fewer native fish while introduced species such as European carp are thriving. In fact, carp now make up more than 80% of the fish stock; a situation widespread across the Murray-Darling Basin where native fish stocks are around 10% of pre-European settlement levels.

Black Rock Gorge, near Bumbalong (NSW), although visually beautiful, only carp are caught here.
(Photo courtesy, Mark Jekabsons, ESDD)

The *Upper Murrumbidgee Demonstration Reach* (UMDR) project is a good example of what can be achieved through collaboration. The project is bringing together community groups, government, business and other organisations to improve river health and reinstate native fish populations in the 100 kilometres section of the river between Bredbo and Casuarina Sands.

The UMDR project is paying special attention to improving riverbank health, increasing in-stream habitat, removing barriers to fish movement, and supporting improved local river flows. A Carp Reduction Plan has also been developed for the UMDR region to assist in managing this pest species.

The current work in the demonstration reach will help minimise the effects of sand in the river channel adjacent to the Lanyon property in the ACT. The work will help native fish swim through this very shallow stretch of river and provide important fish habitat. If successful, the approach used at Lanyon may be suitable for other sand affected river sections.

Demonstrating electro-fishing - one of the key tools used for fish monitoring in the UMDR.
(Photo courtesy of Luke Johnston)

Through the initiative, the project team aims to increase understanding of river health issues and encourage local communities to get involved in scientific studies and community-based river health monitoring to measure progress over the coming decade or so.

This river rehabilitation initiative stems from the Murray Darling Basin Authority's *Native Fish Strategy* which aims to improve fish stocks to 60% of pre-European levels across the basin within the next 50 years. The UMDR project team is made up of representatives of ACT and NSW Governments, regional Natural Resource Management bodies, community groups, corporate organisations and local research institutions.

To find out more head to the website, http://upperbidgeereach.org.au/umdr

‘Platypus Count’ keeps an eye on water

Platypus Count is a great way to become involved in environmental monitoring and education. The scheme encourages community advocacy for aquatic habitat protection and fosters a commitment to environmental stewardship. In the ACT, the success of *Platypus Count* has had the positive effect of increasing community interest in water quality monitoring, an important activity in protecting platypus habitat.

Melody Serena, Australia Platypus Conservancy Biologist (Photo courtesy ESDD)

The Program encourages people to come along on free platypus spotting walks accompanied by knowledgeable guides who provide information on platypus behaviour and habitat. They can also attend expert-led seminars on platypus biology and monitoring or train to become a volunteer with *Platypus Count*. At this stage, data collected by volunteers is managed with the *Australia Platypus Conservancy*.

Platypus Count is a joint venture between *Upper Murrumbidgee Waterwatch* and the *Australian Platypus Conservancy* and funded through *Caring for Country* grants. It was created to help the *Conservancy* gather comparative data, but also because the *Upper Murrumbidgee Waterwatch* wanted to offer volunteers and community a more casual and family friendly monitoring project.

Platypus Walk at Dawn in Queanbeyan (Photo courtesy of ESDD)

A strong community interest in the scheme has resulted in significant environmental benefits for one of our most charismatic native animals and an increased awareness of the harmful effects of littering and illegal fishing practices on them. In the Queanbeyan area, *Platypus Count* has gathered new information about how the platypus responds to floods.

Another key benefit of the initiative has been increased community water quality monitoring along with a passive ‘always there’ approach in habitat management. It has also mobilised the Queanbeyan council to write its river management plan with an eye towards platypus protection and habitat development.

The ACT region is extremely lucky to benefit from good water quality creating suitable habitats for platypus. *Platypus Count* is helping to spread the word to ensure habitats continue to be protected for future generations.

Platypus Count is supported by people of all ages and continues its work building environmental commitment in children. In the future, it hopes to expand into the *Snowy Catchment Management Authority*.

For more information see the Molonglo Water watch website, http://www.molonglocatchment.com.au/molonglo_waterwatch.htm

Small changes: big sustainability gains

Improving sustainability is achievable in the workplace. Changes can be made by replacing old systems with more efficient technologies and making small adjustments to the way we function in workplace buildings. Both are equally important in reducing costs and increasing building sustainability. These are the kinds of changes happening at Dickson in two ACT government buildings; the Dickson Motor Vehicle Registry and the nearby Dame Pattie Menzies House.

Dickson Motor Vehicle Registry

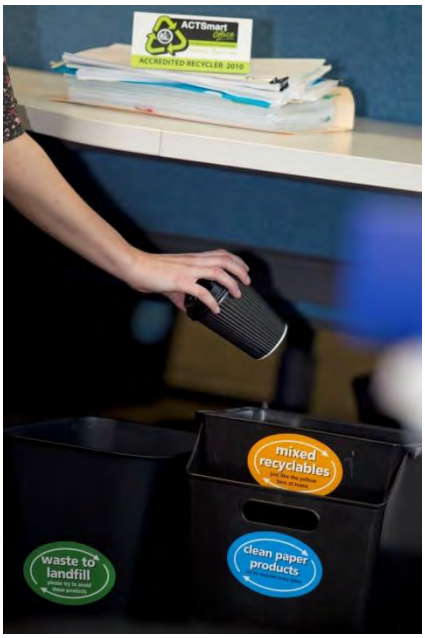
At the Dickson Motor Vehicle Registry, a comprehensive heating, ventilation, and air-conditioning (HVAC) upgrade gave a good base for achieving improvements. However, having staff involved in a *Sustainability Working Group* and providing information about waste and recycling through the Officesmart program has also been really important in making progress. The new HVAC system has been complemented with more efficient lighting in the building and motion sensors to control lighting in toilets and stairwells. As a result of the combined improvements electricity consumption has been reduced by 19%, gas use has reduced by 44% and waste to landfill reduced by 33%.

Dame Pattie Menzies Building

At the Dame Pattie Menzies Building many small, low cost changes have been made, such as altering climate control temperatures and reprogramming lighting and hot water boilers. Other actions have included computerised timer switches for lighting and improving waste recycling. Water usage is better managed by regulating garden watering and introducing water saving shower heads. Involvement of staff, providing awareness programs and use of regular sustainability reminders, are some of the most important aspects of the program.

These small changes have led to both sustainability results and economic benefits. A 29% decrease in energy consumption and savings of $60,730 over a five year period. The building has also had its NABERS (National Australian Built Environment Rating System) rating upgraded from its 2005 rating of 3 to 4.5.

The success of these two initiatives shows that with organisational commitment, planning, some investment of funds, as well as having staff on board to support change and take action, real progress in workplace sustainability can be achieved.



ACTSmart Business and Office waste sorting bins at Dame Pattie Menzies House
(Photo courtesy of ACT Government)

By implementing the changes above both buildings have reduced their green house gas emissions. Staff awareness of sustainability actions can also be taken to other areas of their lives such as in their homes.

For more information on improving energy efficiency in buildings and other ways to improve the sustainability of your home or workplace see the ACT Government ACTSmart website, http://www.actsmart.act.gov.au/home

SEE-Change: small steps towards big change

Sustainability is not about just one project, one action or one event. Building a more sustainable city means making hundreds, maybe thousands, of small adjustments in the way we do things. This is what SEE-Change aims to do in Canberra.

Getting around sustainably can be fun!
(Photo courtesy of SEE-Change)

SEE-Change (**S**ociety, **E**nvironment, **E**conomy) began in 2006 when members of Canberra's academic institutions and the wider community committed to building a more sustainable future for the ACT. SEE-Change has grown in numbers and now has five groups across Canberra. The groups combine environmental and sustainability action in their local area with concern for broader issues like reducing greenhouse gas emissions and tackling climate change.

Groups meet regularly to plan and undertake many different actions from organising and hosting community meetings, workshops and information nights to bulk-buys, over-the-fence tours and much more. A very successful bike trailer hire program makes cycling with kids or cargo a more affordable active transport option. Other programs include back yard sustainability demonstrations and workshops, solar panel bulk buys, retrofitting guidance and much more.

2020 Vision Festival of Young Ideas, ACT Legislative Assembly, 2011
(Photo courtesy of Mel Hill Photography)

A pilot program in 20 ACT schools invited students to submit ideas for reducing Canberra's carbon footprint by 2020. Student entries were displayed at the Canberra *Festival of Young Ideas* in November 2011.

Also new in 2011 is the *Canberra Clean Energy Collective*, a special interest group of SEE-Change members producing investment and delivery models that will make community-funded photo-voltaic arrays a reality in the next 12 months.

Woden SEE-Change Members spread the word at the Southside Farmers Market
(Photo courtesy of SEE-Change).

Woden SEE-Change began work in 2011 with Lyons Early Childhood School and Woden Community Services to set up a community garden at the school. The garden will be open to the broader community.

SEE-Change groups are showing the small things we can do to change our behaviours relating to transport, food production and distribution, energy generation and use, and building design. Sharing information about the many options for living more sustainably is another really important way of moving towards more environmentally friendly lifestyles.

For more information visit the SEE-Change website, http://www.see-change.org.au/

Cotter River Catchment restoration

Revegetation and restoration work on the Cotter River Catchment has resulted in big improvements over the past four years. Thanks to the contribution of thousands of volunteers about 220,000 native trees, shrub and understorey seedlings have been planted in total. In 2010-11 alone, community members donated more than 5,100 hours and planted over 40 thousand plants. The work began back in 2006 as an important partnership between Greening Australia and the ACT Government.

Greening Australia community planting event (Photo courtesy of Greening Australia)

To improve water quality in the Cotter Reservoir, erosion and weed control work has been undertaken along with, run-off and fire management, and monitoring and re-establishing native vegetation. The former pine plantations have been converted to native vegetation providing much improved habitat and protection from predators for rare and threatened species such as the Macquarie Perch, Murray River Crayfish, Two-spined Blackfish and Key's Matchstick Grasshopper.

Members of the Yurung Dhaura Team and their supervisor preparing seedlings for planting at the Greening Australia nursery (Photo courtesy of ACT Natural Resource Management Council)

In March 2011 the *Yurung Dhaura Land Management Team*, of four Indigenous Trainees and a Team Supervisor, were engaged on a two year contract by the ACT Environment and Sustainable Development Directorate in partnership with the Territory and Municipal Services Directorate. Yurung Dhaura, Ngunnawal for *Strong Earth*, was named by the local *United Ngunnawal Elders Council*, and will work to restore at least 6.4km of streambank and 76ha of high conservation ecosystems.

The team, who are combining their work with study in Conservation and Land Management at the *Canberra Institute of Technology,* will implement a series of improvements. These include assessing and controlling pest animal numbers, surveying native fauna and flora, track repair and maintenance and fencing sensitive areas of the Ramsar-listed sphagnum bogs.

Trainees will also monitor water quality, collect native tree seeds and propagate tree seedlings for environmental restoration. The team has laid pig baits over an area of more than 100ha and removed more than eight hectares of dense pine wildling in an area of *Xanthorrhoea* (grass trees), exceeding project targets to date. The Yurung Dhaura team is also working with the Ngunnawal people to document Traditional Ecological Knowledge in the region, and apply this knowledge where permitted, to biodiversity conservation in the catchment.

The Cotter River Catchment project has attracted many partners including the *United Ngunnawal Elders Council*, *Canberra Institute of Technology*, the *Board of the Ngunnawal Healing Farm*, *ActewAG*L, *Greening Australia*, the *Southern ACT Catchment Group Waterwatch Program* and the local Aboriginal community. Restoration work will continue in the lead up to Canberra's centenary and the completion of the enlarged Cotter Dam. Consolidating improvements in water quality and biodiversity will enhance the stability, health and resilience of the Cotter River Catchment.

For more information see the ACT Government Territory and Municipal Services website, http://www.tams.act.gov.au/play

Controlling the Indian Myna: protecting native fauna

The Indian Myna (Photo courtesy of Geoffrey Dabb)

The Indian Myna, not to be confused with the Australian Noisy Miner, poses a serious threat to native wildlife, particularly those birds that nest in the hollows of trees. They are also considered a public nuisance. Their droppings foul backyards, schools and shopping centres; their nesting activities can create fire hazards, and their raucous calls and noisy roosting sites are difficult to ignore. In 2006 the Indian Myna was recorded as the third most common bird in Canberra.

A small group of Canberra bird watchers and conservationists were so concerned about the growing number of Indian Mynas in the Canberra region they decided to take action. The Canberra Indian Myna Action Group Inc. (CIMAG) and Myna control program began in April 2006. Using their own funds, they set about to undertake and promote their work building strong networks with government officers, academics, researchers, the RSPCA and community organisations. The groundswell of public support for control activities has turned the Program into a major community-action movement with around 1300 members.

The Noisy Miner (Photo courtesy of Bill Handke)

The Group is realistic in its aim of controlling Myna numbers rather than trying to eradicate the species. Their success is indicated by the continuing decline in Myna numbers over the past 5 years, with it now recorded as the 13th most common bird in Canberra. Program actions include trapping the birds and a public education program raises awareness of the problems posed by Mynas and what can be done about them.

Currently all control efforts are on private domestic land. With large numbers of Mynas found around shopping centres, schools and nature reserves, the main challenge for the Action Group now is to broaden the control program to public spaces in partnership with government and business.

A CIMAG member with a Myna Trap (Photo courtesy of Geoffrey Dabb)

The Canberra Indian Myna Action Group will continue to support activities based on sound science and animal welfare principles. Currently the Action Group is supporting two PhD research projects focussing on Indian Mynas. The success of the program demonstrates the ecological benefits of community-based action programs and has now inspired 26 similar groups across New South Wales.

For further information see the CIMAG website, http://indianmynaaction.org.au/

Driving Forces

Environmental change can be driven by multiple forces across time and various locations. These driving forces are demographic, social and economic pressures, which impact our environment. Driving forces can be categorised into two types of pressures: direct and indirect. Direct driving forces are the result of explicit actions, such as land clearing. Indirect driving forces, on the other hand, originate from interactions between broad social, economic, political and technological changes over time, and can include shifts in individual and collective values, attitudes and behaviours. While determining immediate effects and considering future scenarios for direct forces is possible, albeit challenging, predicting and planning responses to indirect forces is not as simple. Regardless of the complexity of the task, determining the effects of understanding these forces and planning future responses is the key to achieving progress towards sustainability.

Four driving forces have been identified for the ACT SoE 2011:

- **Population** growth and changing demographics in the ACT, which strongly influence demand for housing, infrastructure, and goods and services, can have significant impacts on all aspects of the environment;
- **Landuse and transport systems,** which require resources, including energy, contribute to emissions and can affect the health of ecosystems and the community's quality of life;
- **Climate variability and change,** which includes seasonal and interdecadal weather pattterns, as well as longer term variations that are accompanying climate change, and impacts on natural ecosystems and resources such as water and vegetation cover as well as the health, well-being and viability of human communities.
- **Consumption**, which is connected with economic performance and growth, level of resource use, waste generation and emissions can have direct impacts on the environment.

This paper draws on a number of expert papers developed for this ACT SoER that address these driving forces, namely:

- *The 2008-09 Ecological Footprint of the population of the ACT* by Dr Chris Dey
- *Buying choices for a more sustainable Canberra* by Dr Sarah Ryan;
- *Canberra's Ecological Footprint: what does it mean?* by Dr Joy Murray and Dr Chris Dey;
- *Exploring individual values and attitudes for a more sustainable Canberra: the example of food* by Dr David Pearson;

- *Weather and Climate of the ACT 2007-11 and decadal trends* by Mr Clem Davis and Dr Janette Lindesay; and
- *Land use and Transport* by Mr Richard Johnston

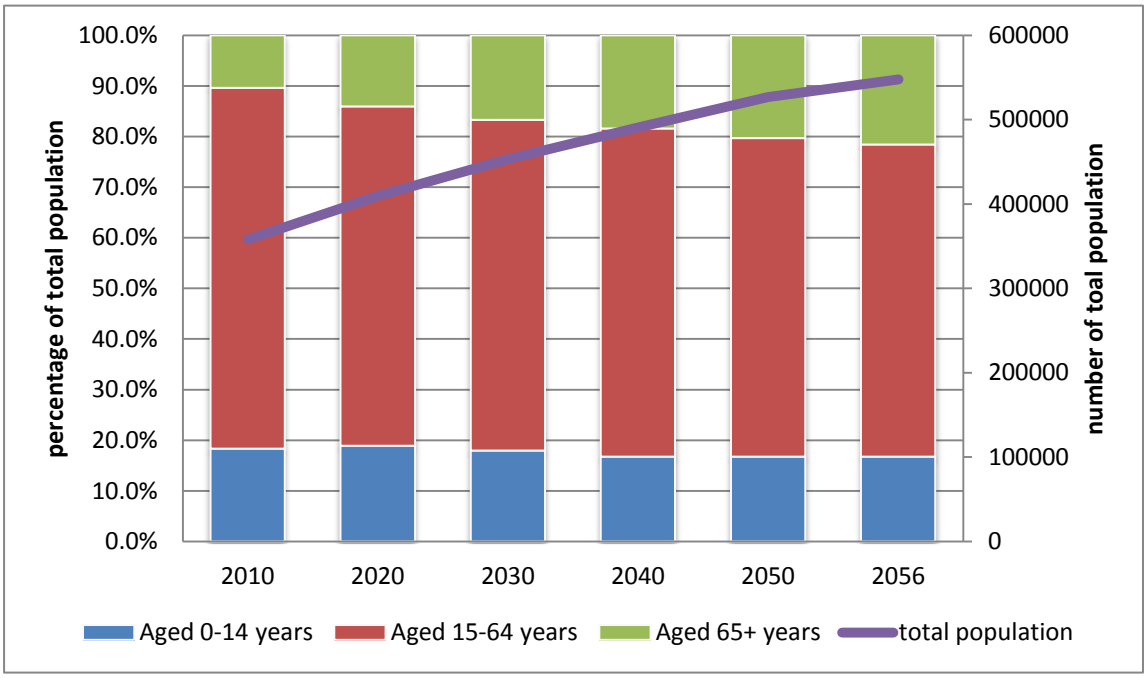
Understanding the role of the four driving forces, as outlined above, is critical for moving towards a more sustainable future. The issues related to each of these forces are discussed below.

Population

The estimated resident population of the ACT on 31 March 2011 was 363,834 persons (CMCD 2011) and it is projected to increase to 434,300 by 2030 and to 500,000 by 2050 (ACTPS 2011). Population growth in the ACT has been higher than the national average annual rate over the past ten years. Interestingly, most of this growth has come from natural increase rather than from interstate or overseas migration (ACT Government 2010a).

Within the abovementioned population increase it is expected that the ACT will experience significant demographic change, with the population of persons aged 65-84 is projected to increase by 170% and those over 85 and over by an enormous 509% (ACT Government 2009). At the same time, the number of persons aged 14 and under in the ACT is projected to increase by only 42%; while the number of persons aged 35-64 (the older working age population) is projected to increase by approximately 43% (Figure 1).

Figure 1. Age Structure and total ACT Population projections, 2007-2056



Source: ACT Government 2009

This projected population growth and demographic change may impact the environment in both negative and positive ways. For instance, an ageing population is a sign of affluence and technological development and is not expected to diminish our material prosperity. However, it is expected to reduce the rate of economic growth due to lower participation in the labour force (ACT Government 2010a). Further, the ageing of the population, coupled with lower birth-rates, is predicted to increase the need to attract additional skilled workers into the ACT (Jackson 2008). Conversely, population growth and change can deliver professional and technical skills and knowledge that adds capacity and resources to a community. This, in turn, can facilitate attitudinal change and result in practical outcomes for improved sustainability, such as greater engagement in biodiversity conservation and resource efficiency actions.

Overall, a growing population poses some serious concerns as it will require additional housing and associated transport, energy, water and waste infrastructure, along with educational, medical, retail, recreational and other services. This can place extreme pressure on our natural resources as well as limit the ability of government to provide required infrastructure, services and support. For example, population growth, along with the predicted effects of climate change, is likely to exert pressure on water supply and demand.

Although ACT residents have demonstrated their ability to reduce water use over the long drought period, there are several concerns pertaining to water supply. The *Water Security for the ACT and Region* report estimated a significant reduction from the average annual and historical inflows to ACT reservoirs in the future (ACTEW 2007). ACT water supplies will come under even greater pressure given the growing population and predictions of increased temperatures and reduced rainfall accompanying climate change. Current water supply security measures, including the enlargement of the Cotter Dam and extraction from the Murrumbidgee River, will provide additional water capacity and storage, aimed to address increased demand and respond to climate variability and change. Yet, associated construction, loss of habitat and alteration to river flows inevitably bring their own set of environmental challenges.

ACT within the Region

A key driver of change is population growth in the surrounding areas of regional NSW, with the population of the Australian Capital Region[1] in 2011, including the ACT, reaching 466,000 (CMD 2010a). The region's population is predicted to grow to over 577,000 by 2031 (CMD 2010a), with recent Australian Government initiatives such as funding for regional health, education and infrastructure projects making regions more attractive to live and work in, especially for families (Crean 2011).

[1] The Australian Capital Region (ACR) comprises the ACT and the 17 surrounding NSW Local Government Areas.

ACT State of the Environment Report 2011

As Australia's largest inland city, Canberra is a major regional centre for the surrounding towns and districts, providing employment, as well as education, health, entertainment and retail services to neighbouring NSW residents (RDA ACT 2010). On the other hand, ACT residents regularly access recreational facilities in rural, coastal and mountain resort areas, contributing to local economies but also making use of the regional infrastructure (e.g. water, energy, waste disposal and roads), as well as various health and other services. Access to these areas by an ageing population is likely to increase reliance on transport modes other than private motor vehicles. While this could mean a positive upward trend in the use of more sustainable forms of transport, services across the region would need to improve markedly. Currently, services are limited to those operating on weekdays between the ACT and surrounding regions, and the availability of such services usually decreases with increasing trip distance (ABS 2010a).

Landuse and transport systems

Changes in the type and intensity of landuse over time place pressure on the environment and on all species, including people living within this natural environment. Landuse changes can alter the environment in highly visible ways, such as vegetation clearing, soil erosion and exotic weed infestation; while changes such as soil and groundwater contamination can be more difficult to identify. In the most modified areas in the ACT, the cumulative impact of clearing, cultivation and urban development have induced a range of local and off-site impacts on soil health and landscape function. These impacts include reduced permeability, structural stability, nutrient cycling and moisture, and carbon holding capacity; increased soil erosion; localised salinity and acidity problems and impairment of hydrological function (NRMC 2009).

Source: ACT Government

Landuse practices and urban development, both within and upstream of the ACT, have impacted the health of rivers and streams in the ACT. In particular, water quality has been diminished by increased sediment and nutrient loads, decreased oxygen concentrations, higher water temperatures, reduced flow, and more frequent algal blooms. Most natural riparian vegetation and habitat has been cleared or severely altered (as reported in the *Land and Water* indicator papers).

River health is of particular concern. Rivers in the Canberra area are either severely impaired or moderately impaired, with the exception of creeks running out of forested areas and the Murrumbidgee River as it enters the ACT, which are recorded to be in good condition (measured against the AUSRIVAS assessment tool). Extraction from waterways and increased run-off from sealed and disturbed surfaces, in both rural and urban areas, has impacted further on the ecosystems and aquatic species of the ACT. In recent years, extended drought and the legacy of severe bushfires have added to development-related pressures (NRMC 2011).

Urban form and landuse in the ACT

The ACT is approximately 2,352 square kilometres in area, with less than one quarter of the land area under urban development. Over the reporting period, the urban footprint of the ACT has increased by about 9%. This change has impacts on biodiversity, hydrology and land health for the ACT. However, we have a large system of protected areas and open space, with about 58% of ACT land (a little over 137,000 hectares) zoned for conservation purposes (Table 1). Changes to areas zoned for water and catchment are largely due to planning adjustments that recognise catchment areas separately from that of other land uses.

Table 1: ACT Land use changes

Zone	2007 ha	2011 ha
Urban	24 789	26 958
Water, including catchment areas	2812	9264
Conservation	136 610	137 349
Other	71 613	62 253
Total	235 824	235 824

Source: ACTPLA

Note: figures are based on zones from the Territory plan and do not always match actual on ground uses

One feature of Canberra's urban development has been the progressive reduction in the single residential block size over time (ACT Government 2011). Further, across Australia, over the past couple of decades, there has been a dramatic increase in house size, to the extent that Australian homes in 2009 were, on average, the biggest in the world (CommSec 2009). Yet for the first time in at least a century, the number of persons per household rose slightly during the 2007-08 year from 2.51 to 2.56 persons. This means that if this trend were to continue, fewer houses would need to be built. However, in the ACT from 2006 to 2026, the number of lone person households and couples without

children is expected to increase much more than that of other household groupings (ABS 2010b). This trend is likely to continue in the future and consequently lead to an increased demand for more and diverse types of housing.

Recent studies indicate big differences between the kind of houses Australians say they would choose and what is being built (Kelly 2011). In particular, more people indicated a preference for semi-detached homes and apartments in the middle and outer areas of both Melbourne and Sydney than are available. The report also found that the reasons for the gap between preferred and available housing is largely the result of incentives provided to residential developers, in the form of financing practices, planning and land issues and material and labour costs (Kelly 2011). These findings are likely to have application to the ACT as well.

Given population projections, over the next 10 years it is estimated that around 30-35,000 new residential dwellings will be built in the ACT (CMD 2010b). Just over half of these are expected to be constructed as part of greenfield development in areas such as Gungahlin and Molonglo. The remaining new dwellings are expected to be built as urban consolidation, primarily in the inner north and inner south (including the East Lake development) and to a lesser extent Belconnen (CMD 2010b). This is of concern as Canberra's current low density and dispersed pattern of land development already pose challenges for the efficient use of urban infrastructure. The way land is used in urban areas affects people's quality of life, influencing the amount of privacy, space, and noise experienced by the residential population, with potential human health effects (ACT Government 2010c).

Source: ACT Government

In Canberra, the residential amenity of suburbs, surrounded by natural landscape, provides many advantages, including the opportunity to enjoy the natural environment and do more physical activities. However, a study commissioned by the ACT Land and Planning Authority comparing four Canberra suburbs with European cities that were

chosen for their liveability and sustainability (ACTPLA 2010), found that compared to the European cities, the Canberra suburbs:

- were much lower in density and efficiency of land use;
- generally provided less public open space per person;
- had more than three times the length of roads;
- provided less housing choice;
- used at least twice as much water; and
- emitted about 10 times more carbon dioxide per person per year.

Considering the expected population growth and increasing affluence of the ACT (two key factors influencing the extent and character of urban development), these results highlight the extent of the challenge we face in creating a more sustainable city.

Open space and nature parks in the ACT

As noted above, more than half the land area of the ACT is zoned for conservation as national park and nature reserves, including Namadgi National Park, Tidbinbilla Nature Reserve and Canberra Nature Park. Canberra also has large expanses of urban open space, which, together with urban trees, district and town parks, local parks and lakes and ponds form the bulk of Canberra's green infrastructure. These spaces not only serve as important habits for native plants and animals, but they also provide benefits as a resource for recreation and tourism. More importantly, these spaces support the health, wellbeing, and sense of place of Canberra residents by enhancing the water quality of waterways and assisting in stormwater drainage (ACTPLA 2008). These spaces also sequester carbon and provide other benefits for mitigating and adapting to climate change. For example, nature reserves and urban green infrastructure help reduce the impacts of climate change by reducing the urban heat island effect. Further, there is strong evidence that access to open space can provide significant mental and physical benefits for the surrounding population (De Vries et al. 2003; Nielsen and Hansen 2007).

While Canberra's parks and open spaces are a major asset, they also present a management challenge (OCSE 2011). As the population continues to grow and the number of visitors continues to increase, pressure on nature reserves, waterways and urban open space is likely to increase as well. Such development pressure for infrastructure and housing, along with increased usage, leads to an increased demand for water for domestic, commercial and recreational use; and an increased risk of increased soil and water pollution, soil erosion, weed infestation and loss of vegetation connectivity. Many of these factors have already been identified as adversely affecting the condition of some nature reserves in the ACT (OCSE 2011). In addition, climate change is predicted to increase the risk of extreme weather events such as heat waves, storms and bushfires. Dealing effectively with these risks in order to balance environmental protection with social and economic realities, will require strategic

planning, resource commitment and collaboration across public, private and community sectors.

Transport

Transport assets, systems and choices have significant impacts on our community and our city, as well as the quality of the environment. Different transport modes such as private vehicles, public transport and walking have different impacts on the environment and human health. These impacts can either be direct or indirect. Road traffic crashes are one example of a direct health impact that may lead to injuries and fatalities (AIHW 2011). On the other hand, a less direct impact is the potential for detrimental health effects resulting from reduced exercise levels for using passive modes of transport. In 2009 in the ACT, 64.9% of men and 50% of women were considered overweight or obese while 42.1% of people over 18 were classified overweight and 25.6% were classified obese (ABS 2011).

Road transport is also a significant source of greenhouse gas emissions and the majority of these emissions are from passenger vehicles. The mode of travel is influenced by land use and transport policies as well as individual behaviours and choices. The reliance on car use in the ACT and the relative lack of heavy industry, such as chemical plants or smelters, means that transport accounts for 24% of the ACT's total greenhouse gas emissions (ACT Government 2010d), a significantly higher figure than for the other states and territories.

Public and private transport-related infrastructure, such as roads, parking areas, service stations, cyclepaths, walkways, driveways, paths and garages, is a part of the urban form and has considerable negative impacts on the natural environment. These impacts include reductions in the permeability of land, vegetation clearing, altering of water flows and impediments to the movements of native animals.

Planners in the 1960s and 70s envisaged 'self-containment', where Canberrans would live and work in the same district and walk or use public transport to travel to work. However, the city is considerably less self-contained than was anticipated in the 1970s 'Y-Plan', with many more people now working in the central area. In addition to this, the ACT now has an extensive road system in relation to its population, compared with that of the other Australian cities. Despite the fact that levels of walking and cycling are above the national average, motor vehicles are by far the most common mode of travel to work for Canberrans (see the *Transport* indicator cluster paper). Finally, although rising fuel prices and predicted shortages in the future may encourage greater use of public and other forms of transport, these shifts would also lead to an uneven distribution of financial and other burdens, particularly for older people and those on low incomes.

ACT State of the Environment Report 2011

Climate

There is now very strong and consistent evidence that the earth's surface is warming rapidly. The number of days with record hot temperatures has been increasing each decade over the past 50 years with fewer record cold days each decade, with the period 2000-2009 being the warmest decade on record (BOM 2010). There is also a high level of confidence in the scientific community that the cause of this warming is human emissions of greenhouse gases. In Australia, changes in ecosystems have already been observed, providing a clear indicator of a changing climate. These changes include genetic shifts in animal populations, changes in breeding and migration patterns and behaviours (Australian Government 2011).

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 heat waves for the ACT and region; and

- a high probability of changes in the current pattern of rainfall 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.

Source: ACT Government

While the precise causes and effects of climate change are both difficult to quantify and only discernable in long-term global trends, the direct impacts of the more immediate and localised weather variations can give indications of what those more far-reaching changes might bring with them. Typically there are almost three times as many heat waves occurring in the hotter and drier El Nino years than in cooler and wetter La Nina years.

While weather patterns over the reporting period have shown considerable variability, few consistent changes in longer-term trends have been observed. However, considering that even small changes, such as those indicating a trend of higher average temperatures, increased weather variability more extreme weather events like storms and heatwaves, is likely to have significant impacts. In particular, human health and wellbeing, food security, biodiversity and the health of ecosystems, along with the viability of water resources, are all likely to be affected. It is thus essential that we plan and take action for these kinds of changes and the resultant impacts.

The *Weather and Climate of the ACT 2007-11 and Decadal Trends* paper prepared for the 2011 ACT State of Environment Report (Davis and Lindesay 2011) presents weather and climate data for the ACT over the reporting period as well as decadal trends. Information from this paper is summarised below.

The ACT region recorded below average rainfall for seven out of the last 10 years (2001-2010), with 2010 being the only year having considerably above average during this period . However, beyond this natural variability, the only trend evident in recent decadal rainfall records for the ACT is a drying trend in autumn, consistent with other parts of south-eastern Australia over the last 10 to 15 years.

Temperatures have stayed above the long-term mean for the entire reporting period. Long-term trends indicate that temperatures have been increasing with more marked increases over the past 10 years in line with the overall trend for Australia. Although the ACT experiences only a small number of heatwaves, the decadal trend indicates an increase in the number of heatwave events and days. This is also evidenced in the nine heatwaves (37 days in total) and 20 hot events (60 days in total) recorded in Canberra Airport during the reporting period.

These results appear to reflect the impacts of El Nino Southern Oscillation (ENSO) events where El Nino events tend to produce hotter summers (as occurred in 2008-09) and La Nina events produce cooler summers in the ACT (as occurred in 2010-11). While climate variability has been evident over the reporting period, long-term trends are consistent with climate change predictions of hotter and drier conditions, along with more extreme climate events (Table 2).

Table 2. Changes in weather phenomena 1961-2010

	1961-1990 Average	2008-2010 Average
Days 35 °C or more	5	11
Days 30 °C or more	30	43
No. Frosts	99	65
No. Thunderstorms	23	20
No. Fogs	44	39
No. Strong Wind Days	26	24
No. Rain Days	105	101
Mean Daily Pressure	1016.7	1017.4

Source: Davis and Lindesay 2011

Wider global, national and regional weather events also have impacts at the local level. Severe drought conditions continued over the early part of the reporting period, with a very hot year and two severe dust storms in Canberra in 2009. The source of these dust storms was the drought-stricken areas like Lake Eyre in South Australia (ABC News 2010) and the local impacts included reduced air quality and visibility and a covering of dust.

These drought conditions had widespread impacts on native and exotic vegetation, the health and reproductive capacity of native species, river and catchment health, groundcover and soil erosion. The end of this drought was marked by heavy rainfall in 2010, with a significant flooding event in Queanbeyan and nearby parts of the ACT in December of that year. Canberra Airport recorded its wettest December day on record on 3 December 2010 (87.6 mm). Such storm and flooding events can cause property and infrastructure damage, while sediment and contaminates brought by high levels of runoff can reduce water quality and damage riparian and aquatic habitats.

Climate change is a global phenomenon that will bring additional pressure to the Territory's water resources and biodiversity, and may significantly change the patterns of bushfire and extreme weather events. The impacts of climate change will also place pressure on infrastructure including health care systems, water and electricity infrastructure and green infrastructures such as nature parks, urban tree and open spaces which will in turn lead to an increase in the greenhouse gas emissions. Climate change is also likely to place increased pressure on leaseholders and land management authorities to ensure more widespread and consistent application of best practice as a buffer against more extreme weather events.

However, climate change may also bring new opportunities. For example, rural land might be a focus for carbon sequestration activities such as planting more trees; restoring and extending native grasslands; assimilating organic waste from urban areas; and capturing environmental and economic benefits of increased soil carbon (NRM 2011). However, long-term improvement in soil health will depend on a planned approach to matching land capability to land use.

Consumption

The ACT is located nationally within a developed market-based economy and consequently, its residents are exposed to high levels of marketing and advertising for goods and services. With very limited local manufacturing or industry, ACT residents are highly dependent on everyday commodities and services that are produced beyond its boundaries, nationally and internationally.

Canberrans are on average the most affluent people in Australia (Table 3) with relatively high disposable incomes to purchase luxury goods and services. In addition, since population growth in the ACT is estimated to be one of the highest levels in Australia (ACT Government 2009), the total environmental impact from ACT residents is continuing to grow, in turn leading to increased total waste generation.

Table 3. Average full time Ordinary time earnings Q4 2010

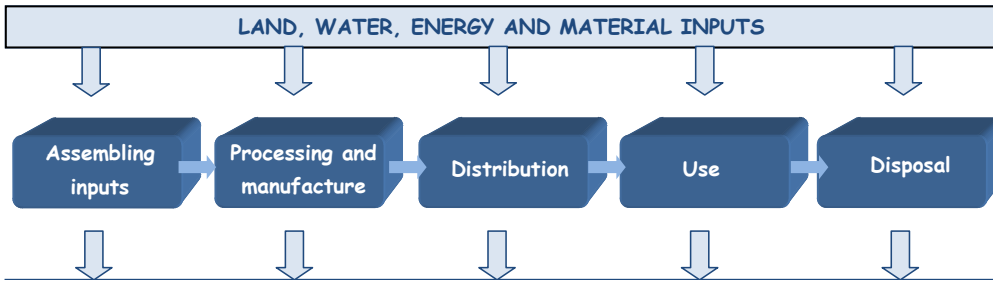
State or Territory	Average Annual Wage
Tasmania	$57 808
South Australia	$60 414
Victoria	$64 620
Queensland	$65 619
Northern Territory	$65 962
New South Wales	$66 565
Western Australia	$73 148
Australian Capital Territory	$76 367

Source: Living in Australia 2011, based on ABS 2010c data

At a global scale, our high rate of consumption, predominantly of goods sourced from outside of the ACT, results in a disproportionately high use of finite global resources, which is largely not evident to the end consumer.

One approach to quantifying and understanding the impact of our consumption is to conduct a Life Cycle Assessment of a consumer product (Figure 2). This measurement approach includes not only the obvious components like the energy to transport goods, but also incorporates all upstream inputs, like the energy used to make the truck that transports the goods and the land and water used for mining and processing the iron ore used in producing the steel for the truck (Ryan 2011:1).

Figure 2. A generalised life cycle of a consumer product used in life cycle assessments



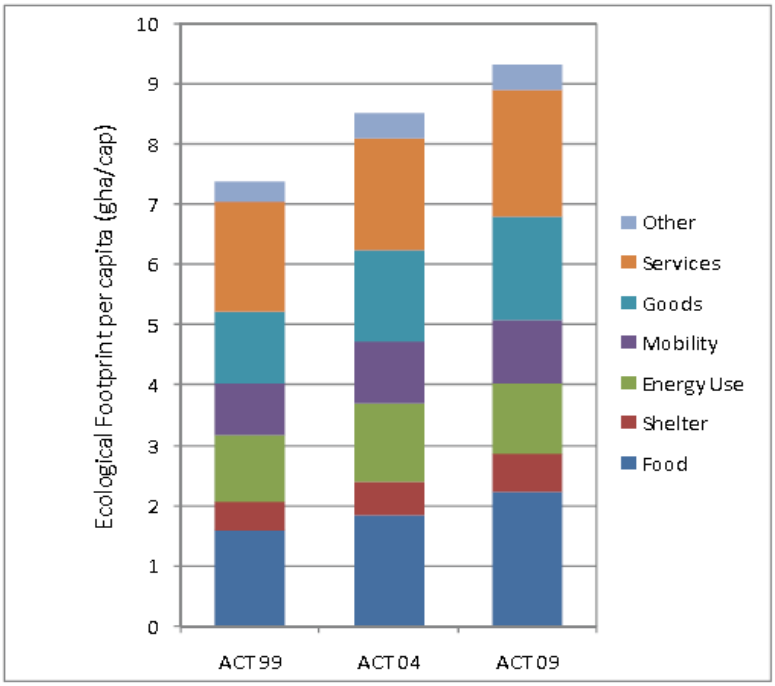
Source: Ryan 2011:3

Environmental impacts of consumer products vary both between the type and the intensity of the impact. For example, disposal of electronic equipment, or 'e-waste', can often result in high levels of toxicity, whereas purchasing of a paper book can lead to loss of forests and ecosystems due to procurement of paper through unsustainable forestry. Life cycle assessments are often used to target 'hotspots' of environmental damage in a product cycle, in order to reduce the environmental impact of our purchases. They can also provide consumers with information to allow them to reduce the environmental impacts of their consumption patterns.

An alternative approach to measuring the environmental consequences of our consumption is to assess the total ecological footprints of the consumer over a period of time. An ecological footprint is a measure of quantity of land and water needed to support the lifestyles of an individual or group of individuals, in relation to the carrying capacity of the world (Murray and Dey 2010:6). Australia has some of the highest per-capita footprints in the developed world. This is mainly because as a wealthy nation, we consume many goods and services, use a carbon-intensive electricity system that is predominantly supplied by coal-fired power stations, and rely on agricultural systems that use a great deal of land in a relatively dry country (Murray and Dey 2011).

The total Ecological Footprint of all ACT residents is approximately 3.2 million global hectares, or equivalent to nearly 14 times the geographical area of the ACT. Electricity supply (including the area of land and water needed to sequester the resulting carbon emissions) and residential building construction are key items contributing to the ACT's Ecological Footprint (Murray and Dey 2011). Despite stabilised impacts from the use of electricity, gas and vehicle fuel by households over the last few years, the overall per person footprint in the ACT continues to increase (Figure 3).

Figure 3. ACT 2008-09 Ecological Footprint



Breakdown of the average per-capita Ecological footprint of the ACT for the three years according to different categories of consumption.

Source: Dey 2010:5

The local impacts of ACT consumption include the loss of open space and agricultural land to housing development and increased traffic congestion or increased time spent on shopping for goods from a growing number of retail outlets (Murray and Dey 2011). Additionally, overconsumption of food and subsequent health complications may put pressure on health facilities (Murray and Dey 2011).

The impacts of the ACT's high consumption and associated large ecological footprint are predominantly felt outside of our borders. ACT consumption of food requires large areas of land for crops, pasture and forest located elsewhere in Australia or the world. This results in land clearing and modification, placing pressure on ecosystems outside ACT borders (Murray and Dey 2011). In a global economy ACT consumption also places pressure on environment and societies in other countries. For example goods purchased in the ACT may be produced in countries or companies with unhealthy working conditions and poorly regulated environmental pollution practices, particularly in less developed countries where labour is often cheaper. In the longer term, ACT consumption also plays a role in generating global impacts, driving climate change through greenhouse gas emissions, reducing and polluting water supplies and depleting global biodiversity (Murray and Dey 2011).

Reducing our ecological footprint will be a complex and challenging undertaking. Efforts will often require balancing competing priorities and making trade-offs. For example, on

one hand, the construction industry makes a large contribution to the ACT footprint but on the other, it provides local employment. Further, many different yet interrelated factors, including a mix of broad socio-political, economic and legal systems, shape our consumption decisions. Our consumption decisions, as noted above, may be determined by our location in an affluent city within a market-based economy, where constant exposure to advertising of products and services is the norm. More personal factors such as our values and attitudes, personality, social connections and experience comprise another set of factors that would drive our consumption pattern. Finally, household or family structure and decision-making around purchasing may be the other factors influencing patterns of consumption (Pearson 2011).

Hence, no single unified approach to understanding these factors and taking actions to alter the consumption behaviour is available. Perhaps the most promising approaches bring together insights from various fields, including psychology and social marketing. These can shed light on motivations and barriers to behavioural change and encourage collaboration between citizens, governments, business and other non-government sectors (UK Cabinet Office 2011).

References

ABC News 2010. *Dust Blankets ACT, NSW*. Australian Broadcasting Corporation. Sydney. http://www.abc.net.au/news/2009-09-22/dust-blankets-act-nsw/1438110 (accessed 12/10/11)

ABS 2010a. *1308.8 - Statistical Information on the ACT and Region.* Australian Bureau of Statistics. Australian Government. Canberra. www.abs.gov.au/ausstats/abs@.nsf/0/E616CB56795B8EDBCA2577EE000C9B7A?opendocument. (accessed 9/11/11)

ABS 2010b. *3236.0 - Household and Family Projections 2006 to 2031.* Australian Bureau of Statistics. Australian Government. Canberra http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3236.02006%20to%202031?OpenDocument (accessed 18/11/11)

ABS 2010c. *6302.0 - Average Weekly Earnings Nov 2010.* Australian Bureau of Statistics. Australian Government. Canberra. http://www.ausstats.abs.gov.au/ausstats/meisubs.nsf/0/967E1D61D897A8CDCA257840000F7025/$File/63020_nov%202010.pdf (accessed 28/11/11)

ABS 2011. *4842.55.001 - Overweight and Obesity in Adults in Australia: A Snapshot, 2007-08.* Australian Bureau of Statistics. Australian Government. Canberra. http://www.abs.gov.au/AUSSTATS/subscriber.nsf/log?openagent&4842055001do001_200708.xls&4842.0.55.001&Data%20Cubes&90855D4FAE8A464BCA25789C0023DC44&0&2007%9608&27.05.2011&Latest (accessed 28/11/11)

ACT Government 2009. *ACT Population Projections 2007 to 2056*. Canberra. http://www.cmd.act.gov.au/__data/assets/pdf_file/0010/119719/act-population-projections-2007-2056.pdf (accessed 12/9/11)

ACT Government 2010a. *Time to Talk: Canberra 2030 - Population.* Canberra. http://timetotalk.act.gov.au/storage/bf77c700a50698a0a623f9ab9c7d2310.31-08%20Population.pdf (accessed 17/9/11)

ACT Government 2010b. *ACT Government Infrastructure Plan 2010*. http://www.cmd.act.gov.au/__data/assets/http://www.cmd.act.gov.au/__data/assets/pdf_file/0019/133165/act-govt-infrastructure-plan.pdf (accessed 20/9/11)

ACT Government 2010c.*Time to talk. Canberra 2030 – Health and Wellbeing Background Report.* Canberra. http://timetotalk.act.gov.au/storage/Planning_Background06_Health.pdf (accessed 24/9/11)

ACT Government 2010d. *Time to Talk, Canberra 2030 – Getting Around.* Canberra. http://timetotalk.act.gov.au/storage/65c9530b44b11463a4240ea3504373d1.31-08%20Getting%20Around.pdf (accessed 12/9/11)

ACT Treasury 2011. *Full Time Adult Average Weekly Ordinary Time Earnings.* ACT Government. Canberra. http://www.treasury.act.gov.au/snapshot/AWOTE.pdf (accessed 11/11/11)

ACTEW 2007. *Water Security for the ACT and Region: Recommendations to the ACT Government.* Canberra. http://www.legassembly.act.gov.au/downloads/submissions/10%20Water%20use%20-%20ACTEW%20Corporation.pdf (accessed 12/11/11)

ACTPLA 2008. *Territory Plan*. ACT Planning and Land Authority. ACT Government. Canberra. http://www.legislation.act.gov.au/ni/2008-27/current/default.asp (accessed 23/9/11)

ACTPLA 2010. *Urban Form Analysis. Canberra's Sustainability Performance: Technical Report*. ACT Planning and Land Authority. ACT Government. Canberra. http://www.actpla.act.gov.au/__data/assets/pdf_file/0013/21046/ACTPLA_Urban_Form_Scenarios_Final_Report_WEB.pdf (accessed 21/4/11)

ACTPS 2011. *Governing the City State: ACT Public Service Review Final Report*. ACT Government. Canberra. http://www.det.act.gov.au/?a=188329 (accessed 12/10/11)

AIHW 2011. *Health and the Environment: A Compilation of Evidence.* Australian Institute of Health and Welfare. Canberra. http://www.aihw.gov.au/publication-detail/?id=10737418534 (accessed 21/11/11)

BOM and CSIRO 2010. *State of the Climate*. Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation. Australian Government. Canberra. http://www.bom.gov.au/inside/eiab/State-of-climate-2010-updated.pdf (accessed 22/10/11)

CMD 2010a. *ACT Population Projections for Suburbs and Districts, 2007 to 2019 and New South Wales Statistical Local Area Population Projections 2006 – 2036*. Chief Ministers Department, ACT Government. Canberra

CMD 2010b. *ACT Infrastructure Plan 2010*. Chief Minister's Department. ACT Government. Canberra. http://www.cmd.act.gov.au/__data/assets/pdf_file/0019/133165/act-govt-infrastructure-plan.pdf (accessed 4/7/11)

CommSec 2009. *Australian Homes are Biggest in the World*. Economic Insights. http://images.comsec.com.au/ipo/UploadedImages/craigjames3f6189175551497fada1a4769f74d09c.pdf. (accessed 9/11/11)

Crean,S. 2011. *Budget 2011-12: Investing In Regional Australia*. Ministry for Regional Australia, Regional Development and Local Government. Australian Government. Canberra. http://cache.treasury.gov.au/budget/2011-12/content/download/ms_rural_and_regional.pdf (accessed 14/10/11)

Davis, C. and Lindesay, J. 2011. *Weather and Climate of the ACT 2007-11 and Decadel Trends.* Report for the Office of the Commissioner for Sustainability and the Environment. Canberra

De Vries, S., Verheij, R.A., and Groenewegen, P. 2003. Natural Environments - Healthy Environments? An Exploratory Analysis of the Relationship Between Greenspace and Health. *Environment and Planning.* 35:1717-1731

Dey, C. 2010. *The 2008-09 Ecological Footprint of the Population of the ACT.* Integrated Sustainability Analysis. University of Sydney. Sydney. http://www.environmentcommissioner.act.gov.au/__data/assets/pdf_file/0015/211182/ACT_Ecological_Footprint_08-09_final_report.pdf (assessed 22/6/11)

Engineers Australia 2010*. Infrastructure Report Card: Water*. Canberra. http://www.engineersaustralia.org.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=C8F26346-DB84-45EF-E104-B53E726D4A61&siteName=ieaust (accessed 20/6/11)

Jackson, N. 2008. *Population Change and Sustainable Futures: Imagining the ACT*. 1 December 2008. Commissioned by the ACT Government for the Sustainable Future Program. Canberra http://www.actpla.act.gov.au/__data/assets/pdf_file/0011/12431/Paper_-_Natalie_Jackson.pdf (accessed 12/10/11)

Johnston, R. 2011. *Landuse and Transport in the ACT.* Report for the ACT Office of the Commissioner for Sustainability and the Environment. Canberra. unpublished

Kelly, J.F. 2011. *The Housing We'd Choose.* Grattan Institute. Melbourne. http://www.grattan.edu.au/publications/090_cities_report_housing_market.pdf (accessed 8/7/11)

Living in Australia 2011. *Wage Facts*. http://www.livingin-australia.com/salaries-australia/ (accessed 18/11/11)

Murray, J. and Dey,C. 2011. *Canberra's Ecological Footprint: What does it mean?.*Report for the ACT Office of the Commissioner for the Environment and Sustainability. Canberra

Nielsen, T.S., Hansen, K.B. 2007. Do Green Areas Affect Health? Results from a Danish Survey on the Use of Green Areas and Health Indicators. *Health Place.* 13:839-850

NRMC 2009. *Bush Capital Legacy: Iconic City, Iconic Natural Assets - Plan for Managing the Natural Resources of the ACT.* Natural Resource Management Council. Canberra. http://www.actnrmcouncil.org.au/files/NRMplan.pdf (accessed 24/10/11)

OCSE 2011. *Facing the challenges – Positioning Our Nature Reserves for the 21st Century.* Report on Canberra Nature Park (nature reserves); Molonglo River Corridor (nature reserves) and Googong Foreshores Investigation. Office of the Commissioner for Sustainability and the Environment. Canberra. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0006/234987/Part_I_Report.pdf (accessed 22/10/11)

Pearson, D. 2011. *Exploring Individual Values and Attitudes For a More Sustainable Canberra: the Example of Food*. Report for the ACT Office of the Commissioner of Sustainability and the Environment. Canberra

RDA ACT 2010. *ACT Strategic Regional Plan 2010*. Regional Development Australia – ACT. Canberra. http://rdaact.org.au/wp-content/uploads/2011/03/RDA_ACT_regional_plan_20102.pdf (accessed 18/8/11)

Ryan, S. 2011. *Buying Choices for a More Sustainable Canberra*. Report for the ACT Commissioner for Sustainability and the Environment. http://www.envcomm.act.gov.au/__data/assets/pdf_file/0011/230312/BUYING_CHOICES.pdf (accessed 20/10/11)

UK Cabinet Office 2011. *Better Choices. Better Deals: Consumers Powering Growth*. Behavioural Insights Team. http://www.cabinetoffice.gov.uk/sites/default/files/resources/better-choices-better-deals.pdf (accessed 20/10/11)

Webb, B. 2011. *Impacts of Climate on the Canberra Nature Park: Risks and Responses.* Report for the ACT Office of the Commissioner for Sustainability and the Environment. ANU Climate Change Institute and Fenner School of Environment and Society. Australian National University. Canberrahttp://www.envcomm.act.gov.au/__data/assets/pdf_file/0004/220477/OCSE_ANU_paper_climate_CNP.pdf (accessed 7/8/11)

Other data sources

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

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

ACT State of the Environment Report 2011

Appendix: Expert Paper papers

The following papers have been used to inform papers in this Volume:

- 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

Office of the Commissioner for Sustainability and the Environment

The 2008-09 Ecological Footprint of the population of the ACT

Prepared by
Integrated Sustainability Analysis (ISA)
The University of Sydney

The University of Sydney
Integrated Sustainability Analysis ™

The 2008-09 Ecological Footprint of the population of the Australian Capital Territory

Report on consultancy work carried out for the

Office of the Commissioner for Sustainability and the Environment

by

Integrated Sustainability Analysis Research Group

The University of Sydney

Date of Report:

Tuesday, 14th December 2010

Cover Photo Credit: Autumnal Warmth, by Adam P. Wilson

http://reddit.wired.com/submissions_water

For further enquiries please contact:

http://www.isa.org.usyd.edu.au

Dr Christopher Dey
Phone: (02) 9351 5979
Fax: (02) 9351 7726
Email: christopher.dey@sydney.edu.au

School of Physics, A28

The University of Sydney
N.S.W. 2006

Contents

1. Executive summary

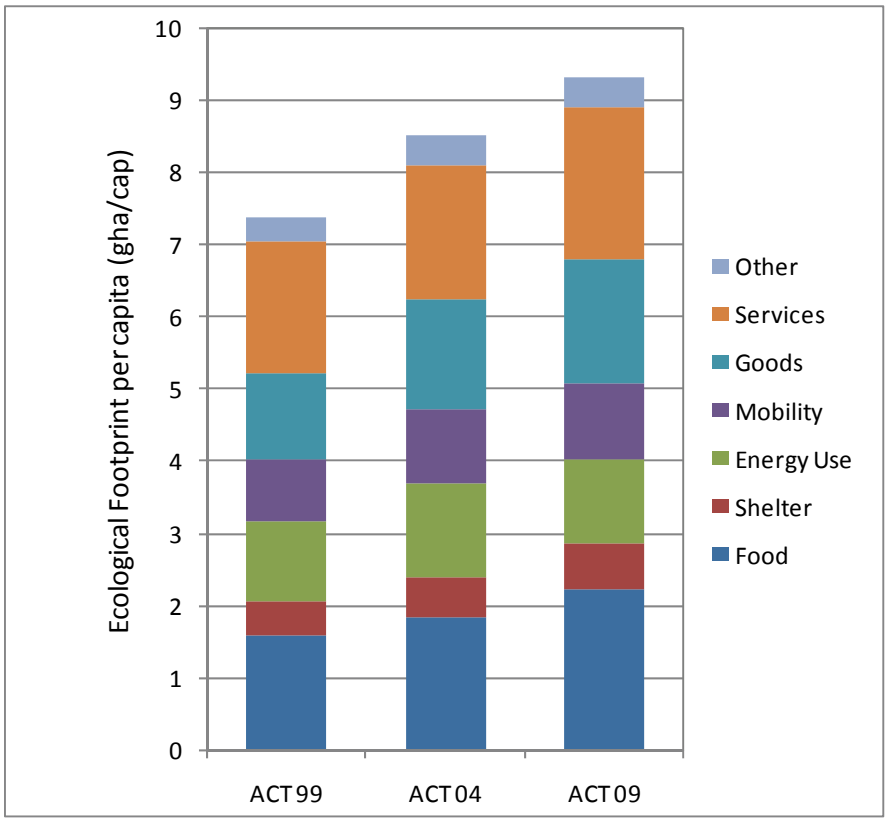
This report presents results of calculations of the Ecological Footprint of the population of the ACT. The Ecological Footprint is a concept for assessing the sustainability of resource use and pollution of households, cities, and entire nations. For example, applied to households, the Ecological Footprint represents the land area equivalence (in hectares) of all the resources required to support the lives of the people in the household, and to absorb their pollution. Although a single indicator, the Ecological Footprint is a powerful concept when compared to the total available productive area on Earth. Globally at present, humanity is already in 'ecological overshoot': meaning we are running down renewable resources faster than they can be regenerated by ecosystems and producing CO_2 faster than it can be absorbed (WWF - World Wide Fund for Nature 2010).

In the calculation of the Ecological Footprint of populations, consumption data are converted into a single index: the land area that represents the exclusive demand that a population places on bioproductivity in order to sustain itself indefinitely. Since the method's conception, many teams around the world have carried out significant modifications and improvements to the concept. Two of these are the implementation of the economic tool of input-output analysis, and the incorporation of a regional, disturbance-based approach. Both modifications contribute to the methodology by adding from macroeconomic theory and biodiversity research. Input-output-based Ecological Footprints are complete in that they cover the supply chains of the entire upstream economy that ultimately enables the production of consumer items. These enhancements are incorporated into the calculations presented here.

The main results are that, on average, the Ecological Footprint of a person living in the ACT in 2008-09 is 9.2 global hectares (gha). With a population of 349,000 people, this amounts to a total area of 3,200,000 global hectares, roughly fourteen times the area of the ACT. This figure includes all upstream impacts, capital requirements, imports, and capital imports. That the Ecological Footprint of the ACT is many times larger than its administrative area represents the fact that impacts of consumption go well beyond arbitrary borders, drawing on productive areas all over Australia and around the World.

ISA has also calculated the Ecological Footprint of the ACT for 1998-99 and 2003-04. Due to methodological changes in the development of the Ecological Footprint, later results are not directly comparable to the 2004 report. Hence a recalculation of 1998-99 data according to current methodology yields an Ecological Footprint of 7.4 global hectares. The overall ecological footprint for the ACT in 2003-04 was 8.5 gha. We have thus seen a growth in the per-capita Ecological Footprint for the ACT of 15% between 1998-99 and 2003-04, and a further 8% increase over the following 5 years. The average Australian's Ecological Footprint is 8.1 gha, or about 13% lower than that for the average resident of the ACT.

The graph on the following page shows the three Ecological Footprint results for the ACT as well as the main components of the footprints. With direct energy use steady or falling in the ACT in the last 5 years, the main contributions to the increasing overall footprint are steadily rising consumption of goods and services. In turn, this increasing consumption is related to strong growth in ACT household income. It is a commonly observed trend in affluent societies, whether at the level of whole nations or at an individual household, that total environmental pressures tend to continue to grow with income, even if the immediate or direct impacts are steady or falling. This trend presents a clear challenge for us to examine closely our consumption patterns and what it means to live in societies with high incomes.



Breakdown of the average per-capita Ecological footprint of the ACT for the three years according to different categories of consumption.

2. Project background

2.1. The Ecological Footprint

The Ecological Footprint is a method aimed at measuring the sustainability of resource use and pollution of populations. Consumption data are converted into a single index: the land area that represents the demand that a population places on the Earth's bioproductivity in order to sustain itself indefinitely. More specifically, the Ecological Footprint is a measure of human demand on the bioproductive land area that is required to support the resource demands of a given population or specific activities. This includes the land area needed to provide biological resources (raw materials, food, timber, etc) as well as the (notional) area required to absorb the carbon dioxide emissions emitted due to the consumption patterns of the Australian Capital Territory's (ACT) residents. This land area sits both within and outside the borders of the ACT. Therefore the Ecological Footprint is an indicator for the impacts of consumption of ACT residents *wherever* the products and services are produced.

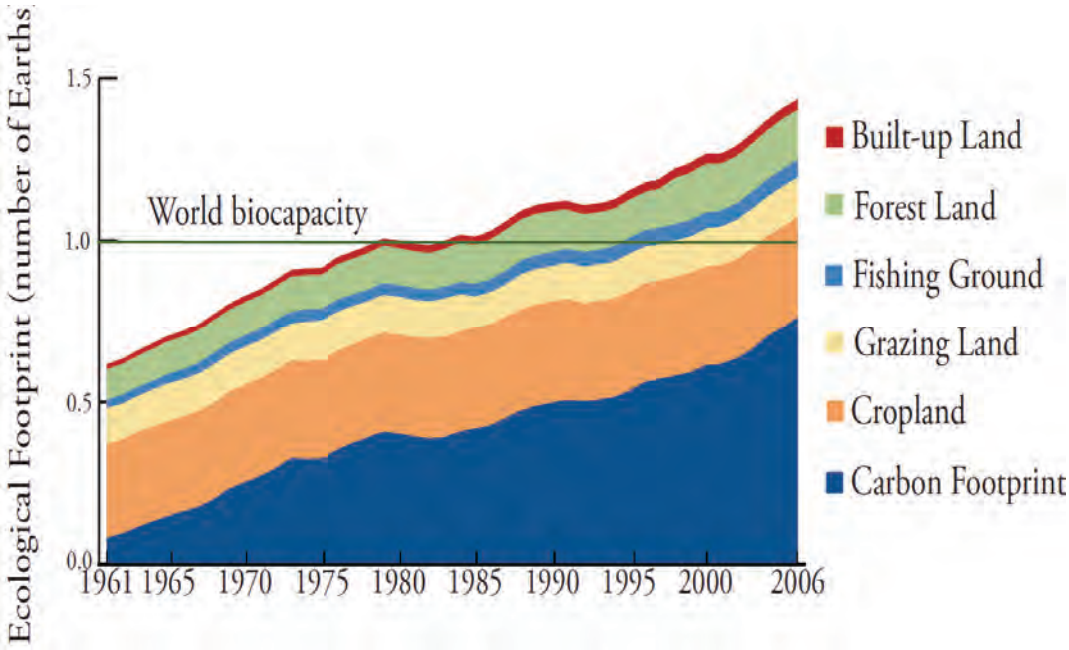
The purpose of the Ecological Footprint is to inform governments of all levels, and others involved in environmental management and decision-making. Stakeholders such as environmental non-government organizations, educators, community groups and individuals may use the information for awareness-raising, and in order to educate about the impact of current consumption patterns.

The Ecological Footprint has been identified as a useful concept and effective tool to communicate key messages in State of Environment reporting, enabling the reader to garner a broad overview of the present environmental situation. The Ecological Footprint has the potential to illustrate symbolically the links between topical environmental issues such as climate change, and an individual's every day, local life style practices and decisions.

Since the Ecological Footprint's inception, many research teams around the world have carried out significant modifications and improvements to the concept. Two of these are the implementation of the economic tool of input-output analysis, and the incorporation of a regional, disturbance-based approach. Both modifications contribute to the methodology by adding insights and expertise from macroeconomic theory and biodiversity research respectively. Input-output-based Ecological Footprints are complete in that they cover the supply chains of the entire upstream economy that ultimately enables the production of consumer items. In the disturbance-based enhancement, local technologies are normalised using yield and equivalence factors in order to relate consumption to the average productivity of all bioproductive hectares on earth.

What exactly is an Ecological Footprint? Let's start with the basic premise that there is a limited amount of productive space on the Earth to sustain life. This bioproductive land area can be measured in global hectares (gha) which represent the average yield of all biologically productive areas on Earth. In 2006 there were 1.8 gha available per person (Global Footprint Network 2006; Global Footprint Network 2009). The Ecological Footprint measures the human demand on this area and contrasts it with the ecological capacity of the planet. It sets out the extent to which we are living beyond the capacity of the planet. It encourages innovation toward 'one planet living'. Ecological Footprints show how much biologically productive land and water a population requires

to support current levels of consumption and waste production using prevailing technology. The world average Ecological Footprint was 2.2 gha per person in 2003, and grew to 2.6 gha per person in 2006 (Global Footprint Network 2009) and 2.7 gha in 2007 (WWF - World Wide Fund for Nature 2010). But as this exceeds the 1.8 gha per person available, it would take 1.4 years to regenerate what humanity consumes in a year. So, in other words, average resource consumption globally results in an 'ecological overshoot' of about 40%. The figure below clearly shows this growing *unsustainability* of the impact of humans on the planet (Global Footprint Network 2009).



2.2. Purpose and aims

The purpose of this project was to carry out the necessary calculations for determining the consumption Ecological Footprint of the ACT and to present the findings in a clear and concise format. The Integrated Sustainability Analysis (ISA) research group at the University of Sydney has employed environmentally extended input-output analysis to perform the calculations. This work builds on the experience from previous projects in other parts of Australia and the ACT.

The aim of this project was to estimate the 2008-09 Ecological Footprint report for the ACT in order to investigate the progress towards or away from sustainability in the ACT. The project has five main objectives:

- To calculate the total Ecological Footprint of the ACT for 2008-09.
- To calculate the Ecological Footprint per-capita of the ACT population.
- To give a comparison to the Australian average.
- To give a breakdown of the most important goods and services contributing to the ACT Footprint.
- To provide a comparison with previous Ecological Footprints.

The following main sections of the report present a brief methodology, followed by the results and then a detailed description of the mathematics behind the methodology and data used.

3. Project methodology

3.1. Overview

The results of this Ecological Footprint analysis of the ACT cover the financial year 2008-09 and meet international standards in Ecological Footprinting. This report considers the bioproductivity Ecological Footprint approach (Wackernagel and Rees 1996), i.e. it focuses on the bioproductive land taken up by human activities and is measured in global hectares (= adjusted hectares that represent the average yield of all biologically productive areas on earth).

This Ecological Footprint assessment is based on (1) input-output analysis, describing the interdependencies between economic sectors in Australia; and (2) household expenditure data and household income data collected by the Australian Bureau of Statistics. By matching the expenditure and income data with the results of the input-output analysis for various categories of goods and services, we are able to assess the per-capita environmental impacts of household consumption.

The Integrated Sustainability Analysis (ISA) at the University of Sydney has assembled a framework for calculating Ecological Footprints tailored to Australian conditions. This framework employs the most detailed and comprehensive information on land disturbance and greenhouse gas emissions available in Australia today, using the Australian Bureau of Statistics' (ABS) comprehensive input-output tables, and the CSIRO's satellite-image-based assessment of land disturbance over the Australian continent. The assessment offered by ISA guarantees full coverage of all upstream impacts on land and emissions, and is therefore the only complete Ecological Footprint assessment to date. Significant truncation errors (often 25-50%) of upstream requirements that are common in conventional Ecological Footprints do not occur in this methodology.

Using the ISA framework, the Ecological Footprint for Australia can be calculated from household expenditure data. This approach has been applied in dozens of applications throughout the past 30 years[8], and is the most robust approach of assessing environmental impacts of populations.

Final Ecological Footprints are based on a static, single-region, open, basic-price, industry-by-industry input-output model of the domestic Australian economy as of 1998-99, coupled with an extensive database on environmental indicators.[1] The methodology has been successfully employed in a range of Australian company and government applications, a pilot program on triple

---

[1] Foran, B., M. Lenzen, et al. (2005). Balancing Act - A Triple Bottom Line Account of the Australian Economy. Canberra, ACT, Australia, CSIRO Resource Futures and The University of Sydney.

With a summary in Foran, B., M. Lenzen, et al. (2005). "Integrating Sustainable Chain Management with Triple Bottom Line Reporting." Ecological Economics **52**(2): 143-157.

See also United Nations Department for Economic and Social Affairs Statistics Division (1999). Handbook of Input-Output Table Compilation and Analysis. New York, USA, United Nations.

, Lenzen, M. (2001). "A generalised input-output multiplier calculus for Australia." Economic Systems Research **13**(1): 65-92.

bottom line (TBL) reporting, and in the widely publicised nation-wide whole-economy TBL study *Balancing Act* (see http://www.isa.org.usyd.edu.au for details).

Results can be interpreted *ex-post*, that is as answers to the questions: "What Ecological Footprint would have been assigned to the user, given base year economic and resource use structure, and assuming proportionality between monetary and resource flows?" Results can however not readily be interpreted in an *ex-ante*, predictive way, such as: "How would the Ecological Footprint change as a consequence of changes in the user's financial and resource flows?"[2]

The following sections provide a detailed exposition of the methodology applied in this work. They are aimed at readers who are unfamiliar with the concept of the Ecological Footprint, and who wish to learn about recent developments. A mathematical exposition of the methodology is included later.

3.2. Background to the Ecological Footprint

The Ecological Footprint was originally conceived as a simple and elegant method for comparing the sustainability of resource use among different populations (Rees 1992). The consumption of these populations is converted into a single index: the land area that would be needed to sustain that population indefinitely. This area is then compared to the actual area of productive land that the given population inhabits, and the degree of unsustainability is calculated as the difference between available and required land. Unsustainable populations are simply populations with a higher Ecological Footprint than available land. Ecological Footprints calculated according to this original method became important educational tools in highlighting the unsustainability of global consumption (Costanza 2000). It was also proposed that Ecological Footprints could be used for policy design and planning (Wackernagel, Onisto et al. 1997), (Wackernagel and Silverstein 2000).

Since the formulation of the Ecological Footprint, however, a number of researchers have criticised the originally proposed method (Levett 1998); (van den Bergh and Verbruggen 1999); (Ayres 2000); (Moffatt 2000); (Opschoor 2000); (Rapport 2000); (van Kooten and Bulte 2000). The criticisms largely refer to the oversimplification in Ecological Footprints of the complex task of measuring sustainability of consumption, leading to comparisons among populations becoming meaningless[3], or the result for a single population being significantly underestimated. In addition, the aggregated form of the final Ecological Footprint makes it difficult to understand the specific reasons for the unsustainability of the consumption of a given population (Rapport 2000), and to formulate appropriate policy responses (Ayres 2000); (Moffatt 2000); (Opschoor 2000); (van Kooten and Bulte 2000). In response to the problems highlighted, the concept has undergone

[2] For interpretation of static input-output models see Miller, R. E. and P. D. Blair (1985). Input-Output Analysis: Foundations and Extensions. Englewood Cliffs, NJ, USA, Prentice-Hall.

[3] For example, as a result of calculations by Wackernagel, M. (1997). "Ranking the ecological footprint of nations."

Some countries with high land clearing rates (Australia, Brazil, Indonesia, Malaysia) exhibit a positive balance between available and required land, thus suggesting that these populations are using their land at least sustainably.

significant modification and improvement (Bicknell, Ball et al. 1998), (Simpson, Petroeschevsky et al. 2000), (Lenzen and Murray 2001).

The original Ecological Footprint is defined as the land area that would be needed to meet the consumption of a population and to absorb all their waste (Wackernagel and Rees 1996). Consumption is divided into 5 categories: food, housing, transportation, consumer goods, and services. Land is divided into 8 categories: energy land, degraded or built land, gardens, crop land, pastures and managed forests, and 'land of limited availability', considered to be untouched forests and 'non-productive areas', which the authors defined as deserts and ice-caps. The 'non-productive' areas are not included further in the analysis. Data are collected from disparate sources such as production and trade accounts, state of the environment reports, and agricultural, fuel use and emissions statistics. The Ecological Footprint is calculated by compiling a matrix in which a land area is allocated to each consumption category. In order to calculate the per-capita Ecological Footprint, all land areas are added up, and then divided by the population, giving a result in hectares per capita.

The total Ecological Footprint for a population can also be subtracted from the ‘productive’ area that population inhabits. If this gives a positive number, it is taken to indicate an ecological ‘remainder’, or remaining ecological capacity for that population. A negative figure indicates that the population has an ecological 'deficit'. According to the first Ecological Footprint calculation (Wackernagel and Rees 1996), Canadians in 1991 had an Ecological Footprint of 4.3 ha per capita and an ecological remainder of 10.9 ha per capita.

3.3. Including all areas of land

In the original Ecological Footprint, areas which were 'unproductive for human purposes', such as deserts and icecaps, are excluded from the calculation (Wackernagel and Rees 1996). A problem with this approach is that deciding which land is 'unproductive for human purposes' is subjective. There are many examples of indigenous peoples who have lived in deserts, in some cases, for thousands of years, such as the Walpiri people of Central Australia. In addition, large tracts of arid and semi-arid land in Australia support cattle grazing and mining. The ecosystems present in these areas have been, and continue to be, disturbed by these activities. Finally, many ecosystems that are not used directly may have indirect benefits for humans through providing biodiversity or other ecosystem functions. Therefore, in a recent calculation of the Ecological Footprint of Australia (Simpson, Petroeschevsky et al. 2000) all areas of land were included, irrespective of their productivity.

3.4. Input-output-based Ecological Footprinting

In the calculation of Ecological Footprints of populations by (Wackernagel and Rees 1996) and (Simpson, Petroeschevsky et al. 2000), the land areas included were mainly those directly required by households, and those required by the producers of consumer items. These producers, however, draw on numerous input items themselves, and the producers of these inputs also require land. Generally speaking, in modern economies all industry sectors are dependent on all other sectors, and this process of industrial interdependence proceeds infinitely in an upstream direction, through the whole life cycle of all products, like the branches of an infinite tree.

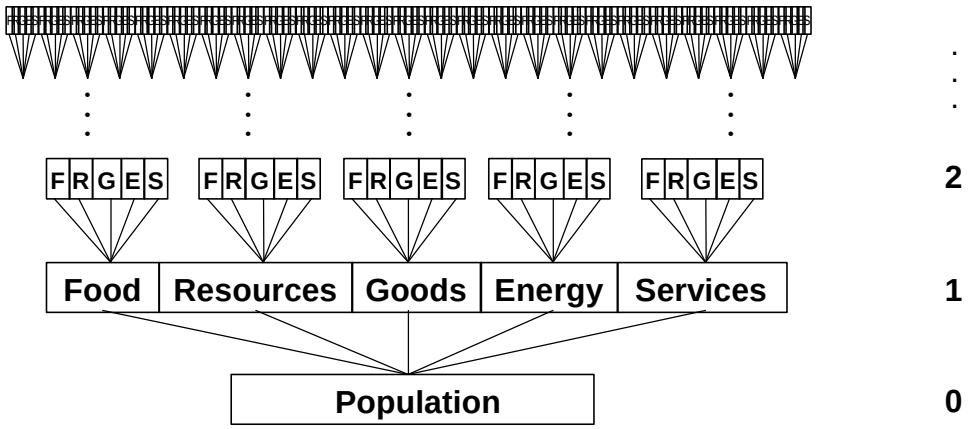


Figure 1: Industrial interdependence in a modern economy: a "tree" of upstream production layers.

Such a production "tree" is shown schematically in Figure 1: the population to be examined represents the lowest level, or production layer zero. The land required directly by the population (for example land occupied by the house, land required to absorb emissions caused in the household, or by driving a private car) is called the direct land requirement. All other, indirect land requirements originate from this layer. The providers of goods and services purchased by the population form the production layer number one, and their land requirements are called first-order requirements. The suppliers of these providers are production layer number two, and so on. The sum of direct and all indirect requirements, is called total requirements.

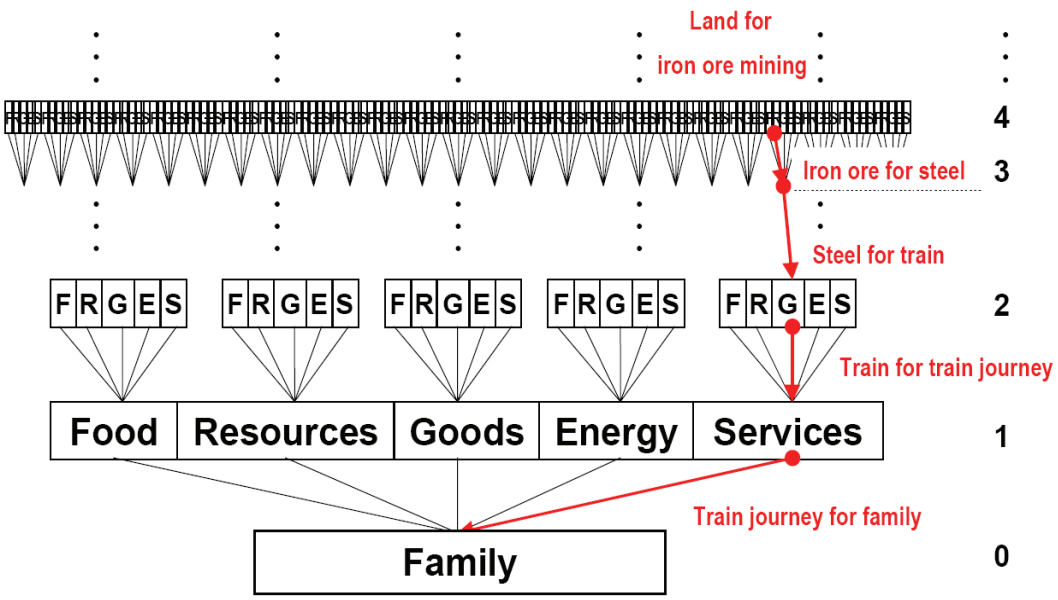


Figure 2: An example of production layers and input paths in Ecological Footprint calculations.

A specific example for direct and indirect requirements in the Ecological Footprint of a family is shown in Figure 2. Direct requirements in production layer zero are represented by the land required for the family's home and for absorbing the emissions caused by the burning of petrol, natural gas and other fuels in the household and the car. One item contributing to the family's Ecological Footprint could be a train journey. The family does not directly require land by using this train. However, the train uses diesel fuel, which causes the emission of greenhouse gases. The rail transport operator providing this service is part of production layer 1, and the land required to absorb these emissions is an example for a first-order indirect requirement. Furthermore, the train itself needed to be built, and the land occupied by the train manufacturer (part of layer 2) is a second-order requirement. Land and emissions associated with the steel plant producing the steel sheet (layer 3) for the train are third-order requirements, the land mined to extract the iron ore (layer 4) for making the steel sheet is a fourth-order requirement, and so on. Each stage in this infinite supply process involves land use and emissions. Figure 1 and Figure 2 demonstrate that calculations that consider only layers zero and one underestimate the true Ecological Footprint.

Even though indirect requirements, production layers and structural paths can be very complex, there exists a method for their calculation: input-output analysis. This is a macroeconomic technique that relies on data on inter-industrial monetary transactions, as documented for example in the Australian input-output tables compiled by the (Australian Bureau of Statistics 2001). It was first applied by (Bicknell, Ball et al. 1998) to calculate an Ecological Footprint for New Zealand.
Since its first application in New Zealand, the use of input-output analysis for Ecological Footprint analysis has grown continuously, to include research organisations all over the world.[4] In 2008, a

[4] Ferng, J.-J. (2001). "Using composition of land multiplier to estimate ecological footprints associated with production activity." Ecological Economics **37**: 159-172.

, Albino, V. and S. Kühtz (2002). Environmental footprint of industrial districts using input-output tables based on production processes. 14th International Conference on Input-Output Techniques, Montréal, Canada, Internet site http://www.io2002conference.uqam.ca/abstracts_papers/new16janv03/Montreal_final_paper.doc.

, Bagliani, M., F. Ferlaino, et al. (2002). Ecological footprint and input-output methodology: the analysis of the environmental sustainability of the economic sectors of Piedmont Region (Italy). 14th International Conference on Input-Output Techniques, Montréal, Canada, Internet site http://www.io2002conference.uqam.ca/abstracts.pdf.

, Hubacek, K. and S. Giljum (2003). "Applying physical input-output analysis to estimate land appropriation (ecological footprints) of international trade activities." Ecological Economics **44**: 137-151.

, Lenzen, M., S. Lundie, et al. (2003). "Assessing the ecological footprint of a large metropolitan water supplier - lessons for water management and planning towards sustainability." Journal of Environmental Planning and Management **46**(1): 113-141.

, Lenzen, M. and S. A. Murray (2003). The ecological footprint - issues and trends. Sydney, Australia, ISA The University of Sydney.

, McDonald, G. and M. Patterson (2003). Ecological Footprints of New Zealand and its Regions. Wellington, New Zealand, Ministry for Environment New Zealand.

, Nichols, M. (2003). An application of the Ecological Footprint method to an eco-tourism resort: A case study of Kingfisher Bay resort and Village, Fraser Island. Faculty of Science. Maroochydore, Australia, University of the Sunshine Coast.

, Wood, R. and M. Lenzen (2003). "An application of an improved ecological footprint method and structural path analysis in a comparative institutional study." Local Environment **8**(4): 365-386.

pilot study was completed for Victoria, for the first time comparing the original method with an input-output-based methodology (http://www.epa.vic.gov.au/ecologicalfootprint/ausFootprint/default.asp). Recently, the Ecological Footprint methodology has been standardised (http://www.footprintstandards.org/), with a strong focus on input-output analysis (Global Footprint Network 2009).

Input-output-based Ecological Footprints have many advantages: they are complete without artificial boundaries, they draw on detailed data sets which are regularly collected by government statistical agencies, and they can be calculated for industry sectors and product groups, for states, local areas and cities, and for companies and households. Finally, in more comprehensive studies input-output-based Ecological Footprints allow valid trade-offs with other sustainability indicators, thus placing the Ecological Footprint within the broader context of the Triple Bottom Line.

3.5. Ecological footprint land types

The Ecological Footprint distinguishes different types of bioproductive areas that provide renewable resources for human consumption. **Cropland** is the land type with the greatest average bioproductivity per hectare and is used for growing crops for food, animal feed, fibre, oils and biofuels. **Pasture** (or grazing land) is used for raising animals for meat, hides, wool, and milk. **Forest** area is natural or plantation forests used for harvesting timber products and fuelwood. Infrastructure for housing, transportation, and industrial production occupies built-up land. This **built land** is not a bioproductive area but it is assumed to have replaced cropland area, as human settlements are predominantly located in fertile areas of a country. **Water** area needed for human consumption includes lakes and rivers used for freshwater provision, hydropower, fishing, freshwater aquaculture and recreational purposes. Finally, **energy land** is the notional area within the Ecological Footprint that is required to sequester carbon dioxide emissions from human activity. Energy land answers the question "how much woodland and forest area would we need to have in order to absorb all CO2 emissions from the burning of fossil fuels?".

3.6. Methodological changes

As previously mentioned, the Ecological Footprint methodology has been standardised (http://www.footprintstandards.org/). Although not perfect, the standard represents an advance on the previous situation where there were several general footprint approaches with some important

---

, Wiedmann, T. and J. Barrett (2005). The Use of Input-Output Analysis in REAP to allocate Ecological Footprints and Material Flows to Final Consumption Categories. York, United Kingdom Stockholm Environment Institute, WWF UK.

, Wiedmann, T., J. Minx, et al. (2006). "Allocating ecological footprints to final consumption categories with input-output analysis." Ecological Economics **56**(1): 28-48.

, Wiedmann, T., J. Barrett, et al. (2007). Companies on the Scale - Comparing and Benchmarking the Footprints of Businesses. International Ecological Footprint Conference, Cardiff, Wales, UK, ESRC BRASS Research Centre, Cardiff University.

, Wiedmann, T., M. Lenzen, et al. (2007). Multiregional input-output modelling opens new opportunities for the estimation of Ecological Footprints embedded in international trade. International Ecological Footprint Conference, Cardiff, Wales, UK, BRASS Research Centre, Cardiff University.

.

differences. Despite the move to a standard approach, or in fact partly because of this, previous Ecological Footprint calculations may not be directly comparable to current calculations. In this section, we refer specifically to the major methodological changes that have occurred from the first calculation of the ACT Ecological Footprint in 2004 to the current calculation.

Perhaps the most significant change that has come from the standardisation of the methodology is the weighting of impacts on the land by global average bioproductivity factors rather than incorporating disturbance based factors. In the previous calculation, Ecological Footprint impacts were expressed in terms of built land; degraded land; cleared land; thinned land; partially disturbed land; reserves and greenhouse impacted land, with applicable weightings related to the projected ecosystem disturbance. In line with the standards, impacts on the land are now weighted by a yield factor in order to relate local productivity of each land type to the global average productivity of each land type. Land types are then weighted by equivalence factors in order to express land type impacts into a standard unit of biologically productive area –the global hectare.

For the particular case of greenhouse emissions, the previously used disturbance methodology related greenhouse emissions to the projected loss of land area due to climate change. In the bioproductivity approach, emissions are instead calculated by the biocapacity required to sequester carbon emissions through photosynthesis. Such land has been called ‘energy land’ in the past and is now sometimes referred to as the ‘carbon footprint’ component of the ecological footprint. Care must be exercised here as this is not the same as other users of the term carbon footprint which refers to the actual greenhouse gas emissions in CO_2-equivalents.

The second major change in methods used in this report is the updating and expansion of the Australian database from a baseline year of 1995 to 1999. The expansion of the database draws from detailed economic commodity reports, allowing the incorporation of a greater number of real physical data points for environmentally sensitive economic sectors. The disaggregation of a number of these sectors adds greater precision to results. The baseline year has been further updated in this report with important aspects such as inflation and major changes in physical accounts such as the national greenhouse gas inventory.

The overall effect of all these changes is usually small at the aggregate level, and more pronounced at the highly detailed commodity level, dependant on the particular consumption patterns of a population. Hence, in order to allow meaningful comparisons to be made from reports for ACT Footprint report for 1998-99 and 2003-04 to this current report, the 1998-99 dataset of consumption practices in the ACT has been expanded to the higher level of detail and processed according to the current methodology. This report, therefore, can be seen to supersede the first report such that previous results can be interpreted against current Ecological Footprint standards.

Finally, it should be noted that gaining full consistency across multiple data sources, years, and methodologies is difficult and not completely achievable given various data availabilities and limitations, changes in definitions and so on. Great care is taken in the work of ISA to achieve as high a consistency as possible.

4. Ecological Footprint results for the ACT

4.1. Overview and key findings

In 2009, it is estimated that the average ACT resident has an Ecological Footprint of 9.2 global hectares (Table 1), three and a half times higher than the world average and five times higher than the average available biocapacity (see Section 2.1). The ACT's 2009 footprint is 13% higher than the Australian average (8.1 gha) in 2009, in turn up from the average of 7.3 in 2004.

The 2009 total Ecological Footprint of 3.2 million global hectares is nearly 14 times the land area of the ACT. Most of the ACT's Ecological Footprint is located in other parts of the world that provide the wide range of goods and services consumed by ACT residents. The Ecological Footprint consists of both "Real Land" (arable land, pasture, forests, built land etc.) and "Energy Land" (the land required to absorb the carbon dioxide emitted through the consumption patterns of a given population)[5].

		ACT 09				
		Ecological Footprint ('000 gha)				
Cropland	**Pasture**	**Forests**	**Energy land**	**Built land**	**Water**	**TOTAL**
329	344	610	1,828	87	1	3,200
		AUS 09				
		Ecological Footprint ('000 gha)				
Cropland	**Pasture**	**Forests**	**Energy land**	**Built land**	**Water**	**TOTAL**
18,054	20,031	36,006	97,229	4,610	47	175,977
		ACT 09				
		Ecological Footprint (gha)				
Cropland	**Pasture**	**Forests**	**Energy land**	**Built land**	**Water**	**TOTAL**
0.94	0.99	1.75	5.24	0.25	0.00	9.2
		AUS 09				
		Ecological Footprint (gha)				
Cropland	**Pasture**	**Forests**	**Energy land**	**Built land**	**Water**	**TOTAL**
0.83	0.92	1.66	4.47	0.21	0.00	8.1

Table 1: The Ecological Footprint of the ACT and the whole of Australia by land type for 2008-09. Results are shown in absolute terms (thousands of global hectares, '000 gha) and per-capita (gha/cap).

For the ACT, the majority of the Ecological Footprint is "Energy Land" (57%). This is due to the heavy reliance on fossil fuels where the major impacts are from the consumption of electricity by households (12% of total), the use of flights and the purchase of petrol for cars (both 4% each of total, see below). In terms of "Real Land", the forest Footprint has the largest contribution with

[5] Refer Section 3.5

about 19% of the total Ecological Footprint. This largely reflects the use of wood in the construction of new houses and for heating.

The Ecological Footprint on farming lands (Cropland and Pasture) in the ACT (0.94 and 0.99 gha respectively) is slightly higher than for the average Australian (0.83 and 0.92 gha respectively), reflecting a higher than average consumption of foodstuffs and the fibres embodied in clothing and housing within the ACT. Combined, the Ecological Footprint of the farming lands account for 21% of the ACT Ecological Footprint compared to 22% of the Australian Ecological Footprint. Built land contributes only 3% to the Ecological Footprint of the average ACT resident, again reflecting just how little of a person's Ecological Footprint is contained within the urban environment.

A comparison of the latest ACT Ecological Footprint to the Australian average (Figure 3) shows a similar breakdown. The average Australian has a per-capita Ecological Footprint of 7.3 gha in 2003-04, rising to 8.1 in 2008-09. The average ACT footprint in 2003-04 was 8.5 gha rising to 9.2 gha in 2008-09.

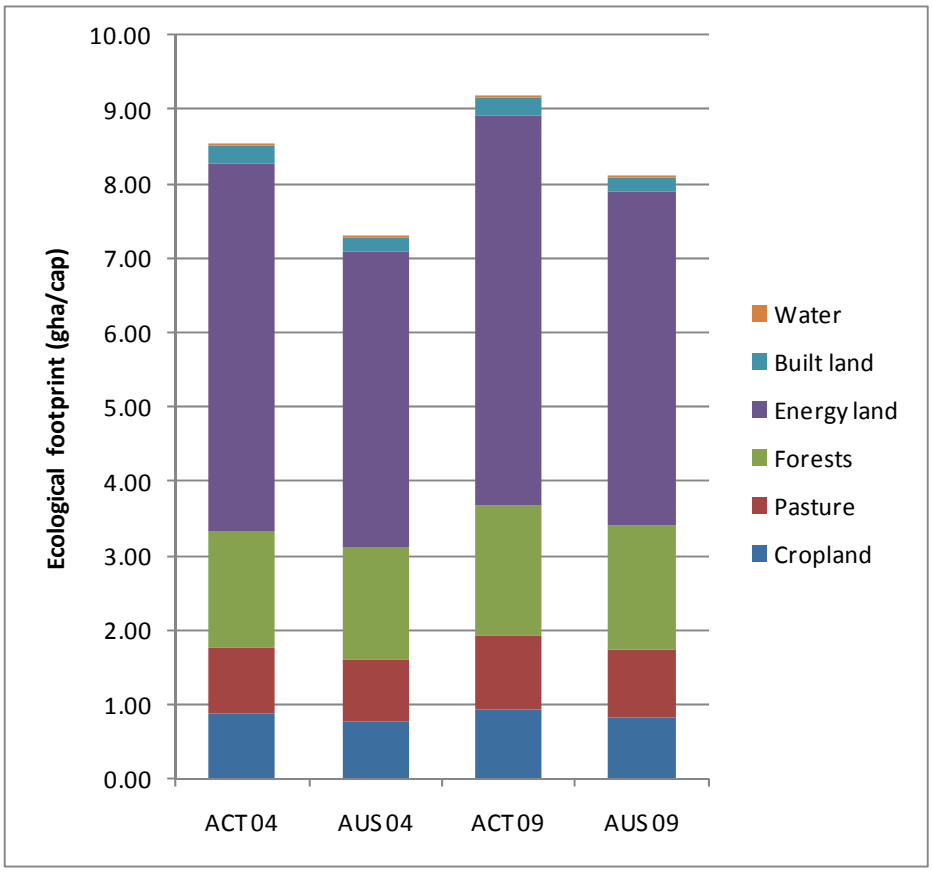


Figure 3: The per-capita Ecological Footprint of the ACT and the whole of Australia by land type for 2003-04 and 2008-09.

4.2. Ecological Footprint by consumption category

The results can be organised by land or by consumption activities, such as travelling, the food we eat, the energy we consume, products we buy and the services we use. The graphs below provide more detail. All upstream impacts are included within each category. As an example the land required to grow wheat, as well as the energy used to harvest the wheat is all included within the "Food" category.

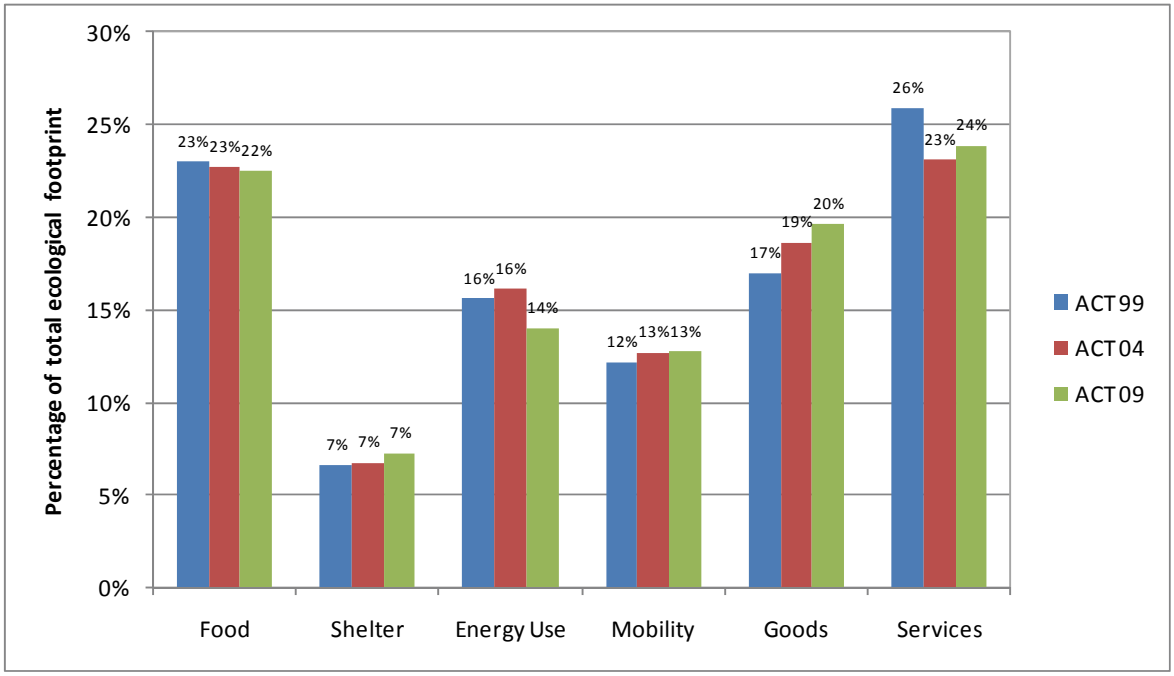


Figure 4: Comparison of Ecological Footprint consumption categories for the ACT for the three years.

Using these categories, the consumption of food and the demand for services have the most significant Ecological Footprint. Fifty-eight percent of the food impact (1.2 gha) is due to plant based food products, whilst the remainder (0.9 gha) is due to animal based products. The "services" category includes a large number of commodities including telecommunication services, financial services, medical, entertainment and government services. The main pattern of consumption in the ACT is reasonably similar to the national average, with slightly lower percentage of food and shelter impacts, but higher impacts in the more tertiary sectors. Energy use impacts are falling absolutely, and more so relatively, as per capita incomes continue to rise.

To give an idea of the difference in impacts embodied within the production practices of each category, Figure 5 compares the Ecological Footprint of each consumption category (in blue) to the expenditure in each consumption category of ACT residents (in red).

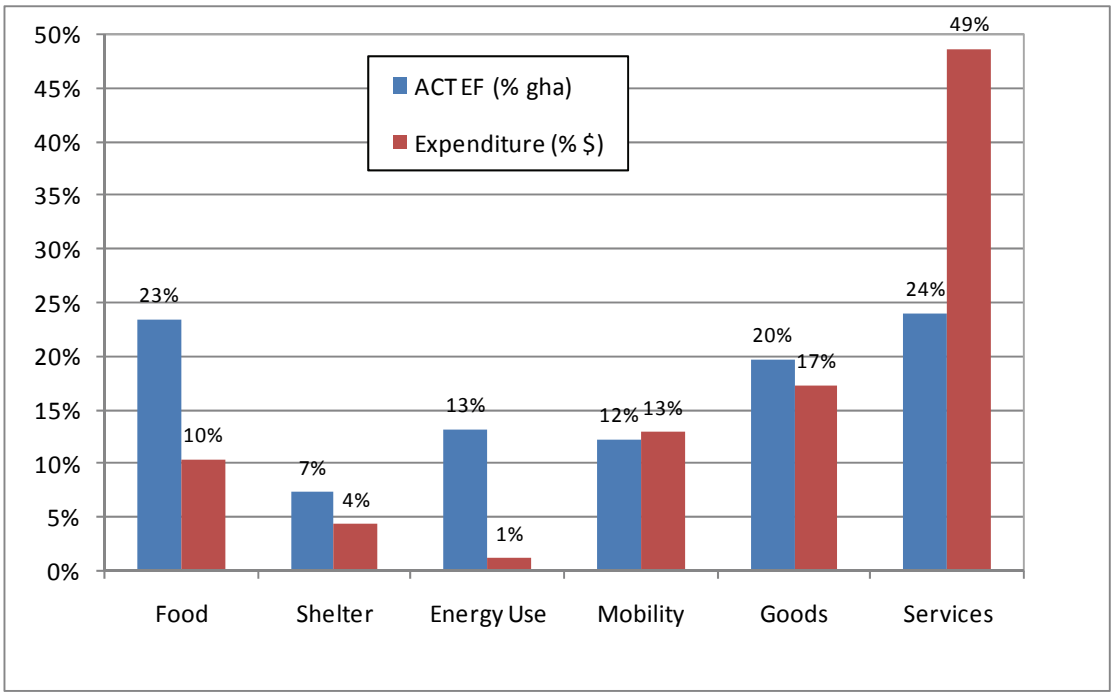


Figure 5: Comparison of consumption categories by Ecological Footprint and Expenditure, ACT 2008-09.

Hence, whilst food accounts for over 22% of the ACT Ecological Footprint, it is due to only roughly 10% of an ACT resident's expenditure ("Expenditure" includes imports, government and capital expenditure). In significant contrast, is the expenditure on services, making up almost 50% of total expenditure, but having an impact of 24%, compared with 21%. Relative to the 2003-04 breakdown, goods and services are becoming more important. This is again due to the continual increase in incomes, and therefore expenditure.

4.3. Ecological Footprint analysis of commodities

The ACT's Ecological Footprint is a measure of land used to provide goods and services for activities such as building cities, growing fruit and vegetables, grazing cows to provide dairy and beef products, growing trees for paper and wood products, and absorbing carbon dioxide produced from using electric appliances, driving cars, operating machinery, etc. Each of these contributes to the Ecological Footprint. The high level consumption categories shown in Figure 4 can hide some of the finer details of the ACT's Ecological Footprint. Under these broad categories exists a breakdown of over 300 consumption activities (commodities). To calculate the Ecological Footprint, expenditure on every commodity by ACT residents has been taken into account. This helps provide a focus on where to take action to achieve maximum reduction in the Ecological Footprint.

Rank	Commodity	Impact (gha/capita)	% of Total
1	Electricity supply	1.07	12%
2	Residential building construction	0.56	6%
3	Retail trade	0.51	6%
4	Hotels, clubs, restaurants and cafes	0.44	5%
5	Air and space transport	0.35	4%
6	Petrol	0.32	4%
7	Other food products	0.29	3%
8	Wooden furniture	0.25	3%
9	Ownership of dwellings	0.24	3%
10	Clothing	0.21	2%
11	Electronic equipment	0.20	2%
12	Beef cattle	0.17	2%
13	Finished cars	0.16	2%
14	Education	0.15	2%
15	Non-building construction	0.14	2%
16	Gas supply	0.14	2%
17	Non-residential building construction	0.14	1%
18	Wheat	0.12	1%
19	Recorded media and publishing nec	0.10	1%
20	Pharmaceutical goods for human use	0.09	1%
21	Community services and religious organisations	0.09	1%
22	Wholesale trade	0.09	1%
23	Federal government	0.09	1%
24	Beer and malt	0.08	1%
25	Sport and recreation services	0.08	1%

Table 2: Top 25 commodities in terms of per-capita Ecological Footprint in the ACT in 2008-09.

These first twenty-five out of the 300 commodities account for two thirds (66%) of the total Ecological Footprint; they are listed in Table 2. All figures reported are in per-capita terms. Error margins for values quoted are in the order of 10-15%. At the top of the table is the impact of electricity consumption. Using electrical power alone adds around 12% (1.07 gha) to each person's Ecological Footprint every year. The ACT meets its electricity needs mostly through coal fired power stations which have one of the highest carbon dioxide emissions of all forms of electricity generation and therefore contributes significantly to the Ecological Footprint. The trend with electricity is for average per capita consumption decreasing by 6% between 2003-04 and 2007-08 (ACT Independent Competition and Regulatory Commission 2009).

The second biggest Ecological Footprint is created by house construction. Building new homes in the ACT adds around half a global hectare to each person's Ecological Footprint every year. In this case it is mainly the forest area needed to grow timber for construction as well as the carbon Footprint of generating energy used in construction that creates this Footprint impact.

Other major contributors are retail trade (3rd) and hospitality (4th). Retail trade reflects the industry sector that sells us our goods and services. The underlying cause of this impact is the fuel consumption of the vehicles used to distribute the goods and the electricity used in shops, and this is why it contributes to the energy Footprint. Food consumption in restaurants, cafes and hotels is the main reason why this service is also high up on the list (0.4 gha/cap, rank 4). Private transportation is also a significant contributor, with air travel ranked 5th and the use of petrol in private automobiles closely following in 6th. Fuel use in passenger vehicles appears to have plateaued in the last few years.

For comparative purposes, the commodity ranking of the 2003-04 Ecological Footprint of the ACT has been calculated according to the current methodology (Table 3). Results at this level of detail are similar to the current year's results. The main difference is that the direct contributions of electricity and petrol are slightly less important: a result of real achievements in limiting electricity use and vehicle kilometres. However, these contributions amount to less than 20% of the total footprint.

Rank	Commodity	Impact (gha/capita)	% of Total
1	Electricity supply	1.1	13%
2	Residential building construction	0.5	6%
3	Retail trade	0.4	5%
4	Hotels, clubs, restaurants and cafes	0.4	5%
5	Petrol	0.3	4%
6	Air and space transport	0.3	4%
7	Other food products	0.3	3%
8	Wooden furniture	0.2	3%
9	Ownership of dwellings	0.2	3%
10	Electronic equipment	0.2	2%
11	Clothing	0.2	2%
12	Beef cattle	0.2	2%
13	Gas supply	0.1	2%
14	Non-building construction	0.1	2%
15	Education	0.1	2%
16	Finished cars	0.1	2%
17	Non-residential building construction	0.1	2%
18	Wheat	0.1	1%
19	Recorded media and publishing nec	0.1	1%
20	Wholesale trade	0.1	1%
21	Federal government	0.1	1%
22	Pharmaceutical goods for human use	0.1	1%
23	Community services and religious organisations	0.1	1%
24	Beer and malt	0.1	1%
25	Sport and recreation services	0.1	1%

Table 3: Top 25 commodities in terms of per-capita Ecological Footprint in the ACT in 2003-04.

4.4. Other data and trends

It is instructive to examine some trends in other ACT data in order to test the validity of these modelling results. The main influence on both the magnitude and increases in Ecological Footprints in development countries is increases in consumption. Consumption is highly correlated with increases in income. The ACT has the highest mean household income of all Australian states, being 28% higher than the Australian average in 2007-08 (ABS 2009). The last decade has seen a considerable increase in the average income of ACT households compared to Australia as a whole (Figure 6).

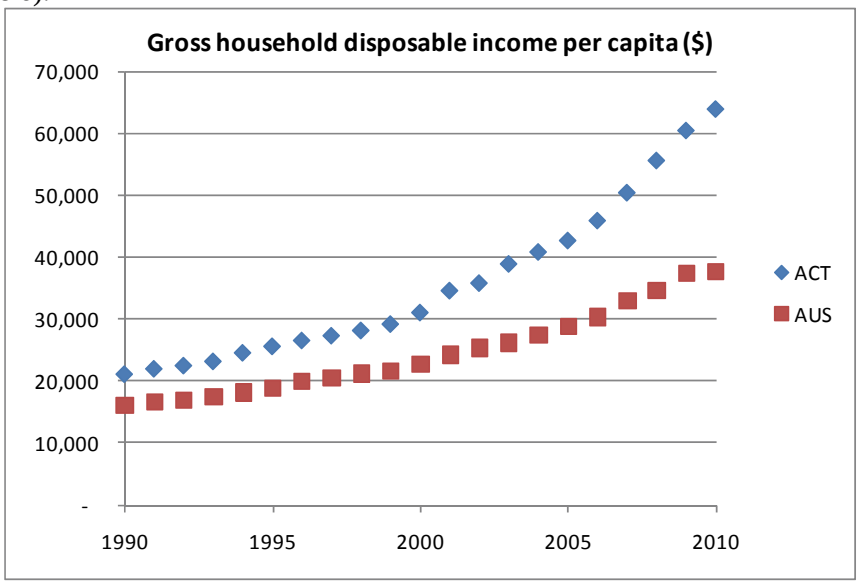


Figure 6: Average gross household disposable income per capita for Australian and the ACT.

Higher incomes generally result in higher expenditures. Figure 7 shows the household final consumption expenditure history for the ACT and Australia. As with income, there is a widening gap between the average expenditures. Note that these data are not exactly consistent with the expenditure data used in the Ecological Footprint calculations, but are indicative of the strong overall trend to higher consumption in the ACT.

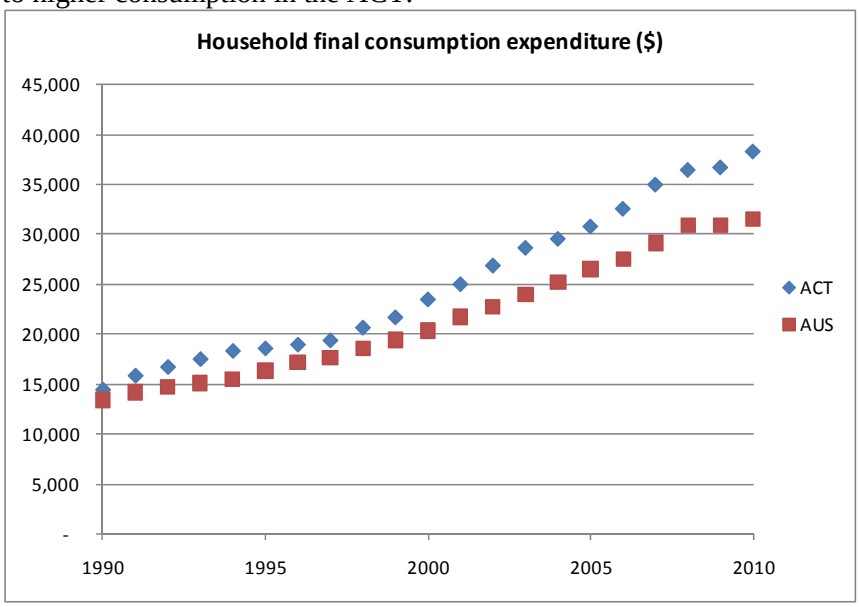


Figure 7: Comparison of average final consumption expenditure.

There has been a small but steady fall in electricity use per household each year from 2003-04 to 2007-08 (ACT Independent Competition and Regulatory Commission 2009), shown in Figure 8. The difference between these two years amounts to a 6% reduction in emissions (Department of Climate Change 2010). Similarly, there has been a 7% reduction in natural gas usage per household from 2003-04 to 2007-08 (Figure 9). Whilst the annual gas data appears to fluctuate more than the electricity usage, there is a general trend downwards in the last 6years.

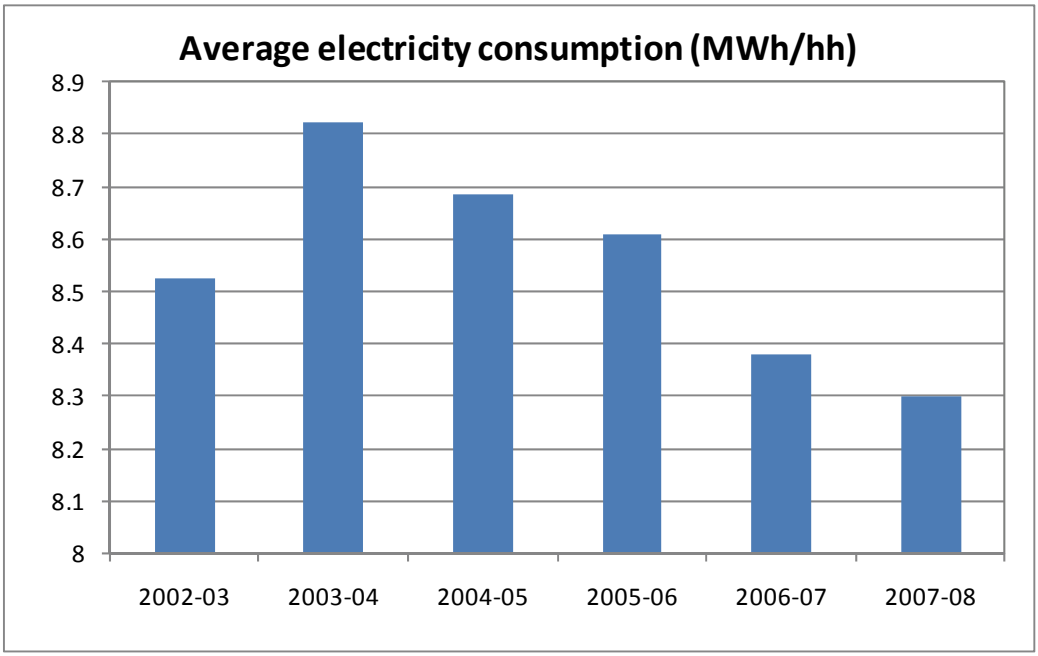


Figure 8: Average annual household (hh) electricity consumption. Emissions from electricity follow the same trend.

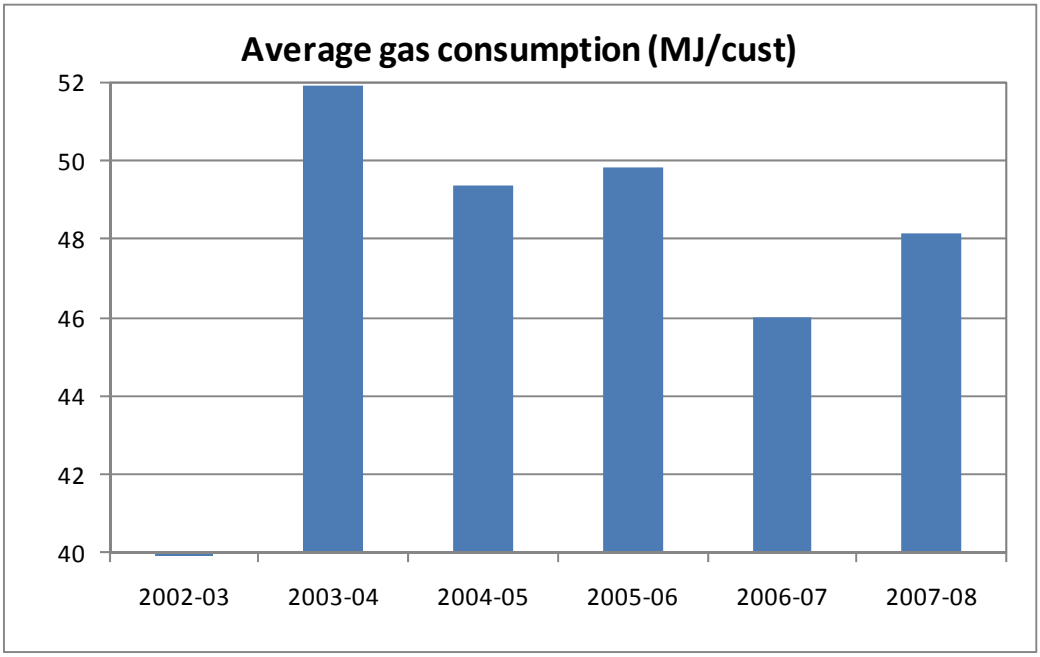


Figure 9: Average annual household (per gas customer) natural gas consumption.

Passenger car travels appears to have levelled off over the last 5 years, but the Bureau of Transport and Regional Economics still predicts the total passenger car equivalent kilometres to increase by 29% in Canberra between 2005 and 2020 (Bureau of Transport and Regional Economics 2007). The following two figures show the absolute and per capita passenger vehicle distances. There is a clear trend in reductions in average passenger vehicle distances per capita.

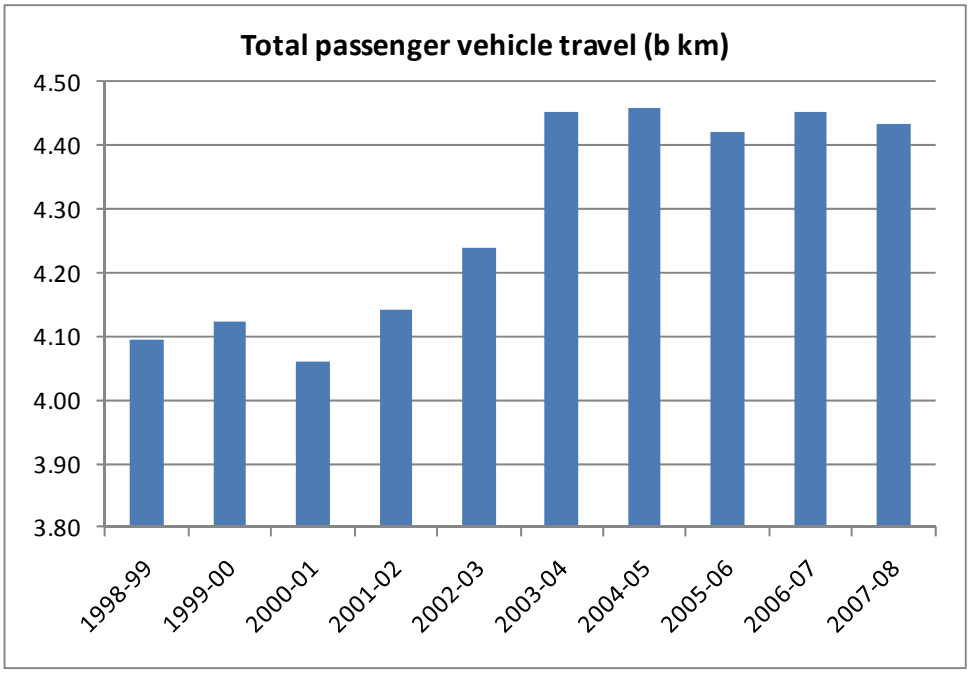


Figure 10: Total vehicle kilometres for ACT passenger vehicles.

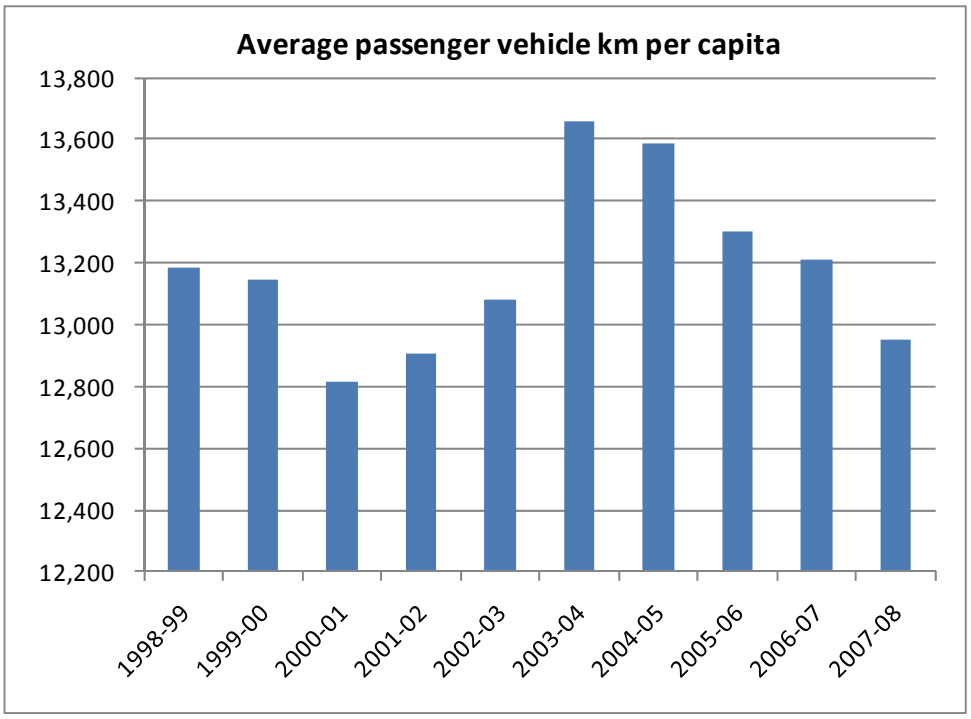


Figure 11: Average per capita vehicle kilometres for ACT passenger vehicles.

4.5. Conclusion

In 2008-09 the ACT Ecological Footprint was 9.2 global hectares (gha) per capita, a growth of approximately 8% from the ACT Ecological Footprint of 2003-04, which in turn was approximately 15% higher than the footprint in 1998-99. In 2008-09, the average ACT resident has a Ecological Footprint some 13% larger than the Australian average. The total Ecological Footprint of all ACT residents is approximately 3,200,000 global hectares, nearly 14 times the geographical area of the ACT. Fifty seven percent of the Ecological Footprint is "energy land" – which mainly reflects the biocapacity required to absorb carbon emissions. Nineteen percent of the Ecological Footprint is in Forests – primarily used within the residential construction industry. In comparison, only 3% of the ACT Ecological Footprint is in Built Land.

Food is responsible for the largest single category of the ACT Ecological Footprint, closely followed by the provision of services to ACT residents. Of the food Footprint, 57% is plant based whilst the remainder is animal based food products. At a more detailed level, the highest ranking commodities contributing to the ACT Ecological Footprint are electricity use, residential building construction, retail trade, hospitality, petrol use and aviation.

The ACT per-capita Ecological Footprint has grown steadily in the last 10 years, though at a slightly decreasing rate. It is clear that if ACT residents want to move away from having one of the highest Ecological Footprints in Australia they will need to make changes in their consumption habits. Despite showing some positive trends in reducing electricity, gas and fuel use, which have contributed to a slight reduction in these components in the footprint, the significant increase in consumption has meant that the ecological footprint associated with Goods and Services has increased. This is the main driving force behind the overall increase in the ACT's Ecological Footprint.

5. Mathematical exposition of the methodology

Some of the more popular studies dealing with the sustainability of cities are Ecological Footprints[6]. This concept adopts the idea of carrying capacity, and by inverting the standard carrying capacity ratio, seeks to characterise an area of land that is needed to sustain a given population indefinitely, wherever on earth this land is located. The obvious result of most Ecological Footprint calculations is that cities appropriate an area of productive land that by far exceeds their physical size, and that therefore they cannot be sustainable (Rees and Wackernagel 1996). While Ecological Footprints are an instructive educational resource for raising awareness about global unsustainability, they have been criticised, for example, because the aggregated form of the final value makes it difficult to understand the specific reasons for the unsustainability of the consumption of a given population (Rapport 2000), and to formulate appropriate policy responses (Ayres 2000); (Moffatt 2000); (Opschoor 2000); (van Kooten and Bulte 2000). Furthermore, Ecological Footprints on sub-national scales underestimate indirect requirements (Bicknell, Ball et al. 1998; Lenzen and Murray 2001). In this work, we therefore focused on providing a disaggregated description of the environmental impact of city dwellers, both in terms of impact types (fuel use, greenhouse gas emissions, land use, etc.) and consumption type (goods, services, energy, water etc.). Furthermore, we take into account indirect requirements from all upstream production layers by using input-output analysis.

5.1. Input-output analysis

Input-output analysis is a macroeconomic technique that uses data on inter-industrial monetary transactions to account for the complex interdependencies of industries in modern economies.

---

[6] See, for example, studies of Vancouver Rees, W. and M. Wackernagel (1996). "Urban ecological footprints: why cities cannot be sustainable - and why they are a key to sustainability." Environmental Impact Assessment Review **16**(4-6): 223-248.

, various cities surrounding the Baltic Sea Folke, C., Å. Jansson, et al. (1997). "Ecosystem appropriation by cities." Ambio **26**(3): 167-172.

and in the UK Simmons, C. and N. Chambers (1998). "Footprinting UK households: how big is your ecological garden?" Local Environment **3**(3): 355-362.

, Santiago de Chile Wackernagel, M. (1998). "The ecological footprint of Santiago de Chile." Local Environment **3**(1): 7-25.

, Canberra Close, A. and B. Foran (1998). Canberra's ecological footprint. Canberra, Australia, Resource Futures Program, CSIRO Wildlife and Ecology.

, Malmö Wackernagel, M., L. Lewan, et al. (1999). "Evaluating the use of natural capital with the ecological footprint." Ambio **28**(7): 604-612.

, Liverpool Barrett, J. and A. Scott (2001). "An Ecological footprint of Liverpool: A Detailed Examination of Ecological Sustainability."

, Guernsey Barrett, J. (2001). "Component ecological footprint: developing sustainable scenarios." Impact Assessment and Project Appraisal **19**(2): 107-118.

, and the Isle of Wight Best Foot Forward and Imperial College (2001). "Ecological footprint of the Isle of Wight."

.

Since its introduction by (Leontief 1936; Leontief 1941), it has been applied to numerous economic and environmental issues, and input-output tables are now compiled on a regular basis for most industrialised, and also many developing countries.

The first input-output tables to be compiled for a city are those constructed by (Hirsch 1959), who surveyed large- and medium-sized companies operating in the St. Louis area, USA, and presents sectoral income, employment, fiscal and land multipliers (Hirsch 1963). (Smith and Morrison 1974), and (Morrison and Smith 1974) review methods to compile input-output tables for cities, based on survey and non-survey techniques. They conclude that non-survey techniques are the most attractive, because of the savings of time and resources they provide to the urban planner, and because they produce reliable results. Based on a comparison of a survey-based input-output table for the city of Peterborough, UK with semi- and non-survey versions, they conclude that the RAS method "proved to be far superior to all the other techniques which were tested" with regard to the similarity of the simulated input-output coefficients to the "true" survey-based ones. (Gordon and Ledent 1980) suggest using such local input-output coefficients for the multi-regional modeling of a system of metropolitan areas.

In this work we use a different approach for regionalisation: we combine the national Australian input-output tables and national data on resource use and pollution (modified by regionalising some important effects) with regional household expenditure data. The assumption inherent in this approach is that products purchased by regional households are produced regionally and nationally using a similar production recipe.[7] The technique of combining input-output and household expenditure data has been used previously by a number of authors[8], with only one study (Moll and Norman 2002) applying this approach to cities.

---

[7] Note that this study is not an analysis of regional but of national impacts. As such, the limitations in the use of national input-output tables for regional studies Czamanski, S. and E. E. Malizia (1969). "Applicability and limitations in the use of national input-output tables for regional studies." Papers of the Regional Science Association **23**: 65-77.

do not apply here. In contrast, the analysis of local impacts or interregional flows requires the estimation of a set of regional input-output tables Tiebout, C. M. (1960). Regional and interregional input-output models: an appraisal. The techniques of urban economic analysis. R. W. Pfouts. West Trenton, NJ, USA, Chandler-Davis Publishing Co.**:** 395-407.

[8] See Herendeen, R. and J. Tanaka (1976). "Energy cost of living." Energy **1**: 165-178.

, Herendeen, R. (1978). "Total energy cost of household consumption in Norway, 1973." Energy **3**: 615-630.

, Herendeen, R., C. Ford, et al. (1981). "Energy cost of living, 1972-1973." Energy **6**: 1433-1450.

, Peet, N. J., A. J. Carter, et al. (1985). "Energy in the New Zealand household, 1974-1980." Energy **10**(11): 1197-1208.

, Aoyagi, M., Y. Kondo, et al. (1992). Analysis of differences of CO_2 emission structure by consumption expenditures of households. 9th Energy System / Economics Conference, Tokyo, Japan.

, Breuil, J.-M. (1992). "Input-output analysis and pollutant emissions in France." Energy Journal **13**(3): 173-184.

, Weber, C. and U. Fahl (1993). "Energieverbrauch und Bedürfnisbefriedigung." Energiewirtschaftliche Tagesfragen **43**(9): 605-612.

, Aoyagi, M., Y. Moriguchi, et al. (1995). "Characteristics of households' energy consumption." Energy and Resources **16**(6): 59-67 (in Japanese).

The Ecological Footprint of households in the SLAs and SSDs examined in this work is determined via

$$\mathbf{F} = \left(\mathbf{Q}^{\text{emb}} + \mathbf{Q}^{\text{hh}}\right) \times \mathbf{Y} . \qquad (1)$$

The variables in Equation 1 are:

F Matrix of household factor requirements.

Its elements $\{F_{ij}\}_{i=1,\ldots,f\,;\,j=1,\ldots,g}$ describe the total amount of factor *i* required by household group *j*. The term *factor* represents resource and Ecological Footprint components (land disturbance; fuel consumption; greenhouse gas emissions). **F** comprises (1) factors $\mathbf{Q}^{\text{hh}}\times\mathbf{Y}$ used directly by the household (in the house or by using private vehicles), and (2) factors $\mathbf{Q}^{\text{emb}}\times\mathbf{Y}$ used by Australian and foreign industries, that are required indirectly to provide goods and services purchased by the household. The latter are also called *embodied factor requirements*. **F** has dimensions $f\times g$, where f is the number of factors (f = 47), and h is the number of household groups. For the city of Sydney for example, the Australian Household Expenditure Survey conducted by the Australian Bureau of Statistics (ABS) distinguishes h = 240 household groups, categorised according to 18 household characteristics (mainly family type) and the 14 SSDs.

, Vringer, K. and K. Blok (1995). "The direct and indirect energy requirements of households in the Netherlands." Energy Policy **23**(10): 893-910.

, Weber, C., U. Fahl, et al. (1995). "Freizeit, Lebensstil und Energieverbrauch." VDI Berichte **1204**: 15-38.

, Kondo, Y., Y. Moriguchi, et al. (1996). "Analysis of the trend of CO_2 emission structure by consumption expenditures of households." Transactions of the Society of Environmental Science **9**(2): 231-240 (in Japanese).

, Lenzen, M. (1998). "The energy and greenhouse gas cost of living for Australia during 1993-94." Energy **23**(6): 497-516.

, Biesiot, W. and K. J. Noorman (1999). "Energy requirements of household consumption: a case study of The Netherlands." Ecological Economics **28**(3): 367-383.

, Munksgaard, J., K. A. Pedersen, et al. (2000). "Impact of household consumption on CO_2 emissions." Energy Economics **22**: 423-440.

, Weber, C. and A. Perrels (2000). "Modelling lifestyle effects on energy demand and related emissions." Energy Policy **28**: 549-566.

, Munksgaard, J., K. A. Pedersen, et al. (2001). "Changing consumption patterns and CO_2 reduction." International Journal of Environment and Pollution **15**(2): 146-158.

, Wier, M., M. Lenzen, et al. (2001). "Environmental effects of household consumption pattern and lifestyle." Economic Systems Research **13**(3): 259-274.

, Carlsson-Kanyama, A., R. Karlsson, et al. (2002). Household metabolism in the Five Cities - Swedish National Report - Stockholm. Stockholm, Sweden, Forskningsgruppen för Miljöstrategiska Studier.

, Cohen, C. A. M. J., M. Lenzen, et al. (2005). "Energy requirements of households in Brazil." Energy Policy **55**: 555-562.

, Lenzen, M., M. Wier, et al. (2006). "A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan." Energy **31**: 181-207.

.

$\mathbf{Q}^{\text{hh}}$ Matrix of household factor multipliers.

Its elements $\{Q_{ij}^{\text{hh}}\}_{i=1,\ldots,f\,;\,j=1,\ldots,s}$ describe the usage by private households of factor *i* per A$ value of final consumption of commodity *j*. $\mathbf{Q}^{\text{hh}}$ has dimensions $f \times s$, where *s* is the number of classified commodities. This number is also equal to the number of classified industry sectors. The version of the Australian *input-output tables* compiled by the ABS used in this work distinguishes $s = 344$ commodities[9] and industry sectors. These range from primary industries such as agriculture and mining, via secondary industries such as manufacturing and electricity, gas and water utilities, to tertiary industries such as commercial services, health, education, defence and government administration.

$\mathbf{Q}^{\text{emb}}$ Matrix of embodied factor multipliers.

Its elements $\{Q_{ij}^{\text{emb}}\}_{i=1,\ldots,f\,;\,j=1,\ldots,s}$ describe the usage of factor *i* per A$ value of final consumption of commodity *j*, (1) by the industry sectors producing commodity *j*, (2) by all upstream industry sectors supplying industry sectors producing commodity *j*, (3) by all upstream industry sectors supplying industry sectors that supply industry sectors producing commodity *j*, and (4) so on, infinitely. $\mathbf{Q}^{\text{emb}}$ thus captures the *total factor requirements* of industries in the entire economy that are needed to produce commodities consumed by households. $\mathbf{Q}^{\text{emb}}$ has dimensions $f \times s$.

$\mathbf{Y}$ Matrix of household expenditure.

Its elements $\{Y_{ij}\}_{i=1,\ldots,s\,;\,j=1,\ldots,h}$ describe the amount of A$ spent on commodity *i* by household group *h* during the reference year. $\mathbf{Y}$ has dimensions $s \times h$.

$\mathbf{Q}^{\text{emb}}$ can be calculated according to the *basic input-output relationship*

$$\mathbf{Q}^{\text{emb}} = \mathbf{Q}^{\text{ind}} \left(\mathbf{I} - \mathbf{A}\right)^{-1} \qquad (2)$$

The variables in equation 2 are:

$\mathbf{Q}^{\text{ind}}$ Matrix of industrial factor multipliers.

Its elements $\{Q_{ij}^{\text{ind}}\}_{i=1,\ldots,f\,;\,j=1,\ldots,s}$ describe the usage of factor *i* by industry sector *j* per A$ value of total output by industry sector *j*. In contrast to $\mathbf{Q}^{\text{emb}}$, $\mathbf{Q}^{\text{ind}}$ represents only factors used directly in each industry, but not in upstream supplying industries. $\mathbf{Q}^{\text{ind}}$ has dimensions $f \times s$.

$\mathbf{I}$ The unity matrix.

[9] The so-called ISAPC sector classification is a non–confidential subset of the Australian Bureau of Statistics' 8-digit Input-Output Product Classification (IOPC8; Australian Bureau of Statistics (2001). Australian National Accounts, Input-Output Tables, Product Details, 1996-97. Canberra, Australia, Australian Bureau of Statistics.

).

Its elements $\{I_{ij}\}_{i=1,\ldots,s;\, j=1,\ldots,s}$ are I_{ij}=1 if i=j, and I_{ij}=0 if $i \neq j$. **I** has dimensions $s \times s$.

A Matrix of direct requirements.

Its elements $\{A_{ij}\}_{i=1,\ldots,s;\, j=1,\ldots,s}$ describe the amount of input in Australian Dollars (A$) of industry sector i into industry sector j, per A$ value of total output of industry sector j. **A** has dimensions $s \times s$. It comprises imports from foreign industries and transactions for capital replacement and growth. **A** captures the interdependence of industries in the Australian economy and their dependence on foreign industries, and – assuming that imports are produced using Australian technology[10] – thus enables the translation of industrial factor multipliers $\mathbf{Q}^{ind}$ into embodied factor multipliers $\mathbf{Q}^{emb}$.

For an introduction into input-output theory, see articles by (Leontief and Ford 1970), (Duchin 1992), and (Dixon 1996). For a history of the development of input-output analysis, see (Carter and Petri 1989), and (Forssell and Polenske 1998). For examples and reviews of input-output studies applied to environmental issues, see (Leontief and Ford 1971), (Isard, Choguill et al. 1972), (Herendeen 1978), (Miller and Blair 1985), (Proops 1988), (Miller, Polenske et al. 1989), (Hawdon and Pearson 1995), and (Forssell 1998). For a description of the assembly of an Australian input-output framework, see (Lenzen 2001).

5.2. Data sources

The main difficulties encountered during the data collection and preparation were due to differences in industry sector classification and differences in data reference year. It was necessary to confront and reconcile data sets documented according to the Australian and New Zealand Standard Industrial Classification (ANZSIC), the Input-Output Product Classification (IOPC), the Australian land use (ALUMC) classification, the Household Expenditure Survey commodity classification, and the reporting format prescribed by the Intergovernmental Panel on Climate Change (IPCC).

Surveys of industries, households and farms are not conducted in identical intervals. Hence, the input-output, household expenditure, resource use and pollution data refer to different years between 1998 and 2003. In order to minimise discrepancies, input-output and factor data was assembled for years closely around 1998-99, where data availability was best. Data were reconciled using RAS matrix balancing[11], and optimisation techniques[12]. As a consequence, small

[10] For example, in this study, Australian energy intensities were also applied to imported items (about 10% of total Australian output), which equivalent to assuming that they are produced using Australian technology. This assumption carries an uncertainty into energy multipliers.

[11] Gretton, P. and P. Cotterell (1979). The RAS method for compiling input-output tables - Australian Bureau of Statistics experience. Eighth Conference of Economists, La Trobe University.

; Junius, T. and J. Oosterhaven (2003). "The solution of updating or regionalizing a matrix with both positive and negative entries." Economic Systems Research **15**(1): 87-96.

.

flows (monetary and physical) are associated with large uncertainties, as indicated in some of the results sheets.

Household Expenditure Survey data

The source of the household expenditure data for the 1998-99 and 2003-04 years was the *Household Expenditure Survey (HES),* published by the Australian Bureau of Statistics, Catalogue No. 6540.0. Data was available at the SSD level for 1998-99. An updated data set was made available in 2006 for the 2003-04 year, however, the ABS would not release data at the SSD level. Hence household expenditure data at the SSD level for 2003-04 has been estimated by creating an initial estimate from the 1998-99 data and subsequently constraining by 2003-04 state data, with a further constraint utilising a breakdown between capital city and rest of state.

Due to changes in the timing of household expenditure surveys, no more recent comprehensive HES was available at the time of this report. Hence various sources are used to estimate the 2008-09 expenditures for Australia and the ACT. These include Housing Income Surveys, regional profiles of the ACT, and a time series of detailed State Accounts, which are consistent with the national accounts.

The household expenditure matrix Y was derived from the 1998-99 Household Expenditure Survey (Australian Bureau of Statistics 2000), while the direct requirements matrix A was constructed from the Australian input-output tables (Australian Bureau of Statistics 1999; Australian Bureau of Statistics 1999); see also (Lenzen 2001). The baseline year for the Ecological Footprint model is 1998-99, hence all prices were deflated to 1999 levels. To do this, the ABS published Consumer Price Index (Australian Bureau of Statistics 2006) was supplemented with Produce Price Indices (Australian Bureau of Statistics 2006) where necessary, and subsequently correlated with the HES data. Price indices were created at a state level, with the assumption that the published price indices in capital cities were similar across each respective state. The importance of state based price indices is particularly evident for such consumer items as automotive fuel, which not only forms a significant component of the population's Ecological Footprint, is also quite volatile over time and across locations.

Data refer to the financial year 1998-99. Since then, especially petrol and gas prices and tariffs may have experienced high variability, which has to be accounted for by continuously and manually adjusting intensities in order to keep them up-to-date. The most accurate way of doing this is to proceed as follows:

- Petrol, GHG: obtain current petrol price (by State) in $/L. Invert, and multiply by 34.2 MJ/L and by 0.066 kg/MJ. Add to the indirect intensity in table below for the respective category.
- Gas, GHG: obtain gas price (by State) in $/GJ. Divide by 1000, invert, and multiply by 0.051 kg/MJ. Add to the indirect intensity in table below for the respective category.
- There is no information on margins and other mark-ups to convert basic prices into purchasers' prices on a state basis. National data was hence used.

[12] Tarancon, M. and P. Del Rio (2005). "Projection of input-output tables by means of mathematical programming based on the hypothesis of stable structural evolution." Economic Systems Research **17**(1): 1-23.

.

Ecological Footprint data

The industrial Ecological Footprint multipliers $\mathbf{Q}_{\text{ef}}^{\text{ind}}$ as well as household Ecological Footprint multipliers $\mathbf{Q}_{\text{ef}}^{\text{hh}}$ were obtained by consulting a range of sources such as fuel statistics (Australian Bureau of Agricultural and Resource Economics 1999), (Australian Bureau of Agricultural and Resource Economics 2000), the Australian National Greenhouse Gas Inventory (Australian Greenhouse Office 1999), (George Wilkenfeld & Associates Pty Ltd and Energy Strategies 2002), the ABS' Integrated Regional Database ((Australian Bureau of Statistics 2001), and a CSIRO report on landcover disturbance across the Australian continent (Graetz, Wilson et al. 1995); (Lenzen and Murray 2001).

Other data

State specific figures were taken from (Australian Greenhouse Office 2004). The full fuel-cycle emission factor for electricity in the ACT is 1.06 kg CO2-e/kWh (Department of Climate Change 2010).

5.3. Uncertainties

Input-output analysis suffers from uncertainties arising from the following sources: (1) uncertainties of basic source data due to sampling and reporting errors, and uncertainties resulting from (2) the assumption made in single-region input-output models, that foreign industries producing competing imports exhibit the same factor multipliers as domestic industries, (3) the assumption that foreign industries are perfectly homogeneous, (4) the assumption of proportionality between monetary and physical flow, (5) the aggregation of input-output data over different producers, (6) the aggregation of input-output data over different products supplied by one industry, and (7) the truncation of the "gate-to-grave" component of the full life cycle (see (Bullard, Penner et al. 1978) and (Lenzen 2001). Standard errors $\Delta Q_{ij}^{\text{emb}}$ of elements in the embodied factor multiplier matrix $\mathbf{Q}^{\text{emb}}$ due to the above sources defy analytical treatment, and can therefore only be determined using stochastic analysis. The $\Delta Q_{ij}^{\text{emb}}$ can be calculated by Monte-Carlo simulations of the propagation of normally distributed perturbations from $\mathbf{Q}^{\text{ind}}$ and $\mathbf{A}$ through to $\mathbf{Q}^{\text{emb}}$ (see (Lenzen 2001). Given the standard errors $\Delta\left(Q^{\text{emb}}+Q^{\text{hh}}\right)_{ik}$ of $\mathbf{Q}^{\text{emb}}+\mathbf{Q}^{\text{hh}}$, and ΔY_{kj} of $\mathbf{Y}$, the total standard error ΔF_{ij} of an element F_{ij} in the household factor requirement $\mathbf{F}$ in Equation 1 is

$$\Delta F_{ij}=\sqrt{\sum_{k=1}^{s}\Delta\left(Q^{\text{emb}}+Q^{\text{hh}}\right)_{ik}^{2}\,Y_{kj}^{2}+\sum_{k=1}^{s}\left(Q^{\text{emb}}+Q^{\text{hh}}\right)_{ik}^{2}\,\Delta Y_{kj}^{2}} \qquad (3)$$

The uncertainty ranges of $\mathbf{Q}^{\text{emb}}+\mathbf{Q}^{\text{hh}}$ cover raw data uncertainty and allocation uncertainty only, as described in (Lenzen 2001).

6. References

ABS (2009). Household Income and Income Distribution, Australia - Detailed tables, 2007-08 (ABS 6523.0). Canberra, Australia, Australian Bureau of Statistics.

ACT Independent Competition and Regulatory Commission (2009). "Licensed Electricity, Gas and Water and Sewerage Utilities: Compliance and Performance Report for 2007–08."

Albino, V. and S. Kühtz (2002). Environmental footprint of industrial districts using input-output tables based on production processes. 14th International Conference on Input-Output Techniques, Montréal, Canada, Internet site http://www.io2002conference.uqam.ca/abstracts_papers/new16janv03/Montreal_final_paper.doc.

Aoyagi, M., Y. Kondo, et al. (1992). Analysis of differences of CO_2 emission structure by consumption expenditures of households. 9th Energy System / Economics Conference, Tokyo, Japan.

Aoyagi, M., Y. Moriguchi, et al. (1995). "Characteristics of households' energy consumption." Energy and Resources **16**(6): 59-67 (in Japanese).

Australian Bureau of Agricultural and Resource Economics (1999). Australian energy consumption and production. Canberra, Australia, Commonwealth of Australia.

Australian Bureau of Agricultural and Resource Economics (2000). "Australian energy consumption and production, Table C1AUST, Historical data update."

Australian Bureau of Statistics (1999). Australian National Accounts, Input-Output Tables, 1994-95. Canberra, Australia, Australian Bureau of Statistics.

Australian Bureau of Statistics (1999). "Australian National Accounts, Input-Output Tables, 1994-95, Commodity Details."

Australian Bureau of Statistics (2000). "1998-99 Household Expenditure Survey - Detailed Expenditure Items, Confidentialised Unit Record File."

Australian Bureau of Statistics (2001). Australian National Accounts, Input-Output Tables, 1996-97. Canberra, Australia, Australian Bureau of Statistics.

Australian Bureau of Statistics (2001). Australian National Accounts, Input-Output Tables, Product Details, 1996-97. Canberra, Australia, Australian Bureau of Statistics.

Australian Bureau of Statistics (2001). "Integrated Regional Data Base."

Australian Bureau of Statistics (2006). Consumer Price Index, Australia. ABS Catalogue No. 6401.0. Canberra, Commonwealth of Australia.

Australian Bureau of Statistics (2006). Producer Price Index, Australia. ABS Catalogue No. 6427.0. Canberra, Commonwealth of Australia.

Australian Greenhouse Office (1999). "Australia's National Greenhouse Gas Inventory."

Australian Greenhouse Office (2004). AGO Factors and Methods Workbook. Canberra, Australia, Australian Government.

Ayres, R. U. (2000). "Commentary on the utility of the ecological footprint concept." Ecological Economics **32**: 347-349.

Bagliani, M., F. Ferlaino, et al. (2002). Ecological footprint and input-output methodology: the analysis of the environmental sustainability of the economic sectors of Piedmont Region (Italy). 14th International Conference on Input-Output Techniques, Montréal, Canada, Internet site http://www.io2002conference.uqam.ca/abstracts.pdf.

Barrett, J. (2001). "Component ecological footprint: developing sustainable scenarios." Impact Assessment and Project Appraisal **19**(2): 107-118.

Barrett, J. and A. Scott (2001). "An Ecological footprint of Liverpool: A Detailed Examination of Ecological Sustainability."

Best Foot Forward and Imperial College (2001). "Ecological footprint of the Isle of Wight."

Bicknell, K. B., R. J. Ball, et al. (1998). "New methodology for the ecological footprint with an application to the New Zealand economy." Ecological Economics **27**(2): 149-160.

Biesiot, W. and K. J. Noorman (1999). "Energy requirements of household consumption: a case study of The Netherlands." Ecological Economics **28**(3): 367-383.

Breuil, J.-M. (1992). "Input-output analysis and pollutant emissions in France." Energy Journal **13**(3): 173-184.

Bullard, C. W., P. S. Penner, et al. (1978). "Net energy analysis - handbook for combining process and input-output analysis." Resources and Energy **1**: 267-313.

Bureau of Transport and Regional Economics (2007). Estimating urban traffic and congestion cost trends for Australian cities. Canberra, Australia, Bureau of Transport and Regional Economics (BTRE).

Carlsson-Kanyama, A., R. Karlsson, et al. (2002). Household metabolism in the Five Cities - Swedish National Report - Stockholm. Stockholm, Sweden, Forskningsgruppen för Miljöstrategiska Studier.

Carter, A. P. and P. A. Petri (1989). "Leontief's contribution to economics." Journal of Policy Modeling **11**(1): 7-30.

Close, A. and B. Foran (1998). Canberra's ecological footprint. Canberra, Australia, Resource Futures Program, CSIRO Wildlife and Ecology.

Cohen, C. A. M. J., M. Lenzen, et al. (2005). "Energy requirements of households in Brazil." Energy Policy **55**: 555-562.

Costanza, R. (2000). "The dynamics of the ecological footprint concept." Ecological Economics **32**: 341-345.

Czamanski, S. and E. E. Malizia (1969). "Applicability and limitations in the use of national input-output tables for regional studies." Papers of the Regional Science Association **23**: 65-77.

Department of Climate Change (2010). National Greenhouse Accounts (NGA) Factors. Canberra, Australia, Commonwealth of Australia.

Dixon, R. (1996). "Inter-industry transactions and input-output analysis." Australian Economic Review **3'96**(115): 327-336.

Duchin, F. (1992). "Industrial input-output analysis: implications for industrial ecology." Proceedings of the National Academy of Science of the USA **89**: 851-855.

Ferng, J.-J. (2001). "Using composition of land multiplier to estimate ecological footprints associated with production activity." Ecological Economics **37**: 159-172.

Folke, C., Å. Jansson, et al. (1997). "Ecosystem appropriation by cities." Ambio **26**(3): 167-172.

Foran, B., M. Lenzen, et al. (2005). Balancing Act - A Triple Bottom Line Account of the Australian Economy. Canberra, ACT, Australia, CSIRO Resource Futures and The University of Sydney.

Foran, B., M. Lenzen, et al. (2005). "Integrating Sustainable Chain Management with Triple Bottom Line Reporting." Ecological Economics **52**(2): 143-157.

Forssell, O. (1998). "Extending economy-wide models with environment-related parts." Economic Systems Research **10**(2): 183-199.

Forssell, O. and K. R. Polenske (1998). "Introduction: input-output and the environment." Economic Systems Research **10**(2): 91-97.

George Wilkenfeld & Associates Pty Ltd and Energy Strategies (2002). Australia's National Greenhouse Gas Inventory 1990, 1995 and 1999 - end use allocation of emissions. Canberra, Australia, Australian Greenhouse Office.

Global Footprint Network (2006). Living Planet Report 2006. WWF. Gland, Switzerland.

Global Footprint Network (2009). Ecological Footprint Atlas 2009. Oakland.

Global Footprint Network (2009). Ecological Footprint Standard 2009. Oakland.

Gordon, P. and J. Ledent (1980). "Modeling the dynamics of a system of metropolitan areas: a demoeconomic approach." Environment and Planning A **12**(2): 125-133.

Graetz, R. D., M. A. Wilson, et al. (1995). Landcover disturbance over the Australian continent. Canberra, Australia, Department of the Environment, Sport and Territories Biodiversity Unit.

Gretton, P. and P. Cotterell (1979). The RAS method for compiling input-output tables - Australian Bureau of Statistics experience. Eighth Conference of Economists, La Trobe University.

Hawdon, D. and P. Pearson (1995). "Input-output simulations of energy, environment, economy interactions in the UK." Energy Economics **17**(1): 73-86.

Herendeen, R. (1978). "Total energy cost of household consumption in Norway, 1973." Energy **3**: 615-630.

Herendeen, R., C. Ford, et al. (1981). "Energy cost of living, 1972-1973." Energy **6**: 1433-1450.

Herendeen, R. and J. Tanaka (1976). "Energy cost of living." Energy **1**: 165-178.

Herendeen, R. A. (1978). "Input-output techniques and energy cost of commodities." Energy Policy **6**(2): 162-165.

Hirsch, W. Z. (1959). "Interindustry relations of a metropolitan area." Review of Economics and Statistics **41**(4): 360-369.

Hirsch, W. Z. (1963). Application of input-output techniques to urban areas. Structural Interdependence and Economic Development. T. Barna. London, UK, MacMillan & Co Ltd**:** 151-168.

Hubacek, K. and S. Giljum (2003). "Applying physical input-output analysis to estimate land appropriation (ecological footprints) of international trade activities." Ecological Economics **44**: 137-151.

Isard, W., C. L. Choguill, et al. (1972). Ecologic-economic analysis for regional development. New York, NY, USA, The Free Press.

Junius, T. and J. Oosterhaven (2003). "The solution of updating or regionalizing a matrix with both positive and negative entries." Economic Systems Research **15**(1): 87-96.

Kondo, Y., Y. Moriguchi, et al. (1996). "Analysis of the trend of CO_2 emission structure by consumption expenditures of households." Transactions of the Society of Environmental Science **9**(2): 231-240 (in Japanese).

Lenzen, M. (1998). "The energy and greenhouse gas cost of living for Australia during 1993-94." Energy **23**(6): 497-516.

Lenzen, M. (2001). "Errors in conventional and input-output-based life-cycle inventories." Journal of Industrial Ecology **4**(4): 127-148.

Lenzen, M. (2001). "A generalised input-output multiplier calculus for Australia." Economic Systems Research **13**(1): 65-92.

Lenzen, M., S. Lundie, et al. (2003). "Assessing the ecological footprint of a large metropolitan water supplier - lessons for water management and planning towards sustainability." Journal of Environmental Planning and Management **46**(1): 113-141.

Lenzen, M. and S. A. Murray (2001). "A modified ecological footprint method and its application to Australia." Ecological Economics **37**(2): 229-255.

Lenzen, M. and S. A. Murray (2003). The ecological footprint - issues and trends. Sydney, Australia, ISA The University of Sydney.

Lenzen, M., M. Wier, et al. (2006). "A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan." Energy **31**: 181-207.

Leontief, W. (1936). "Quantitative input and output relations in the economic system of the United States." Review of Economics and Statistics **18**(3): 105-125.

Leontief, W. (1941). The Structure of the American Economy, 1919-1939. Oxford, UK, Oxford University Press.

Leontief, W. and D. Ford (1970). "Environmental repercussions and the economic structure: an input-output approach." Review of Economics and Statistics **52**(3): 262-271.

Leontief, W. and D. Ford (1971). Air pollution and the economic structure: empirical results of input-output computations. Fifth International Conference on Input-Output Techniques, Geneva, Switzerland, North-Holland Publishing Company.

Levett, R. (1998). "Footprinting: a great step forward, but tread carefully." Local Environment **3**(1): 67-74.

McDonald, G. and M. Patterson (2003). Ecological Footprints of New Zealand and its Regions. Wellington, New Zealand, Ministry for Environment New Zealand.

Miller, R. E. and P. D. Blair (1985). Input-Output Analysis: Foundations and Extensions. Englewood Cliffs, NJ, USA, Prentice-Hall.

Miller, R. E., K. R. Polenske, et al., Eds. (1989). Frontiers of Input-Output Analysis. New York, USA, Oxford University Press.

Moffatt, I. (2000). "Ecological footprints and sustainable development." Ecological Economics **32**: 359-362.

Moll, H. C. and K. J. Norman (2002). Towards sustainable development at city level: evaluating and changing the household metabolism in five European cities. Lifecycle Approaches to Sustainable Consumption, Laxenburg, Austria, International Institute for Applied Systems Analysis (IIASA), National Institute for Advanced Industrial Science and Technology (AIST), and Sustainable Consumption and Production Unit of the United Nations Environment Programme (UNEP).

Morrison, W. I. and P. Smith (1974). "Nonsurvey input-output techniques at the small area level: an evaluation." Journal of Regional Science **14**: 1-14.

Munksgaard, J., K. A. Pedersen, et al. (2000). "Impact of household consumption on CO_2 emissions." Energy Economics **22**: 423-440.

Munksgaard, J., K. A. Pedersen, et al. (2001). "Changing consumption patterns and CO_2 reduction." International Journal of Environment and Pollution **15**(2): 146-158.

Nichols, M. (2003). An application of the Ecological Footprint method to an eco-tourism resort: A case study of Kingfisher Bay resort and Village, Fraser Island. Faculty of Science. Maroochydore, Australia, University of the Sunshine Coast.

Opschoor, H. (2000). "The ecological footprint: measuring rod or metaphor?" Ecological Economics **32**: 363-365.

Peet, N. J., A. J. Carter, et al. (1985). "Energy in the New Zealand household, 1974-1980." Energy **10**(11): 1197-1208.

Proops, J. L. R. (1988). Energy intensities, input-output analysis and economic development. Input-Output Analysis - Current Developments. M. Ciaschini. London, UK, Chapman and Hall**:** 201-216.

Rapport, D. J. (2000). "Ecological footprints and ecosystem health: complementary approaches to a sustainable future." Ecological Economics **32**: 381-383.

Rees, W. and M. Wackernagel (1996). "Urban ecological footprints: why cities cannot be sustainable - and why they are a key to sustainability." Environmental Impact Assessment Review **16**(4-6): 223-248.

Rees, W. E. (1992). "Ecological footprints and appropriated carrying capacity: what urban economics leaves out." Environment and Urbanization **4**(2): 121-130.

Simmons, C. and N. Chambers (1998). "Footprinting UK households: how big is your ecological garden?" Local Environment **3**(3): 355-362.

Simpson, R. W., A. Petroeschevsky, et al. (2000). "An ecological footprint analysis for Australia." Australian Journal of Environmental Management **7**: 11-18.

Smith, P. and W. I. Morrison (1974). Simulating the urban economy. London, UK, Pion Limited.

Tarancon, M. and P. Del Rio (2005). "Projection of input-output tables by means of mathematical programming based on the hypothesis of stable structural evolution." Economic Systems Research **17**(1): 1-23.

Tiebout, C. M. (1960). Regional and interregional input-output models: an appraisal. The techniques of urban economic analysis. R. W. Pfouts. West Trenton, NJ, USA, Chandler-Davis Publishing Co.**:** 395-407.

United Nations Department for Economic and Social Affairs Statistics Division (1999). Handbook of Input-Output Table Compilation and Analysis. New York, USA, United Nations.

van den Bergh, J. C. J. M. and H. Verbruggen (1999). "Spatial sustainability, trade and indicators: an evaluation of the 'ecological footprint'." Ecological Economics **29**(1): 61-72.

van Kooten, G. C. and E. H. Bulte (2000). "The ecological footprint: useful science or politics?" Ecological Economics **32**: 385-389.

Vringer, K. and K. Blok (1995). "The direct and indirect energy requirements of households in the Netherlands." Energy Policy **23**(10): 893-910.

Wackernagel, M. (1997). "Ranking the ecological footprint of nations."

Wackernagel, M. (1998). "The ecological footprint of Santiago de Chile." Local Environment **3**(1): 7-25.

Wackernagel, M., L. Lewan, et al. (1999). "Evaluating the use of natural capital with the ecological footprint." Ambio **28**(7): 604-612.

Wackernagel, M., L. Onisto, et al. (1997). The Ecological Footprint of Nations. Xalapa, Mexico, Centro de Estudios para la Sustentabilidad.

Wackernagel, M. and W. E. Rees (1996). Our Ecological Footprint - Reducing Human Impact on the Earth. Gabriola Island, B.C., Canada, New Society Publishers.

Wackernagel, M. and J. Silverstein (2000). "Big things first: focusing on the scale imperative with the ecological footprint." Ecological Economics **32**: 391-394.

Weber, C. and U. Fahl (1993). "Energieverbrauch und Bedürfnisbefriedigung." Energiewirtschaftliche Tagesfragen **43**(9): 605-612.

Weber, C., U. Fahl, et al. (1995). "Freizeit, Lebensstil und Energieverbrauch." VDI Berichte **1204**: 15-38.

Weber, C. and A. Perrels (2000). "Modelling lifestyle effects on energy demand and related emissions." Energy Policy **28**: 549-566.

Wiedmann, T. and J. Barrett (2005). The Use of Input-Output Analysis in REAP to allocate Ecological Footprints and Material Flows to Final Consumption Categories. York, United Kingdom Stockholm Environment Institute, WWF UK.

Wiedmann, T., J. Barrett, et al. (2007). Companies on the Scale - Comparing and Benchmarking the Footprints of Businesses. International Ecological Footprint Conference, Cardiff, Wales, UK, ESRC BRASS Research Centre, Cardiff University.

Wiedmann, T., M. Lenzen, et al. (2007). Multiregional input-output modelling opens new opportunities for the estimation of Ecological Footprints embedded in international trade. International Ecological Footprint Conference, Cardiff, Wales, UK, BRASS Research Centre, Cardiff University.

Wiedmann, T., J. Minx, et al. (2006). "Allocating ecological footprints to final consumption categories with input-output analysis." Ecological Economics **56**(1): 28-48.

Wier, M., M. Lenzen, et al. (2001). "Environmental effects of household consumption pattern and lifestyle." Economic Systems Research **13**(3): 259-274.

Wood, R. and M. Lenzen (2003). "An application of an improved ecological footprint method and structural path analysis in a comparative institutional study." Local Environment **8**(4): 365-386.

WWF - World Wide Fund for Nature (2010). The Living Planet Report. Switzerland, WWF - World Wide Fund for Nature.

7. Glossary

Biocapacity:	the **actual** amount of land (and water) area available on Earth to support the resources required by human populations.
Ecological footprint:	the amount of biologically productive land required to support a population and absorb its waste (including and most importantly CO_2 emissions).
Ecological Overshoot:	the current situation where the total Ecological Footprint of the Earth exceeds the available biocapacity.
Energy land:	the land equivalence required to absorb the CO_2 emissions produced from combustion of fossil fuels.
GFN:	Global Footprint Network: an organisation with the aim of improving the science behind ecological footprint measurements and promoting more sustainable policy development around the world.
Global hectares (gha):	the unit of measurement of the ecological footprint, related to the average yield of which represent the average yield of all biologically productive areas on Earth.
HES:	Household Expenditure Survey from the Australian Bureau of Statistics (ABS), representing the most detailed information available on what Australian households buy.
Input-output analysis:	IOA is a well-developed macro-economic technique for understanding linkages in economies. The ISA group are world leaders in the application of IOA to sustainability issues.
ISA:	Integrated Sustainability Analysis (research group).

Canberra's Ecological Footprint: what does it mean?

Prepared by

Joy Murray & Christopher Dey
The University of Sydney

(This page has been left blank intentionally)

Canberra's Ecological Footprint: what does it mean?

Prepared for The Office of the
Commissioner for Sustainability and the Environment, ACT

by

Joy Murray and Christopher Dey

The University of Sydney

Date of submission of this version

21 October 2011

For further information please contact:

Dr Joy Murray
Phone: (02) 9351 2627
Fax: (02) 9351 7726
j.murray@physics.usyd.edu.au

Integrated Sustainability Analysis (ISA)
School of Physics, A28
The University of Sydney
N.S.W. 2006

Dr Christopher Dey
Phone: (02) 9351 5979
Fax: (02) 9351 7726
c.dey@physics.usyd.edu.au

Integrated Sustainability Analysis (ISA)
School of Physics, A28
The University of Sydney
N.S.W. 2006

http://www.isa.org.usyd.edu.au

Table of contents

> *"Prosperity consists in our ability to flourish as human beings – within ecological limits of a finite planet. The challenge for our society is to create the conditions under which this is possible. It is the most urgent task of our times." (Jackson, 2009, p. 5).*

1 Introduction - What is the Ecological Footprint?

The Ecological Footprint is a measure of human demand on the bioproductive land area that is required to support our resource demands. It represents the land area equivalence (in hectares) of all the resources required to support the lives of people and to absorb their pollution. It distinguishes six types of bioproductive areas that provide renewable resources for human consumption:

- **Cropland** is the land type with the greatest average bioproductivity per hectare and is used for growing crops for food, animal feed, fibre, oils and biofuels, it is an actual land area needed to provide biological resources;
- **Pasture** (or grazing land) is used for raising animals for meat, hides, wool, and dairy products;
- **Forest** area is natural or plantation forests used for harvesting timber products and fuelwood;
- **Built land** is land used for housing, transportation and industrial production, it is not a bioproductive area but has probably replaced cropland because human settlements are predominantly located in fertile areas;
- **Water** area needed for human consumption includes lakes and rivers used for freshwater provision, hydropower, fishing, freshwater aquaculture and recreational purposes; and
- **Energy land** is a notional land area required to absorb the carbon dioxide emissions due to consumption patterns, energy land answers the question "how much woodland and forest area would we need to have in order to absorb all CO_2 emissions from the burning of fossil fuels?" (Dey, 2010).

The ACT"s Ecological Footprint is a measure of land used to provide goods and services for activities such as building cities, growing fruit and vegetables, grazing cows to provide dairy and beef products, growing trees for paper and wood products, and absorbing carbon dioxide produced from using electric appliances, driving cars, operating machinery, etc. The total Ecological Footprint of all ACT residents is approximately 3,200,000 global hectares, or equivalent to nearly 14 times the geographical area of the ACT. Fifty seven percent of the ACT"s Ecological Footprint is „energy land" – which mainly reflects the biocapacity required to absorb carbon emissions. Nineteen percent of the Ecological Footprint is in Forests – primarily used within the residential construction industry. In comparison, only 3% of the ACT Ecological Footprint is in Built Land (Dey, 2010).

The Ecological Footprint is an indicator for the impacts of the consumption of ACT residents *wherever* the products and services are produced.

Note that „energy land" is sometimes referred to as the Carbon Footprint component of the Ecological Footprint. It is in this sense that the term *Carbon Footprint* is used throughout this document. The high contribution of „energy land" to the Footprint indicates that activities to reduce greenhouse gas emissions will also reduce the ACT"s overall footprint.

2 How does the ACT Ecological Footprint compare with that of other cities, states and territories?

2.1 States and Territories

The average Ecological Footprint of the population of the ACT is one of the highest in Australia. However, caution needs to be exercised in making precise comparisons with other footprints for Australia"s states, territories or major cities, since there can be differences in footprint methodologies. It is not always that exactly the same methodology has been used or the same year/s covered. Footprints for the same entity can change from year to year because of production and consumption activity changes (economic cycles) but also due to land productivity changes relating to natural fluctuations and land use policies.

The overall Australian Ecological Footprint in 2009 averaged 8.1 gha (global hectares) per-capita, up from 6.8 gha in 2007 [1]. This is as calculated by the Global Footprint Network (GFN). By comparison, the ACT"s 2009 per-capita footprint was considerably higher at 9.2 gha, calculated using as far as possible a similar methodology to the GFN. In 2008, Victoria reported a need for 6.8 global hectares per-capita [2] also calculated similarly (see Figure 1).

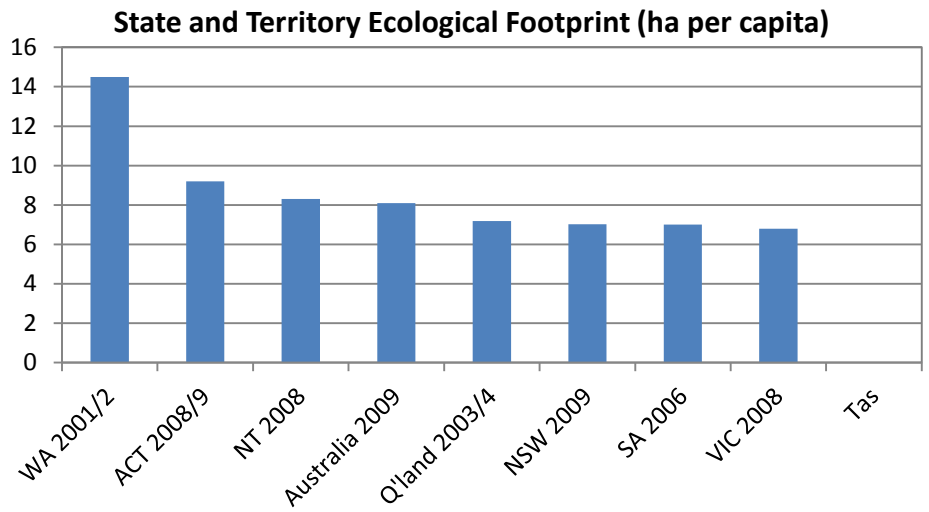


Figure 1: State and territory EFs. Note that different methodologies may have been used and the results shown may represent different years, also the year in which the study was conducted may be different from that of the underlying data. The VIC, ACT, Australian, NSW & Queensland studies used the same or similar methodology but were conducted in different years. The studies are dated: WA, 2001/2[3]; ACT, 2008/9[4]; NT, 2008[5]; Australia, 2009[6]; Queensland, 2003/4[7]; NSW, 2009[8]; SA, 2006[9]; VIC, 2008[10]; Tasmania does not seem to have conducted a state-wide EF study.

[1] http://www.footprintnetwork.org/en/index.php/GFN/page/2010_living_planet_report/ (accessed 13/07/11)
[2] https://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256ce90001cbb5/4a69e348b2b6f513ca25745e0010f50f/$FILE/1267.pdf (accessed 13/07/11)
[3] http://www.soe.wa.gov.au/site/files/pdf/SoE%20Tech%20Paper%204%20Ecological%20Footprint.pdf (accessed 10/08/11)
[4] Dey, 2011
[5] http://ext.cdu.edu.au/newsroom/a/2008/Pages/090219-Assessing-Northern-Australia%E2%80%99s-ecological-footprint.aspx (accessed 10/08/11)
[6] See above footnote 1
[7] Wiedmann et al, 2008
[8] See below footnote 13
[9] http://www.sustainableliving.sa.gov.au/resources/Eco_Footprint_Brochure.pdf
[10] See above footnote 2

According to the NSW State of the Environment Report 2009, the ecological footprint of New South Wales increased from 6.35 hectares[11] per-capita in 1998–99 to 7.02 ha in 2003–04. Over the same period, Sydney's ecological footprint grew from 6.67 to 7.21 ha per-capita indicating some stabilisation in footprint growth over the period. This study was based on the Household Expenditure Survey from the Australian Bureau of Statistics for 2003–04.

For the financial year 2003-04 the average Queensland resident had an ecological footprint of 7.19 gha, nearly three and a half times higher than the world average. At the same time that of Brisbane residents was about 7.3 gha per-capita (Wiedmann et al, 2008). Given that the methodology was generally consistent, this is an increase of 0.43 ha on 2004 (see Table 1).

A 2009 paper by Charles Darwin University"s School for Environmental Research, using ISA methodology, showed that the average Northern Territorian needed 8.3 hectares of land to support themselves [12].

2.2 Cities

In 2010 the Australian Conservation Foundation issued its Sustainable Cities Index. This was compiled from data prepared by the University of Sydney for the 2007 Consumption Atlas[13]. Below is a table comparing the Ecological Footprints of 20 Australian cities for the year 2004, including Canberra (Table 1). Most of the footprint results mentioned above were originally calculated by the ISA research group at the University of Sydney.

Australian Conservation Foundation, Sustainable Cities Index 2010	
City	**2004 EF ha per-capita**
Perth	7.66
Canberra	7.09
Darwin	7.06
Brisbane	6.87
Sydney	6.82
Adelaide	6.72
Townsville	6.55
Gold Coast-Tweed	6.52
Cairns	6.4
Toowoomba	6.36
Melbourne	6.33
Sunshine Coast	6.31
Wollongong	6.14
Newcastle	6.1
Geelong	5.99
Albury-Wodonga	5.8
Ballarat	5.75

Table 1: Per-capita ecological footprint of major Australian cities, from the Australian Conservation Foundation Sustainable Cities Index 2010[14].

[11] Note that these are given in hectares rather than global hectares indicating that a different methodology was used.
[12] http://ext.cdu.edu.au/newsroom/a/2008/Pages/090219-Assessing-Northern-Australia%E2%80%99s-ecological-footprint.aspx (the report compared this with an Australian Footprint of 6.5 hectares) (accessed 14/07/11)
[13] www.acfonline.org.au/consumptionatlas/
[14] ACF Sustainable Cities Index 2010: Information sourced from the ACF Consumption Atlas (www.acfonline.org.au/consumptionatlas) which is based on research by the University of Sydney's Integrated Sustainability Analysis (ISA) team, p. 16. http://www.acfonline.org.au/default.asp?section_id=360 (accessed 13/07/11)

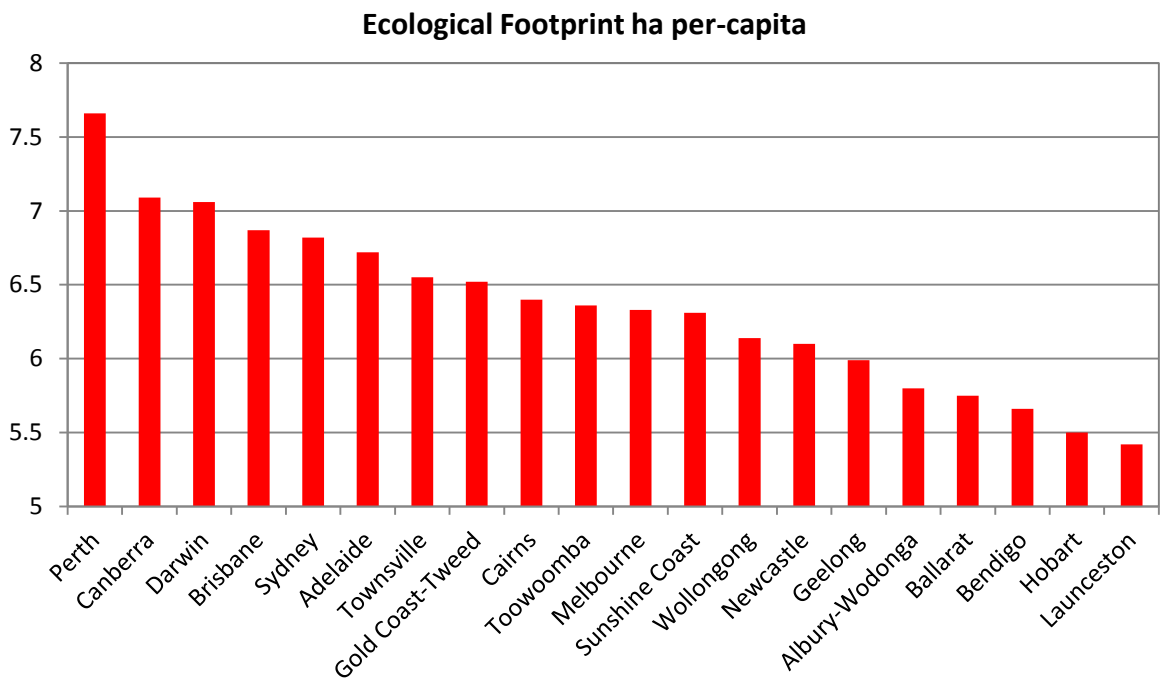


Figure 2: Ecological Footprint in hectares per person per year: A comparison of 20 cities from the Australian Conservation Foundation Sustainable Cities Index 2010 http://www.acfonline.org.au/default.asp?section_id=360

On all measures, it seems that the Ecological Footprints of Canberra and the ACT are high compared with other similar cities and regions. However, the 2011 Footprint Report for the ACT (Dey, 2010) indicates that direct impacts from electricity, gas and vehicle fuel use by households have stabilised or diminished over the last few years[15], which has contributed to a smaller footprint increase. Nonetheless the overall footprint is still rising because of increasing income, and therefore increasing expenditure. The increase of the average ACT household income compared to the Australian average is particularly strong since about the year 2005. It should also be remembered that we are dealing here mainly with per-capita impacts: population growth in the ACT recently was estimated to be about 1.2 per cent per annum[16], one of the highest levels in Australia when compared with the other states and territories. Hence the total impact from ACT residents is continuing to grow.

[15] Reduction 2003/4 – 2007/8: reduced electricity use of 6%; 7% reduction in natural gas use; reduction of approximately 600 vehicle km per-capita.
[16] Estimated to fall to 0.6% per annum by 2055/56 http://www.cmd.act.gov.au/__data/assets/pdf_file/0010/119719/act-population-projections-2007-2056.pdf

3 Why is the ACT's EF so high?

The ACT"s household consumption has grown with the growth of household disposable income. This in turn has driven the increase in the Ecological Footprint (2003-2008) from 7.2 gha to 9.2 gha per-capita (Dey, 2010, p. 21).

> *"With direct energy use steady or falling in the ACT in the last 5 years, the main contributions to the increasing overall footprint are steadily rising consumption of goods and services. In turn, this increasing consumption is related to strong growth in ACT household income. It is a commonly observed trend in affluent societies, whether at the level of whole nations or at an individual household, that total environmental pressures tend to continue to grow with income, even if the immediate or direct impacts are steady or falling. This trend presents a clear challenge for us to examine closely our consumption patterns and what it means to live in societies with high incomes." (Dey, 2010,* p. 4*)*

3.1 Affluence and the EF

The above statement taken from the 2010 report on the ACT"s 2008-2009 Ecological Footprint sums up the core issue for the ACT and for any affluent household, community or country. In modern market economies, the Ecological Footprint is generated predominantly by spending money. The more money available to spend the higher the Ecological Footprint is likely to be. Figure 3 from the 2010 Living Planet Report (p. 77) illustrates this point at a world level.

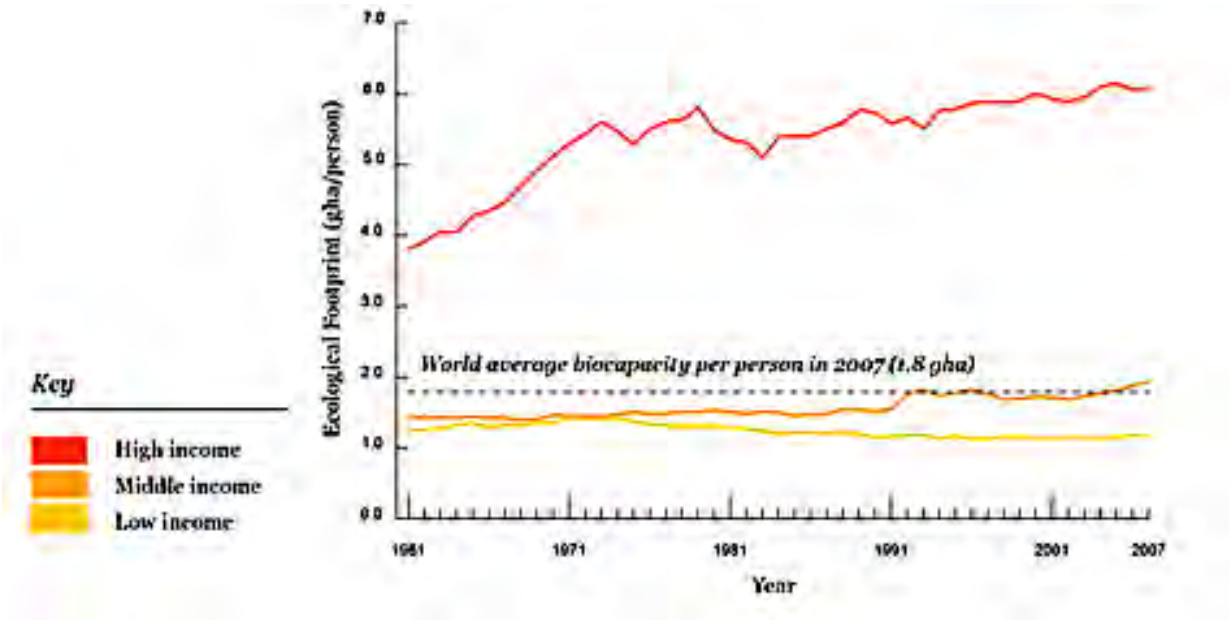


Figure 3: Changes in the Ecological Footprint per person in high-, middle- and low-income countries between 1961 and 2007 The dashed line represents world average biocapacity in 2007 (Living Planet Report 2010[17]).

Affluence is related to the EF because the greater the household income the more *disposable* income there is available for such activities as air or car travel and the construction and furnishing of new dwellings as seen in the ACT – all of which contribute significantly to the Footprint because of their high energy needs (see Table 2 and Figure 3 for example). In the case of wooden furniture and new dwellings land used for forestry is also a factor. A high *disposable*

17 http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/demands_on_our_planet/footprint_income/ (accessed 04/08/11)

income also means that there is more money available for discretionary purchase of manufactured goods, which can contribute considerably to the Ecological Footprint often because of high embodied energy.

This phenomenon is not peculiar to the ACT, neither is it a simple linear relationship. In a comparison of per-capita emissions in Australian states and territories, Lenzen and Cummins (2010) observe that "a AU$10,000 increase at a base salary of AU$50,000 causes a 6% increase in emissions, but only a 3% increase [in emissions] at a base salary of AU$90,000. This is a general pattern observed for emissions (Wier *et al.* 2001), as well as for other environmental quantities [such as water use and land disturbance] (Lenzen and Foran 2001; Lenzen and Murray 2001; Lenzen *et al.* 2006), which can be explained by preferences shifting from emissions-intensive goods to less emissions-intensive services towards higher incomes."

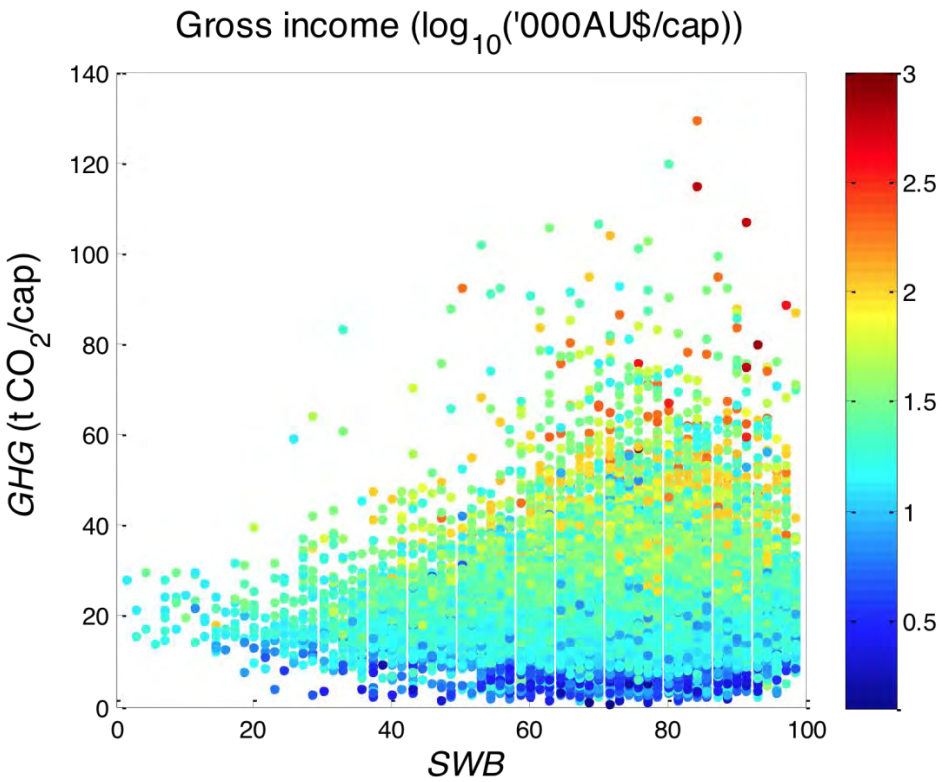


Figure 4: The „income cloud" maps GHG emissions against Subjective Well Being (SWB) over the range of incomes in Australia. The red dots signify high income, blue dots signify low income. Red/orange dots in the lower right region of the graph show high income, high wellbeing and low emissions. Blue/green dots in the top right region show low income, high wellbeing and high emissions (Lenzen & Cummins, 2010).

Lenzen and Cummins (2010) also discuss income (and its related emissions) and *wellbeing*, which is an attempt to provide some indication of quality of life. They found that up to a point wellbeing increases with increased income but for higher incomes, "a 10% increase in income leads to a 0.4% increase in wellbeing, and in a 2.9% increase in emissions … Diminishing additional well-being at increasing incomes has also been observed (see Frey and Stutzer 2002, Tabs. 2 and 5 in Stutzer 2004, references listed on page 15 in Gowdy 2004, and Mayraz *et al.* 2006; Abdallah *et al.* 2008; Brereton *et al.* 2008; Cummins *et al.* 2009)." They conclude that although emissions tend to increase with income this is not the case for wellbeing, with additional income generating diminishing returns in subjective wellbeing (Figure 4).

3.2 The ACT"s Footprint

The key items that make up the ACT's Ecological Footprint are: Electricity supply, residential building construction, retail trade, spending at hotels, clubs, restaurants and cafes, air travel, petrol, food products, wooden furniture, spending associated with home ownership and clothing (Table 2).

Rank	Commodity	Impact (gha/capita)	% of Total
1	Electricity supply	1.07	12%
2	Residential building construction	0.56	6%
3	Retail trade	0.51	6%
4	Hotels, clubs, restaurants and cafes	0.44	5%
5	Air and space transport	0.35	4%
6	Petrol	0.32	4%
7	Other food products	0.29	3%
8	Wooden furniture	0.25	3%
9	Ownership of dwellings	0.24	3%
10	Clothing	0.21	2%
11	Electronic equipment	0.20	2%
12	Beef cattle	0.17	2%
13	Finished cars	0.16	2%
14	Education	0.15	2%
15	Non-building construction	0.14	2%
16	Gas supply	0.14	2%
17	Non-residential building construction	0.14	1%
18	Wheat	0.12	1%
19	Recorded media and publishing	0.10	1%
20	Pharmaceutical goods for human use	0.09	1%

Table 2: Top 25 commodities in terms of per-capita Ecological Footprint in the ACT in 2008-09 (Dey 2010).

Use of electricity constitutes 12% of the ACT per-capita Ecological Footprint. This is high because the ACT's electricity supply comes mostly from coal-fired power stations which have one of the highest carbon dioxide emissions of all forms of electricity generation. Of course, were it not for household energy efficiency measures being in place, the ACT's Ecological Footprint would be even higher. The contribution of residential building to the EF comes mainly from the forest area needed for timber and the carbon footprint from energy used by the construction industry. The retail trade contribution to the EF is from the retail sector's use of fuel in distribution of goods and electricity use in shops. Food consumption and private transport are also major contributors to the ACT's overall footprint. Of the total food footprint 57% is plant based whilst the remainder is animal based food products.

This list of key contributors is not unique to the ACT. A study conducted in 2008 for Victoria using the same methodology found almost the same categories in much the same order of significance (Figure 5).

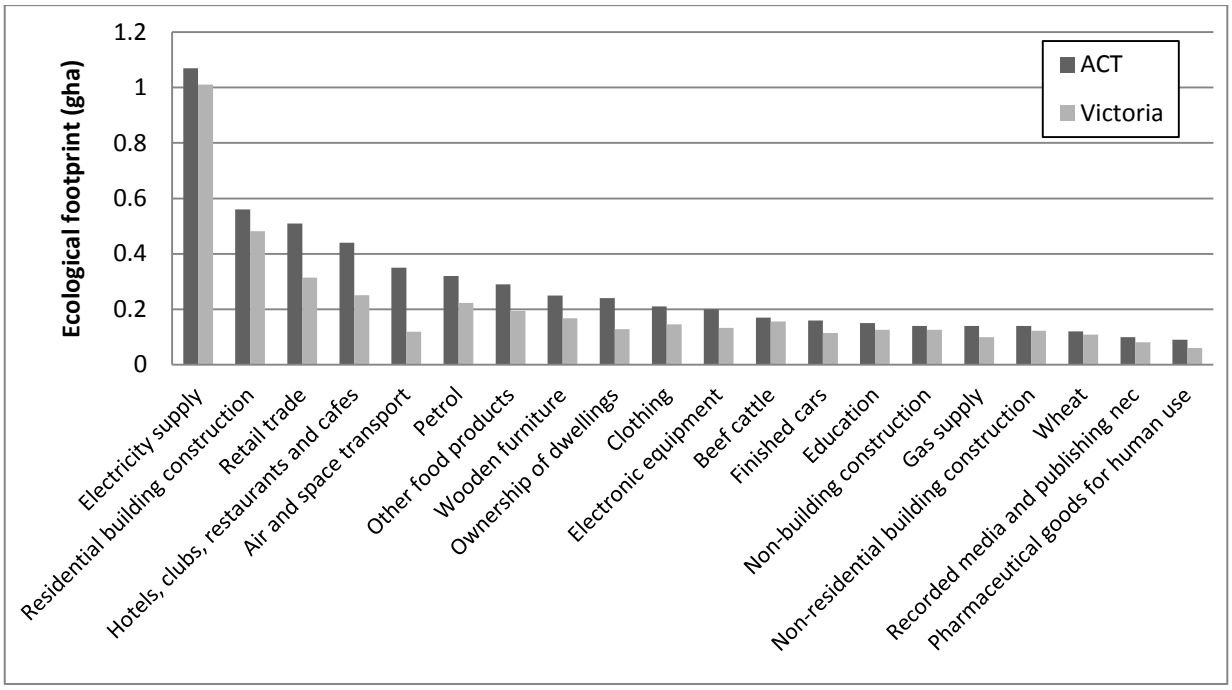


Figure 5: Top ten commodities in terms of per-capita Ecological Footprint in ACT and Victoria. (data for Victoria from Wiedmann, T., Wood, R., Barrett, J. Lenzen, M. & Clay, R. (2008). *The Ecological Footprint of Consumption in Victoria*. EPA Victoria https://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256ce90001cbb5/6a4f318c29647984ca2574710004e3ad/$FILE/ATTAD7EZ/1269.pdf page 9 (Note: item 10 of VIC EF was *Wholesale trade* at 0.08)

It should be noted that Australian consumer ecological footprints are generally high in world terms. We have some of the highest per-capita footprints in the developed world. This is due mainly to the combination of being a wealthy nation, our high-emitting electricity system which currently is mainly coal-fired power stations, and our extensive agricultural systems which use a great deal of land in a relatively dry country.

To put the ACT's footprint in a global context, generally higher income, more developed countries, make higher demands on the planet than poorer, less developed countries. According to the Living Planet Report, 2010 in 2007 " the 31 OECD countries — which include the world's richest economies — accounted for 37 per cent of humanity's Ecological Footprint. In contrast, the 10 ASEAN countries and 53 African Union countries — which include some of the world's poorest and least developed countries — together accounted for only 12 per cent of the global Footprint." (Living Planet Report, 2010, p. 37).

4 What does the ACT EF mean for the ACT and Australia's long term sustainability?

If we were all to have a fair share of the total global hectares available world-wide then the population of the ACT would have to live on 1.8 gha per person This would mean a drastic reduction from the ACT's current 9.2 gha per-capita (Global Footprint Network 2006; Global Footprint Network 2009).

To reduce the ACT"s Footprint to a sustainable[18] level in global terms (i.e. to 1.8 gha per person) looks like an impossible task. Yet the Footprints of all developed nations will need to reduce, if only to provide room for the poorest nations" Footprints to grow to an equitable level. This is an ethical question that faces individuals and governments regardless of their contribution to the global Footprint. Setting manageable targets and defining indicators that will assist in monitoring progress will be essential steps to reducing the local impact and to bringing about a more equitable future.

Much of the ACT"s footprint is embodied in goods and services from outside the ACT. For example the *Agriculture, forestry and fishing* industry contributed 0% to the Gross State Product (GSP) in 2009/10[19]. It is therefore likely that the vast majority of wood used in construction or furniture making is from outside the ACT. It is also likely that much of the food consumed in restaurants and the *Other food products* bought by ACT households are also from outside the Territory. *Manufacturing* also contributed 0% to the 2009/10 GSP suggesting that manufactured goods bought by ACT households will have originated outside the Territory.

While residents can take steps to reduce their overall purchase of discretionary goods, or purchase of goods from outside the Territory"s boundary, it is unrealistic and undesirable in many cases to substitute local for „imported". The report *Buying Choices for a more Sustainable Canberra*[20] discusses for example, the case that foods grown elsewhere in ideal conditions require less material inputs (including transport) than foods grown locally but in less than ideal conditions, which means that „importing" can sometimes be the better Footprint option. However the ACT"s growing per-capita food consumption should be addressed in the interest of long term sustainability and also for general health and fitness promotion. Cutting down on food waste can also make a contribution to overall sustainability.

No modern economy is an island and most trade transactions result in inter-dependencies that support a vast web of local economies elsewhere. Therefore all changes to purchasing habits will have knock-on effects, affecting social and economic sustainability elsewhere. Nevertheless environmental issues need to be addressed and markets will adjust over time with more sustainable industries growing as less sustainable ones diminish. What the ACT government and households can do is use their spending power to encourage changes in supply chains. This can be a change from one product to another such as increasing the number of vegetarian options and

[18] The term *sustainable* here is taken to mean: able to continue at this level without insurmountable social, economic and environmental problems arising. The term *unsustainable* therefore means that social, economic and/or environmental problems that demand attention will arise from the continuation of „normal" business. The EF is a measure of *unsustainability*. In the short term it may be possible to distinguish between local and global sustainability. However in the long term we are all in this together and we must take responsibility for our actions that contribute towards global unsustainability. The ACT"s actions towards a sustainable future will probably take both local and global perspectives – although these two sets of interests will converge over time.

[19] http://www.treasury.act.gov.au/snapshot/GSP.pdf (accessed 04/08/11)

[20] Ryan, S. (2011). *Buying Choices for a more Sustainable Canberra.* Report for the ACT Commissioner for Sustainability and the Environment.

reducing the non-vegetarian when catering for meetings or feeding a family; or it could be a change in supplier, for example purchasing wood or paper only from environmentally certified suppliers. Asking questions of businesses about their supply chains, for example where the wood for furniture originated or if they use recycled paper, can prompt them to explore their own Ecological Footprints and make changes in suppliers if necessary. This will speed up industry changes and support job growth in new and more sustainable enterprises.

Much of the ACT"s Ecological Footprint is tied to developments in the rest of Australia and across the world. Pressure on organisations from citizens, NGOs and governments worldwide to become more sustainable, including a price on greenhouse gas emissions, could be the incentive that some companies need in order to reduce the Footprint embodied in their goods and services. Any changes will reduce embodied emissions in the supply chain which will flow throughout national economies, including Australia"s, and ultimately to the ACT.

It is worth briefly discussing here the notion of what a long term sustainability target might be, and what it would mean for the ACT. For example, should the ACT aspire to a level of consumption equivalent to „one-planet" living? Similarly, in terms of greenhouse gas emissions (carbon footprint), a global sustainable level is approximately 5 tonnes of CO_2-equivalent per person per year. The level in the ACT is approximately 5 times higher than this. This would mean an 80% cut on 2009 levels rather than the current target of 80% cut on 1990 levels by 2050. Thus very significant changes would be required for an ethically defendable, sustainable level of lifestyles to be achieved. This may seem like a daunting task but with a good supporting story and trust in people, the majority of whom want to be associated with creating a better world and a sustainable future, the ACT may be well placed to become an example of innovative action.

5 The distinction between local, national and global impacts from ACT consumption

Contributors to the Ecological Footprint, such as energy use and land disturbance are embedded in goods that move around the world through trade. With a global focus on carbon emissions, people world-wide are becoming more aware of embodied emissions and what this means for our responsibility in reducing them. This awareness of *embodiment* could equally be applied to the Ecological Footprint – the principles are the same.

5.1 Local impacts of ACT consumption

The local impacts of ACT consumption may be noticed, for example, in the loss of agricultural land or natural bush to housing development which is the second highest contributor to the ACT Footprint. People may experience increased traffic congestion or spend more time shopping for goods from a growing number of retail outlets (retail trade is the third highest contributor and petrol is the sixth). Weight gain among some members of the population from overconsumption or the increased consumption of some processed foods may be noticeable and may put pressure on health facilities (fourth and seventh highest contributors). Over the longer term there may also be increased severe weather events to which ACT consumption, like consumption everywhere, has indirectly contributed. However, even local (direct) energy use which is strongly related to local climate, behaviour, housing stock and so on, has a global context, since the resulting greenhouse gas emissions quickly become well-mixed in the atmosphere, with CO_2 in particular having a typical lifetime in the atmosphere of at least 100 years.

On the positive side, the local economy benefits by the contribution that the construction industry makes to the economy (0.6 percentage point contribution to GSP 2010) as well as retail trade (0.1 percentage point contribution to GSP 2010) and accommodation and food services (0.1). Local employment is also a benefit accruing to the ACT economy from the construction industry. Thus any reduction in Footprint is a balancing act. It needs to be sensitive to the local economy while reducing impact on the Footprint. It requires research into what exactly constitutes the Footprint at a micro level – the Footprints of individual projects and businesses in these high impact areas, followed by support programs focused on changes that can be made to project design or in supply chains in order to reduce impacts while retaining local employment.

5.2 National impacts of ACT consumption

All Footprints everywhere, be they carbon, water or ecological, cannot be disentangled from the effects of national or global trade. Consumption of electricity by households constitutes 12% of the ACT's total Footprint. Although this is still the highest contributor to the ACT's EF, average per-capita consumption of electricity decreased by 6% between 2003-04 and 2007-08 (Dey, 2010). The ACT meets its electricity needs mostly through coal fired power stations which have one of the highest carbon dioxide emissions of all forms of electricity generation. Electricity for shops is also a large part of the Retail sector's contribution to the footprint. The national impact of ACT consumption of electricity is in its contribution to our national per-capita emissions which are one of the highest in the world. Although total electricity use in the ACT has increased since 2007-08, national action on emissions will 'trickle through' so that less 'energy land' will be required to sequester electricity emissions over time.

Another national impact of ACT consumption is in its call on cropland, pasture land and forest to support food consumption and the use of timber for building construction and in Australia- made furniture.

5.3 Global impacts of ACT consumption

In a global economy there is no way to isolate oneself from the flow-on effects of global trade. Impacts of ACT consumption of imported manufactured goods are felt elsewhere in the world, for example in unhealthy working conditions in third world countries where air and water pollution from factories is high; or in contributing to severe weather events that devastate communities around the world. However in some instances global trade can have less impact on the environment than would local production of some goods. In such a case the importing of some goods, particularly food, could help to minimise the ACT"s consumption footprint. For example a study by researchers at Lincoln University in New Zealand demonstrated that rearing and distributing British Lamb produced more emissions than importing New Zealand Lamb. This is because New Zealand farmers use more renewable energy and less fertilizer than British farmers[21]. Climate can also effect growing decisions. In 2005 Defra (Department of Food and Rural Affairs, UK) reported that it was more energy-efficient to grow tomatoes in Spain and transport them to the UK than it was to grow them in hot-houses in the UK. Economies of scale can also affect embodied emissions and can in some instances make it more energy efficient to manufacture at a distance and transport food than to buy local.

Contributions to the Ecological Footprint are also embodied in services, for example flights, which are a high contributor to the ACT"s Footprint. In recognition of this global impact of local

[21] http://www.lincoln.ac.nz/story_images/2328_RR285_s13389.pdf accessed 28/11/08

consumption the European Union has determined to penalize countries that do not have a price on carbon, under changes to the EU's emissions trading scheme Qantas will be forced to pay a tax on 15 per cent of its carbon emissions from its nearest port of call[22] in 2012.

6 What can be done by households, communities, and the ACT government to reduce the Ecological Footprint?

> *"…the possibility that humans can flourish and at the same time consume less is an intriguing one. It would be foolish to think that it is easy to achieve. But it should not be given up lightly. It offers the best prospect we have for a lasting prosperity." (Jackson, 2009, p. 7)*

There are three broad strategies for reducing the ecological footprint of the population of the ACT. The first concerns reducing consumption-related impacts in general. This does not have to mean reducing wellbeing, but involves ACT residents making shifts in their consumption patterns to lower footprint goods. The second strategy is for the efficiency of the land used to produce the goods and services consumed by ACT residents to be increased (ie. an increase in the *productivity* of the land). However, the ACT population does not have much potential to increase land productivity given how much they are dependent on footprints generated outside the ACT. The same can be said for most Australian residents who live in cities, with perhaps a realistic conclusion being that the best influence a concerned resident may have on land productivity is from their voting preferences at national level. There is a third strategy though, which is a combination of the first two strategies: *informed and deliberate* changes in consumption by purchasing goods and services from lower footprint sources and categories. By consciously changing consumption patterns ACT residents not only reduce their own footprints, but also start to reduce the Ecological Footprint of across Australia. In the following few sections we will discuss the meaning of this third strategy for the ACT.

What can be done by households?

It would seem that households can contribute towards reducing the Ecological Footprint by changes to their spending patterns, and can do so without affecting wellbeing. Tim Jackson (2009) in his discussion of wellbeing in *Prosperity without Growth?*[23], explores the question of what contributes towards improving wellbeing and discusses why people may be happier and live more sustainably when they "favour intrinsic goals that embed them in family and community rather than extrinsic ones which tie them to display social status." (p. 11). Since shifting away from increased spending on goods, while reducing the Footprint, will not necessarily interfere with feelings of wellbeing it seems that there is much to gain from any changes.

Two changes that will reduce the Ecological Footprint could be encapsulated as – spend less, spend better. The first – spend less – is to reduce overall household consumption (which will include waste), especially of energy and goods – switching to activities for spending time rather than money where possible. The second – spend better – is to always seek out the goods and services that can be delivered in the most Footprint-efficient way. This includes for example buying food that has been produced with the lowest embodied energy, water, land use etc.

[22] Read more: http://www.news.com.au/travel/news/european-union-tax-on-carbon-to-push-up-airfares/story-e6frfq80-1226055808322#ixzz1Rxs4mj5G (accessed 13/07/11)
[23] Now a book: Jackson, T. (2009). *Prosperity Without Growth: Economics for a Finite Planet.* Earthscan: London.

What can be done by communities?

If wellbeing is enhanced, and lifestyles are more sustainable when life goals are embedded in community as well as family, then there is a role for community in reducing the ACT"s Footprint. Many communities already come together for sporting and cultural activities such as local and national celebrations and festivals. Most communities have considerable organisational infrastructure ("natural capital") such as religious bodies, schools and clubs that can be built-on and extended. Supporting a community focus on a range of activities for all age groups would seem to be a good option for reducing the overall Footprint – making it an attractive option to spend time in activities rather than money on goods. Going further, it is usually possible to find links between many of these community fundamental values and with an overall motivation to reduce one"s impact on the planet. For example, this is seen in the direct interest of some religions in environmental issues.

What can the ACT government do?

The ACT government can assist households and communities to reduce their Footprint through new policies and practices. It can also consider sequestration options for offsetting emissions as a measure to reduce its overall impact on the environment.

If households are to spend less on *stuff* it will require an education campaign to explain why and government support for alternatives for spending time rather than money. If households are to „spend better" they will need guidance. Food and product labelling is one way to assist in this. However, it will need to be backed by research that accounts for the full effect of the product rather than, for example, some superficial „food miles" type of labelling.

If communities are to extend their role in organising and supporting local activities that bring people together then education around the benefits and support for implementation will be vital. Support can be in the form of small grants to community organisations, making venues available, making public liability insurance accessible, assisting with security and providing support within a positive framework that removes barriers and welcomes ideas.

However Tim Jackson acknowledges the difficulty in pursing such goals in the face of the dominant consumerist culture and suggests that structural change is the only way to address it. He makes the point that although the task will be difficult because of the way in which goods are "deeply implicated in the fabric of our lives" (2009:10) change is essential if we are to seriously tackle sustainability. He recognises our need for consumerism as a source of identity but suggests that there are „alternative hedonisms" – less materialist pursuits that are nonetheless satisfying. These can include celebration of creative endeavour in all its forms including social, creative and performing arts, sciences and sport. Developing an infrastructure and environment that encourages and supports tempting „alternative hedonisms" for the display of wealth (if necessary), is a role that government can play. One way would be to encourage and reward creative solutions to this dilemma – ones that do not at the same time increase the ACT"s Ecological Footprint[24].

[24] In a slightly different vein but to illustrate government creative thinking: Turku in Finland, the 2011 European capital of culture, introduced cultural prescriptions to combine residents" wellbeing and culture. Its board of healthcare distributed free tickets to cultural events as a supplement to medical treatment. http://www.turku2011.fi/en/news/doctors-prescribe-tickets-cultural-events_en

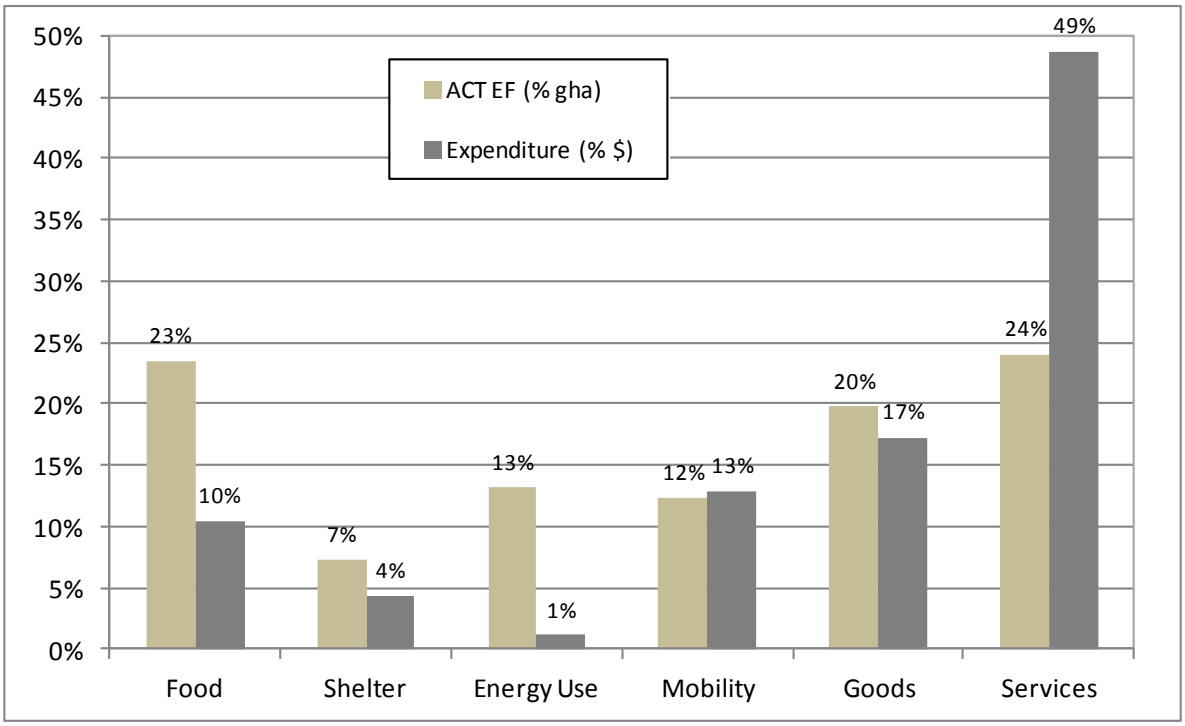


Figure 6: Contributions of consumption categories to total footprints and total expenditure (Dey, 2010). Note that although services represent 49% of expenditure their contribution to the ACT EF is 24%. Compare this with the 17% expenditure on goods which generates 20% of the footprint.

Recognising the value of a shift from buying goods to buying services is a step towards reducing the total Ecological Footprint. The challenge is to provide the type of services that are going to satisfy a range of needs for those on higher incomes and to provide services that are going to encourage a shift in spending habits for those who have not reached the income level where such effects usually kick in naturally. Figure 6 shows the different contributions of consumption categories to total footprints and total expenditure indicating the benefits that could ensue from such a shift.

Government can also assist in reducing the contribution of residential and non-residential building construction at the approval stage of developments. New projects should be assessed on the amount of land disturbed, passive heating and cooling design and water efficiency measures, encouragement for cycling and walking, support for just in time shopping to reduce waste and facilities that encourage community activity.

ACT has a high carbon sequestration potential. The Australian National University used National Carbon Accounting software to calculate how much carbon could be sequestered by revegetation of various of its ACT properties. It was suggested that if 175 ha of the 215 ha Spring Valley Farm property were to become open woodland forest then "a maximum average annual above ground carbon biomass of 89 tC/ha[25]" could be achieved. The report concluded that revegetation efforts can reduce the carbon footprint of the ANU[26] while increasing biodiversity by supporting local vulnerable bird species[27].

[25] Tonnes of carbon per hectare.
[26] It was estimated that the Kioloa (NSW) and Spring Valley Farm sites have the potential to sequester approximately 21,000 tons of carbon over 25 years.
[27] http://www.anu.edu.au/anugreen/files/1352_Daines_carbon_sequestration.AP.pdf

This result accords with the ANU"s 2008 report to the ACT government on the value of trees in Canberra"s streets, parks and reserves (Killy et al, 2008). This report found great potential for sequestration in non-urban estates. While the urban estate, with only 1% of the ACT"s carbon stock, accounts for 48% of the sequestration, non-urban land with 95% of current carbon stock accounts for only around 52% of sequestration. Young fast-growing trees have a high sequestration rate – 0.6 tonnes of carbon per hectare – compared with 0.07 tonnes per hectare for mature native vegetation surrounding Canberra. This suggests valuable potential for sequestration in non-urban revegetation projects.

There is also Ecological Footprint offset potential for the ACT in the management of its own land. Better management and rehabilitation of land which can lead to increases in biodiversity and other measureable improvements, is another local response to the dependence of the ACT on ecological disturbance outside of its boundaries. The notion of „biodiversity offsets" or „bio-banking[28]" is controversial and not without problems when applied to areas wholly within a jurisdiction[29]. However, the perspective here is to offset from within the ACT boundaries, impacts that occur outside the ACT resulting from purchase of goods and services on which the ACT population is reliant, but for which it has no direct management potential.

7 Production and consumption footprints and what they mean for action

Consumption footprints and production footprints are both in use worldwide. They serve different purposes and they give different results. For example the Ecological Footprint bases its calculation on what is *consumed* per-capita irrespective of where the good or service came from. The footprint calculated for the ACT by Dey (2010) is a consumption footprint. It accounts for everything consumed in the ACT irrespective of where that good or service was *produced*. On the other hand National GHG Inventories that are reported to the UNFCCC include emissions from *production* only. They do not include emissions embodied in imports. They take into account everything *produced* within a defined area irrespective of where that good or service is *consumed*. This approach is also used in reporting under the Kyoto Protocol[30].

It is important to understand the difference between them to avoid misunderstandings, or even the undermining of the science, should one or other unwittingly be presented in the media as „*the* footprint" – something that caused a problem in the UK in 2008 (see below). The two different calculation methods also support different possibilities for abatement action. The *consumption* footprint supports consumer action in a global framework because it addresses the full upstream supply chain; the *production* footprint is more useful for reducing emissions in business and industry at a national level.

In the developed world the footprint of everything that is consumed in a geographic area such as a city or state is generally higher than the footprint of everything that is produced by the population of that same geographic area. This is because we consume a lot of imported goods. Very often these are imported from less developed parts of the world. All of these goods embody emissions created during their production. Hence we import those emissions and in consuming the goods, these embodied emissions become part of our (consumption) footprint.

[28] http://www.resource.nsw.gov.au/biocertification/offsets.htm (accessed 15/07/11).

[29] See for example Burgin, S. (2008). BioBanking: an environmental scientist"s view of the role of biodiversity banking offsets in conservation. *Biodiversity Conservation,* 17:807–816.

[30] Note that the two examples of production footprints presented here (national GHG inventories and Kyoto reporting) apply to carbon footprints (GHG emissions) only.

The different consequences for responsibility and ultimately for action have been recognized for some time. Consider the examples below from the Wall Street Journal, 2007.

> "If a gadget is made in China by an American company and exported and used by consumers from Stockholm to Sao Paulo, Brazil, should the Chinese government be held responsible for the carbon released in manufacturing it?" (Wall Street Journal. N.Y. Nov 12, 2007. p. A.2)

In the case of a production footprint the producer is held responsible, and therefore counts, all of the effects of production in reporting for example to the UN (in the case above only GHG emissions have been considered but the principle holds true for the Ecological Footprint, water and all other effects). Country comparisons made by the UN Statistics Division are based on production footprints. However this is not without contention.

> "As China's emissions rise, everyone is pointing the finger of blame at China … The real responsibility for rising emissions should lie with the final consumers in Europe, North America and the rest of the world." (Wall Street Journal. N.Y. Nov 12, 2007. p. A.2)

In the case of a consumption footprint the consumers are held responsible, and therefore count, all of the effects of their consumption. This is what the Ecological Footprint does – it counts what is consumed per-capita irrespective of where the good or service came from.

The considerably different results can be seen in the reporting of trends in the UK. Reports show that between 1992 and 2004 their Kyoto GHG emissions reported a decrease of 13%. However in the same period consumer-based GHG emissions increased by 13% (Figure 7). This led to accusations in the press of misleading the public by reporting that emissions were decreasing when they were actually increasing. The UK government was accused of importing more and more embodied emissions in goods imported from China and in effect therefore „exporting" the government"s „dirty work".

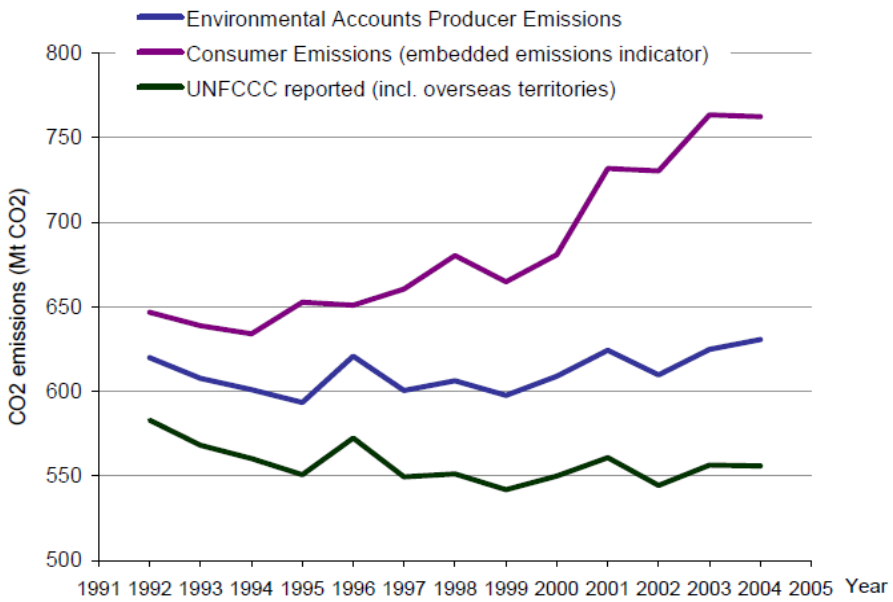


Figure 7: Development of UK CO_2 emissions from 1992 to 2004 according to different accounting principles (note that the vertical scale does not start at zero). From: Wiedmann et al (2008) available at: http://www.isa.org.usyd.edu.au/publications/documents/Defra_EmbeddedCarbon_Main.pdf

The ACT"s footprint captures the production and consumption of all goods and services because it accounts for the full supply chain of every item consumed, whether it is produced locally or imported. It is a measure of the effects of the consumption of the ACT population. As such it is a complete footprint including emissions embodied in all goods and services originating from outside the Territory boundary but consumed in the ACT.

From the UK example above it can be seen that such goods and services (largely goods) add considerably to the overall footprint. However, as discussed above, some imported goods carry a smaller Footprint than a locally produced equivalent. Consumers need to be discerning and well informed if they are to make Ecological Footprint-friendly purchases.

Some measures that households can adopt to reduce their Ecological Footprint (i.e. consumption footprint) are well covered in *Buying Choices for a More Sustainable Canberra* (Ryan, 2011). They will go some of the way to reducing the ACT"s overall footprint. Other measures that households and communities can adopt need to be supported by Government policies and practices that help make it easier and attractive for households and communities to spend time on activities instead of money on *stuff*.

8 Implications of recent trends and some speculation about the near-term future

Residents of the ACT slowed their increase in electricity usage 2002/3 – 2007/8 and their passenger car travel levelled off over that same period. Despite this, the Bureau of Transport and Regional Economics predict the total passenger car equivalent kilometres to increase by 29% in Canberra between 2005 and 2020. One obvious response is to reduce the footprint per distance travelled by vehicles, through more fuel efficient vehicles, different types of vehicles or achieving higher average occupancy. But less obviously action to reduce this trend calls for consideration of the reasons for high car dependency and its relationships with urban form, and then some creative thinking around solutions that would at least slow the increase in vehicle kilometres.

With nineteen percent of the ACT‟s Ecological Footprint in forests – primarily used within the residential construction industry (Dey, 2010:24) – it would seem that building performance deserves closer examination. Consideration of the possibilities for Canberra‟s building stock over the next 40 years will be worth investing some time into. This should include consideration of the broader environmental implications that arise from new housing settlements and general population growth. Such considerations should include an integrated approach to planning so that community gardens, transport including bicycle infrastructure, work, just-in-time shopping, education and leisure are included from at the planning stage of any development.

Food is responsible for the largest single category of the ACT Ecological Footprint (Dey, 2010:24). Of the food Footprint, 57% is plant based whilst the remainder is animal based food products. As discussed above and in Ryan (2011) substitution of local produce, albeit from community gardens may not always be the answer, although it could well be that less food is wasted when the effort to produce it has been personal. This is important because food waste is generally considered a factor in increasing emissions from food purchases. A second factor is health related: over consumption is a factor in the growing problem of obesity. Thus issues around food purchase habits, food growing and consumption are well worth investigation.

9 Discussion of broader footprint indicators for more complete decision making

The Ecological Footprint is an important headline or *endpoint* indicator for unsustainability. It rolls up a great deal of complexity into a single world-view indicator, telling us how much of the planet we are taking up through our lifestyle. An endpoint indicator requires painstaking data collection and complex modeling and computation (for discussion of midpoint and endpoint indicators see Lenzen, 2005). Many think that such simple indicators are easier for people to understand (Heijungs et al., 2003). For example, as a metaphor the Footprint is easy to envisage and extremely useful in conveying a message. However as a basis for decision making it can be criticised as being limited by its very simplicity.

Retaining the complexity also requires a range of what are known as *midpoint* indicators. Decision-making at midpoints has advantages because it allows for more of the complexity from the drivers to be examined; instead of providing a few aggregated numbers, the more multi-facetted midpoint information reveals the multi-dimensionality of the problem and can suggest a range of areas where action might be taken. Decision-making based on indicators is always going to be contentious because endpoints are too uncertain to allow a decision to be made with reasonable confidence, and midpoint information is complex, revealing competing issues that need to be balanced. In the end, people and societies always have to make decisions based on incomplete and uncertain information. However, the existence of some uncertainty should not prevent action being taken. This is the idea behind the "precautionary principle" approach to environmental management.

In the case of the ACT it would be helpful if the Ecological Footprint in future were to include as sub-sets a water footprint, land use footprint and GHG footprint. The Ecological Footprint is an excellent headline indicator, but for practical management and planning, for anything from new suburbs to individual infrastructure choices, a suite of indicators covering both local and indirect effects would enable more sophisticated decision-making.

Perhaps more useful still is the Triple Bottom Line (TBL) approach that takes into consideration not just environmental but also the social and economic effects of how we spend our money. A TBL approach can include the Ecological Footprint as an indicator just as it can include water, energy and land use. All are sub-sets of the overall sustainability (TBL) measure. The ACT"s Policy and Cabinet Division of the Chief Minister and Cabinet Directorate has recently published a discussion paper exploring the possibilities for putting TBL principles into practice through use of a TBL assessment framework[31]. The ACT"s sustainability policy, *People, Place, Prosperity: A Policy for Sustainability in the ACT* commits the ACT Government to embedding TBL assessment into its day to day decision-making processes. A full TBL approach recognises that we live in a complex system of interrelated webs of existence: change one thing and everything changes. If we make a change that affects the environment then there will be social and economic repercussions. The same goes for social and economic changes; they will inevitably in some way affect our environment. Taking a systems perspective acknowledges the complexity and begs that it be dealt with holistically. It is essential if we are going to deal with the tensions that exist for example between reducing environmental impacts and continuing economic growth. The methodology applied by the University of Sydney to the Ecological Footprint calculation is also used for TBL calculations.

[31] Triple Bottom Line Assessment for the ACT Government: A discussion paper, June 2011 http://www.cmd.act.gov.au/policystrategic/sustainability

10 Conclusion

At 9.2 global hectares per-capita the ACT"s Ecological Footprint is high compared with similar entities in Australia and very high when compared with the 1.8 global hectares per-capita available worldwide. The large ACT Footprint is driven by high salaries and high spending.

The ACT successfully reduced electricity, gas and fuel use between 2003/04 and 2008/09, all of which contributed to a reduction in these components in the 2008/09 footprint. It is now time to tackle the significant increase in consumption of goods and services that has pushed the Ecological Footprint to this height. With food the largest single category of the Footprint, closely followed by the provision of services to ACT residents there is a need for some creative thinking around how to reduce these components while maintaining high wellbeing and satisfaction with life for all.

Residential building construction is also contributing noticeably to the Footprint and is likely to increase because the population is continuing to grow. It is therefore important that integrated social, economic and environmental planning be undertaken for any new housing developments.

Finally, and most importantly, if the ACT Ecological Footprint is to be reduced, all government policy and practice must be designed to shift people away from consumption of goods to the consumption of low impact services and importantly to the spending of time in creative and thoughtful ways rather than spending of money on goods and foods that are superfluous and sometimes harmful to a healthy and happy lifestyle.

Sustainable processes and practices must become ubiquitous – a way of life. Although some people will accept such a shift as necessary for a fair and equitable world and will make changes to their lifestyle, it will be made much easier for everyone when sustainability-thinking infiltrates every aspect of government decision making so that infrastructure and policies support rather than work against it.

Reference List

Abdallah, S., S. Thompson and N. Marks (2008) Estimating worldwide life satisfaction. *Ecological Economics* 65, 35-47.

Cummins, R.A., J. Collard, J. Woerner, W. M., M. Lorbergs and C. Perera (2009) *Australian Unity Well-being Index - Report 22.0. The Well-being of Australians – Who Makes the Decisions, Health/Wealth Control, Financial Advice, and Handedness*. Internet site www.deakin.edu.au/research/acqol/index_wellbeing/index.htm, Melbourne, Australia, Australian Centre on Quality of Life, School of Psychology, Deakin University.

Dey, C. (2010). *The 2008-09 Ecological Footprint of the population of the Australian Capital Territory,* The University of Sydney, http://www.envcomm.act.gov.au/

Frey, B.S. and A. Stutzer (2002) What can economists learn from happiness research? *Journal of Economic Literature* 40, 402-435.

Global Footprint Network (2006). Living Planet Report 2006. WWF. Gland, Switzerland.

Global Footprint Network (2009). Ecological Footprint Atlas 2009. Oakland.

Global Footprint Network (2010). Living Planet Report 2010. WWF, Gland, Switzerland and Institute of Zoology, London.

Gowdy, J. (2004) *Toward a new welfare foundation for sustainability*. Rensselaer Working Papers in Economics Number 0401, Troy, USA, Department of Economics, Rensselaer Polytechnic Institute.

Heijungs, R., Goedkoop, M.J., Struijs, J., Sevenster, M. & Huppes, G. (2003). Towards a life cycle impact assessment method which comprises category indicators at the midpoint and the endpoint level. http://www.pre.r.1/download/Recipe%20phase1%20final.pdf . Amersfoort, Netherlands, PRé Consultants.

Jackson, Tim (2009). *Prosperity without growth? The transition to a sustainable economy*. Sustainable Development Commission. Downloadable from http://www.sd-commission.org.uk/publications.php?id=914

Killy P, Brack C, McElhinny C, Cary G and King K (2008). *A carbon sequestration audit of vegetation biomass in the ACT*. ACT Government Report.

Lenzen, M. (2005). Uncertainty in Impact and Externality Assessments: Implications for Decision-Making. *International Journal of Life Cycle Analysis*, 11.1-11.2, pp1-11.

Lenzen, M. & Cummins, R. (2010) Happiness vs the environment - a case study of Australian lifestyles., ISA, The University of Sydney http://www.isa.org.usyd.edu.au/publications/reports.shtml

Lenzen, M. and B. Foran (2001) An input-output analysis of Australian water usage. *Water Policy* 3, 321-340.

Lenzen, M. and S.A. Murray (2001b) A modified ecological footprint method and its application to Australia. *Ecological Economics* 37, 229-255.

Lenzen, M., M. Wier, C. Cohen, H. Hayami, S. Pachauri and R. Schaeffer (2006) A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. *Energy* 31, 181-207.

Mayraz, G., R. Layard and S. Nickell (2006) The functional relationship between income and happiness. . *3rd European Conference on Positive Psychology*. Braga, Portugal.

Peters, G., Jan C. Minx, Christopher L. Weber, and Ottmar Edenhofer (2011). Proceedings of the National Academy of Science of the USA Growth in emission transfers via international trade from 1990 to 2008.

Ryan, S. (2011). *Buying Choices for a more Sustainable Canberra.* Report for the ACT Commissioner for Sustainability and the Environment.

Stutzer, A. (2004) The role of income aspirations in individual happiness. *Journal of Economic Behavior & Organization* 54, 89-109.

Wiedmann, T., Wood, R., Barrett, J. and Lenzen, M. (2008). *The Ecological Footprint of Consumption in Queensland*, Report to the Environmental Protection Agency in Queensland, Stockholm Environment Institute (SEI), The University of York, and The Centre for Integrated Sustainability Analysis (ISA), The University of Sydney.

Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2008) *Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System,* Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney, June 2008. Defra, London, UK

Wier, M., M. Lenzen, J. Munksgaard and S. Smed (2001) Environmental effects of household consumption pattern and lifestyle. *Economic Systems Research* 13, 259-274.

Buying Choices for a More Sustainable Canberra

Report for the ACT Commissioner for Sustainability and the Environment

Sarah Ryan

ACKNOWLEDGEMENTS

The research assistance of Alexei Trundle in the Commissioner's Office is gratefully acknowledged. Alexei did most of the research relating to coffee, televisions and paper books, and drafted the sections on those products.

DISCLAIMER

The information in this report has been assembled from a number of data sources and studies of life cycles of individual or groups of consumer items. In many cases, analyses do not comprehensively cover the whole life cycle, nor is there much data available that specifically applies to goods and services purchased in Canberra. Generalisations from these findings may not apply in specific situations and the author takes no responsibility for readers' actions they take on the basis of the findings in the report.

CITATION

Ryan S (2011) *Buying Choices for a More Sustainable Canberra.* Report for the ACT Commissioner for Sustainability and the Environment. ACT Government, Canberra.

BUYING CHOICES FOR A MORE SUSTAINABLE CANBERRA

Contents

List of Tables

List of Figures

INTRODUCTION

Canberra's ecological footprint

Canberrans have an average ecological footprint of 9.2 gha (global hectares) per person[1]. This is a measure of the area of land needed to supply all the resources and absorb all the waste of the average person in Canberra. The measure includes not only the obvious components like the energy to transport goods around, but also all the upstream inputs, like the energy used to make the truck that transports the goods and the land and water used for mining and processing the iron ore that's used to make the steel for the truck. Thus the full life cycle of a good (or a service, like a bank) is included in the footprint.

Canberrans have an average ecological footprint of 9.2 gha (global hectares) per person.

… the area we need to support all of us [in the ACT] is over 3 million global hectares, about 14 times the land area of the ACT.

Taking all the population of the ACT into account, the area we need to support all of us is over 3 million global hectares, about 14 times the land area of the ACT. At 9.2 gha per person, our ecological footprint is 13% larger than the average Australian footprint, more than three times the world average, and five times each person's share of bioproductive land globally (1.8 gha). Our high footprint is a consequence of high average incomes and high capacity to purchase large quantities of goods and services. In the longer run, and with an even larger world population, this size of footprint won't be sustainable.

The 18 items that contribute the most to this footprint are listed in Table 1[2]. Household energy consumption (electricity, air transport, petrol and gas) is the single largest group of items, accounting for 22% of the footprint; building and infrastructure construction 9%; food 6%; retail trade 6% etc. This information provides very broad guidance to consumers who might want to reduce their ecological footprint. For

Table 1 Items that contribute most to Canberrans' average ecological footprint of 9.2 gha.

The measure includes the impacts of all the inputs to each item.

Item	Footprint (gha/capita)	% of total
Electricity supply	1.07	12
Residential building construction	0.56	6
Retail trade	0.51	6
Hotels, clubs, restaurants, cafes	0.44	5
Air and space transport	0.35	4
Petrol	0.32	3
Other food products	0.29	3
Wooden furniture	0.25	3
Ownership of dwellings	0.24	3
Clothing	0.21	2
Electronic equipment	0.20	2
Beef cattle	0.17	2
Finished cars	0.16	2
Education	0.15	2
Non-building construction	0.14	2
Gas supply	0.14	2
Non-residential building construction	0.14	2
Wheat	0.12	1
SUBTOTAL	**5.46**	**59**

[1] Dey C (2010) *The 2008-09 Ecological Footprint of the Population of the Australian Capital Territory*. Integrated Sustainability Analysis Research Group, The University of Sydney. http://www.environmentcommissioner.act.gov.au/__data/assets/pdf_file/0015/211182/ACT_Ecological_Footprint_08-09_final_report.pdf. Accessed 17 May 2011.

[2] As above.

example, reducing household electricity use by 10% from its average would reduce the footprint by 0.11 gha, about the same amount as giving up eating meat (beef accounts for 0.17 gha but giving this up would require eating more of other foods), or replacing electronic equipment half as often, reducing their footprint from 0.2 to 0.1 gha.

Footprints of individual consumer products

There might also be opportunities for reducing the environmental impact of our buying choices if we had more specific information about the individual products as they are delivered to and purchased in the ACT. The footprint calculations in Table 1 are based on actual buying patterns for the ACT, but the relationship between that data and the amounts of land, water, energy and materials consumed and polluted over the whole life cycle of products and services is based on Australian and global averages at an economic sector level, not an individual product level. Those averages potentially hide a wide range of variation in differences between products within a sector and in the environmental impacts of the same product, depending on how and where it was produced, distributed and purchased. This paper explores the origin and life cycles of a basket of common consumer goods ***as they are purchased and used in Canberra***. The items were chosen to represent some different types of products and different countries of origin, and are those where at least some aspects of their life cycle impacts have been studied. While each has its own particular life cycle, some of the issues explored are common to other consumer items. The basket contains bread, coffee, beef, tomatoes, televisions sets, paper books and AA batteries.

Products explored in the report:

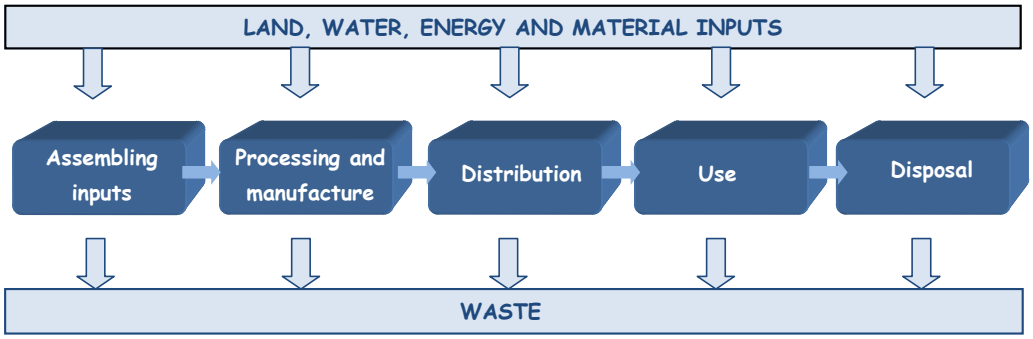
bread
coffee
beef
tomatoes
television sets
paper books
AA batteries.

Life cycle analyses

The basic framework of a product life cycle is shown in Figure 1. Essentially the life cycle consists of all the steps required from sourcing and assembling the raw materials through any processing or manufacturing processes, distribution of the product through various pathways to reach consumers, consumers using them and then disposing of them or their waste at the end of their life cycle. All along the way, inputs of land (e.g. to grow food or trees on, or to build or shops roads on), water (e.g. irrigation water to grow food or water to keep processing plants clean), energy (e.g. fuel and electricity in their direct manufacture or in their transport) and other materials (e.g. minerals or the steel to make the trucks that transport the product or packaging) are used and waste is generated.

Wherever these inputs come from and wherever the waste goes, there are environmental impacts. For example, use of land displaces or fragments biodiversity, use of irrigation water displaces its uses in wetlands and floodplains and disturbs living processes in rivers and use of fossil energy increases greenhouse gases in the atmosphere, changing global climate processes. Toxic materials sent to landfill can leak into groundwater and damage ecosystems (and humans). When global population was small and the use of technology limited, the environmental impact across the globe was also limited. That impact has now grown to the extent that there are concerns for the persistence of ecosystem processes that are important for supporting human life.

Figure 1 *A generalised life cycle of a consumer product.*



Calculating the environmental impact or footprint of the life cycle of a product is a challenging task because of the complexity of supply chains (which can change quite suddenly due to price changes or technological developments), lack of data and the many different ways in which impact can be assessed. Many studies have focused on just a few parts of the life cycle (e.g. the manufacturing step alone) or on just one or a few aspects of environmental impact (e.g. greenhouse gas emissions only, or water use only), so drawing broader conclusions from partial studies has to be done with caution.

Information on the origins and routes of goods coming into Canberra is also patchy so it has not been possible in this report to apply a uniform approach to analysing each item, or to comprehensively compare impact across all phases of the life cycle of each product. Instead the report collates what is readily available, applies wider findings where they are known, and suggests the most obvious "hotspots" in the life cycle, that is, the steps that make the largest contributions to a product's footprint and that are therefore the places where the largest reductions might be found. Hotspots might be missed where information is lacking so these analyses are a first approximation, and a way of raising a range of issues that contribute to footprints, rather than definitive findings.

Hotspots in the life cycle … the steps that make the largest contribution to a product's footprint and are therefore the places where the largest reductions might be found.

Purchasing decisions

The paper focuses on products where the act of purchasing is an obvious one. Less obvious "purchases" take place every time we turn on a device that uses electricity or gas or step into the car. Since non-renewable energy is the single largest component of ecological footprint in Canberra (see Table 1 and the discussion above), exercising choice about these 'purchases' remains a very powerful way of reducing ecological footprints.

Purchasing decisions are also influenced by people's social values about the ways in which products are made and delivered, and these are not usually assessed in a life cycle analysis (although some researchers have begun to develop methods for doing this). Concern for the treatment of animals in the production of food is one example, or concern about providing fair returns to producers in developing countries is another. This report suggests where issues like this might be particularly relevant but it is not the main focus of the analysis.

Purpose of the report

The purpose of the paper is to provide information for Canberra consumers who want to exercise buying choices to reduce their ecological footprint. There are many general sets of principles for 'greener' living (e.g. on the Australian Conservation Foundation website[3] or the Australian Government website[4]) and these are good guidance if there is no specific product information, but they may not deliver the desired outcome in all circumstances. In fact they can sometimes produce the opposite effect: a "perverse" outcome. For example, encouragement to always buy local, on the basis of lower food miles, might require food to be produced in a heated glasshouse, when it could have been produced further away in natural sunshine with a reduced overall use of fossil energy. Intuition about the relative impacts of different steps in a product life cycle does not always produce the right answer.

.. to provide information for Canberra consumers so … they can be more confident that their buying choices actually deliver sustainability benefits

Information alone is rarely sufficient to induce behaviour change, but it can raise awareness of and challenge routine behaviours that involve decisions made with little conscious thought. The *availability of accessible information* remains an important tool in supporting more sustainable decision-making:

> *Climate change, water use, health and safety and intellectual property rights are not usually in the forefront of the purchaser's mind when buying bread. However, although purchase decisions are often made in a matter of seconds they are not made in a vacuum. … Having access to the full upstream production costs of a loaf of bread presents a powerful capability. It can identify where in the supply chain we should concentrate efforts. When combined with a story that provides local and specific details such information has a chance of being heard. Thus more consumers will be able to make informed decisions and the more this information becomes part of life the more likely those decisions can be made in a matter of seconds.*[5]

[3] Australian Conservation Foundation http://www.acfonline.org.au/consumptionatlas/ Accessed 10 Jun 2011.
[4] Australian Government www.livinggreener.gov.au. Accessed 15 Jul 2011.
[5] Murray J, Dey C (2007) *Assessing the Impacts of a Loaf of Bread*. Integrated Sustainability Analysis Research Group, The University of Sydney. http://www.isa.org.usyd.edu.au/publications/ISA_on_Bread.pdf. Accessed 20 May 2011.

BREAD

Buying and use patterns

Australians buy about 60 kg of bread each a year

The typical loaf of bread is purchased in a supermarket or convenience store …

Most Australians eat bread and it is the major source of carbohydrate as well as some of the protein in our diets. Averaging across the whole population and including all types of bread products, we account for about 60 kg each a year, or roughly the equivalent of a large loaf and some rolls each a week. The typical loaf of bread is purchased in a supermarket or convenience store where most of the bread is supplied by two companies, Goodman Fielder and George Weston Foods, using a variety of brands. Together they supply about 60% of the overall bread market[6] but a higher proportion to such stores.

We actually eat somewhat less than 60 kg of bread a year as it doesn't have a long shelf-life. Especially in small households, stale and mouldy bread forms part of the considerable amount of food that is regularly discarded. An audit of Canberra's waste streams in 2003 discovered that 38% of all landfill garbage collected (ie excluding recyclables) was food and kitchen waste[7]; this amounted to about 2kg per person per week. Another Australian study calculated that we spend about $30 per fortnight on food that is not eaten[8]. The study also noted that the ACT was more wasteful than any other state, presumably because our income is higher, we buy more stuff and we can afford to waste more.

Not all discarded food represents pure waste. Some of it is inedible, like peelings and cores. Along with discarded fruit and vegetables, these can be composted at home and used to grow more food; or landfill waste can be used to generate energy via biogas capture; or waste from food manufacture, like fruit and vegetable skins, can be composted or fed to animals. Waste can occur in other steps in the food chain, but a study in the UK found that consumers are the hotspots for discarded food, accounting for over 50% of food losses after production. A third was lost in manufacture and a relatively small amount in retailing[9].

Product flow – paddock to plate

Wheat flour and water are the two main ingredients in a loaf of bread, so this account focuses on these alone. A fuller life cycle analysis would consider the small quantities of other grains, yeast, oil, extra gluten and vitamins that are commonly added to bread.

The major flows of flour and bread to consumers in Canberra are shown in Figure 2.

---

[6] GoGrains. *History of the Bread Industry in Australia*. http://www.gograins.com.au/grainsnutrition/ie/ie16_1.html. Accessed 25 May 2011.

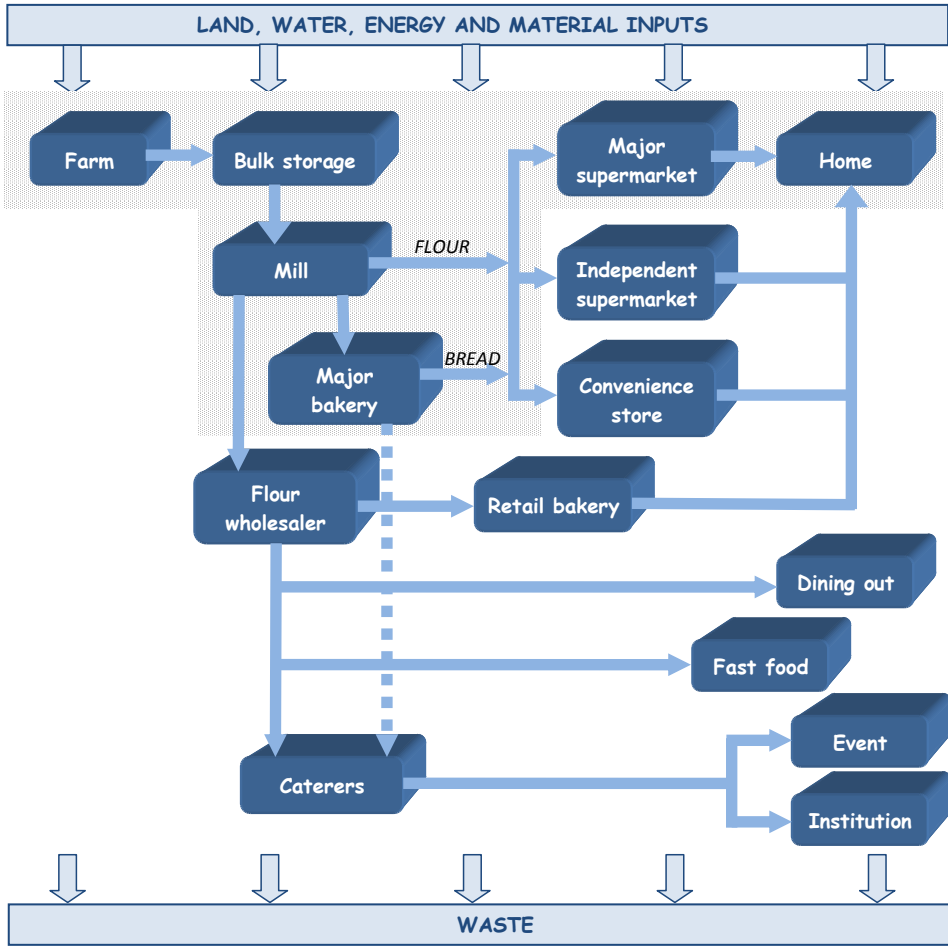
[7] APrince Consulting (2004) *Canberra Residential Waste Audit.* http://www.tams.act.gov.au/__data/assets/pdf_file/0009/136737/Canberra_Waste_Audit_Oct-Dec_2003.PDF. Accessed 30 May 2011.

[8] Hamilton C, Denniss R, Baker, D (2005) *Wasteful Consumption in Australia.* Australia Institute http://www.tai.org.au/documents/dp_fulltext/DP77.pdf. Accessed 30 April 2011.

[9] Department for Environment, Food and Rural Affairs (2007) *Report of the Food Industry Sustainability Strategy Champions' Group on Waste.* UK Government. http://archive.defra.gov.uk/foodfarm/policy/foodindustry/documents/report-waste-may2007.pdf. Accessed 12 May 2011.

Figure 2 Major flows of wheat and flour to produce bread eaten in Canberra.

The shaded area represents the largest volume of flow measure includes the impacts of all the inputs to each item.



Wheat production

Our bread is made almost entirely from wheat and added grains grown in Australia. It takes about 300 square metres, roughly an area 17 metres by 17 metres, to grow the wheat to make the flour from which each person's bread is baked every year[10]. With its population of about 350,000, Canberra's bread footprint in terms of the area of land for growing the wheat, is about 10,000 ha, equivalent to 4% of the area of the ACT. However the soil and climate are not suitable for growing wheat in the ACT and bread eaten in Canberra is most likely to have made from wheat grown in New South Wales where a large grain growing area stretches in a broad band from the north to the south of the state, inland from the Great Dividing Range.

It takes about 300 square metres to grow the wheat to make the flour from which each person's bread is baked every year.

Canberra's bread footprint … is … equivalent to 4% of the area of the ACT.

[10] Calculated from ABS data for population (ABS cat. no. 3235.0) and wheat production (ABS cat. no. 7113 0) in 2008 and flour production data from Flour Millers Council of Australia 2008 (cited in Department of Agriculture and Food (2009) *Overview of the West Australian Wheat Flour Industry and Potential Export Opportunities.* http://www.agric.wa.gov.au/objtwr/imported_assets/content/amt/wheat_flour_report_mar09.pdf. Accessed 12 May 2011.

Bread that is certified as organic might be a choice for people who are concerned about their environmental footprint. There were only about 440 certified organic cereal growers (this includes cereals besides wheat) out of about 30,000 grain growers nationally in 2003[11] so in fact, this is not a practicable choice for large numbers of people. A study comparing organic and conventional wheat farming in Australia found that the land impact of organic wheat was larger than for conventional wheat, but that its irrigated water and its greenhouse gas footprints were smaller[12].

> *… the land impact of organic wheat was larger than for conventional wheat, but … irrigated water and greenhouse gas footprints were smaller [found in one Australian study].*

While numbers may have grown since then, by far the most wheat in Australia is grown using conventional methods involving manufactured fertiliser and herbicides. Nevertheless, there are many industry sponsored initiatives that encourage and support wheat farmers to farm in a more sustainable manner. For example, in response to the findings of research and promotion of more sustainable practices by industry bodies and governments, the majority of wheat in Australia is now grown in 'no-till' fashion[13]. Instead of burning the stubble of the previous year's crop and ploughing the soil several times for weed control before sowing the next crop, farmers are now leaving the stubble intact and sowing the seed directly into the soil. The benefits are mostly in terms of reduced costs (e.g. less fuel), improved soil conservation and improved soil moisture, which all have positive impacts on the environment. However, herbicide use is greater.

Some wheat is grown with irrigation water from the Murray and the Murrumbidgee Rivers, but most of it is grown with natural rainfall. The average NSW water footprint of growing 1 kg of wheat is about 86 litres[14]. This calculation includes any irrigation water, the water embodied in other farm inputs like fertiliser manufacture, and the water needed to dilute excess nutrients in drainage water to acceptable health levels, but not rainwater. Compared to food products grown almost wholly on irrigation water, this is a small water footprint and not a hotspot for a loaf of bread.

After harvest, wheat from individual farms is combined into similar types and grades and stored at local bulk handling facilities before being taken by train or truck to mills, if it is destined for domestic use, or to ports for shipping overseas. Both Goodman Fielder and George Weston Foods own flour mills as well as bakeries, so they have a direct supply chain from the mill to their bakeries and through contracts with major retailers, to supermarket shelves. There are only about 30 flour mills in Australia and most are located in metropolitan areas[15], so the flour in a typical loaf of Canberra bread probably travelled from country NSW to Sydney as wheat and was milled into flour in Sydney. Of the flour destined for bread for Canberrans, around

> *… the flour in a typical loaf of Canberra bread probably travelled from country NSW as wheat and was milled into flour in Sydney..*
>
> *Around two-thirds [of that flour] is transported to Canberra for local baking … and about a third is baked into bread in Sydney … then brought to Canberra.*

---

[11] Halpin D. (2005) *The Australian Organic Industry. A Profile.* Department of Agriculture, Fisheries and Forestry, Canberra. http://www.daff.gov.au/agriculture-food/food/organic-biodynamic/industry. Accessed 18 May 2011.

[12] Wood R, Lenzen M, Dey C, Lundie S (2006) A comparative study of some environmental impacts of conventional and organic farming in Australia. *Agricultural Systems* 89:324–348.

[13] Llewellyn RS, D'Emden FH (2010) *Adoption of No-till Cropping Practices in Australian Grain Growing Regions.* Grains Research and Development Corporation, Canberra. http://www.grdc.com.au/uploads/documents/GRDC_adoption_of_no-till.pdf Accessed 25 May 2011.

[14] Ridoutt and Poulton (2009) SAI Platform. Australia Water footprint Pilot Project: Wheat, Barley and Oats Grown in the Australian State of New South Wales. CSIRO. http://www.csiro.au/files/files/pvkh.pdf. Accessed 16 May 2011.

[15] Department of Agriculture and Food (2009). See footnote 10.

two-thirds is transported to Canberra for local baking (Goodman Fielder and local brands), and about a third is baked into bread in Sydney (George Weston brands) and the bread then brought to Canberra.

Baking

Making bread involves combining the ingredients (about 2/3 flour, 1/3 water, yeast and other additives), mixing the dough, shaping the product, allowing it to rise in a warm place, then baking it and cooling it. Large bakeries slice and wrap the loaves before distribution. In such bakeries these steps are highly automated[16] and allow George Weston, for example, to produce around a million baked products a day in just 14 bakeries across Australia[17].

Water and energy uses are potential hotspots in the baking process. Water is an ingredient in the loaf itself, but is also used for washing and cleaning in the bakery. In addition, water is used in growing or making other ingredients in the loaf, especially dairy products, and is embodied in the manufacture of the buildings and equipment in the bakery. In fact, the water used within the bakery is more than the irrigation water (but not rainfall) used to grow the wheat[18].

Energy use in bakeries is high because of the cooking process and the degree of automation in large bakeries. Natural gas and electricity are the main sources of energy; and in NSW and the ACT where our bread is baked, most of the electricity comes from burning coal and therefore embodies high greenhouse gas emissions.

Footprints across the life cycle

A life cycle analysis of a loaf of bread in Australia found that the retail and consumption phase contributed 55% of the total global warming impact (Figure 3)[19]. Included in the retail stage of this hotspot is the energy needed to control temperatures in retail stores, and included in the consumption stage is energy for freezing and toasting bread. The storage and processing stage (ie bakery) was the second largest contributor. This finding is consistent with a study of the proportion of the energy consumption in the wholesale and retail phase compared to the production phase (but not including consumption) for 400 commodities in the USA[20]. Depending on the product, between 20 and 50% of energy for these two steps was used in the wholesale and retail phase.

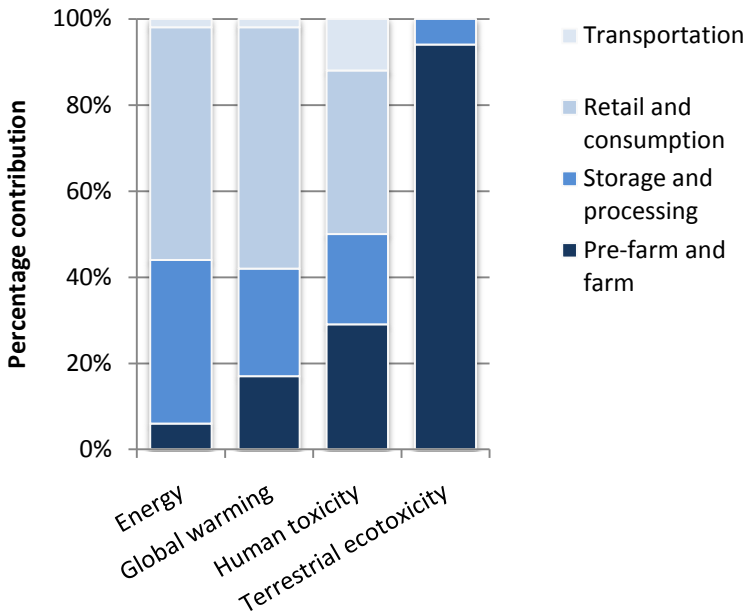
> *… the retail and consumption phase contributed 55% of the total global warming impact [of a loaf of bread, in one Australian study].*

[16] For a description of the automated process see IBIS http://www.foodmag.com.au/news/breaking-bread-habits-of-australias-manufacturers. Accessed 26 May 2011.
[17] George Weston Foods. http://www.georgewestonfoods.com.au/. Accessed 26 May 2011.
[18] Murray J, Dey C (2007) Footnote 5.
[19] Narayanaswamy V, Altham W, van Berkel R, McGregor M (2004) Application of life cycle assessment to enhance eco-efficiency of grains supply chains. *4th Australian Life Cycle Assessment Society Conference*, Sydney 2005. http://www.conference.alcas.asn.au/. Accessed 26 May.
[20] Norris GA, Della Croce F, Jolliet O (2003) Energy burdens of conventional wholesale and retail portions of product life cycles. *Journal of Industrial Ecology* 2003:59-69.

In the Australian study, transportation contributed only a few percent to energy use and global warming impact. This is broadly consistent with a study in Denmark that found that transport accounted for only about 10% of the whole energy footprint of bread[21]. It is also consistent with the USA study referred to above that found the transport energy uses to distribute goods between the place of production and the retail store accounted for only 9% of the total energy use prior to its purchase.

Figure 3 Contribution of phases in the life cycle of bread to some footprint measures.

Terrestrial ecotoxicity is a measure of the impacts of toxic materials on ecosystems. The figure is redrawn from data in the resource at Footnote 19.



Hotspots summary

Growing the wheat is a hotspot in terms of land impacts.

Energy use in retail and consumption is a hotspot for CO2e[22] emissions, followed by the energy use in **baking the bread**.

Social and ethical considerations

The main social and ethical issues that could be considered in the case of bread relate to regional employment. Over 40% of food processing jobs are in non-metropolitan areas[23] and these make a significant contribution to regional economies. As just a few companies dominate the bread baking industry, they have concentrated their mills and bakeries in metropolitan areas at the cost of regional jobs. This enables them to keep their production costs lower and bring consumers bread at cheaper prices because the socio-economic impact of employment location is not factored into the price, just as many environmental impacts are not factored into prices of food.

[21] Munksgaard J, Lenzen M, Jensen T, Pade L (2005) Transport energy embodied in consumer goods: A hybrid life-cycle analysis. *Energy and Environment* 16:27-45.

[22] CO2e is 'carbon dioxide equivalents'. This is a measure of the aggregate global warming potential of a number of gases, including carbon dioxide, expressed in terms of the global warming potential of carbon dioxide. Other greenhouse gases include methane and nitrous oxides. Per gram of gas, these have 25 and 298 times the warming potential of CO2 respectively, over a 100 year timeframe.

[23] Department of Foreign Affairs and Trade (2008) http://www.dfat.gov.au/facts/foodindustry.html Accessed 28 May 2011.

In the absence of food labelling that informs consumers about whole of life cycle impacts, a consumer could make an assessment about the commitment of the company to reducing the footprint of its products. Many companies report on sustainability initiatives in their annual reports or in other documents on their websites. For example, both a sustainability report and a waste report are available for Goodman Fielder[24,25]. Their sustainability report is based on an internationally recognised measurement system, Global Reporting Initiative, and includes a social dimension that addresses both their staff e.g. health, safety and well-being, and socio-economic and environmental aspects of suppliers e.g. of palm oil from developing countries.

On the basis of where company profits go, consumers could also make choices based on ownership of the major bakeries. Goodman Fielder is a company listed on the Australian stock exchange. George Weston is a wholly owned subsidiary of a very large international food company based in the United Kingdom. Franchisees of chain bakeries, like Bakers' Delight, and owners of small or boutique bakeries, tend to be local people.

Your choices

There is relatively little choice for Canberra consumers who might want to reduce the environmental impact of the bread they buy. In terms of land impacts, there is little organic bread produced, and the remainder is not differentiated or labelled according to where or how the wheat was grown or how the bread was baked.

… there is relatively little choice for Canberra consumers who might want to reduce the environmental impact of the bread they buy.

All bread is baked, so there is little leverage there, although the efficiencies of larger bakeries suggests that loaves from those bakeries have smaller footprints. An international review of studies of the life cycle of bread concluded that "A scenario combining organic production of wheat, industrial milling and a large bread factory is reported to be the most advantageous way of producing bread"[26].

Alternatively, sourcing bread from bakeries that can demonstrate that they've invested in sustainability initiatives will reduce the impact of a loaf of bread. A Victorian bakery company, Ferguson Plarre Bakehouses, has made changes to its energy and water supply and management, raw material handling and its vehicles and is offsetting its fossil fuel emissions, saving 5000 tonnes of CO2e emissions[27]. But to the author's knowledge, a choice like this is not available in Canberra.

---

[24] Goodman Fielder (2010) *Sustainability Report 2009-10*. http://www.goodmanfielder.com.au/sites/default/files/PDFs/Environment/2010%20Goodman%20Fielder%20Sustainability%20Report.pdf. Accessed 3 Jun 2011.

[25] Goodman Fielder (2010) *National Packaging Covenant Annual Report July 2008 – June 2009* http://www.goodmanfielder.com.au/sites/default/files/PDFs/Environment/Goodman%20Fielder%20NPC%20Annual%20Report%20F%2709.pdf. Accessed 3 Jun 2011.

[26] Roy P, Nei D, Orikasa T, Xu Q, Okadome H (2009) A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering* 90:1-10.

[27] Ferguson Plarre (2011) http://www.fergusonplarre.com.au/History/Greenhouse-Challenge.html#currentProjects. Accessed 20 Jun 2011.

The high greenhouse gas emissions in the retail and consumption phase offer a potential place to find reductions, but nearly every retail outlet in Canberra is air conditioned so that is not a practical option.

The best opportunities for reducing the footprint of bread are to minimise car transport in its purchase and to ensure that all the bread bought is eaten.

… the best opportunities for reducing the footprint of bread are to minimise car transport in its purchase and to ensure that all the bread bought is eaten.

COFFEE

Buying and use patterns

Australians account for over 2.5kg of coffee per person each year the equivalent of 1250 cups of instant coffee or 357 cups of espresso[28]. Most (83%) of the coffee consumed in the home is instant coffee[29], although this share has fallen since 2004 in the face of increasing sales and use of home espresso and capsule-based coffee machines. The Australian food service industry, however, is estimated to sell 1.26 billion cups of coffee each year, at a total profit of over $3 billion[30]. Ninety percent of the coffees ordered in cafés are milk-based, and 395 million of these are served in takeaway paper, foam or plastic-coated cups[31]. In total, Australians spend $10.7 billion dollars on coffee related products annually, with the 50% of Australians who drink coffee consuming an average of four espresso coffees per week[32].

Australians account for over 2.6kg of coffee per person each year.

… food service industry .. sells 1.26 billion cups of coffee each year

Product flow

Typical flows of three different types of coffee from the farm to the cup are drawn in Figure 4[33].

Production and processing

Global production of coffee is led by Brazil, which produces around 2.25 million tonnes of dry green bean, followed by Vietnam (961,000 tonnes) and Columbia (637,000 tonnes)[34]. Worldwide, it is estimated that 20-25 million people depend on income from coffee crops[35]. Australia imports coffee from over 65 countries. Most of it comes from Vietnam (17,123 tonnes), Papua New Guinea (10,298 tonnes) and Brazil (6,052 tonnes). Locally, far north Queensland produces around 800 tonnes, followed by north-eastern NSW (500 tonnes). The remaining Australian coffee growers produce approximately 300 tonnes annually[36]. However, half of Australian grown coffee is exported overseas, as it is targeted at the boutique 'single-origin' market[37].

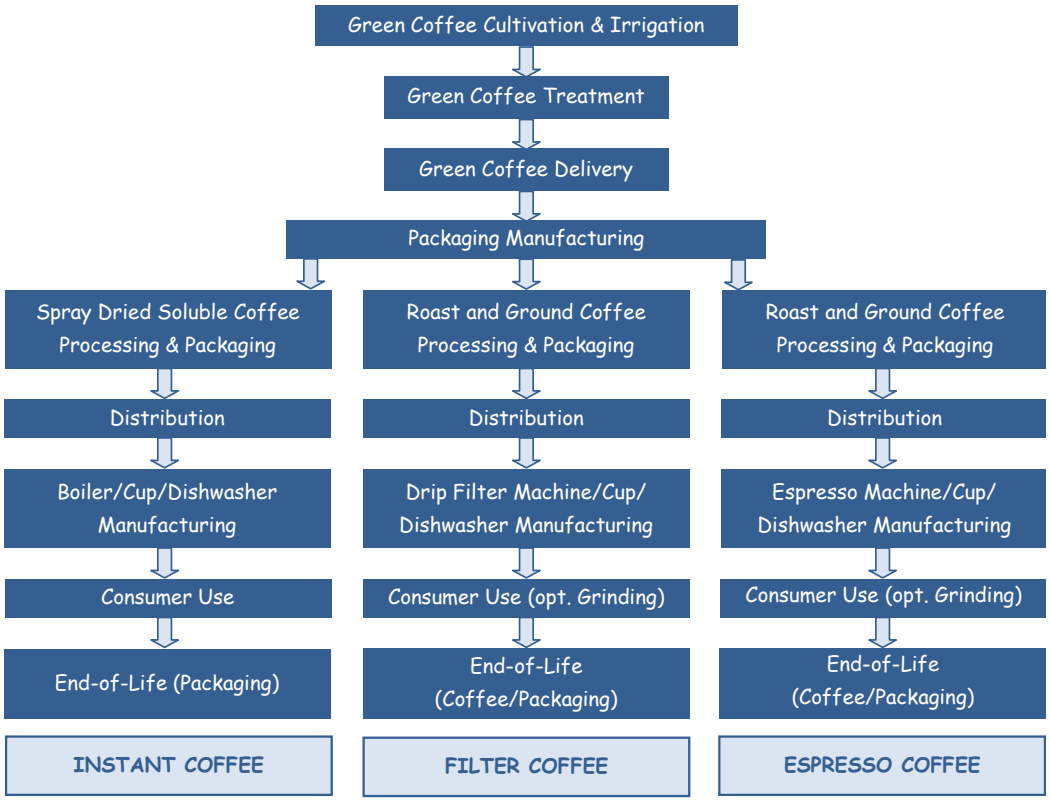
… the origin of most of the coffee drunk in Australia is Vietnam or Papua New Guinea.

---

[28] Pacific Islands Trade and Investment Commission (2007) *Exporting Coffee from the Pacific Islands.* http://www.pitic.org.au/pdfs/exporting/coffee.pdf. Accessed 20th May 2011.
[29] As above.
[30] BIS Shrapnel (2006) *Coffee in Australia 2006-2008*. Industry Report, February 2006, Sydney, Australia.
[31] KeepCup Pty Ltd. (2010) *Environmental Footprint Calculator Considerations* http://www.keepcup.com/userfiles/files/KeepCup%20Calculator%20Considerations.pdf. Accessed 20 May 2011.
[32] BIS Shrapnel (2006) Footnote 30.
[33] Humbert S, Loerincik Y, Rossi V, Margni M and Jolliet O (2009) Life cycle assessment of spray dried soluble coffee and comparison with alternatives (drip filter and capsule espresso). *Journal of Cleaner Production* 17:1351-1358.
[34] As above.
[35] DaMatta F, Ronchi P, Maestri M, Barros R (2007) Ecophysiology of coffee growth and production. *Brazilian Journal of Plant Physiology* 19:485-510.
[36] Rural Industries Research & Development Corporation (2003) *R&D Plan for the Australian Coffee Industry 2003-2008*. Publication Number 03/056. https://rirdc.infoservices.com.au/downloads/03-056.pdf. Accessed 20 May 2011.
[37] Pacific Islands Trade and Investment Commission (2007) *Exporting Coffee from the Pacific Islands.* http://www.pitic.org.au/pdfs/exporting/coffee.pdf. Accessed 20 May 2011.

Figure 4 Typical flows of coffee from the farm to the cup.

The figure is redrawn from a figure in the resource at Footnote 33.



Coffee production involves a number of processes that vary significantly depending on the preferences of the end consumer. In the country of origin, the manner in which the coffee is produced has a significant influence on the environmental impacts of the production of coffee beans. Traditionally, coffee trees have been shade-grown, at a relatively low density per hectare and integrated with other crops and species. However, due to greater profit margins, higher-density 'full-sun' monoculture plantations have rapidly replaced traditional approaches in plantations established in the last 20-30 years[38]. Although these new plantations allow higher yields, they also cause soil degradation, need higher applications of chemical fertilizers and irrigation water and lead to destruction of the migratory bird habitats usually provided by coffee-based poly-cultures. Some other production differences can occur during the extraction of coffee beans from the coffee cherry, however there is little variation in either water or energy use between the 'dry' and 'wet' production methods[39].

At the destination country, green coffee beans go through a range of different roasting, processing and preparation stages. For example, espresso coffee is simply roasted and ground, whereas instant and capsule-based coffees undergo additional processing stages after roasting. The final preparation stage is also a significant source of CO2e emissions, with energy requirements and production of

[38] DaMatta et al. (2007) Footnote 35.

[39] Brommer E, Stratmann B, Quack D (2011) Environmental impacts of different methods of coffee preparation. *International Journal of Consumer Studies* 35:212-220.

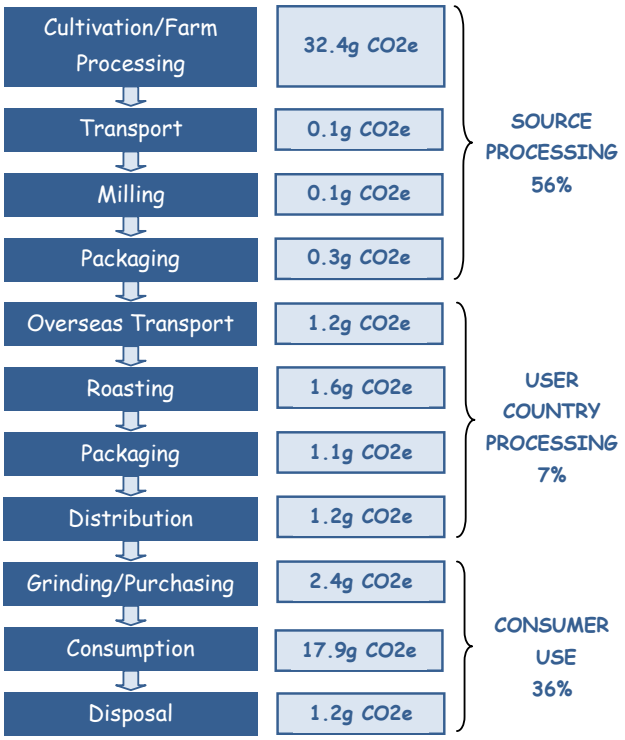
home espresso machines, kettles, other heating methods and the food service industry as a whole all having different impacts on the environmental impact of each cup of coffee[40].

The footprint of making coffee at home

The CO2e emissions of a standard home-made cup of black coffee, as estimated in a German life-cycle analysis are shown in Figure 5[41]. On average, a milk-free cup of coffee was found to have a carbon footprint of approximately 59 g of CO2e, with the bulk of emissions coming from two areas: on-farm cultivation and processing and the preparation for consumption. However, an espresso coffee based on cow's milk increases this basic carbon footprint significantly, with the espresso extraction process being estimated to produce 130 g of CO2e and the milk production and distribution for a standard 250 ml latte adding a further 230 g of CO2e[42]. This footprint is even larger for take-away or café-based coffees, with additional emissions occurring due to takeaway cup production, venue heating and lighting, staff transport and large commercial coffee machines. For example, production of one medium disposable takeaway cup, even before filling it with coffee, is estimated to emit 112 g of CO2e[43] – almost double that of a home-made black coffee.

Figure 5 CO2e emissions of a home-made cup of black coffee in Germany.

The figure is redrawn from a figure in the resource at Footnote 39.



The water needed to grow coffee then produce roasted beans has been calculated to be 20.4 kilolitres per kilogram of beans, most of which is used for irrigation during cultivation of the coffee plant[44]. Instant coffee requires more water per kilogram (39.4 kilolitres) because of the extra processing step, but as a lower weight of coffee product is used to make a cup of coffee, the water requirement per final cup is less than that of espresso. Eighty litres of water are needed overall for a

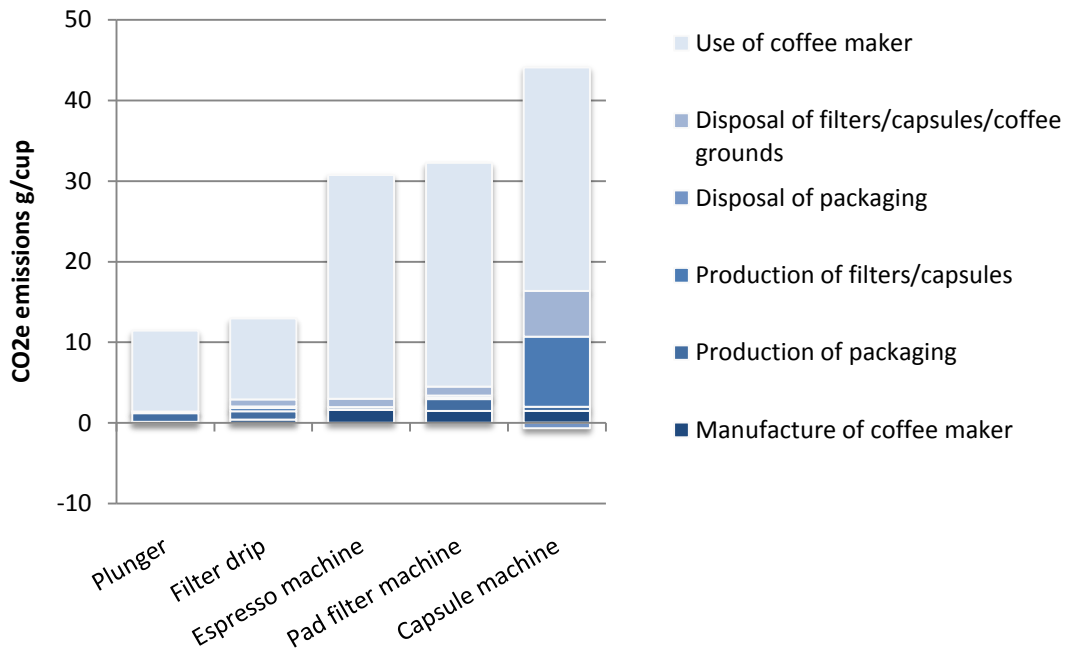
[40] Brommer et al. (2011) Footnote 39.
[41] As above.
[42] CleanMetrics Corp. (2011) *Coffee Drink: Latte (12 Oz) – Analysis Using FoodCarbonScope.* Presentation. http://www.cleanmetrics.com/pages/lattelca.pdf. Accessed 15 May 2011.
[43] Environmental Defense (2000) *Report for the Starbucks Coffee Company/Alliance for Environmental Innovation Joint Task Force.* http://www.edf.org/documents/523_starbucks.pdf. Accessed 13 May 2011.
[44] Chapagain AK, Hoekstra AY (2007) The water footprint of coffee and tea consumption in the Netherlands. *Ecological Economics* 64:109-118.

cup of instant coffee, but 140 litres are required to produce a single-shot cup of espresso[45]. The majority of this is used in the growing, washing and drying phase of producing green coffee beans.

The choice of coffee preparation method can significantly reduce or increase the environmental impact of a cup of coffee. Capsule-based coffee machines produce the most CO2e emissions, with most additional energy use due to production of the coffee capsules themselves (Figure 6[46]).

Figure 6 *CO2e emissions of different methods of preparing a cup of coffee in the home.*

The figure is redrawn from data in the resource at Footnote 44.



Emissions due to the energy requirements for electrical coffee-makers, shown above, are roughly equivalent to the entire on-farm production and processing emissions (shown in Figure 5), and around double the emissions from the preparation of coffee by manual methods such as filter, plunger or instant. In all cases, the energy used to brew the coffee is the hotspot compared to manufacture of the brewing device, and the packaging and disposal of waste. Another European study compared the life cycle impacts of instant coffee, drip and capsule coffee in the home and concluded that overall instant coffee has the smallest impact[47].

The footprint of purchased cups of coffee

Consumption of coffee at a café has a different environmental impact, and although there is no published research comparing the footprint of in-home and café-based coffee consumption, the ecological footprint of Canberra's 444[48] restaurants, clubs, drinking establishments and cafés is a

[45] Chapagain and Hoekstra (2007) Footnote 44.
[46] As above.
[47] Humbert *et al.* (2009) Footnote 33.
[48] ACTPLA (2011) *Planning for Canberra's Night-time Economies*. Research Paper. http://www.actpla.act.gov.au/__data/assets/pdf_file/0003/22665/Night-time_economy_research_paper.pdf. Accessed 10 May 2011.

significant hotspot for the ACT, making up 6% of the ACT's ecological footprint and ranking fourth amongst contributing sectors (Table 1). Of course coffee is only one item consumed at these places, but its footprint in the café or restaurant itself may be similar to most other food prepared and served in such places.

In the food service sector generally, most of the footprint is due to energy use for food preparation (34%) and heating and air-conditioning (28%)[49]. More specifically for coffee, an emissions audit by a coffee supply company in Victoria (Figure 7) found that gas and electricity, machinery and parts, and paper cups were the three hotspots for CO2e emissions, taking all emissions from coffee roasting to serving the coffee, including transport, into account[50]. Adding the takeaway cups and the sugar and coffee packaging together represented 16% of emissions. Avoiding the use of single-sachet sugar packets, teabags and disposable coffee cups by consumers can therefore significantly reduce the carbon footprint of takeaway coffee, with use of low-carbon re-usable coffee cups over a year being calculated to use one-third of the water, half the carbon and half the energy of paper cups for the average Australian consumer[51].

In the food service sector generally, most of the greenhouse footprint is due to the energy use for food preparation (34%) and heating and air-conditioning (28%).

Hotspots summary

In general and across the whole life cycle, the two hotspots for greenhouse gases are **on the farm**, especially in fertilisers and in **drying the beans**, and then in the **final use** phase. Not evident in the studies discussed here, but based on the evidence in other case studies in this report and in the Canberra context, the **car journey** to the shop or café is also likely to be a hotspot.

Within the final use phase, the use of **electronic coffee machines** is a hotspot, whether in the home or in a café or restaurant, and energy use for **heating and cooling cafes and restaurants** is also a hotspot when coffee is consumed outside the home.

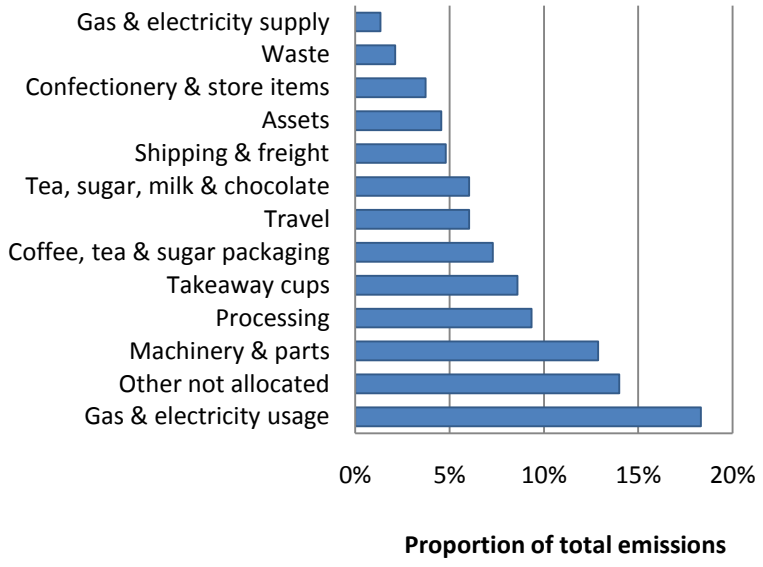
The footprint of **disposable cups** is significant.

The hotspot for water use is on farms where **irrigation** is used to grow the coffee.

[49] Victorian Employers' Chamber of Commerce and Industry (2010) *Small Business and Climate Change: What Affects You and What You Can Do.* Fact Sheet. http://www.vecci.org.au/IR_Advice/Tools-and-Templates/Business_Sustainability/Documents/041725_VECCI_FactSheets_Adjustment_V5.pdf. Accessed 10 May 2011.
[50] Jasper Coffee (2009) *Emissions Audit for Jasper Coffee*. https://www.jaspercoffee.com/about_us.jsp?id=9. Accessed 13 May 2011.
[51] KeepCup Pty Ltd (2010) Footnote 31.

Figure 7 CO2 emissions during a partial life cycle of a cup of coffee from its import to consumption in a café in Victoria.

The figure is redrawn from a figure in the resource at Footnote 50..



Social and ethical considerations

Because almost all the coffee drunk in western countries is imported from developing countries, concerns have been raised about employment conditions and prices paid to local farmers for their coffee. An international system, 'Fair Trade', accredits coffee produced under improved conditions for coffee farmers and workers and using more sustainable production methods (see below), but this accounts for only a small proportion of coffee drunk in Australia.

Your choices

About half the footprint of home-made black coffee is under the control of the producers and processors, and about half under the control of consumers in terms of choice of coffee making method and shopping patterns[52]. For home-made black coffee, not buying or using electronic coffee machines, especially the capsule type, is the most effective way to reduce emissions.

Adding cow's milk to coffee adds substantially to the footprint, so avoiding milk based coffees would be the most effective way of reducing the footprint of a cup of coffee. However, if the reduction in milk consumption is compensated for elsewhere in the diet with dairy products, for nutritional reasons, no saving is made.

For home-made black coffee … not buying or using electronic coffee machines, especially the capsule type

…avoiding disposable cups …

… shopping by car less often but in larger shopping baskets…

… using the car wisely in visiting cafes …

… consumers can choose to buy coffee that is accredited for the conditions under which the coffee is produced …

[52] Humbert et al. (2009) Footnote 33.

Avoiding disposable cups by choosing cafes that serve coffee in china cups, and using your own reusable cup for takeaways will also generally produce environmental benefits. Like other products for the home, shopping by car less often but in larger shopping baskets generally reduces footprints, and using the car wisely in visiting cafes will reduce the footprint of any car travel to them.

For those parts of the footprint that are outside the immediate control of the consumer, consumers can choose to buy coffee that is accredited for the conditions under which the coffee is produced (Table 2). Additionally, an increasing number of Australian cafés and coffee roasting companies are being accredited through the Carbon Reduction Institute, which acknowledges reduced or offset carbon emissions. Choosing to purchase accredited products also helps to build their market share and stimulate innovation across the sector. Some boutique coffee shops have also developed closer direct relationships with producers so that they can explain production methods and employment conditions to consumers.

Table 2 Choices of accreditation systems for coffee in Australia.

Title	Symbol	Key benefits
Rainforest Alliance www.rainforest-alliance.org		• Wide range of sustainable agriculture standards
FairTrade www.fta.org.au		▪ Minimum coffee price for farmers ▪ Money is re-invested in community infrastructure • Restrictions on chemicals
No CO2 www.noco2.com.au		• Carbon emissions calculated and fully offset
NASAA Organic www.nasaa.com.au		• Grown without the use of chemical fertilisers, herbicides or pesticides.

BEEF

Buying and use patterns

Australians consume about 40 kg of beef and veal each a year, 18 kg of pork, 6 kg of mutton and lamb and 31 kg of poultry[53]. As beef is the most popular source of meat, this account will focus on beef produced for the domestic market to illustrate the sustainability issues involved in the processes from meat production through to its delivery to consumers in Canberra. Australia exports an even larger amount of beef; it leaves Australia as chilled or frozen meat or as live animals.

Australians consume about 40 kg of beef and veal each a year

… buy their beef from supermarkets (65%), butchers (27%) or markets and delis (8%).

… a third is eaten outside the home …

Australian consumers buy their beef from supermarkets (65% by volume), butchers (27%) or markets and delis (8%)[54]. The typical purchase is therefore from a supermarket where there are high degrees of vertical integration, especially in the largest two chains, Woolworths and Coles. This means that the retailer has often sourced its meat by direct contract from the grower, although auctions at saleyards remain an additional source when their contract supply is low or prices are attractive.

Beef bought for home cooking is only two-thirds of the total consumed in Australia. About a third is eaten outside the home (e.g. in cafés, restaurants and takeaways); at events like football matches; in institutions like hospitals and residential care homes; and in cafeterias in places like factories and mines, boarding schools, universities, prisons and defence establishments[55].

Statistics from the USA suggest that consumers there do not eat 30% of meat they buy, and that 7% of meat in supermarkets is not sold and is discarded[56].

Flows of meat from paddock to plate

The major routes used to produce and deliver beef to consumers in Canberra are shown in Figure 8.

Beef production

Typical beef production in south-eastern Australia is of grazing on improved pastures, and feedlotting to finish. A small number of beef cattle are grown in the ACT, but they are commonly moved to feedlots in the grain-growing regions to the west of the ACT to improve weight gain and

[53] ABS cat. no. 4306.0 *Apparent Consumption of Foodstuffs, Australia, 1997-8 and 1998-1999*. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4306.0Explanatory%20Notes11997-98%20and%201998-99?OpenDocument. Accessed 2 Jun 2011.

[54] Meat and Livestock Australia (2010) *Australian Meat Purchasing Data July 2010*. http://www.mla.com.au/files/5f7836bd-05f8-4dbb-b162-9d9800e31f9e/australian-meat-purchasing-data-report-june2010.pdf. Accessed 3 Jun 2011.

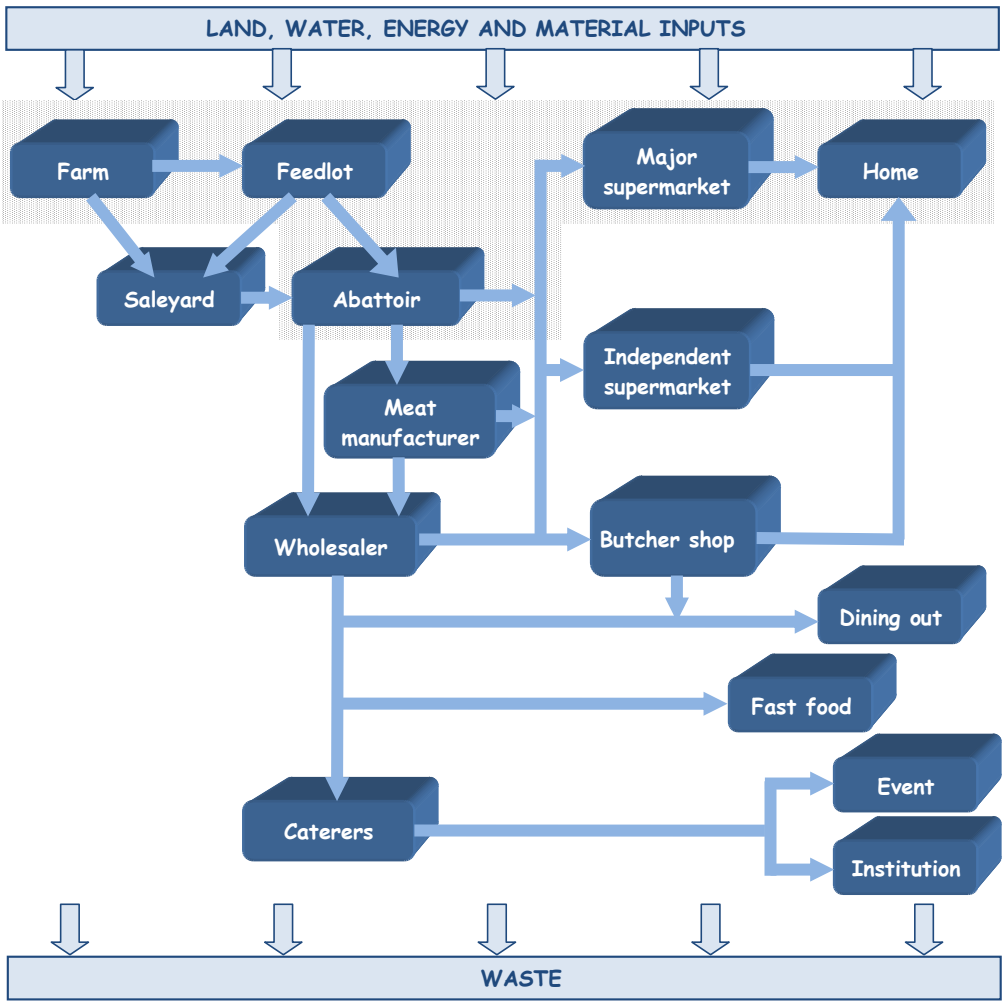
[55] Freshlogic (2007) FOODmap. *A Comparative Analysis of Australian Food Distribution Channels.* Department of Agriculture, Fisheries and Forestry. http://www.daff.gov.au/__data/assets/pdf_file/0003/298002/foodmap-full.pdf. Accessed 3 Jun 2011.

[56] Economic Research Service (2008) *Food Expenditure Tables*. United States Department of Agriculture http://www.ers.usda.gov/Briefing/CPIFoodAndExpenditures/Data/Expenditures_tables/. Accessed 3 Jun 2011.

condition over several months before slaughter. Feedlots tend to be located nearer the source of grain and abattoirs and away from urban populations.

Figure 8 Major flows of meat from paddock to plate in Canberra.

The shaded area represents the largest volume of flow.



The major supermarkets largely purchase their beef directly from farms or feedlots and after slaughter move the meat through a small number of very large distribution centres. The typical piece of beef bought by consumers in Woolworths in the ACT was probably grown anywhere from the north to the south of New South Wales and travelled in refrigerated trucks to Canberra via distribution centres in Wodonga or Sydney[57]. Meat bought at a butcher is more likely to have been grown and slaughtered in a nearer region and purchased by the butcher from a wholesaler. Only a few specialty butchers and restaurants know which farm their meat has come from.

[57] Wooworths (2008) *The Facts About Grocery Retailing at Woolworths*. http://library.corporate-ir.net/library/14/144/144044/items/287977/FactsAboutGroceRetailingatWoolworths.pdf. Accessed 6 Jun 2011.

Grazing of animals on non-irrigated pasture has a large land area footprint but an otherwise relatively small environmental impact as there is little ground cultivation or pest or weed control and relatively little direct energy use on the farm. It takes about 210,000 ha (equivalent to 90% of the area of the ACT) of typical southern tableland grazing area to provide the beef eaten annually in Canberra. Most animals are sent to a feedlot for a final fattening where the direct land area impact is small but they are fed grain grown on agricultural land, which involves larger energy and chemical use. Their nutrient rich effluent can also impact the health of waterways. Emissions of nitrous oxide and ammonia from the manure are also greenhouse gases.

It takes about 210,000 ha (equivalent to 90% of the area of the ACT) of typical southern tableland grazing area to provide the beef eaten annually in Canberra.

A more significant hotspot in beef production comes from their emissions of methane, a much more potent greenhouse gas than carbon dioxide. Methane (CH4) is a by-product of fermentation by microorganisms in the stomach of cattle (and other ruminants like sheep) that enables them to derive adequate nutrition from grass, which is otherwise very indigestible. Because methane has 25 times the greenhouse impact of CO2, and sheep and cattle do emit large amounts of methane, they contribute about 70% of agriculture's contribution to emissions and about 10% of all of Australia's greenhouse gases[58].

Like organic wheat production, there are relatively few certified organic producers of beef: about 270 out of 50,000 producers in 2005[59]. An Australian comparison of organic and conventional beef production[60] found that organic beef production had a significantly higher land area footprint (per $ value of product) but lower CO2e emissions over its life cycle.

Transport

Considerable movement of live animals and then their meat is involved in bringing a steak to Canberra. The number of saleyards and abattoirs has declined significantly in the last decade, partly due to reduced animal numbers during the drought and partly due to market forces making smaller enterprises less profitable. There are now only 60 saleyards in New South Wales and 25 abattoirs[61]; just seven of these that process meat for the domestic market are in the Capital Region (Bega, Cooma, Cootamundra, Gundagai, Harden, Moruya and Young). Once slaughtered, all transport and storage of meat needs to be refrigerated.

Footprints across the life cycle

A study comparing the CO2e emissions profile of lamb produced in New Zealand and the United Kingdom found that even with the addition of shipping NZ lamb to the UK, the much more intensive

[58] Department of Climate Change (2009) *National Greenhouse Gas Inventory. Accounting for the KYOTO target May 2009*. http://www.climatechange.gov.au/en/climate-change/~/media/publications/greenhouse-report/national-greenhouse-gas-inventory-pdf.ashx.Accessed 17 May 2011.
[59] Halpin D (2005) Footnote 11.
[60] Wood et al. (2006) Footnote 12.
[61] Yellow Pages http://www.yellowpages.com.au/. Accessed 6 May 2011.

production system in the UK led to four times the overall emissions of NZ grown meat[62]. The shipping phase contributed 18% of the footprint of NZ lamb. These results highlight the relative importance of the production phase in the life cycle of meat, and the relatively small contribution that transport makes overall. Similar conclusions have been reached in European beef production systems[63].

An Australian comparison of wholly grass-fed cattle and cattle finished in a feedlot indicated that greenhouse gas emissions are about 18% less for meat from feedlotted animals, primarily because the high feed quality reduces their methane emissions[64].

Hotspots summary

The production phase dominates the footprint of meat. Hotspots are **the land area** required for raising the animals and the **methane** that contributes to greenhouse gas emissions.

Social and ethical considerations

Some people have an ethical position that animals should not be killed to provide meat for humans, or that animals should be fed grain when people elsewhere in the world don't get enough to eat.

There are also animal welfare issues in raising, transporting and killing animals. Regulations about minimum standards of care are in place in Australia, but some would argue that these are insufficient, for example cattle can be kept confined in feedlots at high density, often without shade or winter shelter and with high concentrations of manure on the ground.

Your choices

There is insufficient environmental impact data and product labelling to make a general conclusion about the better options for general meat buying in Canberra. Meat from a butcher is more likely to come from a nearer region, and staff are more likely to be able to provide information about its origin than staff in a major supermarket.

Certified organic meat will have involved reduced on-farm impact in terms of chemical use, but not land use.

One choice that can be exercised over beef consumption is to reduce the amount eaten. Reductions in meat consumption, especially red meat, are commonly recommended for health reasons in Western countries. A study in Scotland indicated that changing from the average diet actually eaten to one that is nutritionally recommended, but

…insufficient data and labelling to make a general conclusion …

… reduce the amount eaten…

There is no uncertainty about the benefits of reducing the amount of meat wasted …

… use the car wisely for shopping …

[62] Saunders C, Barber A, Taylor G (2006) *Food Miles – Comparative Energy/Emissions Performance of New Zealand's Agriculture Industry.* Research Report 285. Lincoln University. http://www.lincoln.ac.nz/documents/2328_rr285_s13389.pdf. Accessed 16 June 2011.

[63] Wolf O, Perez-Dominguez I, Rueda-Cantuche JM, Tukker A. Kleijn R, de Koning A, Bausch-Goldbohm S, Verheijden M (2011) Do healthy diets in Europe matter to the environment? A quantitative analysis. *Journal of Policy Modelling* 33: 8-28.

[64] Peters GM, Rowley HV, Wiedemann S, Tucker R, Short M, Schulz M (2010). Red meat production in Australia: life cycle assessment and comparison with overseas studies. *Environmental Science & Technology* 44: 1327-1332.

still includes some meat and dairy, would reduce the ecological footprint by about 15%[65]. A healthy vegetarian diet would reduce the footprint a further 18% ie a 33% reduction from the current average diet – from 0.75 to 0.5 gha. A European study calculated a somewhat smaller decrease of 8% in the environmental footprint of food if the average diet shifted to a more Mediterranean diet containing less milk and meat, and more fish, fruit and vegetables[66].

Choosing other types of meat is another potential option for reducing the relatively high footprint of beef. For example, pork and chicken have lower methane emissions and higher feed conversion efficiencies, but they do rely on being fed grain for their whole lives, compared to beef cattle which graze predominantly on rainfed pasture in Australia. Kangaroos also have lower methane emissions.

A final option is to reduce the amount of meat wasted at home by eating leftovers or extending the life of purchased but unused meat by making it into soups or stews that can be stored or frozen for later use.

Finally, like the previous products, use the car wisely for shopping.

[65] Frey S, Barrett J (2006) The *Footprint of Scotland's Diet. The Environmental Burden of What We Eat*. http://www.wwf.org.uk/filelibrary/pdf/the_footprint_of_scotlands_diet.pdf. Accessed 10 Jun 2011.
[66] Wolf et al. (2011) Footnote 53.

TOMATOES

Buying and use patterns

Fresh tomatoes are the third most popular vegetable[67] in Australians' weekly shop, after carrots and potatoes[68]. Between home and eating out, we each account for about 6 kg of fresh tomatoes grown every year. In addition, we account for a further 20 kg of tomatoes that have been processed into products with longer shelf-life[69]. These include tinned and pureed tomatoes, tomato pastes and tomato sauce, and like fresh tomatoes, they're used in food both in the home and in eating out.

If you are a Canberra resident, you are most likely to shop for fresh tomatoes in a supermarket or grocery store. Sixty-six percent of the money we spend in Canberra on food is spent this way, and only 8% is spent in other retail outlets like greengrocers and markets. The other 26% of our food dollar is spent in cafés and restaurants (18%) and on fast food (9%)[70].

It is also highly likely that your fresh tomatoes have come from Queensland. Queensland grows nearly all the eating tomatoes sold in the wholesale markets of Brisbane, Sydney and Melbourne[71], or supplied directly from the grower to the major supermarkets in eastern Australia. Only 6% of Canberrans report that markets are their preferred place for food shopping[72] and where it is more likely that produce will have been grown locally.

Of the 20 kg of tomatoes used for processed products, 12 kg will have been grown in Australia and 8 kg overseas. Northern Victoria and southern NSW produce almost all Australian processing tomatoes[73], and Italy supplies 70% of imported processed tomatoes[74]. Italian tomatoes are mostly the Roma variety which is not suited to the high rates of mechanisation used in the Australian processed tomato industry. The life cycle analysis of the typical tomato eaten in Canberra therefore begins with the production systems typical of fresh tomatoes grown in Queensland, or of processing tomatoes grown in Victoria or in Italy.

---

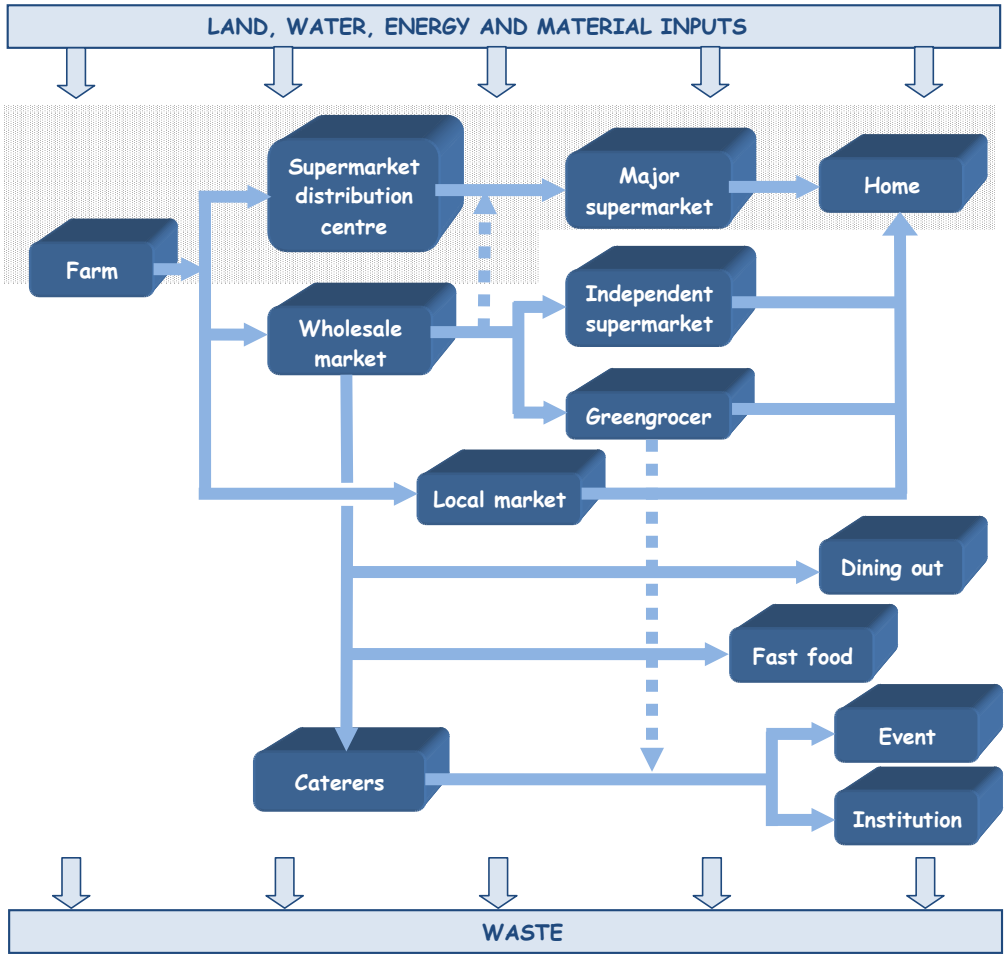
[67] Technically tomatoes are a fruit but they are eaten and classified for data collection as a vegetable.
[68] AUSVEG (2011) Top 10 most popular fresh vegetables revealed. http://ausveg.com.au/_webapp_781778/Top_10_most_popular_fresh_vegetables_revealed. Accessed 15 May 2011.
[69] Calculated from ABS population data cat. no. 3101.0, ABS agriculture data cat. no. 7121.0 2009/10 and Mann (2007) Annual Industry Survey. In *Australian Processing Tomato Grower* 28:5-7.
[70] Department of Agriculture, Fisheries and Forestry (2011) *Australian Food Statistics 2009-2010*. http://www.daff.gov.au/__data/assets/pdf_file/0011/1910819/food-stats2009-10.pdf. Accessed 12 May 2011.
[71] Fullelove G, Wright R, Meurant N, Barnes J, O'Brien R, Lovatt J (1998) *Tomato Information Kit.* Agrilink Series QAL9805. Department of Primary Industries, Brisbane. http://era.deedi.qld.gov.au/1655/. Accessed 8 May 2011.
[72] Sensis (2009) *Consumer Report.* http://about.sensis.com.au/IgnitionSuite/uploads/docs/March2009SensisConsumerReport.pdf. Accessed 15 May 2011.
[73] ABS cat. no. 7121.0 http://www.abs.gov.au/ausstats/abs@.nsf/mf/7121.0.
[74] Apted S, Berry P, Short C, Topp V, Mazur K, Van Mellor T (2006) *International Competitiveness of the Australian Vegetable Production Industry* ABARE eReport 06.5, Canberra. http://adl.brs.gov.au/data/warehouse/pe_abarebrs99001252/pc13401.pdf. Accessed 12 May 2011.

Product flow

The major routes that fresh tomatoes take to reach a consumer in Canberra are shown in Figure 9. The route for processed tomatoes is not shown but for Australian processed tomatoes it essentially needs an additional step between farm and distribution centre and the products are then distributed through the usual grocery distribution pathways. Imported processed products arrive at Australian ports and are then similarly distributed.

Figure 9 Major flows of fresh tomatoes from farm to the place of consumption.

The shaded area represents the most typical for Canberra.



Production

Tomatoes are very sensitive to frost and yield best in warmer climates. Most tomatoes grown in Australia are grown outdoors[75] because it is less costly than growing them in greenhouses and the climate is warm enough. Fresh tomatoes in Queensland are grown year round using different locations depending on the season. They are mostly grown on a trellised system and require hand-

[75] Rural Industries Research and Development Corporation http://www.rirdc.gov.au/programs/established-rural-industries/pollination/tomatoes.cfm. Accessed 2 Jun 2100.

picking as well as on-farm facilities for washing, ripening and keeping them cool; tomatoes for processing in Victoria are grown on the ground, irrigated with trickle irrigation, and picked just once by machine.

A detailed life cycle analysis of typical Australian grown tomatoes has not been done.

A detailed life cycle analysis of typical Australian grown tomatoes has not been done. Like most other horticultural crops, inputs of fertiliser, chemicals, water, equipment and labour are relatively high but the fact that most Australian tomatoes are grown outdoors means the footprint is likely to be less than in countries where tomatoes are mostly grown in greenhouses with higher embodied and operating footprints. Each of those inputs, like fertiliser, has its own upstream environmental impacts. Fertiliser manufacture requires considerable energy. One Australian study found that the energy used to transport fertiliser to a typical Australian farm is less than 1% of the energy used to manufacture the fertiliser[76].

There is also likely to be considerable variability between farms in their environmental impact, depending on their location and farm practices. Through their industry groups, vegetable farmers in Australia are encouraged to improve the sustainability of their farming practices. A grower body, Ausveg, provides a manual and self-assessment checklist of 171 farm activities that impact on sustainability[77]. Just ten of those 171 activities are shown in Box 1 to illustrate the types of activities that would have to be independently assessed on every farm and incorporated into a labelling system if consumers were to be able to choose between food produced in a more rather than a less sustainable fashion. However, this is a purely voluntary scheme which is not independently audited, and nor does the information accompany the product to market. Therefore consumers largely can't choose tomatoes whose production history is known.

While a small percentage of Australian farms do have their production systems certified as organic, and this is a choice for consumers willing to seek these products out, this doesn't apply to the bulk of food available. Organic vegetable farms do have significantly lower energy and water footprints compared to conventional vegetable farms[78].

An example of the variability between farms in tomato production comes from a comparative study of a hi-tech greenhouse production system in northern NSW and a medium-tech greenhouse system near Sydney. (These systems account for much less total production than the Queensland outdoor grown tomatoes.) The medium-tech system had a water footprint of 21 litres/kg tomatoes, compared to 2 litres/kg in the hi-tech system[79]. The difference was due partly to more recycling in the hi-tech system, and partly to inclusion in the footprint of data that relates to the relative availability of the water in the two places. However, moving production to northern NSW because its water footprint is lower would cause its transport energy footprint to increase because of a longer transport distance to Sydney.

---

[76] Wood et al. (2006) Footnote 12.

[77] AUSVEG EnviroVeg Self Assessment http://ausveg.com.au/enviroveg/self_assessment.htm Accessed 19 May 2011.

[78] As above.

[79] Page G, Billoti B, Ridoutt B (2010) Using Life Cycle Assessment (LCA) to assess water use in tomato production. In: Food Security from Sustainable Agriculture. Edited by H. Dove and R. A. Culvenor. *Proceedings of 15th Agronomy Conference 2010*, 15-18 November 2010, Lincoln, New Zealand. http://www.regional.org.au/au/asa/2010/farming-systems/energy-balance/7142_page.htm. Accessed 8 May 2011.

Box 1 A selection of the detail considered in assessing the 'Water and Waterways' category of on-farm sustainability of vegetable production in Australia. Other categories include Energy, Soil, Biodiversity, Chemical Management, Waste, Pests and Diseases. From EnviroVeg self-assessment checklist (Ausveg website).

- Water for irrigation from sources that may cause environmental harm to land and soil, waterways and sensitive areas is managed or treated to minimise the risk of environmental harm.
- The irrigation schedule is based on: weather predictions; water stress symptoms; actual rainfall using rain gauges; wetting front detectors or soil moisture probes.
- The irrigation system is: efficient and minimises water use; causes minimal soil erosion, and minimises energy use.
- Incoming and drainage water in hydroponic systems is monitored for pH and electrical conductivity.
- Water loss is minimised by checking for and repairing leaks on a regular basis.
- Evaporation is minimised from storages and delivery systems.
- Water is recycled where possible.
- Pests are managed in water storages and waterways - including algae, weeds, pest animals and diseases.
- Water discharged from the property is managed or treated to minimise off-site environmental harm.
- Runoff and tail water is channelled into sumps, settling ponds or grassed channels before it goes into storage.

Such "tradeoffs" between different components of the footprint are common. Another example is installing more efficient irrigation systems that rely on pumps to pressurise and move water around. This achieves water savings but increases the use of energy. Unless the energy is coming from a renewable source, an improvement in this water footprint would come at the cost of an increase in greenhouse gas footprint. Storage of food in home freezers is another. This can reduce the number of shopping trips and wastage of food, but it increases energy use.

Transport

The long distances that our fresh tomatoes travel to reach Canberra would often be thought to be a hotspot in their footprint. However, despite the distance, the energy footprint of food transport is only a part of all the energy used to produce and process and deliver it, especially when the embodied energy of all inputs in the life cycle is included. The reason for this is that transporting goods in bulk is extremely efficient. While large trucks emit more greenhouse gases per vehicle than cars (about 5 times more per kilometre) they carry on average about 28,000 kg in goods. Therefore, for the same quantity of emissions a car produces in travelling 10 km to and from the supermarket to purchase 1 kg of shopping, an averagely-laden articulated truck can travel about 50,000 km (Scenario A, Table 3)[80]. This is some 25 times the 2,200 km distance from Bowen in Queensland to Canberra via Sydney. Even if the 1 kg of tomatoes is bought as part of a 10 kg shop, the car shopping trip is still more than twice as costly in terms or emissions as the truck trip from Queensland.

[80] See Appendix 1 for statistics and data sources used in the calculations.

Table 3 Car and articulated truck transport scenarios.

See Appendix 1 for data sources and statistical bases of the calculations.

	Car	Articulated truck	Unit
SCENARIO A, Emissions from a 10 km car round shopping trip to buy 1 kg tomatoes and from 1 kg tomatoes being transported the same distance in an averagely laden articulated truck (the impact of its return journey is attributed to the goods it carries on another averagely laden journey).	2.656	0.00052	kg CO2e
SCENARIO A. Equivalent distance of transport by truck for the same emissions as car journey.	10	50,630	km
SCENARIO B, As for A, but in the car journey the 1 kg tomatoes are part of a larger 10 kg shopping basket and the footprint of the other 9 kg is assigned to the other items.	0.265	0.00052	kg CO2e
SCENARIO B. Equivalent distance of truck journey for the same emissions as car journey.	10	5,063	km

Other studies have reached similar conclusions. It takes more energy for a UK consumer to drive 6.5 miles to buy green beans than it takes to fly the beans from Africa[81]. In Victoria, in a "farm-to-fork" analysis of the greenhouse emissions from transport of fruit and vegetables within the state, 5.5 km was the critical distance (11 km return) for the shopping trip by car; if more than that, the car journey begins to outweigh the longer distances involved in bringing produce from the country to the city[82]. These findings are very dependent on the average distance that consumers travel to shop and the size of the shopping basket; if the distance is reduced or the number of trips in the week is reduced then the longer distances travelled to bring the product to the store do become significant.

It has already been noted (see bread case study) that freight transport accounts for a relatively small part of the life cycle emissions of food products. A study of the life cycles of a number of food products in the USA found that only 6% of the emissions footprint was due to freight transport (using 1500 miles as the average distance)[83]. Over 80% of the footprint was due to food production and processing. This analysis included the contribution of home cooking, which is not frequently done. They estimate this was responsible for 8% of emissions. Transport for shopping trips is not always included in footprint analyses because it is hard to estimate accurately.

These findings mean that using food miles and promoting local production solely because transport distances are reduced is a poor indicator of sustainability in terms of energy use and greenhouse gas.

[81] UK Cabinet Office (2008) Cited in Hogan L and Thorpe S (2009). *Issues in Food Miles and Carbon Labelling*. ABARE Research Report 09.18. http://adl.brs.gov.au/data/warehouse/pe_abarebrs99001677/foodmiles.pdf. Accessed 14 May 2011.

[82] Marquez, L Higgins A, Estrada-Flores E (2010) *Understanding Victoria's Fruit and Vegetable Freight Movements.* CSIRO. http://www.ecoinnovationlab.com/uploads/attachments/398_Understanding%20Vic%20F&V%20Freight%20Movements.pdf. Accessed 14 May 2011.

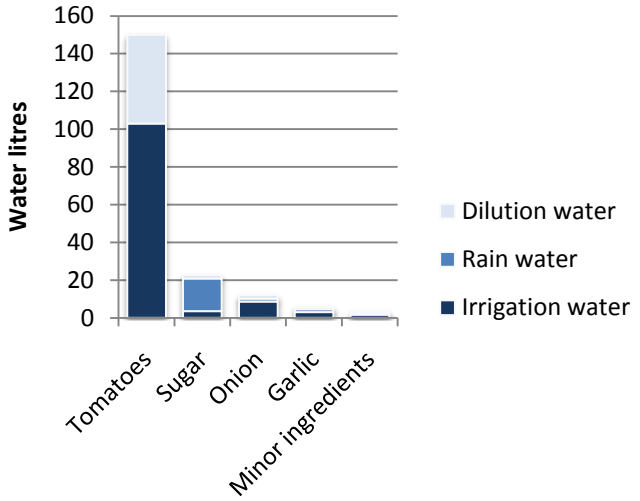
[83] Wakeland W, Cholette S, Venkat K (2011) Food Transportation Issues and Reducing Carbon Footprint. In *Green Technologies in Food Production and Processing* (ed: Arcand Y & Boye J) Springer. http://www.cleanmetrics.com/pages/Ch9_0923.pdf Accessed 3 Jun 2011.

Processing

For processed tomatoes there could be an additional footprint of the energy and water used in processing, and the upstream impacts of the added ingredients (e.g. salt, sugar, the buildings, machinery and packaging), the waste water from the factory and the disposal of the packaging. However, an Australian study[84] of the water footprint of an Australian pasta sauce found that it was dominated by the water used in irrigation to grow the tomatoes (Figure 10).

Figure 10 Water used during the life cycle of processed tomatoes.

The data refer to a 575 g jar of Dolmio© pasta sauce. Dilution water is the water needed to dilute excess nutrients from fertilizers to avoid damage to groundwater. Rainwater includes water used in the processing plant. The figure is redrawn from data in the resource at Footnote 34.



A study in Europe found that packaging and food processing were generally hotspots in the full life cycle of tomato sauce[85], depending on the measure of impact used. These steps had much larger impacts than transport, despite the tomatoes being grown and processed into paste in the Mediterranean, and then made into tomato sauce in Sweden. Like the examples mentioned earlier, this study also found that energy used by consumers in cars to shop for the product was larger than all the transport energy used in the steps before that.

Hotspots summary

For fresh tomatoes bought in Canberra, the hotspots for energy use and CO2e emissions are most likely to be in the final **retail and shopping trip**, followed by **fertiliser use** in the farming step.

For processed tomatoes the water hotspot is in **irrigation on the farm** and greenhouse hotspot is in the **final retail and shopping trip**; with an additional hotspot for the **processing step**.

Social and ethical considerations

A tomato consumer might also like to consider particular social aspects associated with the life cycle of tomatoes. In Australia, one study found that horticulture was a higher on-farm employer of people, per dollar value of product, than any other agricultural product[86], so buying Australian

[84] Ridoutt BG, Eady SJ, Sellahewa J, Simons L, Bektash R (2009) Water footprinting at the product brand level: case study and future challenges. *Journal of Cleaner Production* 17:1228-1235.
[85] Andersson K, Ohlsson T, Olsson P (1999) Screening life cycle assessment (LCA) of tomato ketchup: a case study. *Journal of Cleaner Production* 6:277-288.
[86] Wood *et al.* (2006) Footnote 12.

tomatoes does contribute to regional economies. There was little difference between employment on organic and non-organic farms for horticultural crops.

In relation to imported tomato products, which come mostly from Italy, their price competitiveness in Australia derives mostly from access to low cost labour from northern Africa and from Albania and a little from subsidies available within the European Union[87]. Even knowing this, a consumer would have to weigh up whether an employment opportunity for these people, even at low pay, outweighs no employment opportunity for them in their own countries. On the other hand, consumers might place more value on employment in Australia. As mentioned for bread, food processing in non-metropolitan Australia is a significant employer in some regional communities.

Your choices

Lack of Australian studies of the life cycle impacts of tomatoes, and lack of labelling that reflects the particular life cycle impacts of tomatoes at the point of sale means only very general conclusions can be drawn about making more sustainable buying choices. Like many other consumer products, there is good leverage on reducing impact by reducing energy expenditure in the end steps of retailing and car use for shopping. Shopping less often but buying more each time is effective, as is combining shopping trips with other reasons for using the car. Using public transport, riding a bike or walking are other options.

Lack of Australian studies and … lack of labelling mean only very general conclusions can be drawn …

… reducing impact by reducing … car use for shopping

Consumers might like to choose **fresh tomatoes** that were produced locally, in order to support the regional economy, but this is not an option for most Canberra consumers buying tomatoes from supermarkets. Farmers' markets do provide local and regionally grown tomatoes. As they are usually held outdoors or only semi-covered these markets provide an opportunity to avoid the energy involved in heating and cooling supermarkets and shops. However, the greenhouse impact of individual producers transporting produce in vans or small trucks with relatively high emissions means that their transport emissions in this case can become high if they come from some distance away. In this case, and all other things being equal (e.g. the tomatoes are all outdoor grown or all greenhouse grown, and used the same amounts of water and fertiliser), lower food miles will translate to lower greenhouse impact. Because there are few farmers' markets in Canberra, making a long car journey to shop at them is likely to significantly add to impact.

For **processed tomatoes** purchased in a shop, the country of origin must be stated on the label, so consumers can choose to buy either Australian or imported products. Imported tomato products will likely have higher transport emissions (although shipping is very efficient) and there's insufficient other information about the footprint of their production overseas to make a definitive conclusion about their whole life cycle impact compared to Australian processed tomatoes. Consumers can exercise this choice in a shop, but not when buying tomatoes as part of a meal e.g. in a pizza.

[87] Wood *et al.* (2006) Footnote 12.

TELEVISION SETS

Buying and use patterns

Australians own on average 2.4 television sets per household – almost exactly one television per person[88]. We also purchase over 3.1 million new television sets per year[89]. Each television is in use by at least one household member for between 5 and 8 hours each day, with average weekly use per person around 13.3 hours[90].

Australians own … 2.4 television sets per household.

The average lifespan of Australian televisions sets has reduced from 10 years in 1995 to an estimated 7 years in 2013.

The average lifespan of Australian television sets is decreasing rapidly. Due to the shift to digital and high definition television, as well as the introduction of new projection technologies such as liquid crystal displays (LCD) and plasma display panels (PDP), the lifespan of an average television set has reduced from 10 years in 1995 to an estimated 7 years in 2013[91] as older Cathode-Ray Tube (CRT) displays are rapidly replaced.

Production

The last Australian-made television sets were produced in 2006, before Panasonic shut down their last Australian television set manufactory[92]. Since then, all television sets bought in Australia have been produced overseas, with 74% of Australian sets being produced by Sony, Samsung, LG, Panasonic and Sharp. Australian households imported $3.251 billion of televisions in 2009 alone – an average of $147 per person[93].

The last Australian-made television sets were produced in 2006.

Manufacturing of television sets is an extremely complex production process, with assembly largely occurring in China[94]. Most individual components, such as the LCD displays, are made elsewhere in South-East Asia, with Korea and Taiwan having the largest shares of the LCD display manufacturing market with 44% and 34% respectively[95]. The LCD display alone contains glass, silicon dioxide, indium tin oxide, various polymers and the liquid crystal itself. Although by weight television sets are predominantly made up of glass and plastic (Table 4[96]), they also contain toxic and rare chemicals and metals, including lead, mercury, arsenic and cadmium[97].

---

[88] The Australian Greenhouse Office (2007) *Television Energy Performance Standards and Comparative Energy Labels.* http://www.energyrating.gov.au/library/details2007-factsheet-tv.html. Accessed 12 May 2011.
[89] Environment Protection and Heritage Council (2009) *Decision Regulatory Impact Statement: Televisions and Computers.* http://www.ephc.gov.au/sites/default/files/PS_TV_Comp__Decision_RIS__Televisions_and_Computers__200911_0.pdf. Accessed May 2011.
[90] Nielsen (2008) *Aussie Internet Usage Overtakes TV Viewing for the First Time.* News Release. http://www.nielsen-online.com/pr/pr_080318_AU.pdf. Accessed 17 May 2011.
[91] Environment Protection and Heritage Council (2009) Footnote 89.
[92] As above.
[93] As above.
[94] Digitimes Research (2007) *FPD Report – Taiwan LCD Monitors.* http://www.digitimes.com/Reports/PDF/MONITOR4Q07.pdf. Accessed May 2011.
[95] Chen J and Chen Y (2009) *A System Dynamics Model of the TFT LCD Industry Development in Taiwan.* System Dynamics Society 2009 Conference. http://www.systemdynamics.org/conferences/2009/proceed/papers/P1171.pdf. Accessed 30 May 2011.
[96] Environment Protection and Heritage Council (2009) Footnote 89.
[97] As above.

Table 4 Major material composition of CRT (cathode ray) and FPD (flat panel) television sets.

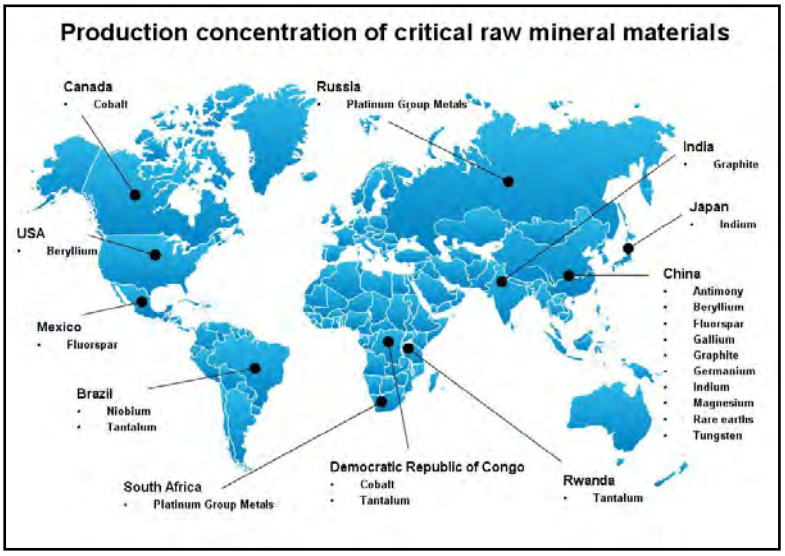
The data is from the resource at Footnote 96.

Material	CRT kg	% of total	FPD kg	% of total
Glass	17.80	67	6.27	22
Plastic	4.86	18	8.59	30
Copper	0.97	4	0.88	3
Iron	0.59	2	4.13	15
Aluminium	0.22	1	1.78	6
Steel/Other metals	0.09	0	5.92	21
Other	2.12	8	0.78	3
Total	**26.65**	**100**	**28.35**	**100**

These raw materials are sourced from all over the globe, as shown in Figure 11[98]. A number of these materials are also in short supply, with lead supplies expected to run out in 42 years, and copper deposits expected to be depleted in 61 years.

Figure 11 Sources of rare minerals used in television sets.

The figure is reproduced from the resource at Footnote 98.



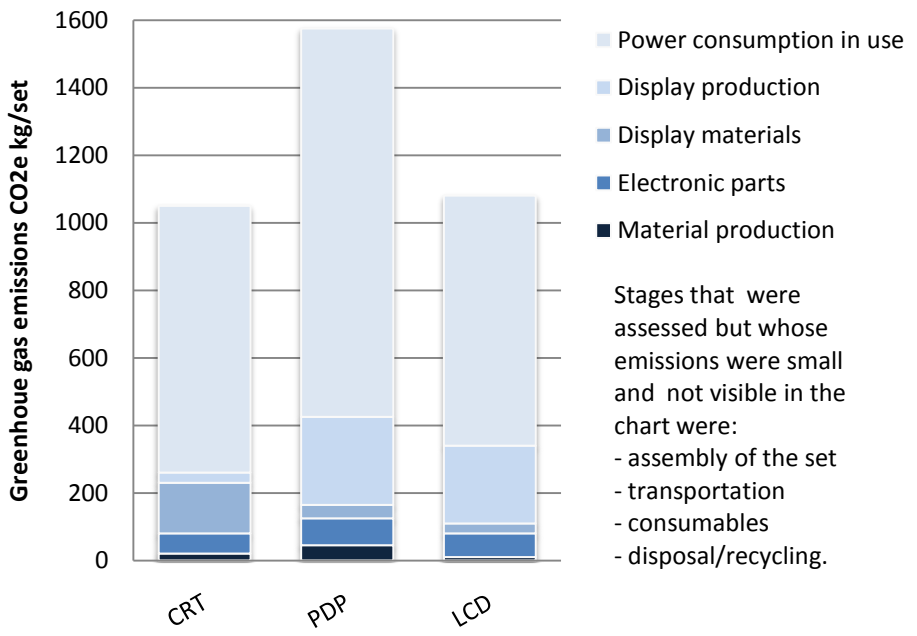
[98] Environment Protection and Heritage Council (2009) Footnote 89.

Footprints across the life cycle

There are a number of ways in which use and consumption of television sets impacts on the environment. Few television manufacturers calculate or disclose the carbon and water footprints of their products, however a recent analysis of a 29" LCD television set has estimated that its production, use and disposal has a footprint of 62,000 litres of water[99]. Data from another life cycle comparison of the average emissions of CRT, PDP and LCD televisions is shown in Figure 11, with another assessment calculating a total carbon footprint of 1241kg of CO2e for a 32" LCD television[100].

Figure 12 Greenhouse gas emissions from different types of television screens.

CRT=cathode ray, PDP=plasma, LCD=liquid crystal. The figure is redrawn from the resource at Footnote 100.



Although the lifespan of television sets is shortening, the energy required for both television use and the 'stand-by' mode of an LCD television comprises over 60% of the total CO2e emitted during a television's life-cycle[101]. This share is set to increase as Australians continue to buy larger, high-definition television sets, which consume much higher levels of electricity[102].

Although the carbon footprint of a television set varies significantly depending on screen size and display technology, the bulk of the emissions occur through consumer use, irrespective of the

[99] Symons D (2009) *Is Water More Important Than Carbon in a Climate Changed World*? *Environmental Law & Management* 21:142-144.
[100] Lin W (2009) *Experience Sharing of the Carbon Footprint of TFT-LCD Panels*. Presentation for AUO, Hsinchu, Taiwan http://www.ftis.org.tw/active/download/2_4.pdf. Accessed 27 May 2011.
[101] As above.
[102] Energy Consult Pty Ltd. (2009) *Baseline TV Power Consumption 2009.* Prepared for Department of the Environment, Water, Heritage and the Arts. http://www.energyrating.gov.au/library/pubs/200919-tv-power-consump.pdf. Accessed 4 May 2011.

television type[103]. As Australia is highly dependent on fossil fuels for electricity supply, the rates of both in use and standby power consumption should be the main environmental considerations when purchasing a television. In general, plasma displays range from 150 to 400 or more watts, whereas LCD displays range from 100-275W[104]. From 2009 television sets imported to Australia must display an energy rating, which states the television set's energy consumption in kilowatt hours, on average, per year[105]. Approximately 1kg of CO2 is emitted for each kWh consumed in the ACT, although households can choose to have their power supplied from renewable sources[106].

Disposal

Australians disposed of 1.5 million television sets in 2008, and are projected to dispose of 2.5 million in 2012. As a waste product, televisions contain a number of hazardous chemicals, such as lead, mercury, cadmium and brominated flame retardants[107]. Over 88% of Australian television sets currently end up in landfill[108], however in the ACT television recycling has been mandatory since 27 April 2010. A lack of regulation of e-waste recycling in the past has resulted in large quantities being processed in developing countries (Figure 13)[109]. A national E-waste recycling scheme is due to be rolled out in eight Australian cities, including Canberra, in 2011[110].

Figure 13 Global flows of e-waste.

The figure is reproduced from the resource at Footnote 109.

[103] Aoe T (2003) Case Study for Calculation of Facto X (Eco-Efficiency) – Comparing CRT TV, PDP TV and LCD TV. Discussion Paper for EcoDesign 2003. http://keskkond.ttu.ee/doc/Case%20study%20TV.pdf. Accessed 13 May 2011.
[104] Energy Consult Pty Ltd. (2009) Footnote 102.
[105] Department of Climate Change and Energy Efficiency (2000) *Fact Sheet – Mandatory TV Labelling and MEPS*. http://www.energyrating.gov.au/pubs/factsheet-tv-labelling.pdf. Accessed 1 May 2011.
[106] Blakers A (2008) *Deep cuts in household greenhouse gas emissions.* http://cses.anu.edu.au/files/0809_greenhouse_emissions_from_home.pdf. Accessed 21 May 2011.
[107] Environment Protection and Heritage Council (2009) Footnote 102.
[108] Australian Bureau of Statistics (2010) *Australia's Environment Issues and Trends.* http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/41D729B432E03FA0CA2576B800164E89/$File/46130_2010.pdf Accessed 10 May 2011.
[109] UNEP/GRID-Arendal (2004) *Who gets the trash?* UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/who-gets-the-trash. Accessed 2 June 2011.
[110] Department of Sustainability, Environment, Water, Population and Communities (2011) *National Television and Computer Product Stewardship Scheme – Consultation Paper on Proposed Regulations.* http://www.environment.gov.au/settlements/waste/ewaste/consultation/pubs/ps-ewaste-consultation-paper.pdf. Accessed May 2011.

Hotspots summary

The environmental hotspot for the average television bought and used in Canberra is in its **greenhouse gas impact through its use in the home** due to the high reliance in Canberra on fossil energy for electricity.

Social and ethical considerations

The major social concerns with television manufacture and disposal are the working conditions of people in developing countries who mine and process the raw materials that go into television sets, work in the factories that make the sets or their components, or are involved in their recycling. Many of these countries have poor health and safety regulations and consequently workers are often exposed to high levels of toxic chemicals. Workers may also have few other employment opportunities and be poorly paid. The country where the set is finally assembled is required to be identified by Australian labelling laws, but as discussed above, their components and their disposal touch a very large number of countries, mostly in the developing world.

Your choices

As most power consumption occurs through use, buying renewable energy at home is the most effective approach to reducing the environmental footprint of a television set. Power can also be saved by turning television sets, as well as set top boxes and home entertainment units off at the wall, rather than putting them on standby mode. Although television sets sold after 2012 in Australia must have less than a 1-watt stand-by mode, some older sets consume as much as 19.7 watts when on standby, which is more than some compact fluorescent light bulbs[111].

The second most effective choice for a television buyer is choice of screen type. Of the three dominant display types available, it is predicted that LCD will continue to dominate the global market[112], partly because plasma displays in general have higher electricity consumption for the same screen size[113] and partly because CRTs have become superseded by newer technologies and are bulkier and more costly to transport. If you are not using renewable energy in the home, an LCD screen probably has the lowest impact. If you are using renewable energy, your choice can be shaped by other preferences because there will be relatively little difference in impact of the different screen types.

… buying renewable energy at home is the most effective approach to reducing the environmental footprint of a television set.

Power can also be saved by turning television sets … off at the wall.

.. an LCD screen probably has the lowest impact..

… buy one that includes Automatic Brightness Control.

… not buying a set that is any larger than necessary for the viewing distance ..

… waiting a while to buy the next new set … or buying a second-hand one

[111] International Energy Agency (2009) *Gadgets and Gigawatts – Policies for Energy Efficient Electronics.* http://www.iea.org/textbase/nppdf/free/2009/gigawatts2009.pdf Accessed 2 May 2011.
[112] Park W, Phadke A, Shah N, Letschert V (2011) *Energy Consumption Trends and Efficiency Improvement Opportunities in Television.* Draft Working Document. http://ies.lbl.gov/drupal.files/ies.lbl.gov.sandbox/SEAD_TVAnalysis_Draft_Working_Document.pdf Accessed 22 April 2011.
[113] Hischier R, Baudin I (2010) LCA study of a plasma television device. *International Journal of Life Cycle Assessment* 15:428-438.

An additional feature to consider if purchasing a new television set is to buy one that includes Automatic Brightness Control. This adjusts the brightness of the display to suit ambient light and can cut backlight power consumption by as much as 30%[114]. Also, as screen size has a significant impact on energy consumption, impact can be reduced by not buying a set that is any larger than necessary for the viewing distance required.

Finally, waiting a little longer to buy the next new set (display technologies are rapidly changing and power consumption is quickly improving due to government regulation and technological innovation) or buying a second-hand one are also options for reducing the environmental impact of having a television.

[114] Texas Advanced Optoelectronic Solutions (2009) *Turning HDTVs Green.* http://www.lcdtvassociation.org/images/TAOS_Turning_HDTVs_Green_White_Paper10302009.pdf. Accessed 2 May 2011.

PAPER BOOKS

Buying and use patterns

Australians purchase over 80 million new books through Australian retailers (mostly from bookshops) each year, at a cost of $1.4 billion dollars[115]. Actual book consumption rates are higher than this however, with Australians increasingly purchasing books online through overseas suppliers, which are not included in Australian data. Australian titles account for roughly 60% of total book sales, although 4% of Australian published books are acquired through overseas suppliers[116]. On average, each Australian buys four new books per year, at a cost of $60[117].

... each Australian buys four books per year

Canberra residents are likely to buy more than this, due to their higher education and income levels.

A recent survey found that 54% of Australians read on a weekly basis, with 90% of readers having read a novel in the last year[118]. Respondents spent an average of 5 hours reading printed books per week, with 68% wanting to spend more time reading than they already did[119].

Increasingly, however, books are being read in digital formats, with 13% of Australians having downloaded an electronic book, or e-book, from a website, and 6% using a portable electronic reading device[120]. Although Australian consumption statistics are not available for electronic book formats, wholesale purchases of electronic books in the United States in 2010 were estimated to be worth over US$350 million, more than twice their value in 2009 and thirty times their value in 2005[121]. A similar trend is expected in Australia.

In the ACT in 2005, retailers of books, newspapers and stationery employed 419 people across 41 retail locations[122], although the recent closures of Borders and Angus & Robertson stores will have reduced this number significantly.

Product flow

A typical route for the production and use of a book is shown in Figure 14. Australia produces about one third (585,000 tonnes) of its printing and writing paper domestically and imports the remainder, over 1 million tonnes annually[123]. Much of this comes from Asia (Figure 15[124]). The origins of these

---

[115] Australian Bureau of Statistics (2005) *Book Publishers Australia 2003-2004*. ABS 1363.0 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1363.02003-04. Accessed 5 Jun 2011.
[116] As above.
[117] Australian Bureau of Statistics (2005) *Book Retailers Australia 2003-2004*. ABS 1371.0 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1371.02003-04. Accessed 5 Jun 2011.
[118] AMR Interactive (2011) *Get Reading! 2010 Campaign Effectiveness Research*. http://www.australiacouncil.gov.au/__data/assets/pdf_file/0015/102453/GR10_-_Final_Research_Report.pdf. Accessed 8 June 2011
[119] As above.
[120] As above.
[121] International Digital Publishing Forum (2010) *Additional eBook Statistics*. http://idpf.org/about-us/industry-statistics#Additional_Global_eBook_Sales_Figures. Accessed 8 Jun 2011.
[122] Australian Bureau of Statistics (2005) Footnote 117.
[123] A3P (2004) *Australian Paper Industry Production Statistics* http://www.a3p.asn.au/admin/assets/pdf/Stats/Statistics%20-%202003-04%20Paper%20Production.pdf. Accessed 8 June 2011.

imported paper supplies are often difficult to identify, with less than 12% of the global forestry industry certified under a sustainable forestry accreditation body such as the Forest Stewardship Council[125]. Ink is most commonly derived from petroleum extracts, although soy-based alternatives are also used[126].

Figure 14 Typical route for the production, distribution and use of a paper book.

Circled steps may take place in Australia or overseas.

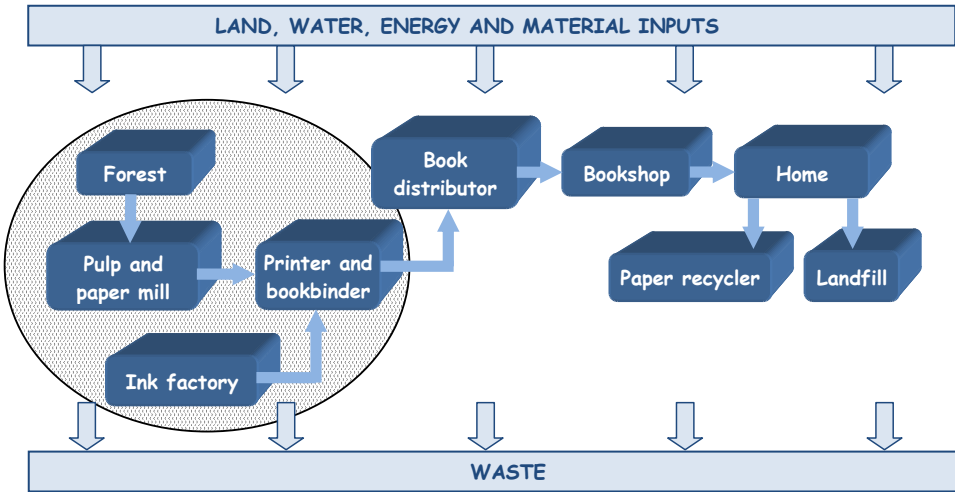
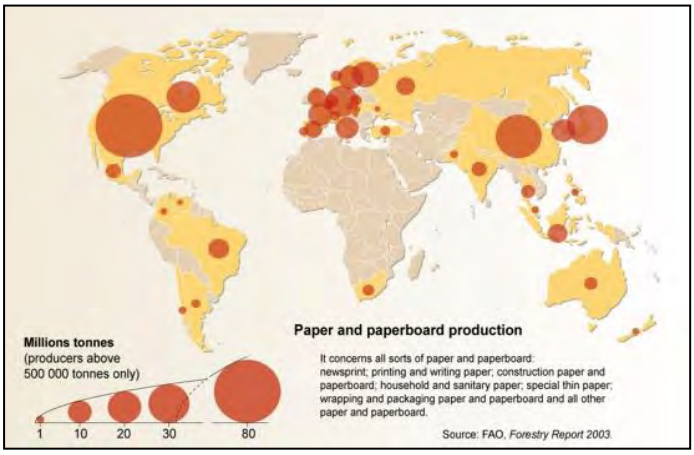


Figure 15 Global sources of paper and paperboard.

The circles represent the relative contributions from different countries. The figure is reproduced from the resource at Footnote 124.



[124] Food and Agriculture Organisation (2003) *Paper and Paperboard Production.* http://maps.grida.no/go/graphic/paper_and_paperboard_production. Accessed 8 June 2011.
[125] Forest Stewardship Council Australia http://www.fscaustralia.org/.
[126] Kozak G (2003) *Printed Scholarly Books and E-book Reading Devices: A Comparative Life Cycle Assessment of Two Book Options*. http://css.snre.umich.edu/css_doc/CSS03-04.pdf. Accessed 9 June 2011.

Book production

The production of printed books requires two primary components – paper and ink. Use of recycled paper in the book publishing industry is low (US estimates are between five and ten percent), with the remaining paper being sourced from both timber and wood 'waste' products, such as woodchip[127]. Relative to the entire timber harvesting industry, book publishing accounts for only 0.64% of timber harvests[128].

The printing phase of book production usually employs one of two methods: offset printing (which uses plates and inks) or digital printing. The latter is used for shorter print runs due to its faster and cheaper set-up time, while the former is commonly used in print-runs of over approximately 1000 copies[129]. Eighty-five percent of Australian print runs use offset printing methods[130]. Most single-colour books are printed in Australia, but non-urgent colour books are mostly printed in Asia[131].

Books are then distributed from the printing office to the publishers' warehouses, where they are re-distributed by truck to book retailers. Books purchased online require additional transport stages, being sent from publisher's warehouses to those of online retailers, who then post out purchases to individual consumers. These additional transport stages can, however, use less fuel than that used by an end consumer when travelling to a bookstore, which can outweigh the total emissions of the production of the book itself. Additional transport stages are also required for the 40% of Australian book purchases that are published overseas.

Footprints across the life cycle

The total carbon footprint of the global book publishing industry has been estimated to be over 12.4 million tonnes of CO2e[132]. In Australia, calculations are only available for the wider paper production industry, which is responsible for over 4.6 million tonnes of CO2e emissions and has a water footprint of 82 billion litres of water[133].

The carbon footprint of a book is highly dependent on its weight and number of pages, but even on a per kilogram basis, estimates vary between 0.6 and 6.3 kilograms of CO2e for each kilogram of book[134]. The most recent assessment of the carbon footprint of a 360 page, 0.6 kg book printed,

---

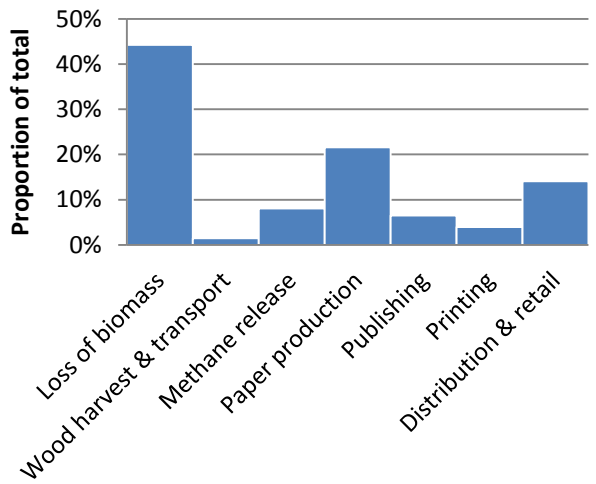
[127] iD2 Communications (2010) *EcoDesign Paper Facts*. http://www.id2.ca/downloads/eco-design-paper-facts.pdf Accessed 7 June 2011.
[128] Upton B (2009) *Forest Growth* http://www.greenpressinitiative.org/documents/MalloyOpinionArticle.pdf. Accessed 8 June 2011.
[129] SelfPublish Australia (2011), *FAQs*. http://www.selfpublish.com.au/book_publishing_FAQs.html. Accessed 8 June 2011.
[130] As above.
[131] Printing Industries Association of Australia and the Australasian Paper Industry Association Ltd. (2010) *Book Industry Strategy Group Joint Public Submission.* http://www.innovation.gov.au/Industry/BooksandPrinting/BookIndustryStrategyGroup/Submissions/463445_Printing_Industries_Association_of_Australia_and_Australasian_Paper_Industries_Association_Ltd.pdf. Accessed 7 June 2011.
[132] Green Press Initiative (2008) *Reducing Climate Impacts: A Guide for the Book and Newspaper Industries.* http://www.greenpressinitiative.org/documents/climateguide.pdf. Accessed 7th June 2011.
[133] A3P (2004) Footnote 123.
[134] Borggren C, Moberg A, Finnveden G (2011) Books from an environmental perspective-Part 1: environmental impacts of paper books sold in traditional and internet bookshops. *International Journal of Life Cycle Assessment* 16:138-147.

distributed, bought and disposed of in Sweden using paper from a Swedish mill found that the life cycle of the book caused 1.2 kg of CO2e emissions[135].

The waste forest biomass (excluding the book), followed by pulp and paper making are the two largest contributors of CO2e emissions in the book life cycle up to and including the retail stage (Figure 16[136]), based on mostly USA data. However, the Swedish study referred to earlier included personal transportation to buy the book in their life cycle analysis and found that driving a car 3 km to purchase the book resulted in the same amount of emissions as the rest of the book life cycle itself[137]. A life cycle assessment of the water footprint of books estimated that production of one 500 page book requires 94 litres of water, and produces 2.3 kg of solid waste[138].

Figure 16 Greenhouse gas emissions of steps in a book life cycle.

The figure is redrawn from data in the resource at Footnote 136.



Hotspots summary

Hotspots in greenhouse gas emissions are in the **forestry** step, in **paper production** and in the **retail and consumer transport** step.

Social and ethical considerations

The source of trees to make paper has environmental and social implications that are not picked up in the types of impact analyses used. Paper sourced from Australian native forests or plantations, or tropical forests or plantations in developing countries overseas, has implications both for biodiversity and the lifestyles or incomes of local people.

Are e-books a more sustainable option?

Whether e-books are a more environmentally-friendly way to read is highly dependent upon the measure of environmental impact used and how the e-book is used, including how many books are read from it during its lifetime[139]. The life cycle of an e-reader has been estimated to have an

[135] Borggren et al. (2011) Footnote 134.
[136] Green Press Initiative (2008) *Reducing Climate Impacts: A Guide for the Book and Newspaper Industries*. http://www.greenpressinitiative.org/documents/climateguide.pdf Accessed 7 Jun 2011.
[137] Borggren et al. (2011) Footnote 134.
[138] Kozak G (2003) Footnote 126.
[139] Moberg Å, Borggren C, Finnveden G (2011) Books from an environmental perspective – Part 2: e-books as an alternative to paper books. *International Journal of Life Cycle Assessment* 16:238-246.

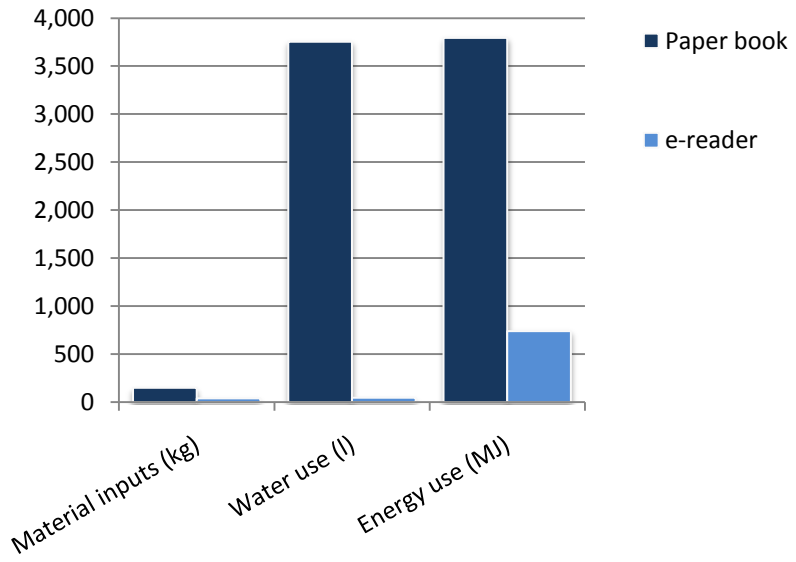
average footprint of 168 kg of CO2e[140], quite high compared to the paper book range of 0.6 to 6.3 kg cited earlier. However, as the device can download and store a large number of e-books, this footprint would be overtaken by the footprint of paper versions if a large number of new paper books were bought in the same life time. For example, a life cycle comparison of the books used in a 4 year university degree in the USA found that over that period, assuming that a student would require 40 text books and only purchased one e-reader, the environmental impacts of e-books were significantly lower (see Figure 17)[141]. However, for the average Australian who consumes only 3 new books a year, it is likely that an e-reader impact would outweigh that of the paper books.

In the case of multi-purpose readers, such as Apple's iPad, it is more difficult to determine the emissions directly attributable to book-reading as it is used for other purposes as well.

If e-books or multi-purpose readers are a preferred option for this or other reasons, purchasing renewable energy will help offset impacts, as 29% of emissions from the e-reader's life-cycle occur through customer energy use[142].

Figure 17 Relative inputs into a paper book and an e-book.

The figure is redrawn from a figure in the resource at Footnote 141.



Your choices

Apart from e-books, options for reducing the environmental impact of reading paper books is to borrow them or purchase them second-hand and share them or give them away afterwards. Like the other consumer products already discussed, any ways in which car journeys for the sole purpose of buying the product can be reduced will have significant benefit.

... for reducing the environmental impact of reading paper books ...

borrow them

or purchase them second-hand

share them

or give them away afterwards.

Reduce car journeys for buying them.

[140] Cleantech Group (2009) *The Environmental Impact of Amazon's Kindle* http://cleantech.com/news/4867/cleantech-group-finds-positive-envi Accessed 1 Jun 2011.
[141] Kozak G (2003) Footnote 126.
[142] Apple Inc. (2011) *iPad 2 Environmental Report*. http://images.apple.com/environment/reports/docs/iPad_2_Environmental_Report.pdf Accessed 7 June 2011.

AA BATTERIES

Buying and use patterns

> *… each of us accounts for 11 [AA or AAA batteries] a year.*

AA batteries are a small but common consumer item whose sales have expanded rapidly as the number of portable electronic goods in households has grown. Remote controls are the single largest use, followed by toys, digital camera, torches, wireless mouses and keyboards and gaming consoles. About 250 million AA and AAA batteries are sold every year in Australia[143], suggesting each of us accounts for 11 a year. If Canberrans buy these batteries at the same rate as other Australians, it would suggest that some 3.8 million of them come to shops to be sold in Canberra every year, possibly even more due to our higher incomes (see Introduction). Nationally, over two thirds of small batteries end up in landfill[144].

Consumers have the choice of buying either disposable alkaline batteries or a battery recharger and nickel-cadmium (NiCd) or nickel-magnesium hydride (NiMH) AA rechargeable batteries. The initial outlay for the rechargeable option is higher but the cost is lower in the long run. Most small dry cell batteries are imported[145]; alkaline batteries are largely made in China and rechargeable batteries largely made in Japan.

The choice between these two options has been explored in a life cycle analysis in the Australian context[146] and this forms the basis for the comparison here. Unless otherwise identified, this reference is the source of all the data quoted.

Product flows

The basic flow of batteries, whether alkaline or rechargeable is shown in Figure 18, although the nature of the inputs of materials, in particular, varies with the two different types.

---

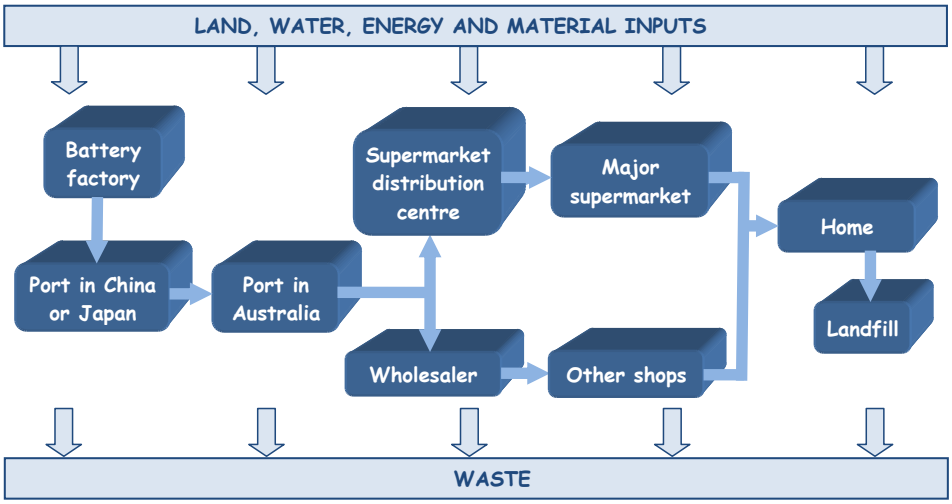
[143] Planet Ark (2010) *Battery Use, Disposal and Recycling in Australia.* http://recyclingweek.planetark.org/documents/doc-513-battery-research-report-final.pdf. Accessed 15 Jun 2011.

[144] Australian Battery Recycling Initiative (2010) *Analysis of Battery Consumption, Recycling and Disposal in Australia*. http://www.batteryrecycling.org.au/wp-content/uploads/2011/06/Battery-consumption-recycling-and-disposal-in-Australia_Executive-Summary.pdf. Accessed 15 Jun 2011.

[145] IBISWorld. *Battery Manufacturing in Australia.* http://www.ibisworld.com.au/industry/default.aspx?indid=271. Accessed 8 June 2011.

[146] Parsons D (2007) The environmental impact of disposable versus re-chargeable batteries for consumer use. International Journal of Life Cycle Assessment 12: 197-203.

Figure 18 Major routes of AA alkaline or rechargeable batteries from the factory to their disposal after use.



Footprints across the life cycle

Like the television, batteries are a longer-lived product whose life cycle has to include their use in the home. To compare the three types of batteries, the analysis assumed delivery of the same total power over the life of each type of battery. Under typical conditions of use and with 50 recharge cycles for the rechargeable batteries, it takes 55 alkaline batteries to provide the same power as 1 NiMH rechargeable battery, or 29 disposable batteries to equal the power from 1 NiCd rechargeable battery.

… it takes 55 alkaline batteries to provide the same power as one NiMH rechargeable battery …

Countering the reduced number of rechargeable batteries required for the same power is the need for the recharger and the additional electricity use needed for their recharge. The additional energy use was calculated as 7.1 MJ for a NiCd battery and 6.5 MJ for a NiMH battery, and obviously nil for the alkaline battery. On the other hand, there is significant energy involved in lighting, heating and cooling retail stores and the analysis allowed 4 MJ per pair of batteries for this component. This would translate to an additional 2 MJ for a single NiMH rechargeable battery but based on the lifetime ratio above, 110 MJ for alkaline batteries. This retailing energy is many times the energy needed for recharging the rechargeable batteries and it represents a hotspot for the alkaline type.

Using these equivalences of battery numbers, standard manufacturing data for their components and for the battery charger, electricity use for recharging and assuming international transport from China to an Australian port, then 25km of domestic travel to a retail store, and 100km travel for the garbage truck (as most batteries are disposed to landfill in Australia), the analysis assessed environmental impact using a model called Eco Indicator 99. This assesses three aspects of impact: damage to human health (in terms of disability years), damage to the environment (in terms of land area affected by plant species disappearance) and an energy term reflecting the additional energy that will be required to extract minerals and fossil fuels as they become more scarce. In all categories, the impact of the alkaline batteries was a hundred or more times greater than that of rechargeable batteries (Table 5).

Table 5 Assessment of impact of different battery types delivering 1 KWh of power and disposed to landfill.

The analysis includes the recharger for the rechargeable batteries. The data is from the resource at Footnote 146.

	NiMH 50 cycles	NiMH 400 cycles	Alkaline
Number of batteries	18	2.3	834
Damage to human health index	15×10^{-6}	5×10^{-6}	1210×10^{-6}
Damage to ecosystem quality index	0.5	0.2	48.5
Energy for extra mined resources MJ	14.3	5.4	1070

An assessment was also made of the benefits of recycling the rechargeable batteries. The study found that compared to landfill, recycling made little difference to the impact on human health and ecosystems because most of the impact occurs before their use, but it did have a 20% beneficial impact on the energy term because some of the material is re-used. There was a health advantage in recycling NiMH batteries over recycling NiCd in terms of both human and ecosystem health because cadmium is toxic, and also in terms of the number of batteries required because NiMH batteries are more efficient.

… recycling made little difference … because most of the impact occurs before their use

but it had a 20% beneficial impact on the energy term.

This battery study didn't include the additional travel from Sydney, the presumed port for arrival of imported goods destined for Canberra, or the travel from home to the retail outlet in a car. Based on the efficiency of long-distance transport in articulated trucks (Table 3), which is the main mode of transport for bulk goods from Sydney to Canberra, this additional impact is likely to be small. However, as shown in some of the previous product case studies, life cycle analyses can be very sensitive to the car journey to do the shopping and this is a further potential hotspot for alkaline batteries which have to be bought much more often.

Hotspots summary

Hotspots for alkaline batteries are in the **non-renewable energy used in wholesaling and retailing**, followed by their **manufacture**. The **car journey for their purchase** is another potential hotspot not quantified in this study but evident from analyses of other consumer products.

The main hotspot for rechargeable batteries is in their **manufacture**.

Social and ethical considerations

Working conditions in the countries of manufacture of the batteries, recharger and their components could be a concern but there is little information about this available. Avoiding NiCd rechargeable batteries will help prevent the exposure of workers to the toxic effects of cadmium.

Your choices

There is clear evidence to suggest that buying and using rechargeable batteries has a significantly smaller footprint than buying alkaline batteries. NiMH rechargeable batteries are a better choice than NiCd rechargeable batteries because of their lower toxicity.

… buying and using rechargeable batteries …

NiMH rechargeable batteries are a better choice than NiCd rechargeable batteries

CONCLUSIONS

Across the products analysed there was only patchy information and technical analyses available about their specific life cycles in Australia. Combined with the absence of labelling about the origins of these (and most other) goods it is difficult for consumers to exercise properly informed buying choices for sustainability.

… patchy information and technical analyses available about specific life cycles … the absence of labelling about the origin of … goods [makes] it difficult for consumers to exercise properly informed buying choices for sustainability.

Australian governments are not currently inclined to increase labelling on products to indicate environmental impact.

Australian governments are not currently inclined to increase labelling on products to indicate environmental impact. A recent multi-government review placed labelling in relation to 'consumer values' (including sustainability) as last in a hierarchy of priorities where human health has the highest priority for government regulation on labelling. The review therefore recommended that labelling related to consumer values should be self-regulatory, that is done by the industries themselves, and that governments would only intervene if they were ineffective [147]. The accreditation, auditing and tracking systems that would be required to increase sustainability information on labels would undoubtedly add to their cost, although the technical capacity to track individual products through scanning technology is available and already often used for other purposes. Industries and governments are only likely to act on improving sustainability labelling when enough consumers demand it.

Despite the lack of specific information, some general themes did emerge from the analyses of just seven products in this report.

Food and fibre products tend to have more impacts in their agricultural/forestry phase; manufactured goods often have more impact in their use phase.

… low contribution of transport to footprints … suggests that the location of Canberra … is not a very significant component of our overall impact …

… our footprint is high because we buy more stuff.

- Food and fibre products tend to have more footprint impacts in their agricultural/forestry phase; manufactured goods often have more impact in their use phase.
- The generally low contribution of transport to individual footprints of the products analysed suggests that the location of Canberra away from major food and manufacturing locations is not a very significant component of our overall impact. As outlined in the ACT Ecological Footprint (see Introduction), our footprint is likely to be high because we have higher incomes than average and we buy more stuff.

[147] Department of Health and Ageing (2011) *Labelling Logic. Review of Food Labelling Law and Policy. Commonwealth of Australia.* http://www.foodlabellingreview.gov.au/internet/foodlabelling/publishing.nsf/content/48C0548D80E715BCCA257825001E5DC0/$File/Labelling%20Logic_2011.pdf. Accessed 25 Jun 2011.

- Within the transport footprint however, the shopping trip to purchase goods is often significant, particularly for food products that must be bought regularly, in contrast to items like televisions that are purchased less than once a year. The nature of Canberra, our dependence on cars and generally high incomes can mean that some shopping trips may be as significant, or even more significant, than the transport of goods some distance to Canberra.

- The same low contribution of transport to footprints means that food miles are a relatively poor stand-alone indicator of the footprint of a product, unless all other things are equal.

- Where other things are not equal, consumers need to be aware of tradeoffs that occur between different categories of environmental impact. For example, a product may have low food miles but have been produced with a high energy input, or a product might have energy ratings without water ratings. For this reason, stand-alone indicators should be treated with caution, as should claims about the sustainability of production methods (e.g. 'organic') that are not certified. They may not be substantiated and/or may be based on stand-alone indicators.

Within the transport footprint, the shopping trip … is often significant …

… food miles are a relatively poor stand-alone indicator of footprint ..

... be aware of tradeoffs between different categories of environmental impact.

… certified organic food generally decreases greenhouse impacts but not impacts associated with the area of land

Packaging was rarely a hotspot for impact.

… around a half of the footprint … is under the control of the consumer…

- Choosing to buy certified organic food generally decreases greenhouse impacts but not impacts associated with the area of land.

- Packaging was rarely a hotspot for impact for the products studied. But like all inputs to the life cycle, reducing the amount and choosing the kind that has least impact is better.

- Very generally, around a half of the footprint of these products is under the control of the consumer: the nature of the shopping trip, how the product is used in the home, the amount of food wasted or the disposal method of manufactured products. Improvements in those aspects outside the control of consumers rely on government and industry actions, although also influenced by consumer demand.

- General strategies to counter the impacts of the home consumption phase include: plan ahead and shop by car less frequently, buying more at a time; combine shopping with other purposes of using a car, use most of the food you buy, purchase renewable energy, keep material goods longer by resisting advertising and peer pressure to upgrade, and recycle where possible but without taking long car journeys to do it.

… strategies to counter the impacts of the home consumption phase include:

plan ahead and shop by car less frequently, buying more at a time

combine shopping with other purposes of using a car

use most of the food you buy

purchase renewable energy

keep material goods longer

recycle where possible but without taking long car journeys to do it.

Finally, this report focussed on finding those parts of product life cycles

that have the greatest impact, because this is where significant reductions are more likely to be found. This does not mean that even small impacts elsewhere should be ignored. Where the evidence is clear and the choice is available, many people frequently exercising small buying choices for sustainability in the longer term will make a difference in reducing the ecological footprint of Canberra.

Appendix 1

Transport statistics and calculations for car and truck travel for 2007. These are the basis for the scenario outcomes in Table 3.

	Cars	Articulated trucks	Unit	Reference
Total emissions per year	44,366	9,956	Gg CO2e	BITRE[148]
Total distance per year	167.04	6.77	billion km	BITRE
Number of vehicles	11,462,400	74,444		BITRE
Emissions per vehicle per year	3.9	133.7	tonnes CO2e	Calculated
Average distance per vehicle per year	14,573	90,941	km	Calculated
Emissions per vehicle per km	0.27	1.47	kg CO2e	Calculated
Average freight-distance per vehicle per year		2,068,700	tonne-km	ABS 9208.0[149]
Average laden distance per vehicle per year		73,800	km	ABS 9208.0
Average load when laden		28.0	tonnes	Calculated
Proportion of total distance that is laden		81%		Calculated

[148] BITRE (2009) *Greenhouse Gas Emissions from Australian Transport: Projections to 2020*. Working Paper 73. Bureau of Infrastructure, Transport and Regional Economics, Canberra. http://www.btre.gov.au/Info.aspx?ResourceId=744&NodeId=16 Accessed 15 May 2011.

[149] ABS cat. no. 9208.0 www.abs.gov.au

UNIVERSITY OF CANBERRA
AUSTRALIA'S CAPITAL UNIVERSITY

Exploring individual values and attitudes for a more sustainable Canberra: the example of food

David Pearson
University of Canberra
Email: david.pearson@canberra.edu.au

Report for the ACT Commissioner for Sustainability and the Environment

ACKNOWLEDGEMENTS
The research assistance of Joanna Temme in the Commissioner's Office is gratefully acknowledged.

DISCLAIMER
The information in this report has been collated from publically available sources which are identified as references. However, very little information is specific to the situation in Canberra and hence generalisations have been made and the author takes no responsibility for any actions that readers may take on the basis of the information provided in this report.

CITATION
Pearson D (2011) *Exploring individual values and attitudes for a more sustainable Canberra: the example of food*. Report for the ACT Commissioner for Sustainability and Environment. Canberra

EXPLORING INDIVIDUAL VALUES AND ATTITUDES FOR A MORE SUSTAINABLE CANBERRA: THE EXAMPLE OF FOOD

Contents

1. Introduction

The fact that 'Our community is treading very heavily on the earth'[1] is now well recognised across diverse sectors of society. However, there is no well developed consensus on how to reduce this footprint.

After extensive consultation the ACT Office for the Commissioner for Sustainability and Environment released a framework for its 2011 State of the Environment Report[2]. This identified four 'driving forces' that cause fundamental pressure on the environment. These being population, land use and transport systems, climate, and finally, consumption.

Consumption determines the level of resource use and associated waste generation. The 2011 State of the Environment Report will consider three consumption driving force indicators; ecological footprint, economy and income, and consumption values. This paper considers the attitudes and values of individuals and their influence on consumption decisions as well as other approaches to achieving desired changes in behaviour. Consumers make numerous decisions that impact on the environment, such as dwelling size and design, transport, energy and source of products. However, this report focuses on food as it has been identified as being one of the largest components of the ACT's ecological footprint[3].

2. Consumption and sustainability

Decisions made by individuals in relation to what products and services they consumer can have a significant environmental impact, especially in countries like Australia, where per capita consumption levels are relatively high. The environmental impact of consumption is due to the combined effects of the production, transport, sale, use and disposal of the products consumed. These impacts can be captured in a lifecycle analysis of individual products. Recent research has used life cycle analysis to determine the ecological impact of some purchases in the ACT[4]. For example the environmental impacts of a 29" LCD TV are estimated to be 62 000 litres of water and 1241 kg of CO2 in the production stage. Additional energy would be used to operate the TV during its working life. And finally, under current Australian practices the TV would mostly likely be disposed of in landfill which has additional impacts in terms of contamination from toxic materials such as lead and mercury[5].

An understanding of how consumption affects the environment is especially relevant to the ACT where choices that individuals make on a daily basis account for over half of the Territory's ecological footprint (Figure 1). Moreover, as shown in Figure 1, the overall ecological footprint of the ACT has increased over the last 10 years primarily due to increased consumption. This trend is associated with increasing household income, and is commonly observed in affluent societies. It is occurring even though there are some areas in which environmental impact has been steady or even falling, such as direct energy use[6].

---

[1] Dr Maxine Cooper, ACT Commissioner for Sustainability and Environment, press release dated 14 December 2010.

[2] ACT-OCSE (2011). *Framework, themes, and indicator groups, ACT SoE 2011 Report*. Canberra: Australian Capital Territory Office of the Commissioner for Sustainability and Environment.

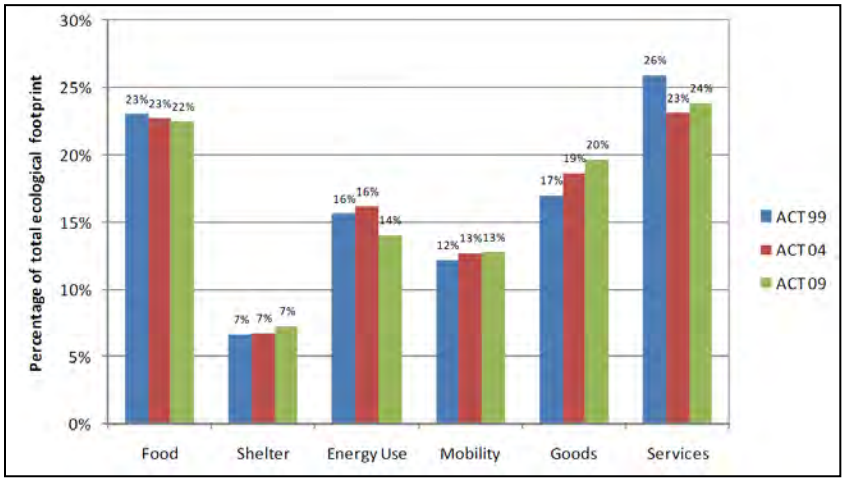
[3] ISARG (2010). *The 2008-09 Ecological Footprint of the population of ACT*. Sydney: Integrated Sustainability Analysis Research Group, University of Sydney.

[4] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment..

[5] However the ACT currently has a mandatory TV recycling scheme, ibid. p. 33.

[6] ibid. p. 4.

Figure 1: Comparison of ecological footprint consumption categories in the ACT in 1999, 2004 and 2009[7]



Source: ISARG, 2010

Ecologically sustainable consumption is a phrase used to describe the aim of reducing the ecological impact of consumption. It is generally seen as being the use of 'services and related products which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardise the needs of future generations.'[8] An emerging awareness of its importance has led the United Nations to set up a framework of programs in sustainable production and consumption within their environment program[9]. These range from making tourism more sustainable through to reducing greenhouse gasses from buildings.

In relation to the decisions made by individuals there are many approaches that promote sustainable consumption that incorporate elements of the 4R's (Figure 2); Refuse to purchase, Reduce purchases, Reuse purchased items, and Recycle purchases that are no longer being used. One approach is that of 'anti-consumption' where individuals are encouraged not to consume[10]. Another is that of 'green consumption' where consumers are encouraged to choose the more environmentally friendly option. This may include choosing electricity that is generated from a more environmentally friendly source such as a wind farm. In some cases these green consumption programs can have unintended outcomes. Such as promoting unnecessary consumption, when, for example, a light globe or appliance is replaced with a more energy efficient model before the original product has reached the end of its life.

[7] ISARG (2010). *The 2008-09 Ecological Footprint of the population of ACT*. Sydney: Integrated Sustainability Analysis Research Group, University of Sydney, p. 17.
[8] NME (1994). *Oslo Roundtable on Sustainable Production and Consumption*: Norwegian Ministry of the Environment.
[9] UNEP (2011) *Sustainable production and consumption* Rome: United Nations Environment Program. http://www.unep.org/themes/consumption/index.asp [accessed 27 July].
[10] Black, I. (2010). Sustainability through anti-consumption. *Journal of Consumer Behaviour, 9*, 403-411.

Figure 2: Waste Management Hierarchy

Most favoured option

Least favoured option

3. Consumption behaviour

3.1 Linking personal values and attitudes

The understanding of consumer values and attitudes is based on theories developed in psychology. These assume that motives for individual choices emerge from a small number of relatively stable values, which in turn form attitudes. The linkage between values, attitudes and choices is constructed through the Theory of Planned Behaviour, and it derivatives, along the sequence of values→attitudes→behaviour.

An extensive academic literature in this area[11] incorporates two practical outcomes in relation to consumption that are pertinent to this report. The first of these is the use of values in marketing communications[12]. In this situation the values held by individuals in a particular target audience are identified. Then a communication is crafted where the message is associated with these values. This approach improves the likelihood of message acceptance (this is discussed in more detail in Section 3.3).

The second relevant area of research explores values→attitudes→behaviour in terms of identifying people's values and then determining their causal link to actual behaviour. Its major contribution is in confirming that there is often a gap or disconnect where actual behaviour is inconsistent with the values identified[13]. The major reasons for this are that choices result from a personal assessment of many factors, values are important but do not dominate over other influences such as financial cost, availability of time, wanting to be included in particular social groups as well as the availability of alternatives that

[11] See, for example, Chapters 11 and 16 in Quester, P., Pettigrew, S. and Hawkins D. (2011*) Consumer behaviour*. Sydney, McGrawHill.
[12] See, for example, Belch, G., Belch, M., Kerr, G. & Powell, I. (2009). *Advertising and Promotion: An Integrated Marketing Communication Perspective*. Australia: McGraw-Hill, pp. 138-40.
[13] See for example Eckhardt, G., Belk, R., & Devinne, T. (2010). Why don't consumers consume ethically? *Journal of Consumer Behaviour, 9*, 426-436.

result from political and industrial leadership[14]. In addition, many consumer choices result from established routines and there are many sources of inertia for individuals in relation to changing their habits. An example in relation to food choices would be an individual who has developed expectations from within their family about what is normal, such as the convenience benefits from highly processed food products, and hence is insensitive to additional information that highlights the high ecological impact of these products.

However it is possible to target interventions to encourage behavioral change before choices become habitual (such as eco driving where new drivers are taught to drive economically) and where habits are broken or unstable (for example 'teachable moments' with new residents in a community, new employees, or parents having a first child). In addition, not all behaviours are habitual, as many are 'one off' or occasional purchases (buying a washing machine for example)[15].

3.2 Alternative approaches to understanding consumption

Although the theoretical constructs of values and attitudes are still used as an approach for understanding what influences consumption there are many other approaches that provide alternative perspectives by incorporating additional relevant variables.

At the broadest level consumers are influenced by the political, economic, societal, technological and legal aspects of the country within which they live. Their social connections also influence their consumption. These include social groups or individuals that they aspire to be like, those that they associate with as well as those to which they do not want to be linked. Finally aspects of the individual and their specific situation influence their consumption; including motivation, personality, experience as well as values and attitudes as previously discussed. In addition dynamics within the living arrangement of the individual will influence their consumption. Hence, household or family structure provides an additional perspective that incorporates factors including who initiates, influences, authorises, makes, and finally, who uses or consumes the products purchased[16].

One of the most popular approaches for influencing consumers that integrates different factors is that of lifestyle. This approach is based on the assumption that many choices are motivated by lifestyle goals as well as values and attitudes. The lifestyle of health and sustainability, often referred to by its acronym of LOHAS, is one such example. Recent research has shown that LOHAS consumers are dedicated purchasers of organic food[17]. Other approaches for understanding consumption include individual self interest being achieved through rational choice and social factors such as individual identity being created through how others perceive the individual[18]. These can also be used in programs to influence consumer behaviour.

---

[14] Isenhour, C. (2010). On conflicted Swedish consumers, the effort to stop shopping and neoliberal environmental governance. *Journal of Consumer Behaviour*(9), 454-469.

[15] See Chapter 1 'Old habits and new routes to sustainable behaviour' by Verplanken, B. in Whitmarsh, L., Oneill, S., & Lorenzoni, I. (Eds) (2011). *Engaging the Public with Climate Change* London: Earthscan, p.24.

[16] See for example, Evans, M., Jamal, A., & Foxall, G. (2009) *Consumer behaviour*, London: John Wiley and Sons Ltd.

[17] BFA (2010). *Australian Organic Market Report 2010*. Brisbane, Australia: Biological Farmers of Australia.

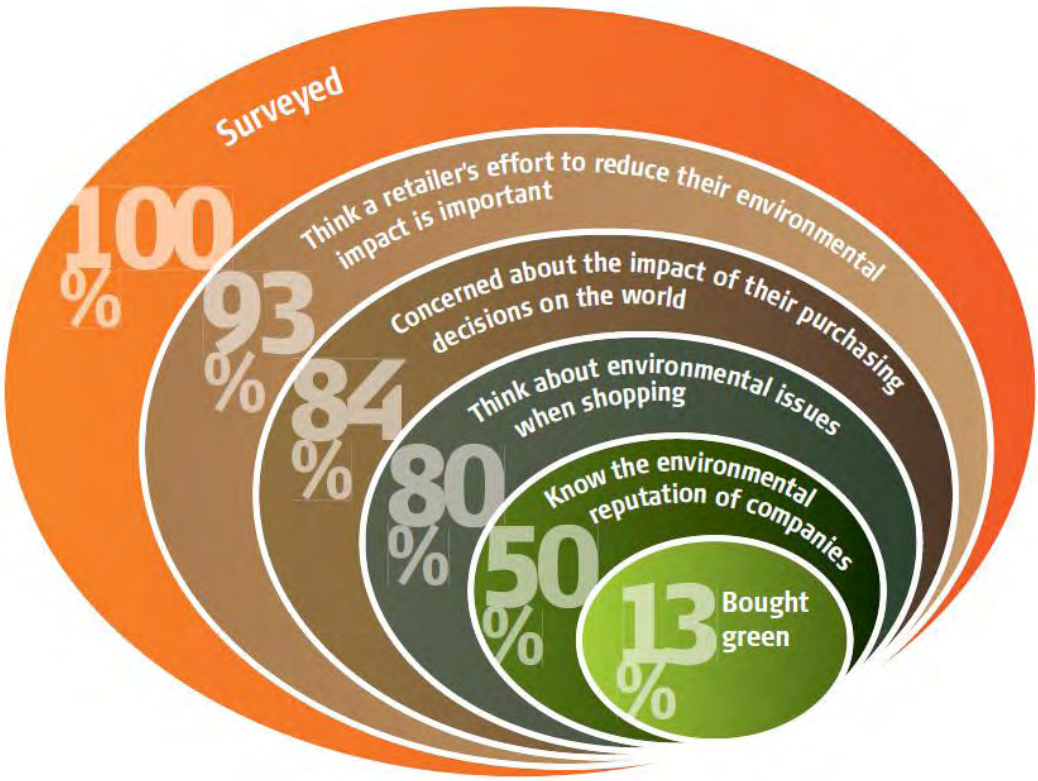
[18] Jackson, T. (2005). *Motivating Sustainable Consumption: a review of evidence on consumer behaviour and behavioural change*. England: Sustainable Development Research Network, Centre for Environmental Strategy, University of Surrey. As well as the more recent book that includes novelty seeking and conspicuous consumption Jackson, T. (2009). *Prosperity without growth*. London: Sustainable Development Commission.

Thus there is not a single unified approach for influencing consumption. Hence in terms of attempting to change behaviour it is common to consider the details of the specific message and target audience, and then select an approach, or combination of approaches, that is most likely to be effective. Community Based Social Marketing[19] is one popular framework used to influence changes in consumption that support environmental sustainability. It has been widely used by governments and non-government organisations throughout the developed world and is supported by a network of practitioners and case studies.

3.3 Green consumption[20] in Australia

As previously mentioned it is common for a gap to exist between what consumers say they would like to do, and what they actually do. This is illustrated by the results of a survey of 1,000 Australian shoppers exiting supermarkets in major cities[21].

Figure 2: Supermarket consumer desires and actions[22]



[19] McKenzie-Mohr, D., & Smith, W. (1999). *Fostering sustainable behavior: an introduction to community-based social marketing.* Gabriola Island, BC, Canada: New Society Publishers.

[20] In this report the term 'green consumption' is used to refer to choices made by consumers where they select the more environmentally sustainable option.

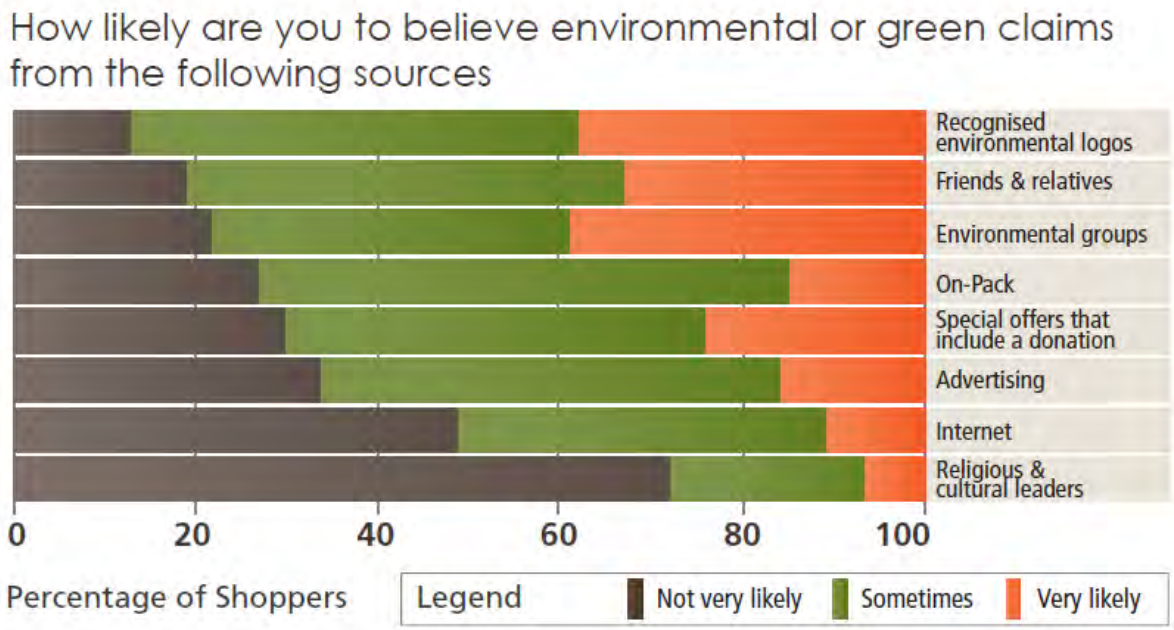
[21] Australian Food and Grocery Council & Netbalance Pty Ltd, 2010. *Green Shopper Summary Report*, www.afgc.org.au/sustainability.html#GreenShopper [accessed 9/8/11].

[22] ibid, p. 3.

As shown in Figure 2, although the majority of consumers (84%) express concern about the impact that their purchases have on the world, only a small number (13%) actually bought an identifiably 'green' product.

Consumers' purchasing decisions are a result of many factors; environmental impact is just one of these. Hence activities that aim to influence behaviour should be informed by data on which factors about a purchase are most important to consumers and which they are willing to compromise on. Results from the previously mentioned survey found that shoppers are most willing to compromise on packaging (27%), but least willing to compromise on convenience (6%). It is important to note that this survey included a range of household goods purchased from a supermarket and hence did not specifically focus on food choices which are also heavily influenced by taste, nutrition as well as considerations of cultural habits.

Figure 3: Consumer's level of trust in different information sources[23]



Studies have shown that consumers were most likely to believe environmental claims from a recognised environmental logo or from friends and relatives. In contrast they are least likely to believe claims from religious/cultural leaders or the internet (Figure 3).

Further, subtle differences may have a major impact on the effectiveness of the activity. For example two UK supermarkets introduced milk sold in plastic bags. This was promoted as a way to reduce packaging as the bags are estimated to contain 75% less plastic than an equivalent sized milk bottle[24]. One supermarket chain has discontinued the bagged milk trial due to low sales whilst in the other supermarket chain sales have exceeded expectations. The key to success would appear to be the decision by the second store to

[23] ibid, p. 5
[24] However the milk bags are assumed to be non-recyclable, unlike many other milk containers.

give their staff free re-usable milk jugs. These staff were able to explain the use of jugs to consumers based on their own experience[25].

4.Encouraging sustainable consumption: the example of food

4.1 Impacts of the food system

As previously mentioned food is a significant component of the ecological footprint in the ACT. A 2010 study by the University of Sydney found that food accounts for 22% of the footprint, second only to services at 24%. Each of which is significantly larger than each of the other four categories of shelter, energy use, mobility and goods. This report also identifies that the economic cost of food consumed in the ACT does not fully incorporate its environmental cost. Its contribution to the ecological footprint, at 22%, is significantly larger than its economic cost at only 10% of ACT residents' expenditure[26].

The amount of food consumed per capita has changed little in recent times[27]. However, the composition of food in the diet is changing as individuals are eating more foods that are prepared outside the home. These include meals away from home that are supplied by the food service sector in restaurants and cafes and ready-to-eat meals from supermarkets as well as confectionery and snack foods. In addition there is a general trend to increasing consumption of foods that are transported from other states and countries. These dietary choices have environmental implications in terms of greater inputs of energy, water and materials for packaging used in production, manufacturing and transport.

Many governments have taken a leadership role in attempting to influence the dietary choices of individuals. Historically these have focused on ensuring that there is enough food and that it is safe to eat. In recent decades additional information has been added that enables consumers to create their own healthy diet. Attempting to encourage environmentally friendly dietary choices, that are also healthy, is a very recent challenge for these governments[28] (a number of programs are discussed in the subsequent section 5.2, Current behavioural changes initiatives).

To understand the impacts of food consumption on the environment a lifecycle analysis can be done for individual food products. This is useful in identifying 'hotpots' in the lifecycle where impacts are particularly high, as well as revealing to what extent the impacts are within the control of the consumer. The following table provides a summary of 'hotspots' identified by Ryan (2011)[29] for selected food products. It includes realistic recommendations for Canberra consumers wishing to reduce the environmental impact of their food consumption.

---

[25] Smithers, 2010, 'Waitrose shelves eco friendly milk containers', article in the *Guardian*, 15 April 2010, www.guardian.co.uk/environment/2010/apr/15/waitrose-milk-containers [accessed 9/8/11].

[26] ISARG (2010). *The 2008-09 Ecological Footprint of the population of ACT*. Sydney: Integrated Sustainability Analysis Research Group, University of Sydney, pp. 17-18.

[27] SoE-WA (2007). *Fundamental Pressures*: State of the Environment Report, Western Australian Government.

[28] See for example, HCN (2011). *Guidelines for a healthy diet: the ecological perspective*: Health Council of the Netherlands. Further, the Australian Government is anticipated to include sustainability criteria in its revised Dietary Guidelines which are anticipated to be released by the National Health and Medical Research Council in late 2011.

[29] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment..

Table 1: Lifecycle analysis for specific food products consumed in the ACT[30]

Product	Hotspots Land impacts	Greenhouse gasses	Water impacts	Recommendation
Beef	Land area required for raising cattle.	Methane produced by cattle.		Consider reducing the amount of beef eaten. Avoid waste: ensure all beef bought is eaten.
Bread	Land area required for growing wheat.	Energy use in consumer shopping trips. Energy use in baking phase.		Avoid waste: ensure all bread bought is eaten.
Fresh tomatoes		On the farm (energy used to manufacture fertiliser). Energy use in consumer shopping trips.		Reduce customer transport impacts.
Processed tomatoes		Energy use in consumer shopping trips. Energy use in processing phase.	Water use on the farm for irrigation.	Reduce customer transport impacts.
Coffee		On the farm (fertiliser). Drying the beans. Final use phase (energy for coffee machine etc). Disposable cups.	Water use on the farm for irrigation.	Avoid electronic coffee machines for home use. Avoid disposable cups for takeaway coffee.

4.2 Priority areas for change

Through a similar process of lifecycle analysis, the UK Sustainable Development Commission has developed a list of household level priority actions for improving the sustainability of the food system. This study used a very broad definition of sustainability, which included more than just ecological outcomes. It is based around the UK Government's principles of sustainable development which are 'ensuring a strong, healthy and just society and living within environmental limits' and it explicitly aimed at integration (rather than trade-offs) between environmental, social and economic outcomes[31]. Thus, the study's recommendations are generally consistent with health guidelines. However, the hierarchy of recommendations does not take into account the relative ease or difficulty of implementation.
The Sustainable Development Commission assessed a range of possible changes to the current average UK diet. It placed highest priority on actions they considered were 'likely to have the most significant

[30] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment.
[31] SDC (2009) *Setting the table: Advice to Government on priority elements of sustainable diets*. London: Sustainable Development Commission, p. 8.

and immediate impact on making our diets more sustainable, in which health, environmental, economic and social impacts are more likely to complement each other.'[32]

The high priority actions identified are:

- lowering consumption of meat;
- lowering consumption of dairy products;
- consuming less low nutritional value products; and
- reducing food waste.

Actions which were likely to result in tradeoffs between different aspects of sustainability were given a lower priority. These were:

- increasing consumption of seasonal and field grown fresh fruits and vegetables (and reducing consumption of foods grown in heated greenhouses);
- only eating fish from sustainable sources; and
- increasing consumption of organic food.

Some examples of the tradeoffs identified are show in Table 2.

Table 2: Tradeoffs in food sustainability[33].

Action	**Positive sustainability impacts**	**Negative sustainability impacts**
Seasonal food	Reduced carbon emissions from heating greenhouses.	Lack of available seasonal fresh fruits and vegetables may lead to lower consumption, with associated negative health outcomes. Increase in the seasonality of horticultural labour which would have negative employment impacts.
Sustainable fish	Slow the global depletion of fish stocks.	May lead to increases in fish farming and associated increases in ecologically harmful nutrient releases from fish farms.
Organic food	Reduction in greenhouse gas emissions, mainly due to reduced use of industrial fertilizer.	Increase in the cost of food, which could impact most on the poorest in society. It was estimated that a diet consisting wherever possible of organic food is around 30% more expensive than the current average diet.

Actions expected to make a smaller contribution towards sustainability were given the lowest priority . These were: reducing energy use in food purchases and cooking; and finally, and drinking tap water rather than from bottles[34].

Although these recommendations are for the UK, they are seen as being relevant to Australia due to a large number of similarities between both average diets and food systems in the two countries. The following discussion identifies the main implications associated with each of these recommendations.

[32] ibid, p. 38.
[33] Ibid, pp. 17-30
[34] ibid, p. 38.

4.2.1 High Priority actions

Reduced meat and dairy consumption

The production of livestock for human food has a large negative impact on the natural environment as well as having both positive and negative impacts on human nutrition. It accounts for a very significant portion of global greenhouse gas emissions with estimates that meat and dairy consumption in affluent developed countries accounts for around 50% of the climate change impact of a typical diet[35]. In relation to meat, dairy and egg products consumed in the ACT they are estimated to contribute almost half (42%) of total ACT food impacts[36].

In Australia methane emissions from livestock make up 11% of Australia's total greenhouse gas emissions[37]. The main components of this are methane from enteric fermentation, nitrous oxide from manure and fertiliser, carbon dioxide from land-use change, and use of energy in agricultural activities[38]. Although it is possible to reduce greenhouse gas emissions per unit of meat or milk produced, reducing consumption will have a bigger and more immediate benefit. This is particularly important in countries, such as Australia, where consumption is above the recommended dietary requirements[39].

While it is important to note that the impact of different climates and farming systems may have a major impact on the ecological footprint associated with the consumption of red meat[40], the impact of beef and dairy cattle in terms of greenhouse gas emissions is significant in both the UK and Australia, despite differences in production systems[41].

Production of meat is a significant part of the Australian economy, and Australia is the world's second largest exporter of beef[42]. Thus it could be argued that the effect of reduced domestic meat consumption will simply be to increase Australia's meat exports rather than actually reducing production levels. A similar phenomenon was addressed by a UK study which concluded that a reduction in domestic meat consumption drives down domestic prices and decreases domestic production but also fosters exports, and thus meat production (and its related environmental impacts) is not reduced to the same extent as demand[43]. Another approach would be move away from farming

---

[35] FSA (2010). *Food and Climate change: A review of the effects of climate change on food* London: Food Standards Agency.

[36] ISARG (2010). *The 2008-09 Ecological Footprint of the population of ACT*. Sydney: Integrated Sustainability Analysis Research Group, University of Sydney.

[37] Wilson, G., & Edwards, M. (2008). Native wildlife on rangelands to minimize methane and produce lower-emission meat: kangaroos versus livestock. *Conservation Letters, 1*, 119-128.

[38] FAO (2006). *Livestock's long shadow*. Rome: Food and Agriculture Organisation of the United Nations.

[39] See for example, Friel, S., Dangour, A., Garnett, T., Lock, K., Chalabi, Z., Roberts, I., et al. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. *Lancet, November*, 46-55. In addition research on the actual amount of meat purchased, eaten and wasted for families in the ACT is being carried out by University of Canberra PhD student Michelle Minehan.

[40] See for example a comparison between the New Zealand and the UK in Saunders, C., & Barber, A. (2007). *Comparative Energy and Greenhouse Gas Emissions of New Zealand's and the UK's Dairy Industry*: Lincoln University, New Zealand.

[41] Peters, G., Rowley, H., Wiedemann, S., Tucker, R., Short, M., & Schulz, M. (2010). Red Meat Production in Australia: Life Cycle Assessment and Comparison with Overseas Studies. *Environmental Science & Technology, 44*(4), 1327-1332.

[42] Meat and Livestock Australia, www.mla.com.au/About-the-red-meat-industry/Industry-overview/Cattle, [accessed 9 August 2011].

[43] Wolf et al, 2010, 'Do healthy diets in Europe matter to the environment? A quantitative analysis' *Journal of policy modelling*, 33 (2011) , 8-28.

beef towards kangaroos (which do not produce methane) for Australia's domestic and overseas markets. It has been argued that this would provide many environmental and human health benefits[44].

Reduced consumption of 'junk food'

Although there is widespread concern about consuming large amounts of food of low nutritional value (some take away food products as well as sweets, soft drinks and the like) from a health perspective, less attention has been paid to the full environmental impact of these products. In part this is because very few full life cycle assessments have been undertaken for these products. However, their impact is significant as demonstrated in a comprehensive life cycle assessment in Sweden where these products were found to account for one third of total climate change impact in the food sector[45].

Reduced food waste

Reducing the amount of food wasted in the household also presents an opportunity for increasing the environmental sustainability of the food system. It has been reported that perishable products, such as fresh fruits and vegetables, and meat, are most vulnerable to waste. It has been estimated that there is $5 billion per year of food waste in Australia[46]. Whilst some waste is unavoidable, it been suggested that better management within the household could reduce food waste from 30% to around 6%[47]. The environmental benefits of reducing food waste include reducing the total amount of food purchased, thus lowering total production and associated environmental impacts. Redirecting food waste out of landfills to composting and other recycling facilities also has benefits such as reducing greenhouse gas emissions from landfills[48] and producing a beneficial end product (compost).

4.2.2 Lower priority actions

Seasonal and field grown fresh fruits and vegetables

Whilst there are many health led initiatives aiming to increase consumption of fresh fruits and vegetables[49] consideration of the environmental as well as health impacts leads to the emphasis on seasonal outdoor production, as opposed to indoor glass-house methods. This is because production greenhouses in cold climates such as the ACT region are typically artificially heated, leading to a higher energy footprint than for outdoor ('field-grown') produce. Avoiding out of season fresh fruits and vegetables will generally result in a more localised diet. For example some products are often imported from overseas (such as oranges, grapes and cherries from the USA) when out of season in Australia.

While reducing the distance that food has travelled from 'farm to plate' will reduce the transport component of the product's ecological footprint this does not provide a true reflection of the much more complex task of choosing low-environmental impact production and supply chains. This is because a focus on food miles reduces opportunities for benefiting from comparative advantages of production methods in different locations and climates as well as economies of scale and scope. Moreover, for many food products freight transport represents a relatively small percentage of the product's total

---

[44] Wilson, G., & Edwards, M. (2008). Native wildlife on rangelands to minimize methane and produce lower-emission meat: kangaroos versus livestock. *Conservation Letters, 1*, 119-128.

[45] Carlsson-Kanyama, A., Ekstrom, M., & Shanahan, H. (2003). Food and life cycle energy inputs: consequences of diet and ways to increase efficiency. *Ecological Economics, 44*(2-3), 293-307.

[46] Baker, D., Fear, J., & Denniss, R. (2009). *What a waste: An analysis of household expenditure on food*. Canberra: Australian Institute.

[47] FSA (2010). *Exploring food attitudes and behaviours in the UK: Findings from the Food and You Survey 2010* London: Food Standards Agency.

[48] SDC (2009) *Setting the table: Advice to Government on priority elements of sustainable diets*. London: Sustainable Development Commission, p. 22.

[49] AG (2011). *Go for 2&5*. Australian Government http://www.gofor2and5.com.au/ [accessed 27 July].

ecological footprint[50]. However there may be other benefits which are important to consumers in choosing local food, such as higher quality, fresher products and supporting the long-term viability of local industries.

Eat sustainable fish

The consumption of fish is supported by a number of health initiatives, such as the National Health and Medical Research Council Dietary Guidelines[51]. However, with many natural fish stocks now under stress due to over-fishing this is being reviewed in the revised Australian dietary guidelines[52]. With this in mind the Australian Marine Conservation Society has produced a Sustainable Seafood Guide for consumers that provides a 'traffic light' system for 60 commonly purchased seafood species[53].

Organic food

The superior environmental credentials of the organic food industry are supported by many influential organizations, including the United Nations who use it as an exemplar of a more environmentally sustainable food production method[54]. Further, with annual sales over $1 billion organic food is now a viable choice for consumers in Australia[55]. However, distribution is not comprehensive and higher prices make it difficult for some consumers to purchase these products.

4.2.3 Lowest priority actions

Reducing energy use and consumption of bottled water

And finally, reducing the amount of energy used in purchasing and cooking foods as well as drinking tap water, which has an environmental impact of less than 1% of bottled water[56], offer additional areas in which the sustainability of the food system could be improved.

4.3 Consumer choices

In relation to consumer's choice of different types of individual food products, there are some areas where lack of alternatives, or lack of information, make it difficult to reduce environmental impacts. For example impact 'hotspots' for a loaf of bread are: growing the wheat (land impacts) and energy use in retail and consumption (carbon emissions). While some consumers may choose to buy organic bread to reduce land impacts there is relatively little organic bread produced (though this might change in response to consumer demand). While consumers can choose to reduce energy use in the consumption phase by not freezing or toasting bread, there is little opportunity to avoid impacts of energy use in retailing in the ACT, where almost every retail outlet is air-conditioned[57]. Lack of information is also an issue for some purchases: for example, retailers are not obliged to label fresh fruits and vegetables as

---

[50] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment, p. 45.

[51] NHMRC (2003). *Dietary guidelines for Australian adults*. Canberra: National Health and Medical Research Council.

[52] NHMRC (2011). *Review of the Dietary Guidelines*. National Health and Medical Research Council. http://www.nhmrc.gov.au/your_health/healthy/nutrition/review.htm#mil [accessed 27 July].

[53] AMCS (2010). Australia's Sustainable Seafood Guide. http://www.amcs.org.au/WhatWeDo.asp?active_page_id=238 [accessed 27 July].

[54] UNEP (2008). *Planning for change: Guidelines for National Programmes on Sustainable Consumption and Production*. Rome: United Nations Environment Program.

[55] BFA (2010). *Australian Organic Market Report 2010*. Brisbane, Australia: Biological Farmers of Australia.

[56] Jungbluth, N. (2006). *Comparison of the Environmental Impact of Drinking Water versus Bottled Mineral Water* Zurich: ESU Services.

[57] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment, p. 9.

'field grown' or 'glasshouse grown', or to state which area of Australia they are sourced from, making it difficult for consumers to take these differences into account in their choices.

However overall Ryan (2011) [58] estimates that around half of the ecological footprint of the consumer products she examined in the ACT is under the control of the consumer. This is in areas such as the shopping trip, how the product is used, and the amount that is wasted. Impacts of consumer transport are particularly significant. For example, in relation greenhouse gasses for 1kg of tomatoes, the amount emitted it is roughly the same for the car travelling 10km to and from a supermarket (assuming that nothing else is purchased at the same time) as an articulated truck travelling 5,000km (even if it is only 'averagely laden'). This report concludes that general strategies to counter the impacts of the home consumption phase include: plan ahead and shop less frequently, buying more at a time, and finally that of combining shopping with other purposes of using a car[59]. This highlights the importance of the final purchasing phase in the total lifecycle impact of food purchases.

All the high priority recommendations of the UK Sustainable Development Commission report (Section 4.2) relate to areas directly under the control of the consumer, and provide a useful guide to actions that consumers can realistically take now, based on current levels of information. However the willingness of consumers to make these choices will depend on a complex range of motivational factors, and recent research investigating this is discussed in the following section.

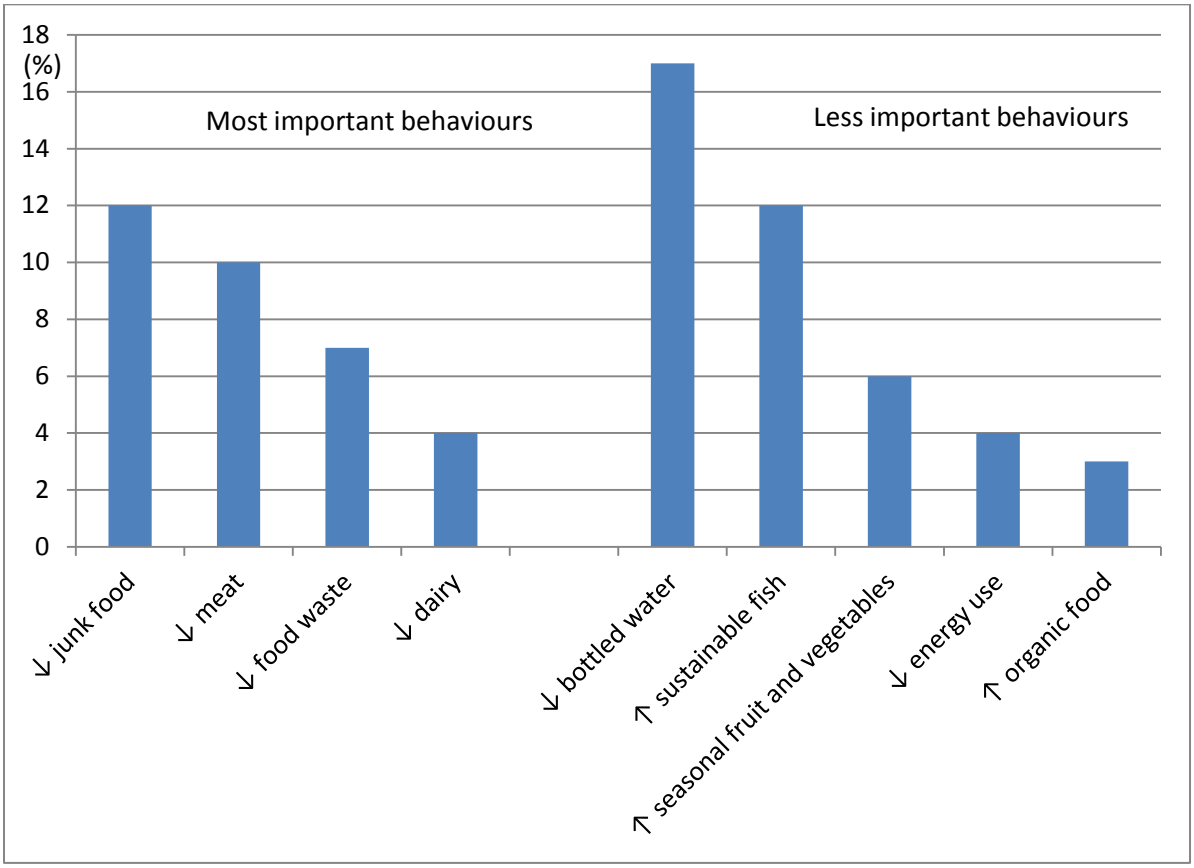
5. Achieving change

5.1 Consumers willingness to change: an ACT perspective

Conclusions from recent research undertaken in the ACT suggests that a significant portion of the population are already engaged in behaviours and that are contributing to reducing the environmental impact of their diet[60] (Figure 4). For example, 12 % of the consumers surveyed claim that they have reduced their consumption of junk food.

[58] ibid, p. 27
[59] ibid, p 27, p.46.
[60] Unpublished research undertaken by the author, some of which was presented as Pearson, D., Rowe, P., & Minehan, M. (2011). *Sustainable diets: What are consumers already doing and what will they do?* Oral presentation at 2nd World Social Marketing Conference, Dublin, 11-13 April.

Figure 4: Percentage of ACT consumers engaging in behaviours that support a more sustainable diet



The results in Figure 4 should be considered as indicative as they are based on a pilot study that incorporated focus group discussions followed by 163 responses from University employees living in Canberra to an online questionnaire. The questionnaire focused on the priority areas for change identified by the UK Sustainable Development Commission and asked questions about what changes consumers had made, or were willing to make, in these areas. As anticipated in a survey of household food buyers, the majority of the respondents (75%) were female and most households (73%) had children living at home. They represented all age groups and living arrangements, ranging from unrelated single adults through the various stages of having children to empty nesters. As would be expected their average levels of education (68% with Bachelors Degree) are higher than the average in the ACT (30%) and Australia (19%). In a similar manner they have relatively high levels of income. With this higher level of knowledge and purchasing power they, on average, are likely to be leaders in terms of their behaviour with respect to reducing the ecological impact of their diets. In terms of the methodology used it is important to note that the collection information was based on self reported behaviour. Hence the results are likely to be overstated as it's how consumers would like to behave rather than how they will actual behave.

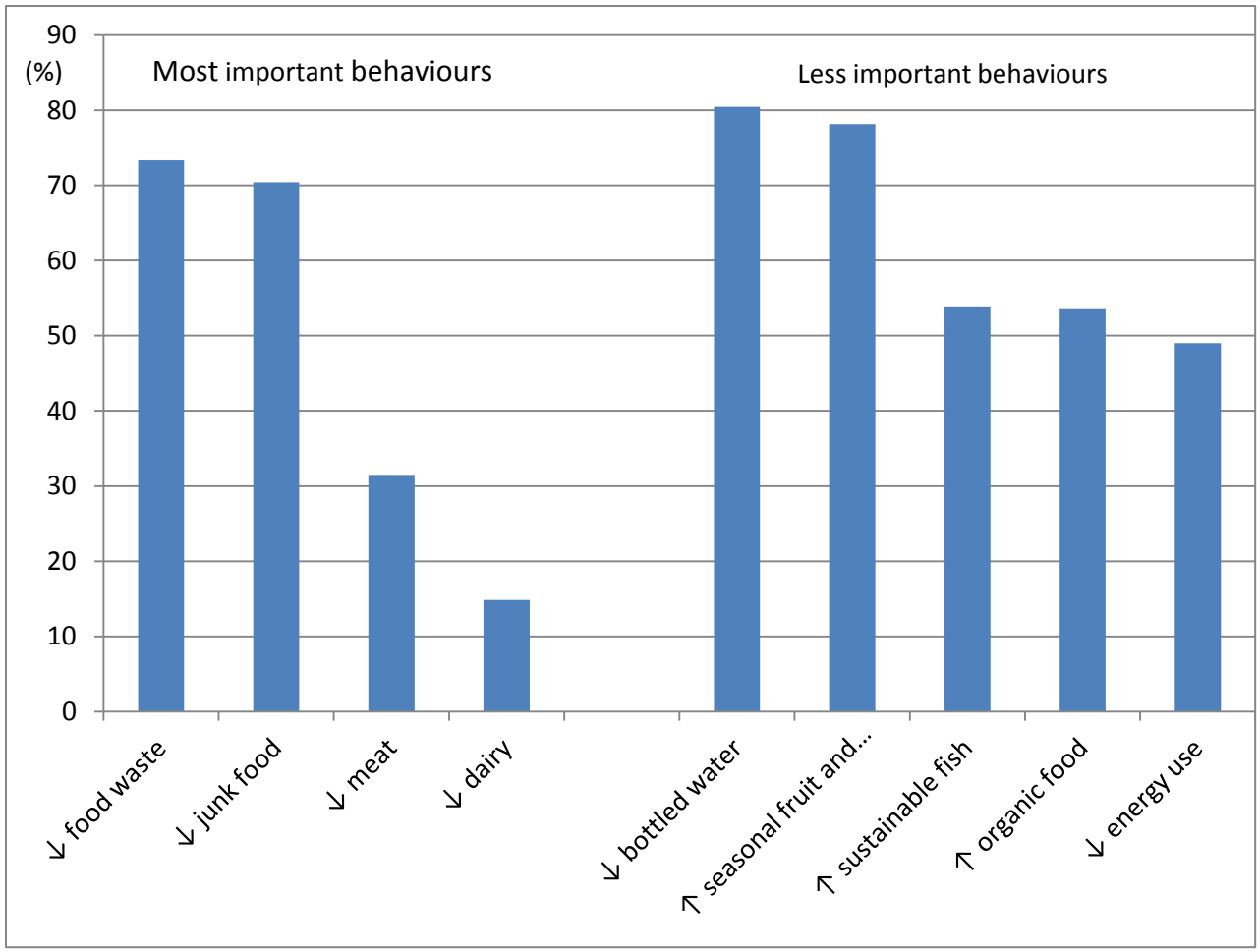
The results in Figure 4 show that in relation to the Sustainable Development Commission's identified high priority areas around 10% of food buyers have already stopped eating junk food and meat. However, it is important to note that the motivation for this may not be concern for the natural environment. Respondents cited reasons such as the impact of these behaviours on their own health as well as animal welfare concerns. This offers a good example of situations where a reduction in the ecological impact may be achieved from indirect motivations and associated actions. Although around

7% of food buyers claim that they do not waste food, within the vast majority of the population who waste food, there are the combined issues of throwing food out as well as eating more than is required. This latter issue is important as a significant portion of the survey respondents, around 30%, were classified as being overweight or obese. The range of motivations for those who have already given up eating dairy products are similar to those for meat. However, they represent a much smaller portion of the population surveyed, at around only 4%.

In relation to the lower priority behaviours almost 20% do not purchase bottled water. Over 10% of food buyers either do not purchase fish, or only purchase fish that has been sourced from sustainable sources. Just over 5% believe that they eat sufficient seasonal fruits and vegetables. Only a small portion, around 4%, have reduced the energy used to purchase, store and cook their food. And finally, around 3% feel that they are purchasing all the organic food that they can.

This research also investigated how likely these food buyers were to change their behaviour when confronted with the statement that it would improve the environmental sustainability of their diets (Figure 5). For example, over 70% of the consumers surveyed would consider reducing the amount of food waste that they generate.

Figure 5: Percentage of consumers in the ACT who would change their behaviour to support a more sustainable diet



In relation to the four most important areas (Figure 5), food buyers in around 70% of households would consider reducing their food waste and consumption of junk food. Around 30% would reduce their

purchases of meat but only 15% would reduce their consumption of dairy products. In relation to the less important areas around 80% would consider reducing their purchases of bottled water and increasing their purchases of seasonal fruits and vegetables. In contrast, around 50% would increase their purchases of organic food and sustainably sourced fish and reduce energy use.
Hence the results from this research suggest that reducing food waste and consumption of junk food are priority areas for any behavioural change initiatives that aim to reduce the ecologic impact of food choices for consumers in the ACT.

5.2 Current behavioural changes initiatives

Government

Many governments have been proactive in using their purchasing power to influence the development of more sustainable food systems. This is often referred to as green public procurement of food. They may recommend specific actions to address different environmental impacts in relation to food, including how food is prepared and served, as well as which products are purchased. Examples range from the European Commission[61] through to Blue Mountains City Council[62].

The 'Healthy and Sustainable Food Choices' guideline provided by the Blue Mountains City Council their food venues now use organic eggs, flour and some regionally sourced meats. Approximately 10% of all ingredients are organic, and 10-20% of fresh produce is locally sourced. There have been minor price increases to some items sold as a result of these changes, and current challenges to further implementation of the guidelines are the cost of organic ingredients and availability of local produce[63]. The Council also provides information on food sustainability for individual consumers as part of its online 'Sustainable Action Guide.' This includes fact sheets on 'Eat less meat' and 'Buy local and seasonal food.'[64]

Byron Bay Shire Council is developing a Sustainable Food Directory that will feature local businesses and community enterprises that support sustainable food practices which they see as supplying locally-grown food, fair-trade, free-range and organic products[65].

Some governments have programs that focus on specific aspects of food sustainability. For example, the NSW Government is currently running a campaign for consumers titled 'Love food - hate waste'[66]. This has been adapted from a similar program in the UK. It aims to reduce food waste by suggesting that consumers purchase appropriate amounts, eat before spoilage occurs, re-use cooked food, avoid overeating, and finally recycling any food waste by feeding it to animals or by composting. It is an example of public education through information, most of which is delivered by advertising. This is similar to the Victorian Government's 'Foodsmart' campaign[67].

---

[61] http://ec.europa.eu/environment/gpp/pdf/toolkit/food_GPP_background_report.pdf [accessed 19/8/11]
[62] http://www.sustainablebluemountains.net.au/imagesDB/resources/BMCChealthysustainablefoodguide.pdf [accessed 19/8/11]
[63] Coburn, J. Personal communication, 11/8/11
[64] http://www.sustainablebluemountains.net.au/resources/sustainable-action-guide/food-and-drink/ [accessed 19/8/11].
[65] www.byron.nsw.gov.au/media-releases/2011/04/01/sustainable-food-directory-free-advertising-spaces [accessed 26 July 2011].
[66] http://www.lovefoodhatewaste.nsw.gov.au/ [accessed 27 July 2011].
[67] http://www.foodsmart.vic.gov.au/FoodSmartWeb/ [accessed 9 August 2011].

It is interesting to note that the Australian Government is not inclined to legislate for additional labeling on food products that would provide an indication of their environmental impact. A recent multi-departmental government review placed labeling in relation to 'consumer values,' which would include ecological sustainability, as last in a hierarchy of priorities[68]. Not surprisingly human health remains the highest priority for them in relation to food labeling information for consumers .

Not-for-profit organisations

The Food For Life Partnership[69] is an example of not-for-profit organisations working together to improve the quality of food in UK schools. They provide three levels of awards for achievements that are centred around the development of leadership in food activities, its quality and provenance, education, culture, and community involvement. For the top level gold award the school must be a hub of good food culture in their community, actively involving parents and community groups in cooking and growing activities. Further, their school meals must be at least 75% freshly prepared, 50% local and 30% organic. In addition more than 70% of pupils must choose to eat school meals.

Ozharvest – Canberra[70] is an example of a not-for-profit organisation which directly reduces food waste by collecting excess perishable food from caterers, restaurants and grocers and distributing it to charities which provide food for disadvantaged people in Canberra and Sydney.

Other organisations focus on the ACT. These include Real Food Canberra who see their mission as 'redefining food for the earth and the eater' through educating 'young people about the benefits of eating sustainable (environmentally, ethically and nutritionally) food' [71]and Canberra Organic Growers Society who aim to 'encourage the general public to adopt organic growing methods'[72].

Universities

Bruce Hall, which is a residential college for students located at the Australian National University, has recently introduced food sustainability initiatives in both its catered and self-catered areas. These programs arose out of two student projects in association with the ANU Sustainability Office 'ANUgreen'[73]. While the Hall's kitchen was already composting all food waste, the new programs have increased the proportion of local produce used from about 20% to up to 80%[74]. Meat options have been reduced from two choices to one at each meal, and a vegetarian choice is now available to all students, rather than being restricted to 'special diets'. The college also uses posters and on-table flyers to promote these initiatives at functions and provides information on where to buy local produce to self-catering students. The same local produce suppliers are also used by another ANU student residence, Ursula Hall[75].

---

[68] COAG (2011*). Labelling logic*. Canberra: Council of Australian Governments, p. 45.
[69] http://www.foodforlife.org.uk/ [accessed 22 July 2011].
[70] http://www.ozharvest.org/index.asp [accessed 9 August 2011].
[71] http://realfoodcanberra.org/ [accessed 6 September 2011].
[72] http://www.cogs.asn.au/ [accessed 6 September 2011].
[73] Shiner, A. 2009, *Bruce Hall Dining Hall Sustainability Audit: Student Factsheet, http://www.anu.edu.au/anugreen/index.php?pid=1211; Christoe, S.* (2010) *Sustainable Campus Dining at Bruce Hall: Student Factsheet,* unpublished.
[74] 'Local' is defined as from the Australian Capital Region, an identified aggregation of local government regions with a radius of approximately 100 km from Canberra. The proportion of local produce used in 2011 has been affected by the 2010 Queensland Floods, as local growers have had access to more lucrative markets previously supplied by Queensland growers.
[75] Wanell, D. personal communication, 17/8/11.

The Halls' Executive Chef reports that these changes have been very positive, as the local produce is of noticeably higher quality and the changing seasonal produce necessitates a more creative approach to menus. While there have been minor cost increases associated with the changes these have not been passed on to residents as there have been savings in other areas. Possible expansions of the program – for example to include organic produce – are unlikely at this time due to prohibitive costs and issues with reliability of supply[76].

A further development of this project has been the creation of a set of sustainable food guidelines for caterers[77]. This was produced as a student project in association with the not-for-profit group Real Food Canberra as previously mentioned. It highlights the environmental, health and financial benefits that can result from making catering systems more sustainable. At this stage no other ANU residential colleges have adopted these guidelines[78].

The University of Canberra became a 'bottled water free' campus in early 2011[79]. New water bubblers and bottle refill stations have been installed for students and staff that offer a chilled water alternative to bottled water. Previously Bundanoon in the Southern Highlands of NSW became Australia's first bottled water free town[80].

5.3 Implications for achieving change

On the basis of the preceding review of the publically available information there is evidence of numerous activities encouraging a more ecologically sustainable diet, most of which are being led by Government and Non-Government organizations, rather than industry. Further these activities are generally targeting the areas that are having the largest impact on the environment, namely the reduction of food waste, junk food and meat products.

Most of these activities are using information campaigns to provide consumers with knowledge thus allowing them to make more informed choices. As such they have the capacity to provide a gradual change in the values and attitudes held by consumers. However, consideration of more interventionist approaches that take into account and respond to the complex of issues informing individual choices (as discussed in Section 3.2), such as increasing the price of products that have a high ecologically impact through increased taxation, or removing them from the marketplace as an extreme example of 'choice editing' may be justified if more rapid reductions in ecological footprint are considered necessary.

6. Conclusions

To reduce the ACT's ecological footprint in an absolute, as well as on a per capita basis, it will be necessary to address many aspects of sustainable consumption and production. Influencing values and attitudes provides one perspective for nudging individual choices towards more environmentally sustainable alternatives. However many of these choices are so deeply embedded in social and structural contexts, as well as habit, that changing these behaviours is far from straightforward.

---

[76] ibid.
[77] http://realfoodcanberra.org/wp-content/uploads/2011/01/TRANSITION-GUIDE_FINAL.pdf [accessed 22 July 2011].
[78] Christoe, S. personal communication, 2/8/11.
[79] http://www.canberra.edu.au/monitor/2011/feb/10-bottledwater [accessed 6 September 2011].
[80] http://www.news.com.au/nsw-town-of-bundanoon-votes-to-ban-bottled-water/story-0-1225747578818 [accessed 25 Oct 2011]

It is vital to include consideration of food in reducing the ACT's ecological footprint. This is because it represents a significant proportion of the Territory's footprint and offers an opportunity to engage all residents by embedding changes in their daily habits. This is not to dismiss other lower impact areas where many consumer frequently exercising small impact choices for sustainability will add up to something significant[81]. It is recognised that diets and their associated food systems are hugely complex and that there are many areas in which environmental sustainability of food production and processing systems may be improved. However, engaging consumers in a number of interrelated behavioural changes can create an important demand led pressure on the rest of the system. For this reason it is necessary to consider actions that address food purchases, consumption and disposal.

In considering what actions governments, industry and non-government organisations may take to encourage consumers to make sustainable food choices it is important to consider the data presented in this report in terms of what changes will have the greatest impact and what changes consumers are actually willing to make. For example, although providing information about the impacts of high meat consumption is a positive step, only a modest number (around 30%) of ACT food buyers are likely to reduce their meat consumption. Thus achieving a significant behaviour change is likely to require a substantial investment. On the other hand, many more ACT food buyers (over 70%) are likely to reduce food waste and consumption of junk food. This suggests that programs such as the NSW Government's 'Love food - hate waste' have a higher chance of creating behaviour change that results in a positive ecological impact in the ACT. In addition, engaging in activities that aim to reduce consumption of junk foods will provide co-benefits of reducing the ecological footprint whilst simultaneously improving human health. Also, it is interesting to note that non-government organisations are showing visible support for these government initiatives, whilst support from industry is less visible.

Thus in conclusion, in the absence of a single solution, it would appear that a mix of interventions would be required to reduce the ecological impact of the food system in the ACT. Further research could be undertaken to identify more details of actual food consumption patterns prior to recommending priority areas for intervention. Ultimately, it is likely that significant change could be achieved when consumers are nudged through prompts and encouraged by individuals and their physical environment to make many incremental and enduring adjustments in their habits.

[81] Ryan, S. (2011). *Buying Choices for a more sustainable Canberra*. Canberra: Office of the Commissioner for Sustainability and Environment, p. 46.

EcoInsights

Issues for Future Sustainability and Environmental Management in the ACT and Region

Report for the Office of the Commissioner for Sustainability and the Environment
Australian Capital Territory
November 2011

Office of the Commissioner for Sustainability and the Environment

This Horizon Scan was produced with funding from the Office of the Commissioner for Sustainability and the Environment in the ACT (OCSE)

Facilitated and researched by Steven Cork, EcoInsights, with valuable inputs staff in the OCSE a range of stakeholders from the ACT and region

Steven Cork
Principal, EcoInsights
Telephone: 02 6257 4289 Mobile: 0417 498 649
Email: stevecork@grapevine.net.au
Web: http://grapevine.net.au/~anncork

Contents

Executive summary

According to leading strategic thinkers and futurists, a key to dealing with the uncertainties of the future is to anticipate the range of plausible futures, 'rehearse' what life might be like in different ones, and decide what actions we might take to prepare for and/or shape the future that unfolds. To help prepare the ACT for a range of plausible futures, the Office of the Commissioner for Sustainability and the Environment (OCSE) is undertaking horizon scanning for the ACT State of the Environment report, focusing on sustainability and environmental issues likely to have a significant impact in the ACT and Australian Capital Region in the next 20 or so years.

This document summarises inputs from two stakeholder workshops and literature scanning. The report is organised under section-headings that reflect key topics that emerged from the workshop dialogues. Section 11 discusses implications for sustainability and environmental management in the ACT and region.

Global drivers of change

The factors that could affect sustainability and environmental management in the ACT and region in coming decades are not just those that are obviously sitting on our doorstep. Many trends and events happening in other parts of the world could potentially have important direct or indirect affects.

Between the two workshops and the additional literature and media scanning, the following key global drivers of environmental and social change in the ACT and region were identified:

- Globalisation (which means that Australia and the ACT are not immune to change occurring elsewhere in the world)
- Global power shifts affecting Australia's region (especially the possibility that power and influence will move further towards the eastern countries, which Australia is closely associated with)
- Global economic uncertainty (which could go in many different directions and involve a wide range of countries in different ways)
- Decline in oil supplies and tensions and uncertainties associated with transitions to alternative energy sources
- Shortages of water in many countries and associated shortages of food, which could not only affect markets for Australian commodities but also see Australia playing a role in providing aid
- Climate change, which is likely to affect the ACT and region in many ways, including the frequency and severity of extreme weather events, food security and immigration
- A growing rich-poor divide and increasing inequity (the ACT and region is not immune to the forces generating this divide)
- Political unrest arising from combinations of all of the above

Perceptions about past change

Workshop participants identified a range of major changes in the ACT and region over the past 30 years that give hints about futures change. Changes that loomed large included an increase in impacts of human settlements on the natural environment, a decrease in emphasis on activities in the 'outdoors', an increase in the harshness of the climate (drought, fires), the emergence of peak oil with its far-reaching social, economic and environmental implications, and perhaps a decrease in the depth of people's knowledge about many issues due to the rise of the Internet. On the other hand, stakeholders observed that awareness of environmental issues has grown, climate change has become recognised as a major issue and actions to prepare for it have commenced, the relationships between humans and the environment are becoming a focus for urban design in the region, communities are increasingly engaged in decision making, and the

Internet has provided breadth of knowledge and flexibility for work-life balance.

Immigration and population are issues discussed much more now than they were, although probably not as much or as openly as they should be.

Resource limitations

It would be easy for the ACT and regional communities to become complacent about water, after surviving the last decade of drought and with extensions to the Cotter dam almost completed. Responses to future potential water shortages will be major factors shaping urban development and lifestyles in the ACT and region in the next few decades.

Climate change and the need to make transitions to new sources of energy are converging to create major challenges and opportunities. The ACT and region face particular challenges due to their relatively high dependence on oil, especially for transportation and agriculture.

These conclusions raise possibilities like: the emergence of new businesses based on provision of energy to Canberra; greater cooperation and better strategic planning driven by the need for sustainable energy strategies; a new wave of undesirable environmental impacts caused by a scramble to capture part of emerging energy markets; and risks that some communities in the region might become marginalised because they cannot afford costs of energy.

Health, food and wellbeing

Declining mental health of young people, and especially declining hope for the future, are emerging and worrying trends. There are opportunities for the ACT and region to make better use of locally grown food and outdoor activities to increase health and wellbeing outcomes, but there are also global trends driving less outdoor activity and more 'virtual' activity indoors.

It is well known that economic pressures, aging of the population, and the prospect of longer lives raise issues for future health and environmental management, but these trends acting together have the potential to generate both major additional challenges and opportunities for innovative solutions. The ACT and region are already showing signs of retired people becoming more engaged in addressing environmental and health issues at the community level and this could be a sign of the region's future over the next few decades.

There are still concerns about how prepared Australian settlements are for major health challenges, including a disease pandemic.

These conclusions raise the question of whether measures of human wellbeing, as they evolve in the next half-decade or so, might become an integral part of reporting on the state of the 'environment' in this region.

Technology

Developments in information and communication technologies (ICT) over the next two decade are likely to have huge and unpredictable impacts on all aspects of life in the ACT and region, including where and how people live and work, engagement of diverse stakeholders in complex strategic dialogue about environmental and social issues, transportation, food production, health, medicine and even, potentially, large-scale manipulation of the environment. Much of the promise and uncertainty of technology in the future is likely to come from convergence among technologies.

Around the world, many governments have responded to the risks and uncertainty created by rapidly changing technology by becoming less flexible and more cautious — the future might be characterized by see-sawing between risk-aversion and risk-taking by different nations and different sectors to gain competitive advantage.

The likely advances in communication technology in the next decade and beyond will very likely place increasing pressure on government instrumentalities, such as state of the environment reporting units, to report change continuously, to make information readily available to any who request it, and to allow greater involvement of stakeholders in decision-making. This raises many challenges to do with issues like costs of data acquisition and distribution and maintaining security of both internal government communication systems and private details of stakeholders.

Another possible implication of rapidly improving technological capacity is the a risk that private or public decision-makers might be tempted to use environmental technologies to make large-scale interventions in ecological systems, either to address perceived problems or to improve functionality. Some experts are very worried about the outcomes of some 'geo-engineering' possibilities.

What we think and how we live

Attitudes affect not only how we respond to change but also how we perceive the risks and possibilities of the future.

Australians see the environment and the economy as our two most significant problems — many are willing to modify their lifestyles to protect the environment.

The ACT has been rated the state or territory least despondent about the future.

In Australia and globally there is an increase in 'bottom-up' community action on environmental sustainability, and this trend is evident in our region. Virtually all participants in the workshops felt that the major global drivers of change are pushing communities like those living in this region to live more sustainably and simply.

Can the people of the ACT and region — where levels of education, wealth and resources are high — do a better job than others in Australia and the world at addressing complex social-ecological problems like climate change, equitable water use, peak oil, an aging population and global financial upheavals? How can we learn collectively from the many different approaches and sources of knowledge available in the region?

Urban design and transport

It is possible that Canberra could lose its green spaces if pressure to develop and the costs of maintaining the green spaces were to rise. This would fundamentally change the character of Canberra and probably have effects on health and wellbeing that ultimately would be more significant than economic gains.

Care needs to be taken that changes in urban structure do not reduce opportunities for people to meet and interact.

Processes are emerging that bring environmental management together with urban design and management in the ACT and region — will we see this trend continue and what might it mean for the nature of Canberra in the next few decades? How this trend develops is likely to affect the nature of home ownership, transportation, food and many other aspects of lifestyle.

Relationships between the ACT and the region

The relationship between Canberra and the surrounding region might develop in a range of ways in the next few decades:

- New approaches to governance to tackle emerging linked social and environmental challenges
- Greater provision of energy and other resources within the region, reducing reliance on external resources and increasing resilience

- Many more people living in the region and working remotely for a Canberra-based employer
- Canberra might grow or shrink, even collapse, depending on changes in roles of government, energy and water supply and pricing, and emergence of new technologies, especially ICT

A post-growth economy is a possible, but highly challenging, future for the region

These diverse possible trends raise the question of what alternatives are being considered for the economic development of the ACT and region and how these might be integrated into thinking about sustainability and environmental management.

Biodiversity

The factors considered in other parts of this report all have the potential to affect biodiversity directly or indirectly.

Attitudes of people towards biodiversity will be a key driver of action for its protection, and yet it is by no means certain that biodiversity conservation will continue to be seen as important or even necessary.

Concerns have been raised that governance and institutional arrangements in Australia and elsewhere are inadequate to deal with ecological crises that set off cascades of environmental and social impacts.

Evidence of declines in the health of the world's (and Australia's) soils, together with proposals for action to address these declines, may mean that soils and soil biodiversity are a focus for environmental management for the next decade or more.

Effort is needed in the next decade to make real progress on reducing and, hopefully, reversing the major pressures on biodiversity in Australia, which have been growing for several decades. It would be easy for governments to become resigned to slow progress, but with the prospect of surprising new knowledge and technologies we must also be thinking about how we might respond if suddenly major progress was possible, but with it an increased risk of unintended side-effects.

Resilience

The concept of resilience is getting more and more attention, especially by regional communities. For the ACT and region, key challenges will be to maintain diversity — of skills, ideas and workers — and a sufficiency of resources so that the region and its people can remain resilient and have high capacity to adapt to future challenges and opportunities.

A major risk faced by communities around the world is the temptation to focus too much on so-called 'specified resilience' (known or expected pressures) and to invest too little in general resilience to cope with the unexpected.

Challenges for the region in the next decade include:

- using government programs and non-government activities to contribute to dialogue across ACT and regional communities about the nature of resilience and the linkages between environmental and social resilience
- addressing resilience in environmental assessment and management programs
- remaining vigilant for signs of undesirable resilience (i.e., processes that prevent desirable change) and being able to avoid it

Implications for sustainability and environmental management

Environmental policies and management aimed at achieving sustainability in the ACT and region in the next few decades will need to deal not only with ongoing environmental pressures and changes but also with social and economic change

driven largely by forces external to Australia.

These global forces, together with local ones, influence many aspects of the region's social and economic processes, which have powerful influences on the natural environment and are also influenced by it through a range of benefits that contribute to human wellbeing.

The next few decades are likely to be characterised by extreme climatic events and economic and social surprises. The ability of the region's ecosystems and the communities that rely on them will depend in part on anticipation of possible shocks, generating and maintaining diverse ideas and resources to cope with surprises, and having effective networks of engaged and cooperating people to detect and respond appropriately to change.

The state of the environment process is one logical mechanism for assessing the adequacy of both human and ecological resources for these tasks and facilitating cross-sectoral dialogue and networking that engages and empowers communities and discipline experts.

1

Introduction

Futures thinking

According to leading strategic thinkers and futurists, a key to dealing with the uncertainties of the future is to anticipate the range of plausible futures, 'rehearse' what life might be like in different ones, and decide what actions we might take to prepare for and/or shape the future that unfolds. As individuals we rehearse multiple futures daily. For example, a trip to work could involve things like a missed bus, a flat tyre, a sick child, a traffic jam, forgetting our wallet, an obnoxious fellow traveller and many other possibilities. If any of these happen we already know what to do, because we have 'rehearsed' them unconsciously. When we get together in organisations and societies, however, we tend to shut down thinking about multiple possible futures and get on with the current job, assuming someone else is doing the strategic and future thinking.[1] Often no-one is because we are all busy and all assuming someone else is doing it.

This project

The Office of the Commissioner for Sustainability and the Environment (OCSE) is undertaking horizon scanning for the ACT State of the Environment report, focusing on sustainability and environmental issues likely to have a significant impact in the ACT and Australian Capital Region in the next 20 or so years. This scanning builds on a range of published horizon scans at local to national scales in Australia and elsewhere and on the Canberra 2030 'time to talk' program.

Dealing with uncertainty

Although nothing about the future is certain, some things are more likely than others. When a trend is already well established, it is likely to continue into the future, although we cannot be sure for how long. Trends that are only starting to emerge might not continue to develop. So-called 'weak signals' — evidence that we think might signal a trend but we cannot be sure — are of much lower certainty. Things that we imagine might happen under certain circumstances are of the lowest certainty but are nevertheless important because disruptive surprises often come from events that have not happened before and/or new combinations of trends that can only be imagined rather than predicted. Strategic thinkers and futurists usually are careful to distinguish between relative certainties and possibilities. In this report, a high degree of likelihood of trends and events is indicated by the use of words like 'is likely to', whereas possibilities are indicated using words like 'might', 'could', or 'it is possible that'.

EcoInsights was engaged to scan a range of literature and media for emerging drivers of change and to facilitate two workshops at which around 40 selected stakeholders from the ACT and region discussed issues potentially affecting sustainability and environmental management in the ACT and region in the future.

A wide range of stakeholders took part, representing health, building, education, research, forestry, agriculture, water management, conservation, local government, the ACT Government and other sectors of society. Several of the ACT's Young People Ambassadors (http://www.youngambassadors.org.au/about/) took part. The ages ranged from high-school age to retirees, so memories and information about the past varied widely.

Importantly, the scanning process was not intended to be a comprehensive review of the literature. It was to focus discussion on nascent issues that might have been overlooked in other reviews.

Planning for the future of the ACT and region

Thinking about the future of the ACT and region should be done by everyone who has an interest in the long-term prospects of this part of Australia and its people. We all have different ideas, experiences and skills to bring to dialogue about the future.

At the level of governments, thinking about the future of the ACT and region is brought together in a range of interacting plans and policies. *The Canberra Plan* — a strategic framework defining a direction for Canberra over the next two decades — includes an Economic White Paper, a Social Plan and a Spatial Plan.[2] It is underpinned by the ACT Government's vision for a future Canberra: *People Place Prosperity: a Policy for Sustainability in the ACT*. The ACT and the surrounding region are under different government jurisdictions, but a joint strategy — the *ACT and Sub-Region Planning Strategy* — has been in place since 1998.

The State of the Environment Report is one source of information about the ACT and region that feeds into these planning processes. The inclusion of this horizon scan extends the level of strategic thinking included in considering the state and future trends of the environment in this part of Australia. In doing so it is among a growing number of jurisdictions around the world that are taking this stronger future-focus. The recent UK National Ecosystem Assessment[3] is the latest example of a national state of the environment assessment that included scenarios for the future of the relationships between people and the natural environment.

This document

This document summarises the inputs from the workshops and literature-scanning. The headings of the sections reflect the author's perceptions of key topics that emerged from the workshop dialogues. Section 11 discusses implications for sustainability and environmental management in the ACT region.

Global drivers of change

The factors that could affect sustainability and environmental management in the ACT and region in coming decades are not just those that are obviously sitting on our doorstep. Many trends and events happening in other parts of the world have the potential to affect the ACT and region directly or indirectly.

Between the two workshops and the additional scanning, the following key global drivers of environmental and social change in the ACT and region were identified:

- Globalisation
- Global power shifts affecting Australia's region
- Global economic uncertainty
- Decline in oil supplies and tensions and uncertainties associated with transitions to alternative energy sources
- Shortages of water in many countries and associated shortages of food
- Climate change
- A growing rich-poor divide and increasing inequity
- Political unrest arising from combinations of the above

Globalisation is the trend towards unification of economic and other processes worldwide through reductions in barriers to trade and other interactions between countries. It is seen by many as a process to achieve equality of opportunities (e.g., with respect to trading rules) but is seen by others as a process that reduces cultural diversity and adaptability and is potentially open to corruption by powerful interests. The Millennium Ecosystem Assessment[4] suggested that global connections between countries could help decision-makers deal with widespread threats like disease outbreaks.

In the context of the ACT, one of the major implications of globalisation is that this territory cannot isolate itself from global economic, social, and environmental influences. This means that thinking and acting to keep the region resilient and

adaptive must take account of what is happening in other parts of the world. It will be a challenge to build resilience to shocks that are hard to anticipate and even harder to control, and part of this region's preparations for the future must include the ability to adapt to surprises. The issues of personal and community resilience are discussed in Section 10 of this report.

One of the manifestations of a globally connected world has been that Australia has not been immune to the repercussions of the global financial crisis. Since 2008, there have been many impacts on the economy of the ACT and region. If there are further upheavals in the next few years, the resilience of the ACT's economy could be tested by both helpful and unhelpful economic pressures. At the moment, some of the major possible pressures, both positive and negative, appear likely to come from Europe, as it struggles with economic difficulties, and China, as its economy appears set to become increasingly dominant but could also falter, at least temporarily.[5] The fortunes of Brazil, Russia and India are also considered by many commentators as having potential to stimulate or inhibit global financial processes, and there is always the chance of other economies, currently not on our radar, having important influences on Australia.

Much has been written in the past decade, and especially since the global financial crisis, about how economic power is shifting towards eastern countries.[6] With that shift has been a comparable movement of hope for the future. According to the Pew Research Centre, many more Chinese, Brazilians and Indians think their country is going in the right direction than do Britons, Americans and French, and more and more companies are investing in emerging markets and sidelining the developed world.[7] As Australia is increasingly an integral part of the southeast Asian region, our economic and political future might become even more strongly aligned with that of Asian countries, or Australia might find its inclusion in regional affairs reaches a limit or it might choose to limit that engagement. All of these possibilities have economic and political implications that could affect trade and other relations between the ACT and region and Asian neighbours.

The International Energy Agency's (IEA) latest World Energy Outlook report stated that the peak in oil availability has arrived.[8] The reports estimated that the world economy will demand at least 40% more energy by 2030. Over 75% of the global increase in energy use from 2007- 2030 is expected to be met through fossil fuels, especially coal. An estimated 77% of the power stations required to meet demand are yet to be built.

While it seems almost certain that peak oil is here, and that this is likely to lead rising prices for an increasingly rare commodity, its effects on people's lives are uncertain in many ways. For example, on the one hand government might develop orderly approaches to making the transition from oil to other energy sources. On the other hand, several global analyses suggest that there may be uncertainty and disruption as governments initially try to avoid changing policies with respect to energy and subsequently panic and scramble to transition to new sources of energy.[9]

This uncertainty could affect many aspects of life in the ACT and region, including the stability and effectiveness of governments, how people in communities move around and interact, and social inequities, as some in society can cope with costs and uncertainties while others struggle. The ACT and region currently has relatively high reliance on fossil fuels, but that could change. Depending on the extent and nature of the uncertainty around transitions to new energy sources, environmental management could either have an increasing importance or could be neglected while governments focus on seemingly more urgent issues. This raises new challenges for those seeking to keep good environmental management on the agendas of decision makers.

A shortage of water in relation to demand is a problem for many countries and regions around the world. Water shortages in other parts of the world can affect

environmental management in Australia, for example, by affecting demand for food in other countries and therefore demand for Australian produce both through markets and as aid.

Major potential impacts on the ACT and region as a result of climate change acting as a global driver include: changes in frequency and intensity of extreme events (e.g., bushfires, heatwaves, rainfall, hailstorms); food insecurity issues in other countries requiring assistance from Australia; rethinking and strengthening the roles of protected areas and other approaches to biodiversity conservation and provision of ecosystem services to people; and the possibility of climate-change refugees coming to Australia.[10] The potential for substantial numbers of refugees settling in regional Australia, including the ACT perhaps, could have major benefits as well as challenges in the future.

Most commentators agree that the rich–poor divide is increasing rather than decreasing globally, and this is a contributor to unrest, including terrorism, in many countries. This gap has a range of other indirect effects on the ACT. For example, low wages in other countries affect the competitiveness of Australian businesses in global markets and can affect the affordability of sustainability strategies for ACT and regional businesses. This rich-poor gap is also a direct concern within the ACT and region, which will be discussed in later sections.

All of the above global drivers can contribute individually to political unrest and they can become very powerful disruptive influences when they interact in undesirable ways.

Key emerging issues for the ACT and region

Appendix 1 is a diagramatic representation of key issues raised by participants in the two workshops and the author's interpretation of how these issues are inter-related. This will be a daunting diagram for some readers. Its purpose is to allow those who are interested to explore relationships between issues. For those not interested in these details, the key implications are summarised below and in the following sections of this report.

The workshops revolved around several major topics:

- Resource limitations (water, oil and others)
- Health, food and welfare
- Technological change
- The way we think and how we live (lifestyles, work, attitudes and demography)
- Urban design and transport
- Relationships between the ACT and the region
- Personal and community resilience

These topics form the main headings for the rest of this report, following a consideration of the key changes that have affected what we see and experience in the ACT and region today.

2

Perceptions about past change

Table 1 summarises the views of stakeholders about key trends and events that have shaped sustainability and environmental management in the ACT and region over the past three decades.

Changes of concern that loomed large included: an increase in impacts of human settlements on the natural environment; a decrease in emphasis on activities in the 'outdoors'; an increase in the harshness of the climate (drought, fires); the emergence of peak oil with its far-reaching social, economic and environmental implications; and perhaps a decrease in the depth of people's knowledge about many issues due to the rise of the Internet.

On the other hand, stakeholders observed that: awareness of environmental issues has grown; climate change has become recognised as a major issues and actions to prepare for it have commenced; the relationships between humans and the environment are becoming a focus for urban design in the region; communities are increasingly engaged in decision making; and the Internet has provided breadth of knowledge and flexibility for work-life balance.

Immigration and population are issues discussed much more now than they were, although probably not as much or as openly as many stakeholders would like.

Table 1: Summary of stakeholder perceptions of key trends and events driving change in sustainability and environmental management in the ACT and region over the past three decade

1980s	*1990s*	*2000s*
Environmental development	Denial of environmental problems	Tree plantings
Evidence of climate change (acceptance has taken 30 years)	Internet/ mass communication	Ethical implications of environmental decline discussed
Assumption that technology will solve climate change	Activism professionalised	Instant experts (Wiki, internet)
Role of women	Community sector engaged	Evidence of peak oil - Cost of petrol becomes a public issue
Urban sprawl	Gene technology	Bushfires, drought
Globalisation	Loss of land to urban development	Population increase causing concerns
Overuse of water starting to become apparent	Urban density increasing	Increased immigration becomes and issue
Growth of Tuggeranong	Water becomes more of an issue	
Exercise was done in the outdoors	Environmentalists and local communities sometimes conflicting	
Threatened species legislation	Exercise increasingly done in gyms rather than outdoors	
Mass production, consumption, disposal	Cities infringing on the environment	
	Environmental education in schools	

3

Resource limitations

Key points

It would be easy for the ACT and regional communities to become complacent about water, after surviving the last decade of drought and with extensions to the Cotter dam almost completed

Responses to future potential water shortages will be major factors shaping urban development and lifestyles in the ACT and region in the next few decades

Climate change and the need to make transitions to new sources of energy are converging to create major challenges and opportunities

The ACT and region face particular challenges due to their relatively high dependence on oil, especially for transportation and agriculture

Water and energy limitations pose challenges but also offer opportunities

Water, energy and climate change are very tightly interlinked with one another.[11] For example, many ways in which people manage water require energy (e.g., pumping water and growing food currently require energy from fossil fuels). Climate itself is affected by how water and energy are managed and it affects options for generating hydroelectric, wind and solar power.

Recent surveys by SustainAbility and GlobeScan revealed that 87% of experts rated water as the world's most urgent challenge, compared with 82% for climate change.[12] Internationally, the scientific journal Nature published a study showing 80% of the world's population living with insecure fresh water supply.[13] In Australia we have seen the unprecedented focus on water in the Murray Darling Basin and the widespread droughts in various parts of Australia in the 2000s.

But we are also seeing the first glimmers of hope that water might bring people together and be a catalyst for new and more effective ways to approach environmental challenges. There are hopeful signs of cooperation over water in the middle east,[14] and the replacement of forests and other vegetation after the Canberra fires — something that was much less likely to have occurred before the fires — brought people together and underpinned the need for such strategic thinking.

A major issue discussed in the workshops was the potential for Canberra's population to become more dispersed as people take advantage of opportunities offered by communication technology to work remotely and not have to live in the same city or town as their employer. While this dispersed population offers many benefits for health, life-fulfillment and growth in local economies, it has the potential to place high demands on water supplies to regional towns. The different possible mixes of industries that the ACT could foster to ensure a sustainable economic future also will have implications for water usage and supply options.

A major source of uncertainty for people charged with managing natural resources is how governments deal with the dual challenges of peak oil and climate change. Several scenarios about how Australia and other countries might deal with these dual challenges identify the orderliness or disorderliness of policy transitions as key uncertainties affecting the ability of communities to adapt.

The first step in transitions to new energy sources is likely to be an increased focus

on coal and gas, which is already providing both challenges and opportunities for regional communities in parts of Australia. As this process unfolds it is likely to have direct and indirect effects on the ACT and regional communities. For example, it is likely to affect demand and opportunities for development of alternative energy technologies and businesses, in both positive and negative ways. The transition to new energy sources is a potential source of conflict among nations as they seek to shore up their supplies of resources.[15]

Current policy settings in Australia deal with water, energy and climate change somewhat separately. Will Australia and/ or the ACT manage to bring these issues together in policy and management? How might environmental management in the ACT proceed under orderly or disorderly transitions to new energy and climate change policies?

Alternative energy technologies and strategies

The movement to alternative energies, such as biofuels and wind farming, is underway and there is already considerable investment in the ACT and region. Some workshop participants from the region pointed out that Canberra draws considerable resources from the surrounding area and is likely to increase this reliance in the next few decades. This could be both a boon to regional economies and a burden, with respect to different resources at different times.

Supplying energy might be one area that expands. The suggestion was made in the workshops that small scale, safe nuclear reactors (for example, based on thorium) might be established in this region. China recently revealed that it was launching a new energy program based on thorium reactors.[16] This technology, pioneered in the USA, is said to be safer and cheaper than conventional nuclear power and to produce a thousand times less hazardous material. Some commentators suggest that this might 'mark the passage of strategic leadership in energy policy from an inert and status-quo West to a rising technological power willing to break the mould'.[17] Others suggest that the technology will not be safer.[18] This remains a very uncertain possibility for the ACT and region but one that could change our future greatly if it develops.

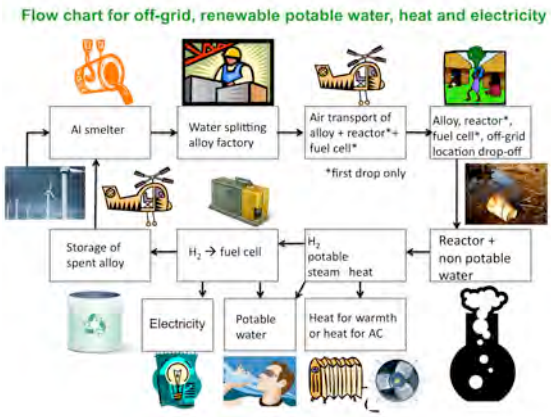


Figure 2: Researchers have developed an aluminium alloy that could be used in a new type of mobile technology to convert non-potable water into drinking water while also extracting hydrogen to generate electricity. Such a technology might be used to provide power and drinking water to villages and also for military operations[19]

Workshop participants considered the many ways in which adapting to other new sources of energy could affect lifestyles and infrastructure in the ACT, and this is discussed Sections 6 and 7. One suggestion that came up several times was the idea of towns, or even suburbs, developing their own capacity for generating power, independently of power-distribution grids. Such ideas are gaining traction around the world (see Figure 2).

Challenge questions

How might the emergence of new businesses based on provision of energy to Canberra and other major urban centres in the ACT affect the growth and distribution of urban populations and their impacts on the natural environment?

Might the focus on developing a sustainable regional energy supply also

allow integrated and strategic planning for environmental management at broad geographic scales across the region (e.g., long-term thinking about a suite of reserved areas to maintain the resilience of the region's communities to unexpected future shocks – see Section 10)?

Might we see a new wave of undesirable environmental impacts caused by a scramble to capture part of emerging energy markets?

The region already provides power for the ACT and Canberra (e.g., hydro, wind). What opportunities might there be for this role to grow, even to the point of the region exporting energy to other regions? What other possibilities might emerge in the next decade or two that currently are not on our planning radars?

Are there risks that some communities in the region will become marginalised because they cannot afford costs of energy and how might this affect strategies for integrating environmental management with other aspects of human well-being?

4

Health, food and wellbeing

Key points

Declining mental health of young people, and especially declining hope for the future, are emerging and worrying trends

There are opportunities for the ACT and region to make better use of locally grown food and outdoor activities to increase health and wellbeing outcomes, but there are also global trends driving less outdoor activity and more 'virtual' activity indoors

Convergence between economic pressures, aging of the population, and the prospect of longer lives raise issues for future health and environmental management

There are still major concerns about how prepared Australian settlements are for major health challenges, including a disease pandemic

A growing focus on mental health, wellbeing and hope for the future

Gross Domestic Product is generally recognised to be an inadequate measure of real societal progress, but there is concern that if political parties focus on measured wellbeing before measures are sufficiently developed then life might get worse rather than better for many people.[20] In Australia, local governments and catchment management authorities are being encouraged to include measures of social wellbeing along with indicators of environmental trends in their plans and monitoring programs.[21] Although the definition and measurement of happiness remain hotly-debated topics,[22] there is emerging agreement that the 'five forms of capital' (human, social, natural, physical, financial) are important for both adaptive capacity and social wellbeing.[23] It is likely that this debate will increasingly involve all government and non-government organisations that deal with the environment in Australia.

The dominant narrative about young people's health in Australia is that it is continuing to improve. Richard Eckersley, however, suggests that the opposite may be closer to the truth. He argues that mortality rates understate the importance of non-fatal, chronic ill-health, and self-reported health and happiness do not give an accurate picture of wellbeing. Mental illness and obesity-related health problems and risks have increased. These trends are not confined to the disadvantaged. The causes stem from fundamental social and cultural changes of the past several decades. Which story is repeated most and believed will affect how governments and society as a whole address youth health issues.

The cost of staying healthy

The cost of preventable diseases is growing and will be a major burden on future generations as Australia's population ages. Many regional communities are struggling to provide health services at adequate levels. Will we reach a point soon where the investment of money in keeping people alive will have to be limited?

Participants on both stakeholder workshops emphasised the opportunities offered by the ACT and region in terms of fresh and nutritious food and the possibilities of meeting people's needs from local markets. This not only offers options for better health but also for reduced consumption of fuels in transportation to market (so-called 'food miles'). It should be noted, however, that

resource consumption in transportation of food to Canberra from elsewhere is a relatively small proportion of our ecological footprint,[24] so the current benefits of local food are more significant with respect to nutrition and self-sufficiency. How this might change in the future with respect to the price of food as a result of increasing oil costs is a matter for speculation.

Over the past decade or so, obesity has been identified as one of the major emerging threats for affluent societies. This has led to the assumption that obesity is mostly about rich people over-indulging in high-fat food. However, health professionals are increasingly warning us that obesity is also caused by poverty – both in terms of lack of money to buy good food and lack of knowledge to make good choices. At the same time concerns are being raised that the growing ubiquity of electronic communication is contributing to monetary and knowledge-poverty by empowering those that can afford access to the Internet and disempowering and marginalising those that can't.[25] As these trends converge, might the ongoing digital revolution contribute to further widening of the gaps between rich and poor, informed and uninformed, and healthy and unhealthy, even in an affluent country like Australia? Might a well-off region like the ACT and surrounds be in danger of overlooking this emerging problem?

These and other issues are being addressed as part of the growing discipline of healthy urban design.[26] Linking human health and wellbeing with the ways in which settlements are designed — for example by encouragement of exercise, intellectual stimulation and social relations through the arrangements of buildings, other structures and spaces — is likely to be a major feature of change in the next decade and beyond. Economic fluctuations and other elements of social change could either facilitate or discourage this sort of reform. Urban design is the focus of Section 7 of this report.

Challenge questions

Might human health benefits of a healthy environment be recognised and built into preventative medicine or might we see reduced investment on the environment and declining health as a result?

Are we doing enough to consider how the mental health of people in the region, including their hopes for the future and their ability to cope with technological change and feel part of society, interacts with their views about environmental management and their willingness to support sustainability policies and programs?

How might the debate about measuring human wellbeing evolve and affect the ACT and region? Might it offer ways to bring focus onto previously overlooked issues? Might it become an integral part of reporting on the state of the coupled social and ecological environments in this region?

5

Technology

Key points

Developments in information and communication technologies (ICT) over the next two decades are likely to have huge and unpredictable effects on life in the ACT and region, including where and how people live and work, engagement of stakeholders in strategic dialogue about environmental and social issues, transportation, food production, health, medicine and even large-scale manipulation of the environment

Much of the promise and uncertainty of technology in the future is likely to come from convergence among technologies

Around the world, many governments have responded to the risks and uncertainty created by rapidly changing technology by becoming less flexible and more cautious — the future might be characterized by see-sawing between risk-aversion and risk-taking by different nations and different sectors to gain competitive advantage

Promises of technology

Participants in the workshops consistently emphasised the promise of information technologies. Evolving social networking sites and other sources of information-exchange and retrieval make it possible to deal with a much greater amount of information than has ever been possible before. Google recently released details of a new search algorithm that enables them to anticipate what information people want on the basis of past searching — essentially giving people what they want before they ask.[27] Although this offers promise for much greater efficiency in information retrieval there are also warnings that it could lock us into past thinking patterns and work against innovation.

Complex environmental and social issues such as those faced recently by the Murray Darling Basin Authority could potentially be addressed through multi-stakeholder dialogue facilitated by improved information technologies. This would make huge differences to the way environmental management and sustainability are addressed. It is also likely to pose a major future challenge for government bureaucrats, however. Meeting growing expectations of the public to be engaged in all aspects of decision-making and to have access to large amounts of data will be increasingly demanding and risky.[28]

Another major aspect emphasised by participants in workshops was the flexibility provided by ICT for people to live and work remotely from where their employer is located. This could have major impacts on the region. For example, we may see a movement of population away from Canberra and into surrounding towns and villages. This creates opportunities for local economies but it also poses challenges in terms of infrastructure such as roads, water, and access to Internet.

Vertical farming and other forms of farming in cities are emerging as serious propositions. The idea of setting up farms within cities, for example in abandoned buildings, has been around since the 1980s. Urban agriculture has had a resurgence in popular futurist and science literature (including articles in *Scientific American*, *Time*, *Popular Science*, and *The New York Times*).[29] Various projects around the world, including the Vertical Farms project at Columbia University,[30] envisage raising food crops and animals indoors in multi-storey skyscrapers, in closer proximity to consumers. Suggested advantages include year-round production, more-

efficient use and reuse of water and other resources, and protection from threats ranging from epidemics to terrorism. The American city of Detroit is seriously thinking about using the space it has acquired due to the downturn in the motor vehicle industry for city farming.[31] As food security becomes a greater concern, could approaches such as this find their way onto the agenda of cities like Canberra and/or other centres in this region?

Might new technologies generate the biggest boom ever? There is a suggestion that a new technology boom that could create billions of jobs around the world might be around the corner, based on nanotechnology, solar and wind power, water supply systems and desalination plants, space tourism and environmental restoration projects.[32] If such a boom does emerge in the next decade or two, what role might the ACT and region play and how might such a boom affect the way that environmental management and sustainability are practiced in this region? Might the ACT become an exporter of experience based on the development and demonstration of approaches to environmental management?

Challenges of technology

Optimism about advances in computing and information technology is offset to some extent by concerns about the potential for runaway advances to take over our lives.

If computing power continues to double each 15 months (Moore's Law), it will create some interesting and largely unimaginable challenges and opportunities for humans by around 2030, when a technological 'singularity' is expected by some.[33] The term 'singularity' refers to a time when change occurs so quickly it is impossible to contemplate what its impacts might be.[34] Current desktop computers have a processing capacity similar to insects or reptiles but by about 2030 it is forecast that they will surpass the capacity of the human brain.[35] Imagine, for example, if current limitations on collection and analysis of environmental and social data were removed and we had the technology to do whatever we wanted to achieve sustainability? Would we be able to make wise decisions? What might be the implications for governance structures, the ways in which communities and organisations function, the ways in which decisions are made?

Multi-collaborative engagement technologies offer a key to better engagement with stakeholders and better problem solving. They potentially play major roles in political decision-making and education – a role that includes not only opportunities but also significant challenges. A recent strategic analysis of challenges facing governments with respect to information and communication technology pointed to the escalating expectations of the public to be involved in all aspects of information interpretation and decision making.[36] It will be important to consider infrastructure to support all elements of these channels of communication so the ACT and region can take advantage of cross-disciplinary and cross-geographic opportunities, production of novel ideas, and access to a diversity of ideas and skills from other regions, states and countries. Increasing power and reach of ICTs increases access to the creative genius of groups of people and opens opportunities for adaptation to change, but it also means that, particularly public officials, need to find ways to manage provision of information, access and security issues not even dreamt of now.

Rapid increases in computing and information technologies have the potential to affect where people live. What might happen, for example, if it becomes progressively unnecessary for government to be physically located in one place? Might we see movement of residents and offices away from Canberra with major consequences for economies, social cohesion and environmental management in the region?

There is emerging evidence that the so-called 'digital divide' between young people and their parents or older

employers is growing. It is suggested this will become a bigger problem has longevity is increased by improved medicine over the next few decades.

Young-old divides are not the only social tensions affected by the growth of computing technologies. Research from the United States suggests that, in general, immigrants are much more likely to embrace modernity than current residents, potentially increasing tensions around race and competition for jobs.[37] Might this become an increasingly important factor in the future of the ACT if multiculturalism continues to grow?

Food security is an issue being discussed around the world at the moment. Many of the technological innovations discussed in the literature relate to better ways of producing food, including artificial foods like artificial meat (see below). Many challenges still remain for addressing declining productivity in Australia and elsewhere and the extent to which some new form of 'Green Revolution' emerges or doesn't emerge may have major impacts on land management and life in general and the ACT and region.[38]

Some workshop participants expressed concern about emerging trends towards negative health reactions to food constituents, like grains, declining control over other food constituents, especially genetically modified ingredients, and declining diversity of crops, due to modern approaches to food production. The emergence of responses like production of grain-free food was noted as a possible sign that counter trends might be emerging.

One extreme technological possibility, which could pose challenges for the ACT and region, is artificial meat. Cultured meat (i.e., meat produced *in vitro* using tissue engineering techniques) is being developed as a potentially healthier and more efficient alternative to conventional meat. A recent research paper showed that artificial meat uses much less energy than many other sources of meat and results in a small fraction of water and land use and greenhouse gas emissions.[39] Could this be the first sign of many other artificial food products to emerge in coming decades? If such technology becomes mainstream, what impacts might it have on land management? How might it affect regional economies? How might land previously used for grazing and other agricultural land uses be managed? Who might do that management?

Taking the suite of evolving new technologies together (i.e., biotechnology, genetic technology, nanotechnology), might humans soon have the power and inclination to try to improve on nature? The Millennium Ecosystem Assessment scenario team[40] explored several possible futures for the world, including one in which the power and technology to make wholesale changes to environmental processes became available within a few decades. They concluded that a major challenge would be how to deal with the temptation to 'improve on nature' by redesigning ecosystems. There are already ideas being put forward for addressing climate change that include massive interventions like positioning large sunshades in space, releasing particles (e.g., sulphate aerosols) into the stratosphere to scatter sunlight back into space, and seeding oceans with chemicals to stimulate uptake of carbon dioxide.[41] Informed commentators acknowledge both the potential benefits and major potential for catastrophic unintended consequences from such 'geo-engineering' approaches.[42]

A number of new pollutants that are already building up in the environment have been shown to lead to deformities and disrupted hormonal functions in wild animals as well as humans. These include a range of breakdown products from common pharmaceuticals,[43] and several perfluorinated compounds used to make products such as Teflon, semiconductors, stain-resistant coatings, and fire-fighting foams.[44] The effects on wildlife and other species of the microscopic fragments formed as plastics disintegrate are as yet unknown but are causing growing concern, especially as plastics now make up around 60–80% of general litter globally.[45] Another new source of pollution

is nanoscale silver, which is used as an antimicrobial agent with widespread potential uses in the manufacture of refrigerators, chopsticks, air conditioners, air purifiers, baby pacifiers, food preparation equipment, teddy bears, vacuum cleaners and a wide range of medical devices, as well as for reducing the odour of clothes and treating plant pathogens.[46] Nanosilver can enter the aquatic environment through many routes, accumulate and potentially affect the microbial processes that fertilise soil, as well as killing or interrupting reproductive processes in a range of will animals.

A major emerging socio-technological trend is fear of the pace of technological development amongst government decision-makers worldwide.[47] It is argued that industry in general has embraced the need for constant innovation to keep up with, or get ahead of, competitors, but that the constraints on public administration have made this very difficult for governments. Some commentators have argued that this is one of the driving forces for the increasingly entrenched nature of politics in the western world and the apparent reluctance of governments to make decisions that involve selection and application of new technologies. Perhaps the debate about a national broadband network in Australia recently is an example of this phenomenon?

Challenge questions

How might rapidly changing technologies and their by-products change the demands on state of the environment reporting over the next few decades and how might governments respond to the increasing demands for not only better data but also greater engagement of stakeholders in the process?

Is there a danger that private or public decision-makers in the ACT and region might be tempted to use emerging technologies to make large-scale interventions in environmental processes, either to address perceived problems or to improve functionality?

What processes are in place for considering the risks of such interventions?

How might the changing nature of communication technology affect the distribution of the region's population and what implications might this have for the relationships between Canberra and the region in the future?

6

What we think and how we live

Key points

Australians see the environment and the economy as our two most significant problems — many are willing to modify their lifestyles to protect the environment

The ACT has been rated the state or territory least despondent about the future

Globally, in Australia, and in this region there is an increase in 'bottom-up' community action on sustainability

Virtually all participants in the workshops felt that the major global drivers of change are pushing communities like those living in this region to live more sustainably and simply

Communities in the ACT in region are still sufficiently connected with the natural environment to enable many of these changes to occur

What we think

The issues of attitudes, lifestyles, demographic change, urban design, transportation and relationships between Canberra and the rest of the region were intertwined in the discussions in the workshops. These are discussed in the next three sections. This section deals with attitudes, lifestyles and demographic changes.

Much of what happens in the future will be determined by the attitudes, education and beliefs of people who make and influence critical decisions – which means most people to some degree. In the most recent ANU poll on attitudes towards the environment (2008) respondents thought that the environment and the economy were the two most significant problems facing Australia.[48] Around half of those sampled were prepared to pay more to protect the environment, and high proportions of these people regularly take actions likes recycling rubbish and conserving water and energy. Global warming and population growth were considered to be the two most serious threats to the future wellbeing of the world.

Two interesting statistics emerged from a recent national survey of attitudes by the insurance industry.[49] It reported that 94% of Canberrans aged 16-31, and 85% of those aged 32-47, said they could be selfish. The ACT was reportedly the most selfish state or territory in Australia. Perhaps of greater relevance to sustainability and environmental management, the ACT was also the least despondent about the future.

We should not underestimate the influence of global trends in attitudes as these spread rapidly and affect our own thinking. A recent Pew Research Centre survey of global attitudes across 46 countries found that levels of concern about the environment had risen since the 2002 survey but that concerns about industrial development are higher in many, especially developing, countries. China, for example, is making great steps towards addressing environmental concerns but not at the cost of lost industrial production.

A trend that has been emerging steadily around the world for over a decade, which is also evident in Australia, is an increase in 'bottom-up' community action with respect to environmental management and sustainability. In Australia, an increasing number of community-initiated initiatives, such as the Transition Towns movement,[50] the See Change movement,[51] and the Communities in Landscapes Project,[52] together with existing community-

community partnerships like Landcare and new ones like the community indicators framework in Victoria,[53] aim to establish principles for sustainable living from the ground up. More broadly, it has even been suggested that 'national security' should be reconsidered to include all aspects of the emotional, financial and physical well being of Australians and not just protection from invaders and terrorists.[54] There are many examples of groups trying to break down the inefficient hierarchies of distribution that waste resources: or example, farming communities selling products directly to Asian markets.

Such movements might continue to grow steadily over the next decade and beyond as the social capital of communities is build and they develop less dependence/ reliance on governments,[55] or they could wax and wane as interest, resourcing, key participants and opportunities come and go. One possible development could see state of the environment reporting becoming more closely aligned with community action and monitoring programs, which is a possibility potentially facilitated by improvements in information technology (see Section 5).

How we think

At a fundamental level, the question is being asked: 'Are human minds incapable of dealing with complex challenges?' Behavioural economists are finding that humans are highly susceptible to misleading arguments and struggle to make rational decisions about even mildly complicated issues.[56] Psychologist Daniel Gilbert[57] argues that humans have evolved a brain that reacts to threats that are intentional, immoral, imminent, and instantaneous. Although threats like terrorism meet these criteria, others, like environmental degradation, water shortages, climate change and poor physical and mental health of young people, don't meet the criteria because they happen too slowly and, in general, cannot be blamed on particular people with evil intent. Systems-analyst John Sterman has shown that most people struggle to understand even simple conceptual models of the global climate system, and so are unable to appreciate the sorts of decisions that governments need to take in order to stabilize atmospheric carbon dioxide concentrations.[58] The ability to recognize the limits of our knowledge, to break out of deeply held mindsets and think differently is becoming a vital part of the sustainability conversation. Might the high level of education in the ACT make a difference to how we deal with environmental issues in the next few decades or will people in this region continue, like people elsewhere, to struggle with complex challenges?

Education could be dramatically different in the next few decades. Some forecasters suggest that skills like writing and interpersonal skills might drastically decline in the next two decades and that the written word might disappear by 2050.[59] Others suggest that schools will respond to these declines by teaching interpersonal skills and writing as specialist courses.[60] The convenience of electronic distance-education could see students studying from wherever they want to live and there could be little or no need for physical universities, schools and technical colleges. How might this affect the economy and nature of Canberra and the ACT and region? If such changes occur, might they happen quickly or slowly, gradually or in bursts?

Sustainable living

Virtually all participants in the workshops felt that the major global drivers of change are pushing communities like those living in this region to live more sustainably and simply (that is, within the parameters of resource availability and with less complexity of transactions at work and in society than at present). They could see two major alternative trajectories for the future: one that fails to recognize the value of good environmental management and one that does. Both of these trajectories show signs of emerging but it is not clear what the balance

between the two might be in the next few decades.

If people become overwhelmed by the challenges of climate change, environmental decline, water shortages, and food insecurity, and become pessimistic about being able to do anything about it, they might take the path of focusing on self-interest.[61] Many in the workshop suggested that eventually there would need to be some form of payback for this trajectory. For example, food produced in a region might be unacceptable in markets that require green credentials and/or we could face major ecological repercussions as ecosystems that support our lives and lifestyles with services like water filtration, pest control, erosion control, and cultural values begin to fail. At the very least, this trajectory would not encourage the sort of strategic thinking needed to anticipate and prepare for potential future shocks (e.g., extreme variability of weather generated by climate change) and would leave the region's communities with potentially low resilience and low adaptive capacity.

The alternative trajectory is a move towards more sustainable living. Workshop participants saw a range of ways in which resource-use could be reduced in the region's future, including increased use of bicycles, including electric bicycles, increased communal transport, smaller houses and gardens, local food production and consumption, reductions in waste production, and greater forward-thinking about relationships between population, consumption and the environment.

The ways in which Australia's population debate evolves in the next decade could have profound effects on sustainability and environmental management in the ACT and region. The question of how many people Australia can support is confused with a debate about immigration policy.[62] Furthermore, the focus in the past few years has been almost entirely on crowding in the suburbs of major cities and there has been little or no consideration of the environmental factors influencing how many people Australia can support.[63] In the next decades this debate might continue as it has or we might see some depth of thinking that enables quality of life and environmental objectives to be met simultaneously. This might lead to a much more sophisticated consideration of sustainability and environmental management across urban and rural boundaries, which could offer many opportunities, and probably a few challenges as well, to the ACT and region.

A note of caution has been sounded by the company SustainAbility in its review of trends in 2010. It notes that: '*The sustainability agenda is becoming dangerously narrow and subjective with many companies making important, low-hanging, but ultimately deficient progress on the full range of sustainable development issues within their organizations.*'[64] Adding to this poor progress, there are signs of a backlash from consumers against so-called 'greenwashing' (large companies claiming environmentally friendly production credentials for their products on flimsy or even fraudulent grounds). How might the sustainability and accreditation debates play out in the ACT and region in the next decade? What is on the agendas of political parties? What ideas might be emerging from outside government?

Two extreme possibilities have been proposed in the literature that could disrupt sustainability and environmental management in Australia: Large-scale acquisition of land by foreign interests; and garbage wars.

Over the past decade, and particularly since the global food and financial crises, there has been increasing acquisition of large areas of arable land in developing countries by foreign governments and private companies.[65] Such land acquisitions have the potential to inject investment, technology and market access into agriculture and rural areas in developing countries, but they also pose challenges for land management agencies and for the economies of regional communities. While some recent

press reports suggest that this might be a problem,[66] Mick Keogh, Executive Director of the Australian Farm Institute, recently argued that: *'whether or not the farmland is owned by an "Australian" or a "foreigner" seems somewhat immaterial'.*[67]

According to some global forecasters *'Recycling has delayed the "garbage glut" that threatened to overflow the world's landfills, but the threat has not passed simply because it has not yet arrived'*.[68] Globally, many places are running out of space for municipal solid waste disposal. Recycling has proved to be effective but can it keep up with production? Beyond 2025 or so, the developing countries are anticipated to close their repositories to foreign waste.[69] This is when developed countries might face a crisis unless they develop more waste-to-energy and recycling technologies.

Challenge questions

Can the people of the ACT and region do a better job than others in Australia and the world at addressing complex social-ecological problems like climate change, equitable water use, peak oil, an aging population and global financial upheavals?

How can we learn collectively from the many different approaches and sources of knowledge available in the region?

7

Urban design and transport

Key points

Increasingly, urban design is considering the mental and physical health and wellbeing of people but this trend is only one of many influencing development of human settlements

It is possible that Canberra could lose its green spaces if pressure to develop and the costs of maintaining the green spaces were to rise. This would fundamentally change the character of Canberra and probably have effects on health and wellbeing that ultimately would be more significant than economic gains

Care needs to be taken that changes in urban structure do not reduce opportunities for people to meet and interact

Emerging pressures on urban design

A thread is emerging in some literature suggesting that at least some cities might be better for the environment than is usually conveyed in popular media. Expansion of cities, and the associated agricultural and other industries required to meet the needs of city-dwellers, have been one of the most potent pressures on biodiversity and environmental function over the last 100+ years. However, city-analyst Edward Glaeser[70] argues that our cities are the hope for the future if they are managed in ways that promote efficiency of resource-use and innovation to address environmental issues. Several models for sustainable cities have been proposed for Australia and some action is being taken to apply these approaches.[71] But, as discussed further below, these trends are only some of those acting on the development of Australian cities, including the need to prepare for climate change.[72]

Movements towards more sustainable lifestyles would likely have impacts on urban design, like redesign of road and bicycle networks, new transportation options (especially to accommodate an expected proportion of aged people in the region within the next two decades). Many participants saw a continuation of the current trend toward urban infill and apartment living, which would require ongoing innovation to provide housing options.

Workshop participants discussed new forms of ownership of property, which might emerge as a counter to the current trend of increasing costs of home ownership, which is excluding many young people from the current pattern of ownership. Participants thought that the communities in the ACT and region are still sufficiently connected with the natural environment to enable many of these changes to occur, whereas many larger cities now find it hard to re-establish links between people and the environment.

Linking with the discussion on resilience (see Section 10) was a discussion about the multicultural nature of Canberra's population. This was seen as an asset for many reasons, including the diversity of ideas, approaches and beliefs that could be brought to bear to address future challenges and opportunities. Participants thought there would need to be careful thinking to nurture this asset through periods of economic pressure if they arise over the next few delegates. It was seen as a strong possibility that the immigrant proportion of Canberra's population, and probably that of the region more generally, might grow in the next few decades due to the interaction of resource stresses (water, food and space) in other parts of the world with climate change and political unrest.

Green places and places to meet

The importance of green spaces and places for people to meet was a key issue identified by workshop participants. On the one hand, the possibility was raised that Canberra might lose its green spaces if pressure to develop and the costs of maintaining the green spaces were to rise. This would fundamentally change the character of Canberra and probably have effects on health and wellbeing that ultimately would be more significant than economic gains.

On the other hand, it was suggested that 'green' (environmental) infrastructure might become the dominant infrastructure of concern in cities, including Canberra. Cities have a long history of managing what can be considered hard infrastructure (e.g., roads, sewerage pipes, electricity lines). Recently the concept of green infrastructure has emerged. This green infrastructure consists of our trees, parks, waterways and the like – all the soft parts of our landscape. It is costly to maintain yet this goes unrecognized and it is not managed in the same way we manage hard infrastructure. Therefore, it could be declining in quality even though it has enormous social and environmental value. In the future could it be so valuable that it has equal priority with hard infrastructure? How might that change in thinking and prioritization come about? Canberra has significant green infrastructure but how might we manage it in the future?

A further issue, related to those above, was the possible effects of changes in urban structure on how people meet and interact. A key component of community resilience is networking between people so that ideas can be shared and trust and cooperation built. People in regional towns know the importance of halls and clubs. In Canberra's development to date there has been a major focus on establishment of shopping malls. Whether we like them or not, these have become important meeting places. Participants in the workshops could imagine this changing in the future, especially if the focus on consumerism and economic growth were to decline. They could see the possibility of far fewer retail outlets and perhaps the return to local shops or other means of distributing goods. Without casting judgment on whether this sort of trend is desirable or undesirable, it was pointed out that there would need to be thinking about how to provide alternative venues for people to meet, especially as there are likely to be many calls on the ingenuity, cooperation, and trust of community in the next few decades.

Challenge questions

What processes are in place to bring environmental management together with urban design and management in the ACT and region?

Do these take resilience and sustainability into account in both urban and rural settings?

8

Relationships between the ACT and the region

Key points

The relationship between Canberra and the surrounding region might develop in a range of ways in the next few decades:

- New and innovative approaches to governance to tackle emerging linked social and environmental challenges
- Greater provision of energy and other resources within the region, reducing reliance on external resources and increasing resilience
- Many more people living in the region and working remotely for a Canberra-based employer
- Canberra might grow or shrink, even collapse, depending on changes in roles of government, energy and water supply and pricing, and emergence of new technologies, especially ICT

A post-growth economy is a possible, but highly challenging, future for the region

Canberra's relationship with the region

Canberra is seen as both an asset to the surrounding region and a sometimes problematic consumer of regional resources. There is growing pressure on local councils and communities from Canberrans retiring to coastal and rural areas and expecting equivalent health and other services to what was available in Canberra. Discussions in the workshops covered a wide range of issues related to the relationship between Canberra and the region. Some of these have already been addressed in the preceding sections, such as the potential future role of the region in providing energy and other resources to Canberra, and the role of Canberra as a source of employment for people living in the region. Others include issues relating to regional governance and the economy of the region.

Adaptive governance is emerging as a major opportunity and challenge for Australia, the ACT and the region

Resilience researchers have been saying that Australian society needs to move further towards polycentric (decentralised) governance (sharing authority, responsibility and resourcing more broadly across society so that the people best placed to detect and respond to change at appropriate time and spatial scales are empowered to do so) if Australia is to be resilient to future challenges, especially environmental ones.[73] There have been moves towards polycentric governance in the recent past (e.g. the Natural Heritage Trust and the establishment of catchment management bodies in many states), but some experts argue that governments are not confident enough to take this as far as it needs to go.[74] The current Australian government calls for a move from 'govern*ment* to govern*ance*'.[75]

Resilience and governance was a central theme in the discussions held in the workshops. There was broad agreement that having appropriate governance systems is vital. These systems should allow for a degree of experimentation and self-organisation when dealing with problems that are resistant to current governance approaches. Might the ACT and region experiment with new governance models in the next decade or so?

Experiences with the ACT bushfires, and lessons learned from a range of disasters elsewhere in Australia and the world, are

providing many insights into how to improve governance at a range of scales in the ACT and region. Participants in workshops recognised that the levels of education and experience across environmental and social disciplines and in governance issues is high in the ACT and region and that this should allow this region to be a focus for developing and testing new approaches.

The emergence of stronger regional governance might be hampered if the apparent trend towards greater environmental litigation seen elsewhere in the world becomes mainstream in Australia. Internationally, there are suggestions that countries will take each other to international environment courts over air pollution, water flow and quality and climate change issues.[76] In Australia is it plausible that even governments might be brought to task for not taking steps to ensure resilience and adaptive capacity are maintained? As yet, these are ill-defined concepts but as understanding grows might governments at all levels be exposed to similar moral hazards as cigarette companies were when they became aware that their actions had potentially major negative effects on public health?

Economy and things of value at a regional scale

The region is unique in having a major city that is still in the process of developing close to a range of smaller regional centres with access to a wide range of natural environments ranging from mountains coasts. There are also sufficient remaining natural environments to allow strategic investment in conservation as well as other land uses to maximise the chances of sustainable economies, societies and ecosystems into the future. Participants talked about, for example, proposals to circle Canberra with national parks and other reserved areas to build its resilience in terms of provision of clean water and a range of other 'ecosystem services' (discussed further below).

Patterns of economic development in western countries might be disrupted in the next fee decades in several ways. One of the limitations to traditional economics is that it does not deal well with non-linear (e.g., threshold) change and complex systems — i.e., systems that change their rules as they adapt. A new discipline of 'econophysics' is said to be emerging. This involves the application of complex-systems modelling to economics.[77] Other new approaches to economics that are being discussed around the world. If ever such new approaches are likely to be tried out at a regional scale, the ACT and region are a logical place for this to happen, given the high level of education and entrepreneurship here.

Many of the new approaches to assessing and stimulating economic growth revolve around recognising the benefits from ecosystems that in the past have been overlooked in mainstream decision-making and economic valuation. This might be about to change. For around four decades, there has been a growing discussion about so-called 'ecosystem services' (benefits to humans from nature). The late 1990s and early 2000s saw a lot of debate worldwide about how these benefits might be recognised both in economic and other terms. But it seemed that advocates of this way of thinking kept running up against resistance from mainstream economic thinking. Over the past few years, it appears that this has changed due to the secondment of Pavan Sukhdev to deliver two international environmental projects *The Economics of Ecosystems and Biodiversity* (TEEB) and the *Green Economy Report* (for UNEP's Green Economy Initiative).[78] Sukdev is a career banker and took a sabbatical from Deutsche Bank from 2008 till 2010 to lead TEEB. This credibility seems to have allowed the reports from these projects to be taken seriously at high levels globally. In Great Britain the UK National Ecosystem Assessment delivered its report this year with great fanfare from government. [79] There is renewed interest in Australia, with stewardship and conservation-tender programs being set up by the Australian and several state governments based on ecosystem services.[80]

Globally, in addition to peak oil, a number of important resources are likely to peak in availability in the next few decades, including antimony, tantalum and zinc, which are all important in production of components of electrical circuits and/or batteries.[81] Scarcity is traditionally considered to be a key driver of the price of goods and services and therefore a central component of economies. Therefore, one scenario for the next few decades is scarcity-driven economic fluctuations in many countries, including Australia.

However, an alternative scenario is the emergence of a 'post-scarcity' economy that requires new business models and institutions. The suggestion is that nanotechnology and other emerging technologies may well make scarcity a thing of the past (because materials will be assembled from atoms). [82] A post scarcity world would be very different from the current one and is almost unimaginable to most people – but so were the collapse of communism, the rise of the Internet and the September 11 attacks on New York City, before they happened.[83]

Might some aspects of the natural environment — biodiversity, for example — be some of the last scarce resources on earth and therefore very valuable? Might society decide it can do without anything that cannot be manufactured from scratch? How might this affect Australia's and the ACT's places in the world's economy?

As discussed in Section 5, there is a suggestion that a new technology boom might be around the corner, based on nanotechnology, solar and wind power, water supply systems and desalination plants, space tourism and environmental restoration projects that could create billions of jobs around the world. Clearly, there are several, very different, ways in which economic development based around natural resources might proceed in the ACT and region in the near future, all of which have major implications for how Canberra, large regional centres, and smaller settlements interact. The issue of regional governance (discussed above) is brought into even sharper focus when these economic possibilities are considered.

Challenge questions

How can consideration of the importance of adaptive governance be built into the 'management effectiveness' components of state of the environment reporting?

Can state of the environment assessments and reporting can play more effective roles in the networking of information and ideas within communities?

What alternatives are being considered for the economic development of the ACT and region and how might these be integrated into thinking about sustainability and environmental management?

Can environmental management be used as part of strategies to attract diverse mixes of industries and workers to the ACT and region?

With the possibility of fluctuations in the regions economic fortunes in coming decades, how can sustainability strategies and environmental management programs maintain steady progress?

Will Canberra expand around its current fringes or might we see a more diffuse expansion and people who are employed from Canberra live and work in the region for large parts of the year? If this is to happen, can it be done in a planned and collaborative way so that both challenges and opportunities are anticipated and prepared for?

9

Biodiversity

Key points

The factors considered in other parts of this report all have the potential to affect biodiversity directly or indirectly (Figure 3)

Attitudes of people towards biodiversity will be a key driver of action for its protection, and yet it is by no means certain that biodiversity conservation will continue to be seen as important as it currently is

Concerns have been raised that governance and institutional arrangements in Australia and elsewhere are inadequate to deal with ecological crises that set off cascades of environmental and social impacts

Evidence of declines in the health of the world's (and Australia's) soils, together with proposals for action to address these declines, may mean that soils and soil biodiversity are a focus for environmental management for the next decade or more

Nascent trends

Biodiversity is the variety of living things. The factors considered in other parts of this report all have the potential to affect biodiversity directly or indirectly (Figure 3). Biodiversity in the ACT and region is one component of the environment considered in the various state of the environment reports produced regularly by ACT, NSW and local Governments. These reports consider the range of pressures in biodiversity and how those might change in the future. This section does not attempt to repeat or summarise those analyses. Rather, several nascent issues that might directly or indirectly affect biodiversity are considered. This is not meant to be an exhaustive or comprehensive list of nascent issues — it intends to generate thinking about possibilities.

Attitudes towards biodiversity conservation

It has been argued that denial of major threats like climate change and HIV (Aids) are predictable social and political phenomena.[84] Based on public responses to previous major threats, social psychologists in the USA suggest that denial of not only climate change but also biodiversity loss is likely to increase as scientific evidence of these issues accumulates.[85] This would be a perverse outcome of scientific research and one we would hope does not occur, but it is a possibility based on sound logic and one that should be thought about and prepared for. Are we already seeing signs of this sort of perverse attitude emerging with respect to climate change and water management in Australia?

How seriously are we taking the risk of ecological collapses?

Many decision-makers and members of the public appear to regard the possibility of ecological collapses due to loss of key species as an extreme view, even though leading scientists think this is a very plausible possibility.[86] Workshop participants pointed out that insects are a key component of biodiversity and there are early signs that there might be collapses in some species or groups of species that could precipitate large-scale ecological collapses. Problems faced by honey-bees globally, and threats to Australian native bees, from introduced species are two examples.[87]

Although it is not new to conservation biologists, media discussion of another

period of mass extinctions is becoming more commonplace and could become a key topic for public debate in the next decade.[88] This media attention presents an opportunity for wider discussion of the issues. The risk of having this information widely known, however, is that people might think there is no point in trying to save species that are so vulnerable.

If we do face collapses of some ecosystems, it is likely that these will cause other collapses in a cascade like the traditional image of dominoes falling. These cascading crises rapidly become social as well as ecological problems. Although we hope this won't happen, it is prudent to ask how Australia's institutions (e.g., government, non-government bodies, community groups) might anticipate and cope with such challenges. Two recent studies concluded that the lack of early warnings about many ecological crises, the abrupt nature of ecological change, and the mismatch between decision-making capabilities and the cross-scale dynamics of social-ecological change pose major challenges for today's decision makers at all levels from global to local.[89] This challenge relates to calls for greater attention to adaptive governance (Section 8).

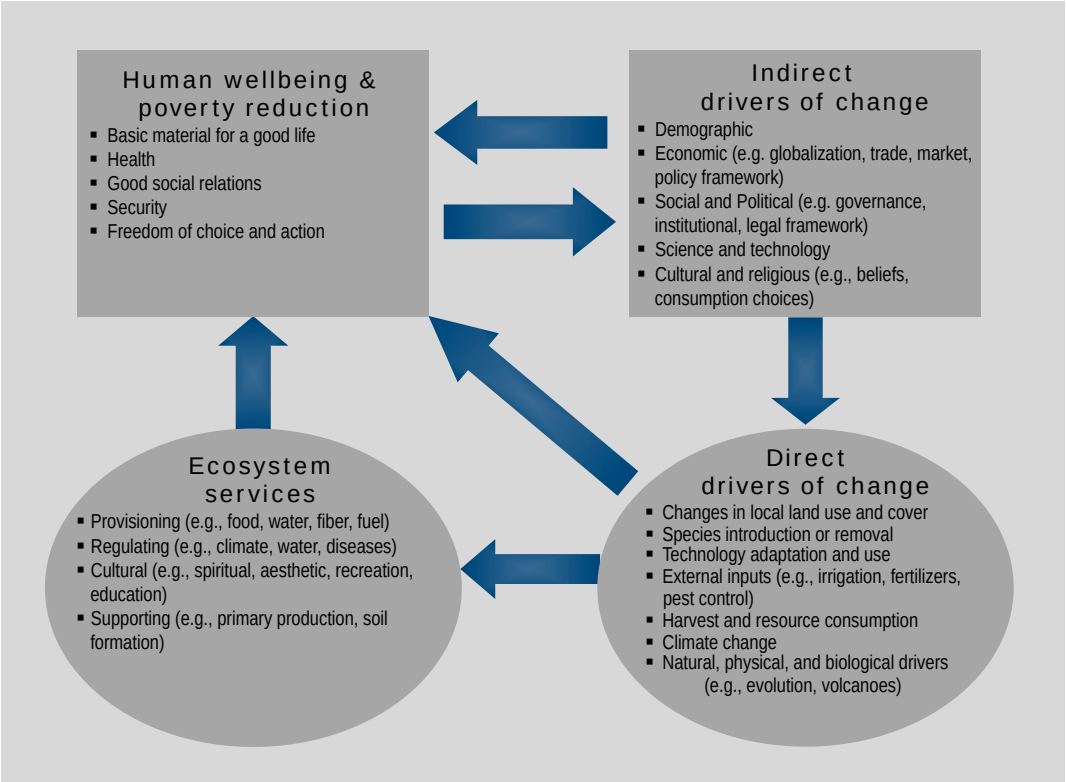


Figure 3: Conceptual framework developed by the Millennium Ecosystem Assessment to link drivers of change with to human wellbeing via ecosystem processes and the benefits they provide to people[90]

What if pests were no longer a problem?

State of the environment reports around the world and in Australia consistently conclude that invasive plants and animals are among the most significant pressures on biodiversity. Therefore, most thinking about future challenges is about how to control these pressures. What if, however, advances in technology over the next few decades led to breakthroughs in controlling pests? This is a prospect facing those battling the spread of various diseases by mosquitoes, for example. A range of modifications of the genome of one of the key mosquito species is under development that could lead to its eradication.[91] Questions are being asked about what ecological implications this might have. Could this be just one early

sign of other leaps forward in controlling pests? Are planners and managers capable of dealing with the far-reaching effects of removing whole suites of pests from ecosystems?

Soils and soil biodiversity are likely to be the focus of much attention in the next decade and beyond

Calls for large-scale approaches to rescuing the world's soils are gathering momentum. Large-scale functional shifts appear to be occurring in soils worldwide.[92] Soil erosion exceeds formation for one third of world's croplands,[93] and for most Australian landscapes.[94] The ACT includes areas identified nationally as priorities for erosion control and addressing soil health.[95] Lester Brown, president of Earth Policy Institute, has proposed a global rescue program for the world's soils with an estimated cost of US$185 billion, or around 12% of global military budgets.[96]

At a finer scale, there are reports that, as a result of disturbances to some ecosystems, earthworms are colonising places where they used not to occur. In Australia ants and termites play a bigger role than earthworms in other countries, so the spread of introduced earthworms could be a major future problem. This is just an example of imbalances that appear to be occurring in soil ecosystems. Several international scans have raised fears that soil ecosystems could fundamentally change in the near future due to losses of soil carbon, acidity and other physical changes.[97]

Assessing the management of soils and the benefits they provide to Australians is becoming recognised in key environmental management strategies and plans in Australia, including the Australian Government's Caring for Our Country program.[98] Whether an issue that is largely invisible to many people can continues to attract strong attention from decision makers will depend on many factors, including how the current debates about addressing carbon emissions versus capture and storage of carbon in ecosystems proceed and what champions of the cause of better soil management emerge.

The carbon debate and its implications for biodiversity

Although it is very much a current issue, the debate currently happening in the political sphere about policy approaches to reducing carbon emissions into the atmosphere could evolve in a number of different directions in the future, some of them considered unlikely or even unimaginable now. At one extreme in this debate, there is the argument for a 'wait and see' approach that involves little action. At the other extreme, many highly reputable scientists argue that failure to take major action immediately will set Australia and the world on a path that involves high risks to ecosystems, economies, and human wellbeing generally.[99] The likelihood of major extreme climatic events in the region the next few decades has been discussed previously in this report, and various analyses have been made of how this might affect biodiversity directly.[100] The extent to which policies explicitly focus on improving information about biodiversity and its responses to climate change will also create future opportunities and challenges. For example, the Australian Government's recent emissions policy includes a biodiversity fund for this purpose.[101] How such investments are used and how seriously they are taken in decision-making will be a major determinant for future trajectories for biodiversity in the region and beyond.

Emerging issues for protected areas

Globally, much has been achieved in terms of conserving forests. This is true also in Australia. Now, concerns are being raised that this increased protection might shift pressure onto non-forest ecosystems. Globally there is a range of processes underway to reduce carbon emissions caused by harvesting of trees and to improve the sustainability of forest management. It has been suggested that this might increase pressure to convert or modify other ecosystems, especially savannahs and wetlands, for food or biofuels.[102] It might seem that this trend is unlikely in this region, but it would be prudent to be watching how it develops internationally as a way to gain early warning of both how such a trend might emerge here and how the trend elsewhere might affect this region (e.g., through affects on markets).

International horizon scans suggest that there is a high risk of many protected area networks failing to protect biodiversity under climate change.[103] The WWF has released a report pointing out that most jurisdictions in Australia have a long way to go the achieve even 15% representation in reserves (although the ACT comes close to meeting the target).[104] While these shortfalls suggest that reserve networks might struggle to cater for biodiversity as climate changes, other projects are being developed to connect reserves and other remnant ecosystems on private land to create connected habitat that has a chance of saving many species.[105] How well initiatives like this work is an uncertainty that may well be critical in the future of Australia biodiversity. For example, the full range of possibilities currently exist, from little or no support, with major detrimental effects on biodiversity, to major support, with major benefits not only for biodiversity but for humans in terms of better water, pest control, erosion control, cultural benefits, tourism opportunities and range of other 'ecosystem services'.

Sutherland et al.[106] raise the possibility that 'assisted colonisation' – moving species to sites where they do not currently occur or have not been known to occur in recent history – might become a necessity for dealing with the impacts of climate change on biodiversity. If this happens then current approaches to maintaining protected area networks might need to be rethought and modified. This could see some fundamental changes to how conservation and biodiversity management are practiced.

Challenge questions

How much thinking is happening about future challenges that might require changes to approaches to biodiversity conservation?

Are we in danger of accepting that the same pressures will persist and the same approaches will be appropriate, and not thinking enough about how we might respond if we had to tools to solve many current problems?

10

Resilience

Key points

The concept of resilience is getting more and more attention, especially by regional communities

For the ACT and region, key challenges will be to maintain diversity — of skills, ideas and workers — and a sufficiency of resources so that the region and its people can remain resilient and have high capacity to adapt to future challenges and opportunities

A major risk faced by communities around the world is the temptation to focus too much on so-called 'specified resilience' (known or expected pressures) and to invest too little in general resilience to cope with the unexpected

Resilience thinking

Resilience is a new topic that excites some but scares others. The idea is that we might not know exactly what sustainability will look like in the future but we can prepare our ecosystems and our societies to cope with a range of possibilities.[107] The key ingredients of resilience are diversity (of skills, ideas, resources, species etc.), networks that don't fall apart (e.g., losing a key person does not mean that a community loses its ability to cope), the ability to experiment, learn and share information, and the ability of ecological systems or societies to find their own solutions.[108] There are suggestions that many of the short-term decisions that are being made in Australia are reducing our national resilience.[109]

Factors potentially influencing the region's resilience

Much of the discussion at the workshops was about ways to make the ACT and region economically, socially and environmentally sustainable and resilient. Many ideas were about ways to create a competitive advantage for the region. Section 3 discussed options for energy generation in the region. Another potential source of competitive advantage is the promotion of the ACT and region as a place for innovation and advanced education and research. All of these are worthy ideas, but the region will need to be cautious about over-specialisation, which could reduce diversity and options for adaptation. Some other factors that might work against building and maintaining the region's general resilience include: reducing cultural diversity; developing an imbalance between younger and older people in the workforce; and focusing too much on 'specified resilience' and too little on general resilience (explained below).

The specified resilience trap

Leading resilience researchers have argued that there can be trade-offs between building the ability to cope with known risks and nurturing the ability of communities to deal with a range of unexpected shocks. For example, it is important for the ACT and region to anticipate and prepare for climate change, bushfires, drought, peak oil, housing shortages, unemployment, an aging population and other specific, expected challenges. However, if this were done in ways that diverted attention and/or resources from building skills, trust, cooperation, and other components of the capacity of communities to respond to unexpected shocks, then this could leave the region vulnerable to such shocks. This might happen, for example, if governments focused strongly on building infrastructure to cope with known threats

and neglected engagements or capacity building among the public. The ACT is said to have done a good job of addressing both infrastructure ('hard hat') and social ('soft hat') issues after the Canberra bushfires in 2003,[110] and it might be argued that this type of balanced approach is a model for building the regions resilience in the future.[111]

Can we have too much resilience or resilience of the wrong sort?

It is sometimes overlooked that resilience is not always good and that too much resilience can sometimes be a major challenge — such as when we want to change a system that refuses to respond to our efforts.[112]

In this report we have discussed the possibility that in the future there could be a widening gap between rich and poor, informed and non-informed, empowered and not empowered in the ACT and region. The wider these gaps grow, the more people on the resource-poor side experience processes that act to keep them there (e.g., loss of influential networks, lack of opportunities and ideas, lack of ability to take advantage of whatever resources are available).[113] Addressing these types of 'poverty traps' requires discouraging rather than encouraging the resilience of this particular system.

At the other extreme are so-called 'rigidity traps', which occur when societies get so stuck in their ways that they cannot adapt to change.[114] These systems eventually are likely to become unresilient and vulnerable to external pressures but they can persist for some time and be hard to change even when those in them would like to change them.[115] Aspects of Australia's health system,[116] the wheat-belt of Western Australia,[117] and the global financial system[118] appear to be examples. Some farmers who successfully adapted (i.e., were resilient) to the drought of the 2000s, have suggested that this short-term resilience might have perpetuated a system that really needs to transform into something different.[119]

Just as Donald Horne in his book 'The Lucky Country' warned Australia not to become complacent as a result of our long run of good luck, workshop participants cautioned the ACT to be careful to not become too comfortable with the generally high levels of education, income and quality of life that we enjoy. While these are valuable resources on which to build a sustainable future, we need to be watching for signs of change and thinking strategically about how to prepare for challenges and opportunities.

Challenge questions

How can government programs and non-government activities contribute to dialogue across ACT and regional communities about the nature of resilience, both environmental and social?

How can resilience be addressed in environmental assessment and management programs, given that general resilience cannot be precisely measured and there is never a way of knowing whether a community has enough?

How can we remain vigilant for signs of undesirable resilience and be able to avoid it?

11

Implications for sustainability and environmental management

Key points

Environmental policies and management aimed at achieving sustainability in the ACT and region in the next few decades will need to deal not only with ongoing local and national environmental, social and economic pressures but also with change driven largely by forces external to Australia

The next few decades are likely to be characterised by extreme climatic event and economic and social surprises. The ability of the region's coupled ecosystems and communities will depend in part on anticipation of possible shocks, generating and maintaining diverse ideas and resources to cope with surprises, and having effective networks of engaged and cooperating people to detect and respond appropriately to change

The state of the environment process is one logical mechanism for assessing the adequacy of both human and ecological resources for these tasks and facilitating cross-sectoral dialogue and networking that engages and empowers communities and discipline experts

The environment and people cannot be separated

Although this project was run as part of the ACT's state of the environment reporting process, the dialogue in the workshops ranged widely across social, technological, economic, environmental, and political factors likely to influence environmental processes in the future. This illustrates both the variety of pressures that potentially affect sustainability and environmental management in the ACT and region and the high-level knowledge and understanding among the participants. It also reinforces the growing attitude among environmental and social scientists that the environment and people need to be considered as one tightly inter-connected system rather than as separate systems that sometimes affect one another.

The focus in the workshops was strongly on aspects of the lifestyles of people living in the region and the ways in which human settlements function. There appeared to be a tacit assumption that changes need to be made to move towards a more sustainable future and that these changes mostly involve reducing resource consumption and improving equity and human wellbeing without impacting negatively on the environment. This illustrates that a wide cross-section of stakeholders regard the interactions between people and the environment as key determinants of the future of the region and its human inhabitants, even though not everyone agreed on how to address the implications of those interactions.

We have seen recognition of the importance of the environment wax and wane several times over the past few decades, both among the public and on political agendas, but the drought of the past decade and the increasing evidence about climate change have raised the possibility that our usually benign environment might spend at least some of the next few decades outside what we usually consider the 'safe operating space' for comfortable human life.[120] Adaptation to these changes is occupying the minds of researchers but it is also a major challenge for governments and society's leaders because the sort of social changes that are likely to be needed will

require public support and, behind that, public understanding of the issues and their implications.

The sort of dialogue encouraged in this project is a model for what is needed across society. Some readers might not think the ideas reported here are all that new, while others will be altered to possibilities they had never thought of. The authors of this report could have drawn on a huge body of literature that raises all sorts of wild ideas about changes that could happen in even 5-10 years, but he has not done this because the importance of this process was that stakeholders listened to one another's insights and explored for themselves what challenges and opportunities might arise when even not so way out possibilities are considered together.

The oil company Royal Dutch Shell was a pioneer of futures-thinking in the 1960s. Shell's strategists initially tried to develop detailed plans for dealing with alternative possible futures but found that first they had to change the culture of the organisation to accept that alternative futures were possible and that having 'strategic' conversations about what change was possible and what to do about it was worth doing.[121] When the oil crisis unexpectedly happened in the 1970's, Shell coped with that shock better than most other oil companies not because it had predicted the shock but because it had contemplated the possibility of something like that. This lesson is as valid for the ACT and region today as it was for Shell in the 1960s.

Relevance to state of the environment reporting

In state of the environment reporting around the world there is an emerging trend towards considering the environment as being tightly coupled with human social and economic systems. There are few indicators of the state of these coupled systems but this is an area that is under rapid investigation. In Australia, for example, there is concentrated attention on developing plans for a national approach to collecting environmental-social-economic information that can be incorporated with more traditional measures in Australia's national measures of progress.[122]

In a few cases around the world, state of the environment reports have started to look at the use of future scenarios as a way to consider how relationships between humans and the environment might develop under a range of future conditions. The approach being taken by the ACT is leading the way in terms of building futures-thinking into state of the environment reporting in Australia. This scan has started a process of getting stakeholders thinking about future drivers of change. A useful further step in future state of the environment reports would be to consider alternative development pathways that the ACT and region might take, and what the region might be like if different futures unfolded.

Considering alternative future scenarios would allow the ACT and region to consider:

- What specific trends and events in relationships between people and the environment might cause different to emerge
- What indicators might need to be measured to assess which possible future(s) might be playing out (i.e., early-warning indicators)
- What actions might need to be prepared for once early warning of the direction of change has been received.

Many of the discussions emerging from the workshops emphasised the need for communities, in both cities and regions, to become engaged in thinking about solutions to complex, interlinked environmental and social problems. The enthusiastic and productive dialogue that ensued at the workshops suggests that the state of the environment reporting, at least in ACT and region, is one natural process that could provide a venue for the sort of cross-society dialogue that is being called for. Undoubtedly the responses of

workshop participants were partly due to the inclusive, collaborative and communicative approach taken by the OCSE in the ACT.

Challenge questions

The following challenge questions, which are drawn from those at the end of previous sections, focus on roles for government and other sectors of ACT and regional society in achieving sustainability and better environmental management. The reason for posing them as questions rather than recommendations is that dealing with the future requires dialogue and thinking among relevant stakeholders about the range of alternative trajectories of change. It is the process of asking questions such as those below that will help to prepare the ACT and region for the future. There are no right answers and all opinions are relevant when dealing with the future.

How might the debate about measuring human wellbeing evolve and affect the ACT and region? Might it offer ways to bring focus onto previously overlooked issues? Might it become an integral part of reporting on the state of the coupled social and ecological environments in this region? This would ideally involve a range of government and non-government stakeholders engaging in open dialogue — how can such a process be established and maintained?

How can government and non-government sectors together contribute to dialogue across ACT and regional communities about the nature of resilience and the linkages between environmental and social resilience?

How can resilience be addressed in state of the environment reporting and other avenues for assessing progress towards sustainability, given that general resilience cannot be precisely measured and there is never a way of knowing whether a community has enough?

How might the demands for reporting on the state of the environment and providing relevant information on demand change over the next few decades and how might governments respond to the increasing demands for not only better data but also greater engagement of stakeholders in the process?

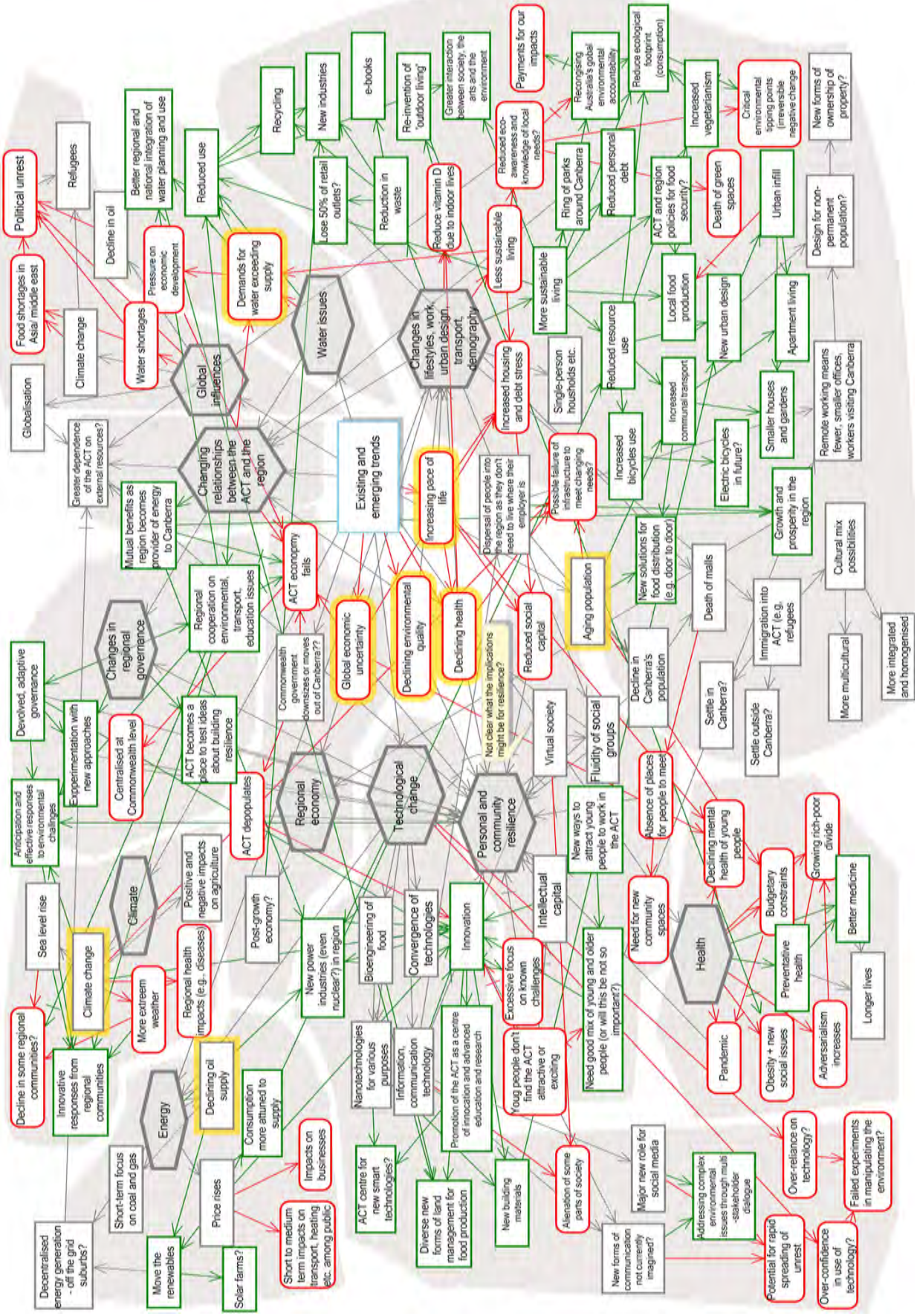
What processes are in place for considering the risks of land management and institutional interventions?
What alternatives are being considered for the economic development of the ACT and region and how might these be integrated into thinking about sustainability and environmental management?

How can consideration of the importance of adaptive governance be built into the 'management effectiveness' components of state of the environment reporting and other processes for assessing progress towards sustainability?

12

Appendix: Stakeholder views about key drivers of change and emerging issues

Figure A1.1 (over page): Representation of stakeholder views about key drivers of change and emerging issues. Green rectangles and arrows = factors and relationships perceived to be useful; Red = harmful factors and relationships; Grey = neutral or no clear balance of desirability. Arrows with a cross-bar = counteract the factor they point to. Yellow highlighted rectangles = key drivers of change. Grey hexagons = broad groupings of ideas. The purpose of this diagram is to allow readers interested in a particular aspect to see how that was thought to relate to other aspects of the region's future. Although it is a complex diagram, the author thought it was preferable to a long list of issues with no indication of their interrelationships.


Existing and emerging trends
Global influences
Changing relationships between the ACT and the region
Changes in regional governance
Climate
Energy
Regional economy
Technological change
Personal and community resilience
Health
Water issues
Changes in lifestyles, work, urban design, transport, demography
Political unrest
Food shortages in Asia/ middle east
Refugees
Decline in oil
Better regional and national integration of water planning and use
Reduced use
Recycling
New industries
e-books
Re-invention of 'outdoor living'
Greater interaction between society, the arts and the environment
Payments for our impacts
Recognising Australia's global environmental accountability
Reduce ecological footprint (consumption)
Increased vegetarianism
Critical environmental tipping points (irreversible negative change
New forms of ownership of property?
Globalisation
Climate change
Water shortages
Pressure on economic development
Demands for water exceeding supply
Lose 50% of retail outlets?
Reduction in waste
Reduce vitamin D due to indoor lives
Reduced eco-awareness and knowledge of local needs?
Less sustainable living
Ring of parks around Canberra
Reduced personal debt
ACT and region policies for food security?
Death of green spaces
Urban infill
Design for non-permanent population?
More sustainable living
Reduced resource use
Local food production
New urban design
Apartment living
Increased housing and debt stress
Single-person households etc.
Increased communal transport
Smaller houses and gardens
Remote working means fewer, smaller offices, workers visiting Canberra
Increased bicycles use
Electric bicycles in future?
Greater dependence of the ACT on external resources?
Mutual benefits as region becomes provider of energy to Canberra
Increasing pace of life
Dispersal of people into the region as they don't need to live where their employer is
Possible failure of infrastructure to meet changing needs?
Growth and prosperity in the region
Cultural mix possibilities
ACT economy fails
Regional cooperation on environmental, transport, education issues
Global economic uncertainty
Declining environmental quality
Declining health
Reduced social capital
Aging population
New solutions for food distribution (e.g. door to door)
Death of malls
Immigration into ACT (e.g. refugees)
More multicultural
More integrated and homogenised
Devolved, adaptive governance
Experimentation with new approaches
Centralised at Commonwealth level
ACT becomes a place to test ideas about building resilience
Commonwealth government downsizes or moves out of Canberra??
Not clear what the implications might be for resilience?
Virtual society
Fluidity of social groups
Decline in Canberra's population
Settle in Canberra?
Settle outside Canberra?
Anticipation and effective responses to environmental challenges
ACT depopulates
Positive and negative impacts on agriculture
Post-growth economy?
New power industries (even nuclear?) in region
Bioengineering of food
Convergence of technologies
Innovation
Intellectual capital
New ways to attract young people to work in the ACT
Absence of places for people to meet
Need for new community spaces
Declining mental health of young people
Budgetary constraints
Growing rich-poor divide
Better medicine
Sea level rise
Climate change
Regional health impacts (e.g., diseases)
Excessive focus on known challenges
Need good mix of young and older people (or will this be not so important?)
Preventative health
Longer lives
Decline in some regional communities?
Innovative responses from regional communities
More extreem weather
Declining oil supply
Consumption more attuned to supply
Nanotechnologies for various purposes
Information, communication technology
Promotion of the ACT as a centre of innocation and advanced education and research
Young people don't find the ACT attractive or exciting
Pandemic
Obesity + new social issues
Adversarialism increases
Short-term focus on coal and gas
Price rises
Impacts on businesses
ACT centre for new smart technologies?
Diverse new forms of land management for food production
New building materials
Alienation of some parts of society
Major new role for social media
Addressing complex environmental issues through multi-stakeholder dialogue
Over-reliance on technology?
Failed experiments in manipulating the environment?
Decentralised energy generation - off the grid suburbs?
Move the renewables
Solar farms?
Short to medium term impacts on transport, heating etc. among public
New forms of communication not currently imagined?
Potential for rapid spreading of unrest
Over-confidence in use of technology?

13

References/ endnotes

[1] Slaughter R. (1996) Futures studies: From individual to social capacity. Futures 28, 751-62

[2] ACT Government. (2007) The Canberra Spatial Plan. ACT Government, Canberra, <http://apps.actpla.act.gov.au/spatialplan/index.html>

[3] UK National Ecosystem Assessment. (2011) The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge, UK.

[4] Millennium Ecosystem Assessment (MA). (2005) Ecosystems and Human Well-Being: Synthesis. Island Press, Washington DC, USA.

[5] World Economic Forum. (2010) The Future of the Global Financial System. World Economic Forum, Geneva, <http://www3.weforum.org/docs/WEF_Scenario_FutureGlobalFinancialSystem_Report_2010.pdf

[6] World Economic Forum. (2010) The Future of the Global Financial System. World Economic Forum, Geneva, <http://www3.weforum.org/docs/WEF_Scenario_FutureGlobalFinancialSystem_Report_2010.pdf>.

[7] The Economist, December 2010 (http://www.economist.com/node/17732859)

[8] http://www.worldenergyoutlook.org/

[9] Shell. (2008) Shell Energy Scenarios to 2050. Shell International, The Hague, the Netherlands, <http://www-static.shell.com/static/public/downloads/brochures/corporate_pkg/ scenarios/shell_energy_scenarios_2050.pdf>.
Holmgren D. (2008) Future Scenarios. http://www.futurescenarios.org.

[10] CSIRO (Commonwealth Scientific and Industrial Research Organisation). (2008) Climate Change Adaptation in Australian Primary Industries, report prepared for the National Climate Change Research Strategy for Primary Industries. CSIRO, Canberra, Australia.
Department of Sustainability and Environment Victoria. (2009) Securing our natural future: A white paper for land and biodiversity at a time of climate change. Department of Sustainability and Environment Victoria,, Melbourne, <http://www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/ 9DB1809566C926A1CA25767E001128C7A87712F40FADECFFCA2576 7300162346>.
Dupont A. & Pearman G. (2006) Climate Change and Security. Lowy Institute Paper 12. Lowy Institute for International Policy, Double Bay, NSW, Australia,
Garnaut R. (2008) Garnaut Climate Change Review. Final Report. Cambridge University Press, Melbourne, <http:// www.garnautreview.org.au/CA25734E0016A131/pages/draft-report>.
Long S. & Walker C. (2005) Climate Refugees: the hidden cost of climate change.
Mackey B., Watson J. E. M., Hope G. & Gilmore S. (2008) Climate change, biodiversity conservation, and the role of protected areas: An Australian perspective. Biodiversity 9, 11-18.
Marshall N. A., Marshall P. A., Tamelander J., Obura D., Malleret-King D. & Cinner J. E. (2009) A Framework for Social Adaptation to Climate Change: Sustaining Tropical Coastal Communities and Industries. IUCN, Gland, Switzerland.
Steffen W., Burbidge A. A., Hughes L., Kitching R., Lindenmayer D., Musgrave W., Stafford Smith M. & Werner P. (2009) Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change. A report to the Ministerial Council commissioned by the Department of Climate Change, Canberra. Department of Climate Change, Canberra.
Stokes C. & Howden M. (2010) Adapting Agriculture to Climate Change: Preparing Australian Agriculture, Forestry and Fisheries for the Future. CSIRO Publishing, Melbourne.

[11] See SustainAbility's Jeff Erikson's recent blog (http://www.sustainability.com/blog/energy-and-water-on-a-collision-course).

[12] Al-Shawaf M. (2011) Ten Trends from 2010. SustainAbility, <http://www.sustainability.com/blog/ten-trends-from-2010>

[13] (http://www.bbc.co.uk/news/science-environment-11435522)

[14] http://www.emwis.org/thematicdirs/news/2011/02/new-strategic-foresight-group-report-blue-peace-rethinking-middle-east-water

[15] Holmgren D. (2008) Future Scenarios. <http://www.futurescenarios.org>.
Shell. (2008) Shell Energy Scenarios to 2050. Shell International, The Hague, the Netherlands, <http://www-static.shell.com/static/public/downloads/brochures/corporate_pkg/scenarios/shell_energy_scenarios_2050.pdf>.

[16] Evans-Pritchard A. (2011) Safe nuclear does exist, and China is leading the way with thorium. Telegraph online 20 Mar 2011, http://www.telegraph.co.uk/finance/comment/ambroseevans_pritchard/

[17] Evans-Pritchard (2011), as above

[18] Professor Aiden Byrne, ANU, personal communication August 2011

[19] Woodall, J (2011). Portable tech might provide drinking water, power to villages. Purdue University News Service, May 3 2011, http://www.purdue.edu/newsroom/research/2011/110503WoodallWater.html (Accessed September 1, 2011)

[20] http://www.economist.com/debate/overview/204&sa_campaign=debateseries/debate79/alert/round/opening

[21] Gale R., Brock P. & Milham N. (2010) Economic sustainability and social well-being. In: Technical Report 12 Monitoring, Evaluation & Reporting Program Technical Report Series pp. 1-66. Industry and Investment NSW, Orange, NSW

[22] Tierney, J. (2011). A New Gauge to See What's Beyond Happiness. The New York Times, 16 May 2011 http://www.nytimes.com/2011/05/17/science/17tierney.html

[23] Brown P. R., Nelson R., Jacobs B., Kokic P., Tracey J., Ahmed M. & Devoil P. (2010) Enabling natural resource managers to self-assess their adaptive capacity. Agricultural Systems 103, 562-8; Nelson R., Kokic P., Crimp S., Meinke H. & Howden S. M. (2010) The vulnerability of Australian rural communities to climate variability and change: Part I—Conceptualising and measuring vulnerability. Environmental Science & Policy 13, 8-17, <http://linkinghub.elsevier.com/retrieve/pii/S1462901109001312>; Nelson R., Kokic P., Crimp S., Martin P., Meinke H., Howden S., de Voil P. & Nidumolu U. (2010) The vulnerability of Australian rural communities to climate variability and change: Part II--Integrating impacts with adaptive capacity. Environmental Science & Policy 13, 18-27

[24] Ryan S (2011) Buying Choices for a More Sustainable Canberra. Report for the ACT Commissioner for Sustainability and the Environment. ACT Government, Canberra.

[25] Allenby, B.R. and Sarewitz, D. (2011). The accelerating techno-human future. The Futurist 45, 30-33.

[26] Planning Futures Pty Ltd. (2009) Planning for Health - A study on the integration of health and planning in South Australia. SA Health, Adelaide.
Kent J., Thompson S. & Jalaludin B. (2011) Healthy Built Environments - A Review of the Literature. Healthy Built Environments Program, City Futures Research Centre, UNSW, Sydney.

[27] Pariser, E. (2011). The troubling future of internet search. The Futurist 45, 6-8.

[28] Misuraca G., Rossel P. & Codagnone C. (2011) Foresight And Policy Modelling On ICT For Governance: Exploring The Next Frontiers. In: Fourth International Seville Conference on Future-Oriented Technology Analysis (FTA) FTA and Grand Societal Challenges – Shaping and Driving Structural and Systemic Transformations, Seville, Spain.

[29] Wagner, CG (2010). Vertical farming: An idea whose time has come back. The Futurist 44. 2 (Mar/Apr 2010): 68-69.

[30] http://www.verticalfarm.com/

[31] http://www.youtube.com/watch?v=fN5_YLfsoXg&NR=1

[32] McKinley Conway (2010) Coming: The Biggest Boom Ever! The Futurist, May-June 2010, p.

[33] Broderick D. (2001) The Spike: How Our Lives Are Being Transformed by Rapidly Advancing Technologies. Tom Doherty Associates, New York,

[34] Broderick D. (2001) The Spike: How Our Lives Are Being Transformed by Rapidly Advancing Technologies. Tom Doherty Associates, New York,

[35] Moravec, H. (1998). When will computer hardware match the human brain? Journal of Evolution and Technology. Vol. 1 — March 1998, <http://www.transhumanist.com/volume1/moravec.htm>

[36] Misuraca, G, Rossel, P., and Codagnone, C.(2011). Foresight And Policy Modelling On ICT For Governance: Exploring The Next Frontiers. In: Fourth International Seville Conference on Future-Oriented Technology Analysis (FTA) FTA and Grand Societal Challenges – Shaping and Driving Structural and Systemic Transformations, Seville, 12-13 May 2011.

[37] Allenby, B.R. and Sarewitz, D. (2011). The accelerating techno-human future. The Futurist 45, 30-33.

[38] Cribb J. (2010) The Coming Famine. The Global Food Crisis and What We Can Do to Avoid It. CSIRO Publishing, Melbourne.

[39] Public Administration Vol. 89, No. 2, 2011, 361–380)

[40] MA. (2005) Ecosystems and Human Well-Being: Volume 2. Scenarios. Island Press, Washington DC, USA, <http://ww.maweb.org>; Cork S. J., Peterson G. D., Bennett E. M., Petschel-Held G. & Zurek M. (2006) Synthesis of the storylines. Ecology and Society 11, [online] <http://www.ecologyandsociety.org/vol11/iss2/art11/>

[41] Sutherland W. J., Clout M., Côté I. M., Daszak P., Depledge M. H., Fellman L., Fleishman E., Garthwaite R., Gibbons D. W., De Lurio J., Impey A. J., Lickorish F., Lindenmayer D., Madgwick J., Margerison C., Maynard T., Peck L. S., Pretty J., Prior S., Redford K. H., Scharlemann J. P. W., Spalding M. & Watkinson A. R. (2010) A horizon scan of global conservation issues for 2010. Trends in ecology & evolution 25, 1-7, <http://eutils.ncbi.nlm.nih.gov/entrez/eutils/elink.fcgi?dbfrom=pubmed&id=19939492&retmode=ref&cmd=prlinks>

[42] Homer-Dixon T. (2009) When wise words are not enough. Nature 458, 284-5

[43] Langdon K. A., Warne M. S. J., Smernik R. J., Shareef A. & Kookana R. S. (2011) Selected personal care products and endocrine disruptors in biosolids: an Australia-wide survey. Science of the Total Environment 409, 1075-81, <http://eutils.ncbi.nlm.nih.gov/entrez/eutils/elink.fcgi?dbfrom=pubmed&id=21216442&retmode=ref&cmd=prlinks>

[44] Sutherland W. J., Bardsley S., Bennun L., Clout M., Côté I. M., Depledge M. H., Dicks L. V., Dobson A. P., Fellman L. & Fleishman E. (2011) Horizon scan of global conservation issues for 2011. Trends in Ecology & Evolution 26, 10-6, <http://linkinghub.elsevier.com/retrieve/pii/S016953471000265X>

[45] Suhterland et al. (2011), as above

[46] Teuten, E.L. et al. (2007) Potential for plastics to transport hydrophobic contaminants. Environ. Sci. Technol. 41, 7759–7764

[47] Allenby, B.R. and Sarewitz, D. (2011). The accelerating techno-human future. The Futurist 45, 30-33.

[48] Australian National University. (2008) Public Opinion Towards the Environment. ANU, Canberra, <http://publicpolicy.anu.edu.au/anupoll/documents/2008-10-29_ANUpoll_environment_report.pdf>.

[49] Mannheim M. (2011) Canberrans 'Australia's most selfish'. In: The Canberra Times online. Fairfax Media, Canberra, http://www.canberratimes.com.au/news/local/news/general/canberrans-australias-most-selfish/2222089.aspx.

[50] NSW Communities. (2011) Transition Towns. NSW Communities, <http://nswcommunities.org.au/setts.html>.

[51] See Change. (2011) Communities Creating a Sustainable Canberra. See Change, Canberra, http://www.see-change.org.au/.

[52] Ampt P. & Doornbos S. (2011) Communities in Landscapes Project Benchmark Study of Innovators. DRAFT Report September 2011. University of Sydney, Sydney.
Communities in Landscapes. (2010) Working together to integrate conservation and production across Box-Gum Woodlands. Communities in Landscapes, NSW, <http://cil.landcarensw.org.au/>

[53] Wiseman J., Heine W., Langworthy A., McLean N., Pyke J., Raysmith H. & Salvaris M. (2006) Measuring wellbeing. Engaging Communities. Developing a community indicators framework for Victoria. Institute of Community Engagement and Policy Alternatives (ICEPA), Victoria University, the VicHealth Centre for the Promotion of Mental Health and Social Well Being, School of Population Health, University of Melbourne and the Centre for Regional Development, Swinburne University of Technology, Melbourne.

[54] Behm A. (2010) Security, prosperity and resilience. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 59-63. CSIRO Publishing, Collingwood, Victoria, Australia

[55] Butler G. (2005) Sustainable communities: the important role of local government in building social capital. In: 2nd Future of Australia's Country Towns Conference pp. Published on-line. Centre for Sustainable Regional Communities, La Trobe University, Bendigo, Victoria, <http://www.latrobe.edu.au/csrc/2ndconference/refereed>

[56] Ariely D. (2008) Predictably irrational. Harper Collins, London

[57] http://vimeo.com/10324258

[58] Sterman J. D. (2008) Risk Communication on Climate: Mental Models and Mass Balance. Science 322, 532-3

[59] Educating children for tomorrow's world Marx, Gary. The Futurist 35. 2 (Mar/Apr 2001): 43-48.

[60] Literary Learning in The Hyperdigital Age Bauerlein, Mark. The Futurist 44. 1 (Jan/Feb 2010): 24-25.

[61] Eckersley R. (2005) Well & Good: Morality, Meaning and Happiness. Text Publishing, Melbourne.
Eckersley R. (2006) Losing faith in the official future. Australia Institute newsletter June.
Eckersley R. (2006) What's wrong with the official future? In: After Blair: Politics After the New Labour Decade (ed G. Hassan). Lawrence and Wishart, London, U.K.
MacKay H. (2007) Advance Australia ... where? How we've changed, why we've changed, and what will happen next. Hachette, Australia.

[62] D Cocks, 'Reflecting on the population debate', Australian Mosaic, vol. 7, 2004, pp. 5–8, viewed 19 October 2010, http://www.labshop.com.au/dougcocks/MOSAICARTICLE.htm.

[63] Cork S. (2010) Ways forward in the population and environment debate. Parliament of Australia, Department of Parliamentary Services, Canberra, <http://www.aph.gov.au/library/pubs/PEPU/PopulationEnvironDebate.pdf>.

[64] Al-Shawaf M. (2011) Ten Trends from 2010. SustainAbility, <http://www.sustainability.com/blog/ten-trends-from-2010>

[65] Al-Shawaf (2011), as above

[66] Bita N. (2011) Asia leads the charge in Aussie land grab. In: theaustralian.com.au. The Australian, <http://www.theaustralian.com.au/national-affairs/asia-leads-the-charge-in-aussie-land-grab/story-fn59niix-1226085921522>

[67] http://www.farminstitute.org.au/BlogRetrieve.aspx?PostID=74156&A=SearchResult&SearchID=2296862&ObjectID=74156&ObjectType=55

[68] Marvin J Cetron and Owen Davies (2010) Trends Shaping Tomorrow's World: Forces in the Natural and Institutional Environments. The Futurist, July-Aug 2010, p. 43

[69] Cetron & Davies, as above.

[70] Glaeser E. (2011) Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier. Penguin Press, USA.

[71] Newman P. (2010) Resilient cities. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 81-95. CSIRO Publishing, Collingwood, Victoria, Australia.
Newman P. & Jennings I. (2008) Cities as Sustainable Ecosystems. Island Press, Washington DC.

[72] Norman B. (2010) A low carbon and resilient urban future: a strategic approach to settlement planning for climate change. Department of Climate Change, Canberra.
Thom B., Crane J., Cox R., Farrell C., Hayes P., Kay R., Kearns A., Low Choy D., McAneney J., McDonald J., Nolan M., Norman B., Nott J. & Smith T. (2010) National Climate Change Adaptation Research Plan: Settlements and Infrastructure. National Climate Change Adaptation Research Facility, Brisbane.

[73] Cork S. (2010) Resilience and Transformation - Preparing Australia for Uncertain Futures. CSIRO Publishing, Collingwood, Victoria, Australia

[74] Marshall G. R. (2010) Governance in a surprising world. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 49-56. CSIRO Publishing, Collingwood, Victoria, Australia; Marshall G. R. & Stafford-Smith D. M. (2010) Natural resources governance for the drylands of the Murray–Darling Basin. The Rangeland Journal 32, 267-82

[75] Marsh D., Lewis C. & Fawcett P. (2010) Citizen-centred policy making under Rudd: network governance in the shadow of hierarchy? In: The Rudd Government: Australian Commonwealth Administration 2007 - 2010 (eds C. Aulich and M. Evans). ANU E-Press, Canberra.

[76] The Futurist, World Trends & Forecasts, Sep-Oct 2010, p 10.

[77] The Futurist (2010). Outlook 2011. The Futurist , November-December 2010, 29

[78] http://www.teebweb.org/Home/tabid/924/Default.aspx

[79] http://uknea.unep-wcmc.org/

[80] http://www.nrm.gov.au/; Cork S., Stoneham G., Lowe K., Gainer K. & Thackway R. (2007) Ecosystem Services and Australian Natural Resource Management (NRM) Futures. In: Paper to the Natural Resource Policies and Programs Committee (NRPPC) and the Natural Resource Management Standing Committee (NRMSC). Australian Government, Canberra, <www.environment.gov.au/biodiversity/publications/ecosystem-services-nrm-futures/pubs/ecosystem-services.pdf>

[81] Aguilar-Millan, S., Feeney, A., Oberg, A., and Rudd, E. (2010). The Post-Scarcity World of 2050-2075. Futurist, Jan-Feb 2010, p. 35.

[82] Aguilar-Millan, S., Feeney, A., Oberg, A., and Rudd, E. (2010). The Post-Scarcity World of 2050-2075. Futurist, Jan-Feb 2010, p. 35.

[83] Schwartz P. (2003) Inevitable Surprises: Thinking Ahead in a Time of Turbulence. Gotham Books, New York.

[84] Dyson, T. (2005) On development, demography and climate change: the end of the world as we know it? Popul. Environ. 27, 117–149

[85] Dickinson, J.L. (2009) The people paradox: self-esteem striving, immortality ideologies, and human response to climate change. Ecol. Soc. 14, 17

[86] Scheffer M., Carpenter S. R., Foley J. A., Folke C. & Walker B. H. (2001) Catastrophic shifts in ecosystems. Nature 413, 591-6.
Dobson A., Lodge D., Alder J., Cumming G. S., Keymer J., McGlade J., Mooney H., Rusak J. A., Sala O., Wolters V., Wall D., Winfree R. & Xenopoulos M. A. (2006) Habitat loss, trophic collapse, and the decline of ecosystem services. Ecology 87, 1915-24, http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=22074451&site=ehost-live.

[87] Cunningham S. A., FitzGibbon F. & Heard T. A. (2002) The future of pollinators for Australian agriculture. Australian Journal of Agricultural Research 53, 893-900, http://www.publish.csiro.au/paper/AR01186. Ricketts T., Regetz J., Steffan-Dewenter I., Cunningham S., Kremen C., Bogdanski A., Gemmill-Herren B., Greenleaf S., Klein A.-M., Mayfield M., Morandin L., Ochieng A. & Viana B. (2008) Effect of landscape context on pollination in agricultural crops: a review. Ecology Letters 11, 499-514

[88] Butchart S. H. M., Walpole M., Collen B., van Strien A., Scharlemann J. P. W., Almond R. E. A., Baillie J. E. M., Bomhard B., Brown C., Bruno J., Carpenter K. E., Carr G. M., Chanson J., Chenery A. M., Csirke J., Davidson N. C., Dentener F., Foster M., Galli A., Galloway J. N., Genovesi P., Gregory R. D., Hockings M., Kapos V., Lamarque J.-F., Leverington F., Loh J., McGeoch M. A., McRae L., Minasyan A., Morcillo M. H., Oldfield T. E. E., Pauly D., Quader S., Revenga C., Sauer J. R., Skolnik B., Spear D., Stanwell-Smith D., Stuart S. N., Symes A., Tierney M., Tyrrell T. D., Vié J.-C. & Watson R. (2010) Global Biodiversity: Indicators of Recent Declines. Science 328, 1164-8, http://www.sciencemag.org/content/328/5982/1164.abstract.

[89] Galaz V., Moberg F., Olsson E.-K., Paglia E. & Parker C. Institutional and political leadership dimensions of cascading ecological crises. Public Administration 89, 361-80.
Walker B., Barrett S., Polasky S., Galaz V., Folke C., Engstrom G., Ackerman F., Arrow K., Carpenter S. & Chopra K. (2009) Looming global-scale failures and missing institutions. Science 325, 1345, <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=3705432588860391556related:hAAurk5XbDMJ>

[90] MA (Millennium Ecosystem Assessment). (2005) Ecosystems and Human Well-Being: Synthesis. Island Press, Washington DC, USA, <http://ww.maweb.org>

[91] Sutherland W. J., Bardsley S., Bennun L., Clout M., Côté I. M., Depledge M. H., Dicks L. V., Dobson A. P., Fellman L. & Fleishman E. (2011) Horizon scan of global conservation issues for 2011. Trends in Ecology & Evolution 26, 10-6, <http://linkinghub.elsevier.com/retrieve/pii/S016953471000265X>

[92] Sutherland W. J., Bardsley S., Bennun L., Clout M., Côté I. M., Depledge M. H., Dicks L. V., Dobson A. P., Fellman L. & Fleishman E. (2011) Horizon scan of global conservation issues for 2011. Trends in Ecology & Evolution 26, 10-6, <http://linkinghub.elsevier.com/retrieve/pii/S016953471000265X>

[93] Brown L. R. (2011) Eroding futures. Why healthy soils matters to civilisation. The Futurist 45, 23-30

[94] Upcoming nation state of the environment report, personal communication

[95] Hairsine P. B., Barson M., Randall L. & Wilkinson S. N. (2009) Indentifiaction of areas in Australia where soil loss from hillslope erosion could be reduced. Australian Government, Canberra

[96] Brown L. R. (2011) Eroding futures. Why healthy soils matters to civilisation. The Futurist 45, 23-30

[97] Frehlich, L. et al. (2006) Earthworm invasion into previously earthworm-free temperate and boreal forests. Biol. Inv. 8, 1235–1245.
Sutherland W. J., Bardsley S., Bennun L., Clout M., Côté I. M., Depledge M. H., Dicks L. V., Dobson A. P., Fellman L. & Fleishman E. (2011) Horizon scan of global conservation issues for 2011. Trends in Ecology & Evolution 26, 10-6, <http://linkinghub.elsevier.com/retrieve/pii/S016953471000265X>

[98] Australian Government. (2008) Caring for our Country - Outcomes 2008-2013. Australian Government, Canberra, http://www.nrm.gov.au/publications/books/caring-outcomes.html.

[99] Garnaut R. (2008) Garnaut Climate Change Review. Final Report. Cambridge University Press, Melbourne, http://www.garnautreview.org.au/CA25734E0016A131/pages/draft-report.

[100] Steffen W., Burbidge A. A., Hughes L., Kitching R., Lindenmayer D., Musgrave W., Stafford Smith M. & Werner P. (2009) Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change. A report to the Ministerial Council commissioned by the Department of Climate Change, Canberra. Department of Climate Change, Canberra.
Dunlop M. & Brown P. R. (2008) Implications of climate change for Australia's National Reserve System: A preliminary assessment. Department of Climate Change, Canberra.

[101] Australian Government. (2011) Clean Energy Future: Land use. Australian Government, Canberra, http://www.cleanenergyfuture.gov.au/clean-energy-future/land-use/#content03.

[102] Australian Government (2011), as above

[103] Australian Government (2011), as above

[104] Taylor M. F. J., Sattler P. S., Fitzsimons J., Curnow C., Beaver J., Gibson L. & Llewellyn G. (2011) Building Nature's Safety Net 2011: The State of Protected Areas for Australia's Ecosystems and Wildlife. WWF-Australia, Sydney

[105] Mackey B., Watson J. & Worboys G. L. (2010) Connectivity conservation and the Great Eastern Ranges corridor. In: An independent report to the Interstate Agency Working Group (Alps to Atherton Connectivity Conservation Working Group) convened under the Environment Heritage and Protection Council/Natural Resource Management Ministerial Council. Department of Environment, Climate Change and Water NSW, Sydney; Worboys G. L. & Good R. B. (2011) Caring For Our Australian Alps Catchments: Summary Report For Policy Makers. Department of Climate Change and Energy Efficiency, Canberra

[106] Sutherland W. J., Clout M., Côté I. M., Daszak P., Depledge M. H., Fellman L., Fleishman E., Garthwaite R., Gibbons D. W., De Lurio J., Impey A. J., Lickorish F., Lindenmayer D., Madgwick J., Margerison C., Maynard T., Peck L. S., Pretty J., Prior S., Redford K. H., Scharlemann J. P. W., Spalding M. & Watkinson A. R. (2010) A horizon scan of global conservation issues for 2010. Trends in ecology & evolution 25, 1-7, <http://eutils.ncbi.nlm.nih.gov/entrez/eutils/elink.fcgi?dbfrom=pubmed&id=19939492&retmode=ref&cmd=prlinks>

[107] http: www.resalliance.org

[108] Walker B. & Salt D. (2006) Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press, Washington DC, USA

[109] Cork S., Walker B. & Buckley R. (2008) How Resilient is Australia? Australia 21, Canberra, <http://www.australia21.org.au/whats_new.htm>.
Cork S. ed. (2010) Resilience and Transformation - Preparing Australia for Uncertain Futures. CSIRO Publishing, Collingwood, Victoria, Australia

[110] Nicholls S. (2010) The role of communication in supporting resilient communities. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 181-7. CSIRO Publishing, Collingwood, Victoria, Australia.

[111] Citraningtyas T. (2010) Beyond resilience in the face of disaster - transforming adversity by transforming ourselves and our systems. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 189-96. CSIRO Publishing, Collingwood, Victoria, Australia.

[112] Walker B. & Salt D. (2006) Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press, Washington DC, USA.
Cork S. (2010) Resilience of social-ecological systems. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 131-42. CSIRO Publishing, Collingwood, Victoria, Australia

[113] Carpenter & Brock (2008), as above

[114] Carpenter & Brock (2008), as above
Allison H. E. & Hobbs R. J. (2004) Resilience, adaptive capacity, and the "Lock-in Trap" of the Western Australian agricultural region. Ecology and Society 9, 3 [online], <http://www.gbcma.vic.gov.au/downloads/wshop_resilience_reading/resilience_west_aust.pdf>.

[115] Cork S. (2010) Resilience and Transformation - Preparing Australia for Uncertain Futures. CSIRO Publishing, Collingwood, Victoria, Australia

[116] Eckersley R. (2010) Population health - a forgotten dimension of social resilience. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 115-20. CSIRO Publishing, Collingwood, Victoria, Australia

[117] Allison H. E. & Hobbs R. J. (2004) Resilience, adaptive capacity, and the "Lock-in Trap" of the Western Australian agricultural region. Ecology and Society 9, 3 [online], http://www.gbcma.vic.gov.au/downloads/wshop_resilience_reading/resilience_west_aust.pdf.

[118] Buckley R. (2010) Resilience and global financial governance. In: Resilience and Transformation - Preparing Australia for Uncertain Futures (ed S. Cork) pp. 65-71. CSIRO Publishing, Collingwood, Victoria, Australia

[119] Cork S., Price R. & Connell D. (2010) Capacity to adaptively manage under climate change and variability - final report and project summary. Murray-Darling Basin Authority (MDBA), Canberra.

[120] Rockström J., Steffen W., Noone K., Persson Å., III F. S. C., Lambin E., Lenton T. M., Scheffer M., Folke C., Schellnhuber H., Nykvist B., Wit C. A. D., Hughes T., Leeuw S. v. d., Rodhe H., Sörlin S., Snyder P. K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R. W., Fabry V. J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P. & Foley J. (2009) Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14, 32 [online] http://www.ecologyandsociety.org/vol14/iss2/art32/, http://www.ecologyandsociety.org/vol14/iss2/art32/.

[121] Wack P. (1985) Scenarios: Uncharted waters ahead. Harvard Business Review September-October, 74-89.
Wack P. (1985) Scenarios: Shooting the rapids. Harvard Business Review November-December, 3-14.

[122] Australian Government Department of Sustainability, Environment Population and Communities. (2011) The National Plan for Environmental Information. Australian Government Department of Sustainability, Environment, Population and Communities, Canberra, http://www.environment.gov.au/npei/index.html.
Australian Bureau of Statistics. (2010) 4655.0.55.001 - Towards an integrated environmental-economic account for Australia, 2010. Australian Bureau of Statistics, Canberra.

Weather and climate of the ACT 2007-11 and decadal trends

Clem Davis and Janette Lindesay

Fenner School of Environment & Society
ANU College of Medicine, Biology & Environment

December 2011

Citation:

Davis, C. and Lindesay, J. 2011. *Weather and Climate of the ACT 2007-11 and Decadal Trends.* Report for the Office of the Commissioner for Sustainability and the Environment. Canberra

ACT State of Environment Report 2010 - Weather

Summary

During the three-year period 2008-2010 the weather in the ACT was generally warmer than the long-term climate average (1961-1990), with drier conditions in 2008 and 2009 and wetter than average conditions in 2010. All weather indicators were consistent with these conditions.

At Canberra Airport rainfall was 54% above average in 2010, whereas 2008 and 2009 were drier than normal. The number of rain days was below average in 2008 and close to average in 2009 and 2010. This indicates that average rainfall intensity (the average amount of rainfall recorded on each rain day) was lower than normal in the dry year (2009) and higher than normal in the wet year (2010).

Above-average temperatures were recorded during this period both during the day (mean daily maximum temperatures) and at night (mean daily minimum temperatures). In terms of the mean daily temperature (the average of mean daily maximum and minimum temperatures) 2009 was the second hottest year since records began in Canberra in 1939/40; the hottest year was 2007. Although 2008 was the coolest year in the period 2003-2010, mean daily temperatures were 6% above the long-term average.

The number of hot days in summer in particular was considerably above average in 2009, with 69 days of 30°C or more. On the other hand, 2008 and 2010 had an average number of hot days in this category (30 and 31 days respectively). These results may reflect the impacts of ENSO events in the ACT region: El Niño events tend to be associated with drier, hotter conditions in spring and summer, and La Niña events with cooler, wetter conditions in those seasons. 2008/9 was an El Niño year and 2010/11 was a La Niña year.

Significant weather-related events that impacted on the ACT during the reporting period are listed below:

1. Dust storms were reported in Canberra on 15/4/2009 and 22/9/2009 with visibility reduced to 3 to 4 km.
2. A very strong La Niña event impacted on rainfall in the ACT region during 2010.
3. A small number of frost events occurred in 2009 and 2010.
4. A reduced number of fog events occurred in 2008 and 2009.
5. A particularly hot year was recorded in 2009.
6. There were four heavy rainfall days recorded over the period and three heavy rainfall events (over multiple days), with a significant flooding event in Queanbeyan that also impacted on the ACT in December 2010.
7. Canberra Airport recorded its wettest December day on record on 3 December 2010 (87.6 mm).

All data used in this analysis were sourced from the Bureau of Meteorology and came from official Bureau of Meteorology weather records. The Bureau of Meteorology installed a new observation site at Canberra Airport in September 2008, approximately 400 m from the long-running original site which was established in

1939. Data for 2008 were analysed from the original airport site and data for 2009 and 2010 were analysed from the new airport site. Research is currently being undertaken to determine the optimum method for combining the data from the two sites to form a continuous long-term record. Appendix A provides a comparative analysis of the data from the two sites over the period September 2008-November 2010, at which time the original site was closed.

Table 1: Weather Indices, Canberra Airport

Year	1961-1990 Average	2008	2009	2010
Annual Rainfall (mm)	623.2	530.4	431.4	959.6
Rainfall Anomaly (mm)		-92.8	-191.8	+336.4
Mean Daily Max Temperature (^{o}C)	19.5	20.4	21.7	20.3
Max Temperature Anomaly (^{o}C)		+0.9	+2.2	+0.8
Mean Daily Min Temperature (^{o}C)	6.5	7.1	7.5	7.3
Min Temperature Anomaly (^{o}C)		+0.6	+1.0	+0.9
Mean Daily Mean Temperature (^{o}C)	13	13.8	14.6	13.8
Mean Temperature Anomaly (^{o}C)		+0.8	+1.6	+0.8
3 pm Relative Humidity (%)	47.5	43	41.7	48.3
3 pm Relative Humidity Anomaly (%)		-4.5	-5.8	+0.8
Mean Daily Sunshine (Hrs)	7.6	8.1	7.9	7.7
Sunshine Anomaly (Hrs)		+0.5	+0.3	+0.1
Mean Daily Evaporation (mm)	4.6	4.8	4.9	4.1
Evaporation Anomaly (mm)		+0.2	+0.3	-0.5
Mean Hourly Wind Run (km)	8.2	8.0	8.4	7.7
Wind Run Anomaly (km)		-0.2	+0.2	-0.5

Table 2: Phenomena

Year	1961-1990 Average	2008	2009	2010
Days 35 ^{o}C or more	5	4	20	8
Days 30 ^{o}C or more	30	30	69	31
No. Frosts	99	85	58	53
No. Thunderstorms	23	22	20	18
No. Fog Days	44	28	26	62
No. Strong Wind Days	26	26	25	22
No. Rain Days**	105	94	103	106
Mean Daily Pressure	1016.7	1017.2	1016.8	1018.1

** A rain day is defined as a day on which 0.2 mm or more of precipitation has been recorded in the 24 hours to 9 am. This precipitation could include rainfall as well as dew, fog or frost.

The smaller number of fog days recorded in 2008 and 2009 reflect the lower than average rainfall and dry environmental conditions during these years; in contrast the number of fog days in the wet year of 2010 was the highest recorded since 1985. The small number of frost days in each of 2009 and 2010 reflect the lengthy period of above average minimum temperatures from September 2008 to March 2010.

It is likely that the number of days on which temperatures equalled or exceeded 30°C or 35°C in 2009, and the number of frost days in 2010, are records. This cannot be verified until the question of combining the records from the two airport observation sites has been resolved.

Rainfall

Monthly rainfall time series over the period July 2007- June 2011 in terms of annual rainfall, monthly time series, anomalies from the 1961-1990 monthly means and rainfall accumulation against the monthly mean are shown in Figure 1. The deficit between the actual rainfall accumulated over this period and the mean is 49.8 mm. The monthly rainfall data reflect the dry period 1 July 2007- January 2010 followed by the wet period February 2010 – February 2011.

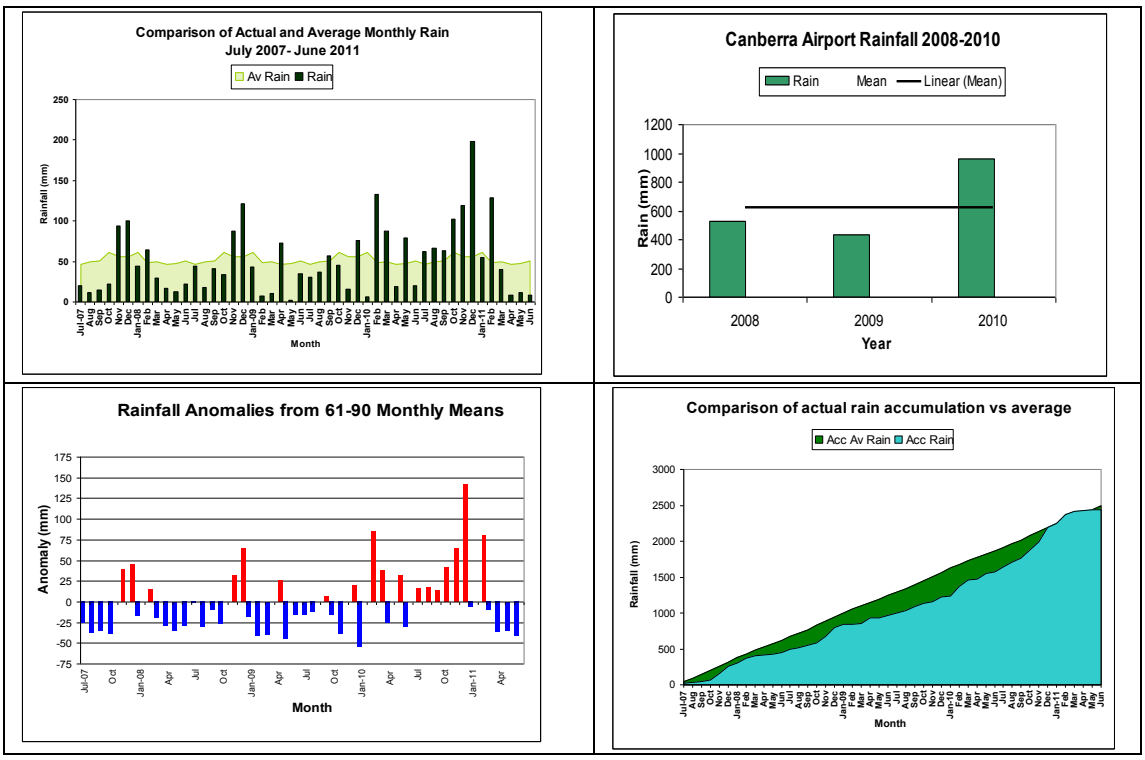


Figure 1: Rainfall at Canberra Airport, 2007-2011.

Long Term Trends

As the correlation between rainfall at Queanbeyan and at Canberra Airport is extremely high (Figure 2), the longer Queanbeyan rainfall record can be used as a proxy for rainfall at Canberra Airport for long term analyses. The long term time series of annual and seasonal rainfall at Queanbeyan for the period 1871-2010, shown in Figure 3, illustrate the overall decline in annual rainfall since the early 1990s which is due largely to reduced rainfall in spring and autumn. Similar trends are observed in other parts of south-eastern Australia. The decline was offset to some extent by relatively high rainfall in spring and summer 2010.

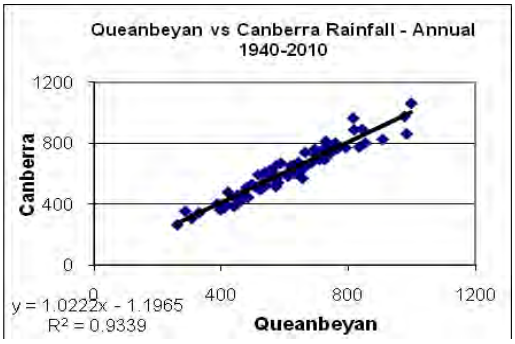


Figure 2: Comparison of annual rainfall at Canberra Airport and Queanbeyan.

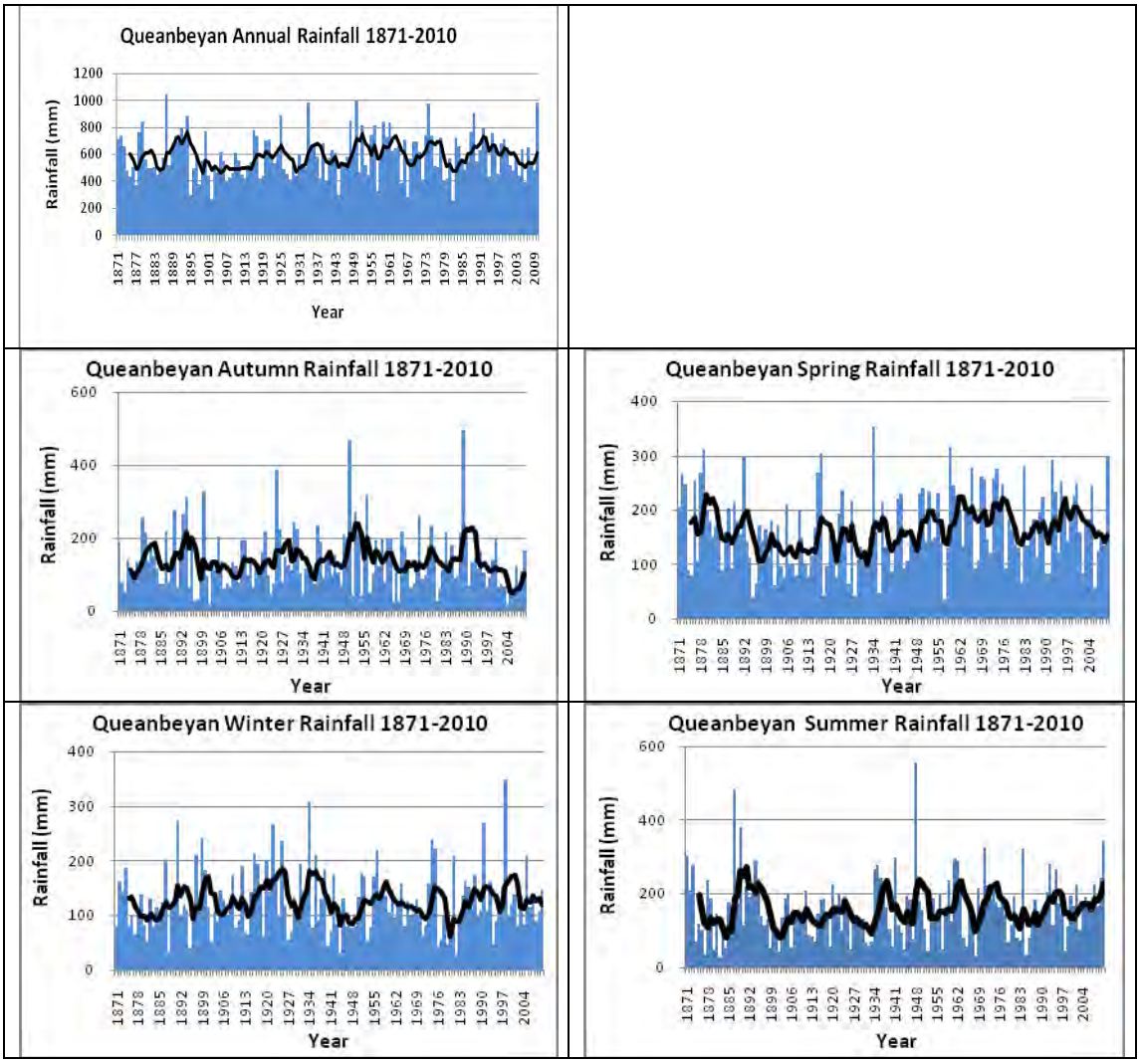


Figure 3: Time series of annual and seasonal rainfall at Queanbeyan with 5-year running mean.

The ACT region has now recorded below average rainfall for 7 of the last 10 years (2001-2010); 2010 is the only year with considerably above average rainfall (982 mm) during this decade. 2010 was the fourth wettest year on record at Queanbeyan (where the record is 1043.4 mm in 1887), and the wettest year since 1974 (975.6 mm).

Decadal trends in rainfall are shown in Figure 4 for the period 1871-2010. There is no clear change in rainfall outside natural variability over this period, except in autumn when a drying trend is evident over the last 40 years, with the most recent decade having the lowest autumn rainfall on record.

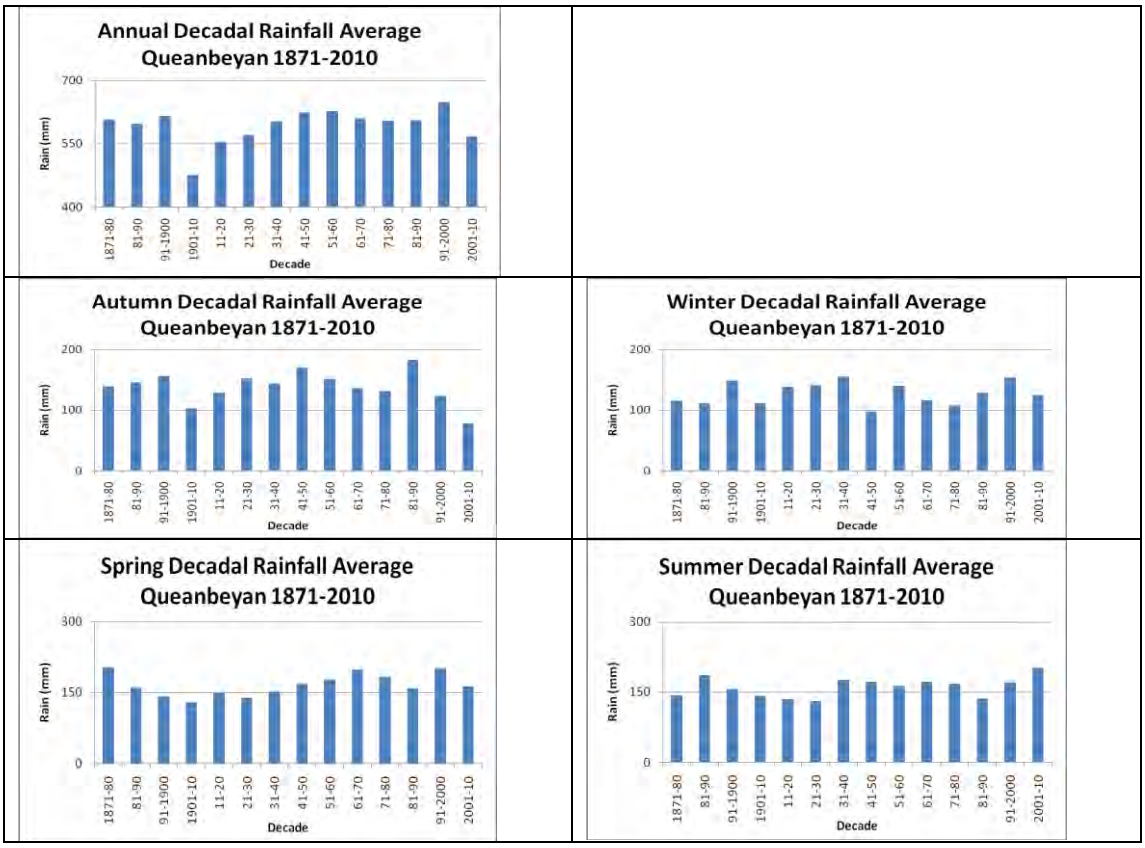


Figure 4: Decadal trends in annual and seasonal rainfall at Queanbeyan, 1871-2010.

Rainfall in the ACT region, particularly during winter and spring, tends to be affected by the El Niño Southern Oscillation (ENSO) phenomenon. The main measure used by the Bureau of Meteorology in determining an ENSO event is the Southern Oscillation Index (SOI), which is an index based on the air pressure differences at sea level between Darwin and Tahiti. Sustained strongly positive values (in the 80th percentile of all SOI values) indicate a La Niña event, and sustained negative values (20th percentile) mark an El Niño event. Table 3 lists the average winter/spring/summer SOI values in the period 2007-2010, and the correlations between winter and spring average SOI and rainfall at Queanbeyan is illustrated in Figure 5.

Table 3: Average SOI for 2007-2010

Year	Av Jun/Nov SOI	Av Sep/Nov SOI	Av Sep/Feb SOI
2007	3.4	5.6	11.1
2008	10.2	14.9	13.7
2009	-3.9	-5.8	-8.2
2010	16.8	19.9	21.5

Both 2008 and 2010 are identified as La Niña events. Although 2009 does not fit the definition of an El Niño year under these criteria, once the SOI values during summer and Pacific Ocean sea surface temperatures are taken into account it has been defined as an El Niño year.

Overall, the impacts of ENSO events in 2008 and 2009 on rainfall in the ACT were minimal. During the 2008 La Niña event rainfall was below average (with the exception of November and December), while in 2009, which was generally drier than average, there was close to average rainfall during winter and spring which minimized any overall impact from the El Niño event. Rainfall during 2010 did reflect the impact of the strong La Niña event with generally wet conditions in most months. This is considered the strongest La Niña event since 1917 and is one of the strongest on record. The impact of this event is evident when the Australian rainfall decile values are examined for this period; the extent of the heavy rainfall over most of Australia in 2010/11 is shown in Figure 6. The Jun/Nov SOI values for the 1876-2010 period and the monthly SOI values for the January 2007- June 2011 period are shown in Figure 7.

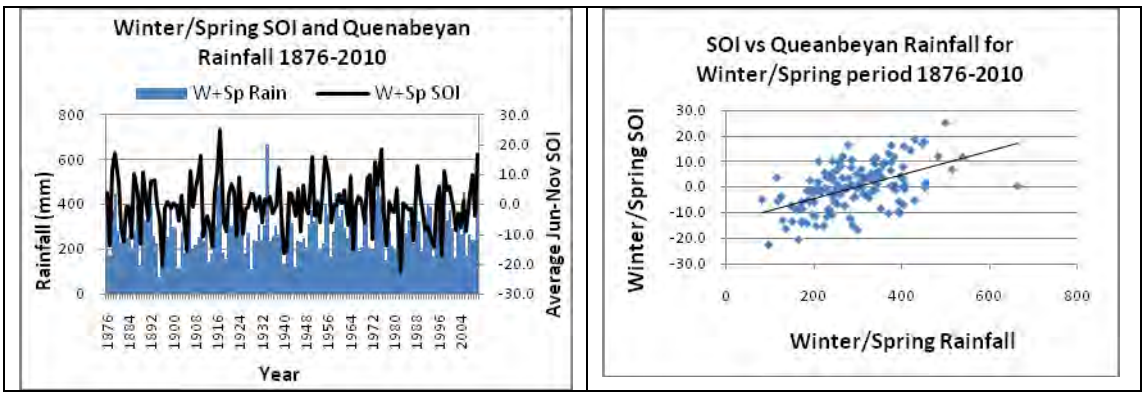
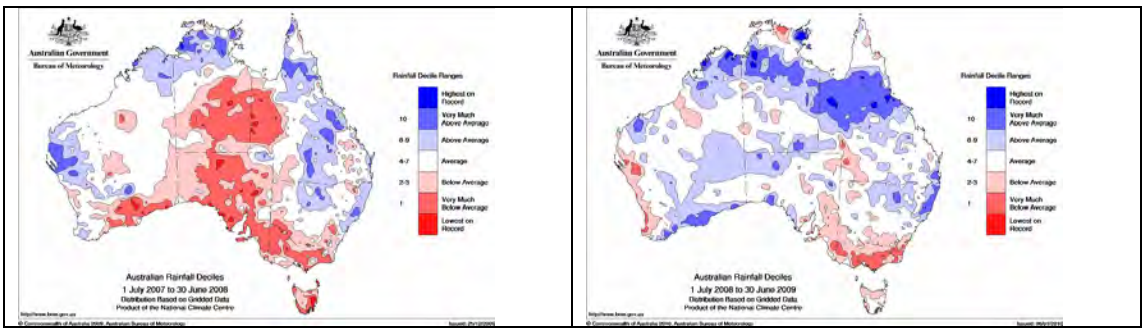


Figure 5: Comparisons of Winter + Spring rainfall at Queanbeyan with average June/November SOI.



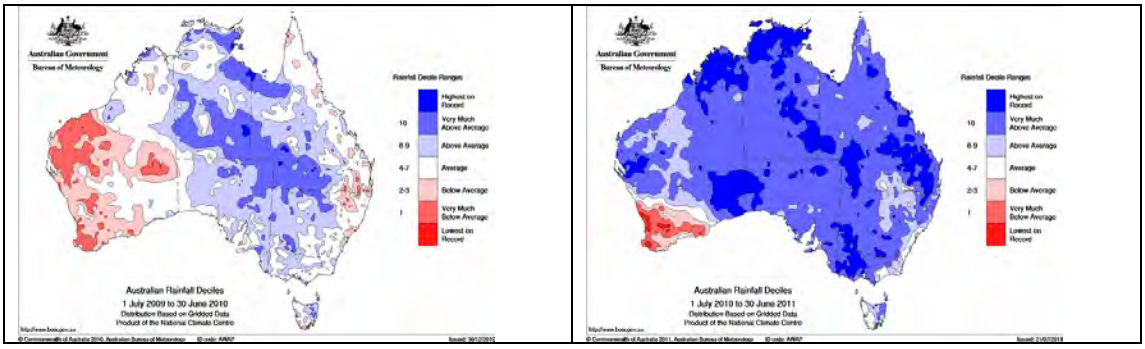
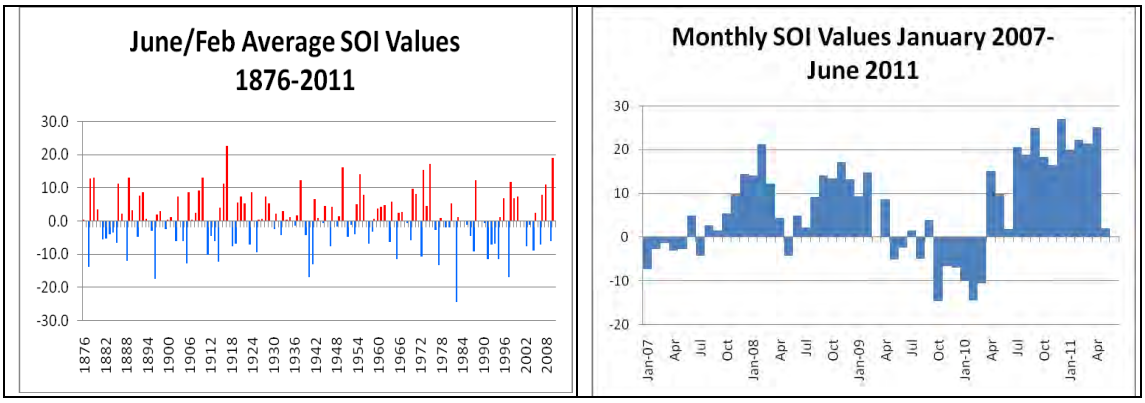


Figure 6: Australian rainfall decile values for the four 12-month periods July-June 2007/08, 2008/09, 2009/10 and 2010/11.

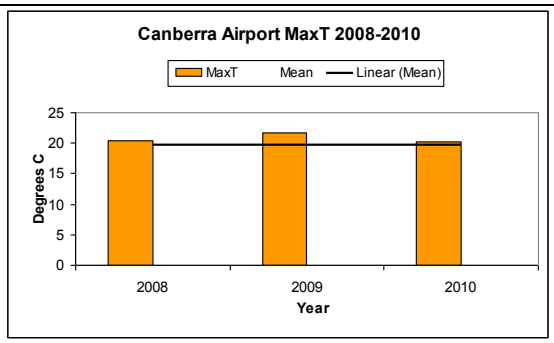


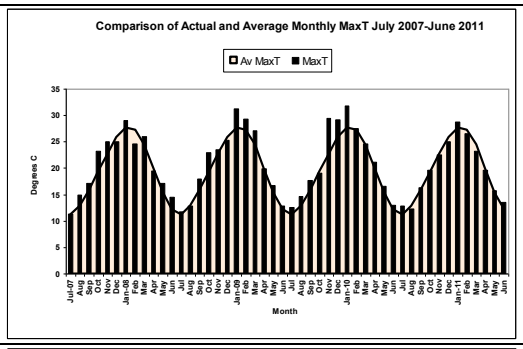
(a) (b)

Figure 7: (a) June-February SOI values, 1876-2011; (b) monthly SOI values, January 2007-June 2011.

Temperature

Monthly values of maximum temperatures, minimum temperatures and mean temperatures at Canberra Airport for the period July 2007 –June 2011 are shown in Figures 8, 9 and 10 respectively. Monthly temperatures have remained above the long term mean throughout the period. While maximum temperatures tended to be higher than average for most of 2009, they were close to average in 2010 and slightly above average in 2008. The slightly cooler than average conditions during January-March 2010 reflects the increased rainfall and cloud cover during this period. On the other hand, minimum temperatures were above average for most of the period, particularly during 2009. The period April-May 2010 was considerably cooler than average and a significant number of frosts were recorded during May 2010. The mean monthly temperature was above average throughout the reporting period.





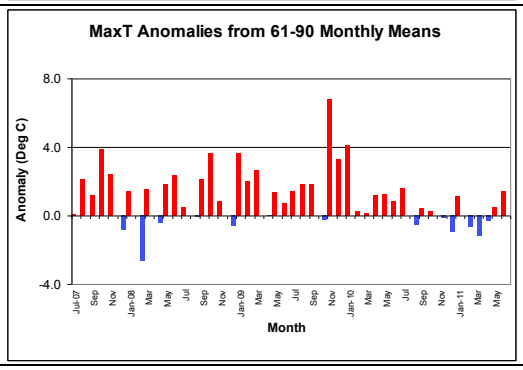
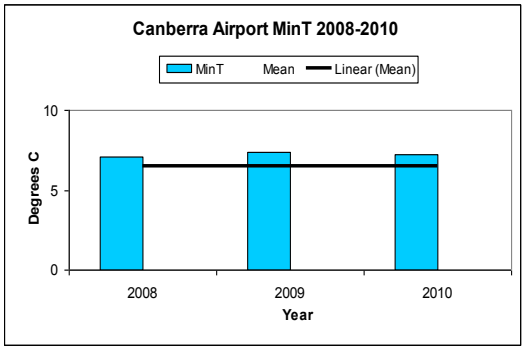
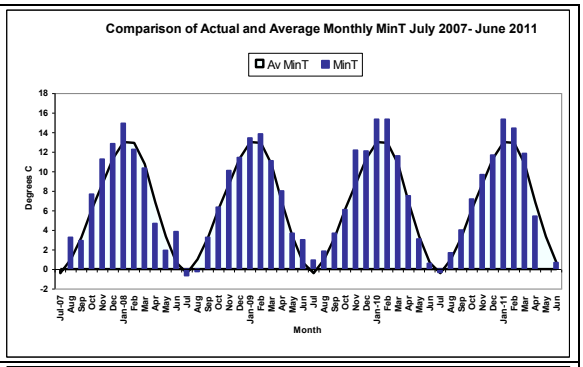


Figure 8: Monthly means of daily maximum temperatures at Canberra Airport, July 2007-June 2011.





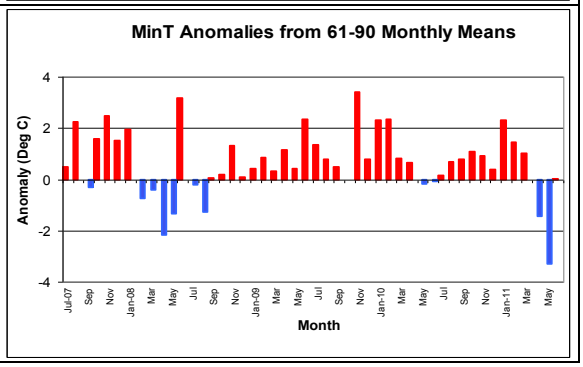
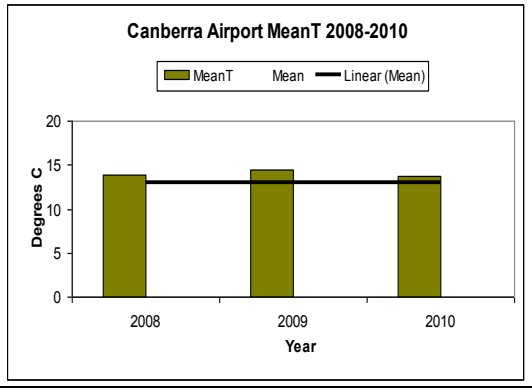
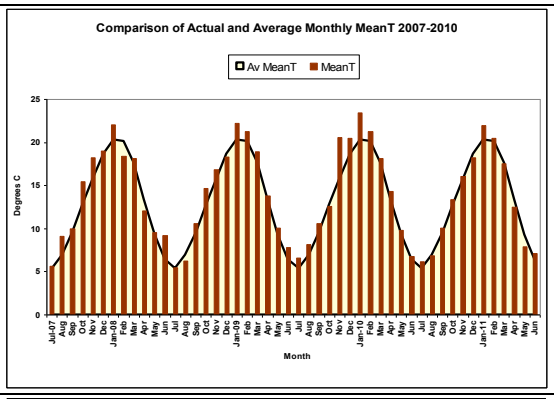


Figure 9: Monthly means of daily minimum temperatures at Canberra Airport, July 2007-June 2011.





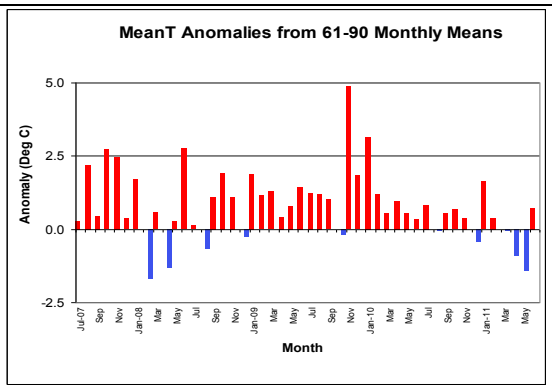
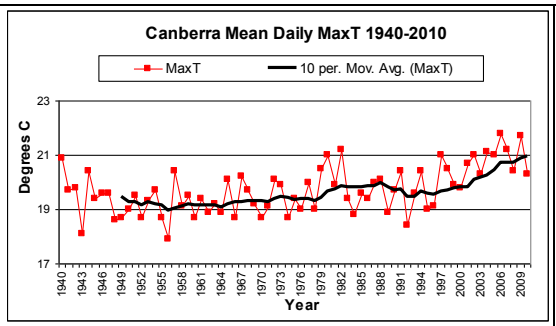
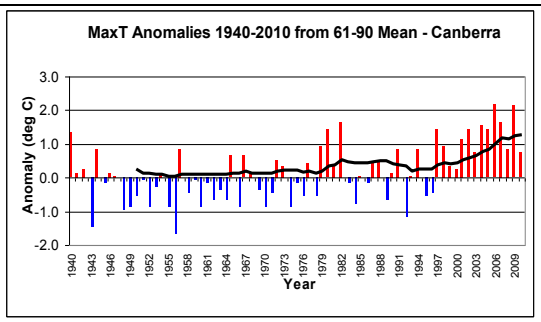


Figure 10: Monthly means of daily average temperatures (average MaxT+MinT) at Canberra Airport, July 2007-June 2011.

Long Term Trends

An analysis of long-term temperature data at Canberra Airport (Figures 11-13) indicates positive trends in annual maximum, minimum and mean temperatures, with most of the increase occurring during the last 15+ years. This increase is also clearly reflected in the graphs of temperature anomalies from the 1961-1990 long-term averages, and in the decadal trends. The increases in annual temperatures are consistent with the overall trends for Australia, although the Canberra anomalies are larger than that for Australia as a whole. Most recently, although 2010 was cooler than other recent years due to lower maximum temperatures resulting from the strong La Niña event and associated higher than average rainfall, it remained warmer than the 1961-1990 mean. Long-term trends, particularly in minimum temperatures, show that the region has continued to warm.





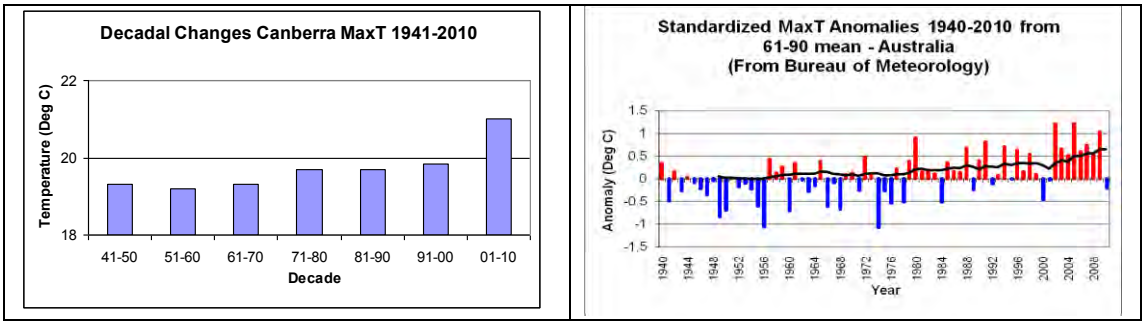


Figure 11: Long term trends in maximum temperatures for Canberra and Australia with 10-year running mean.

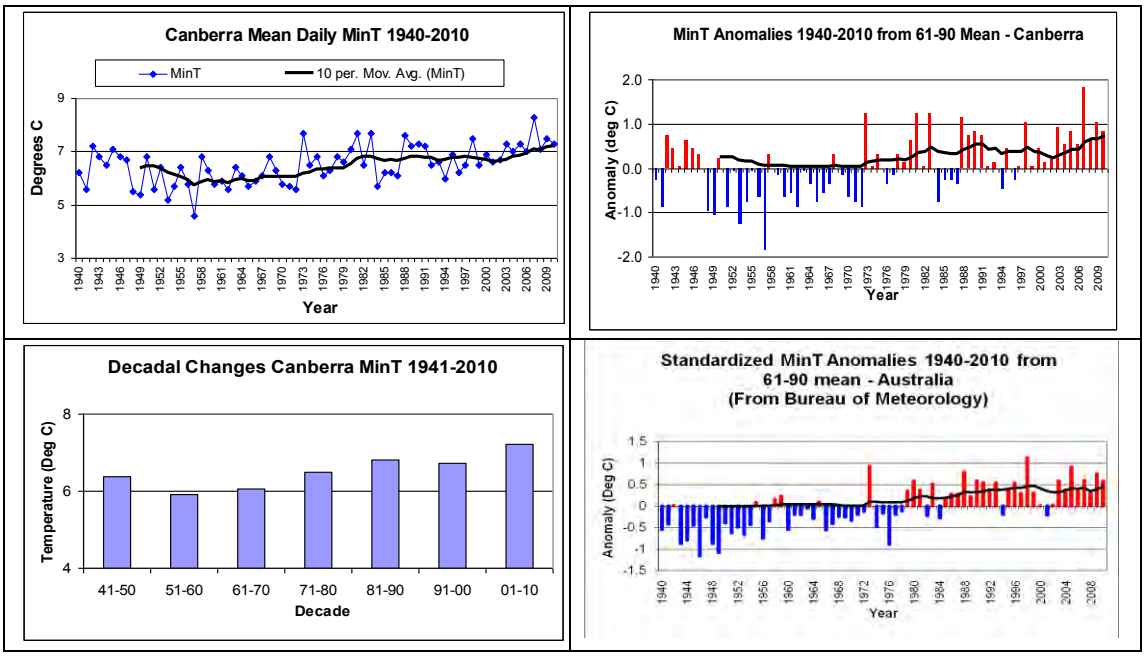
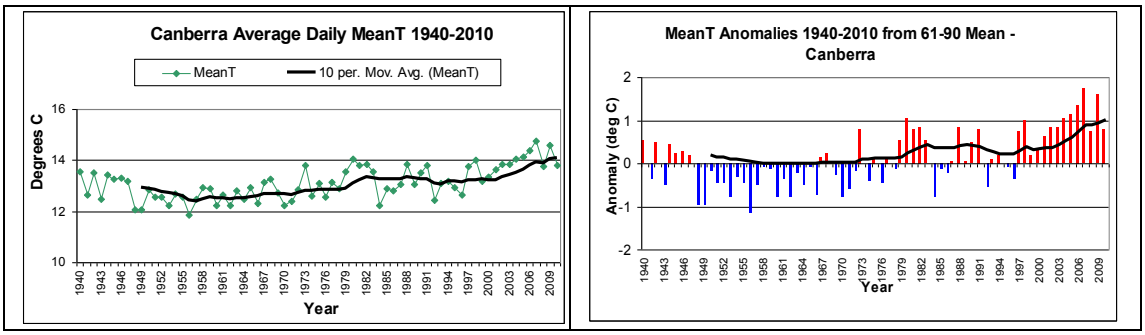


Figure 12: Long term trends in minimum temperatures for Canberra and Australia with 10-year running mean.



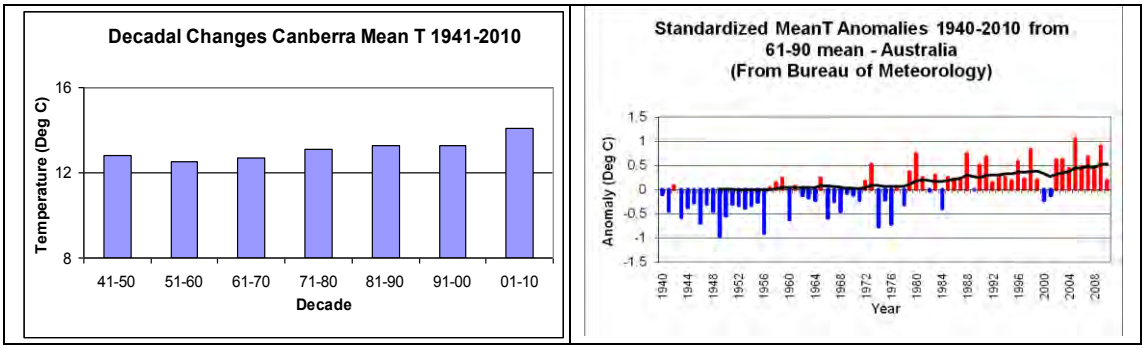


Figure 13: Long term trends in mean daily temperatures for Canberra and Australia with 10-year running mean.

Decadal averages of seasonal values of maximum and minimum temperatures at Canberra since 1941 are shown in Figures 14 and 15. The increases in both maximum and minimum temperatures have occurred across all seasons, most noticeably in spring and summer maximum temperatures in the most recent decade.

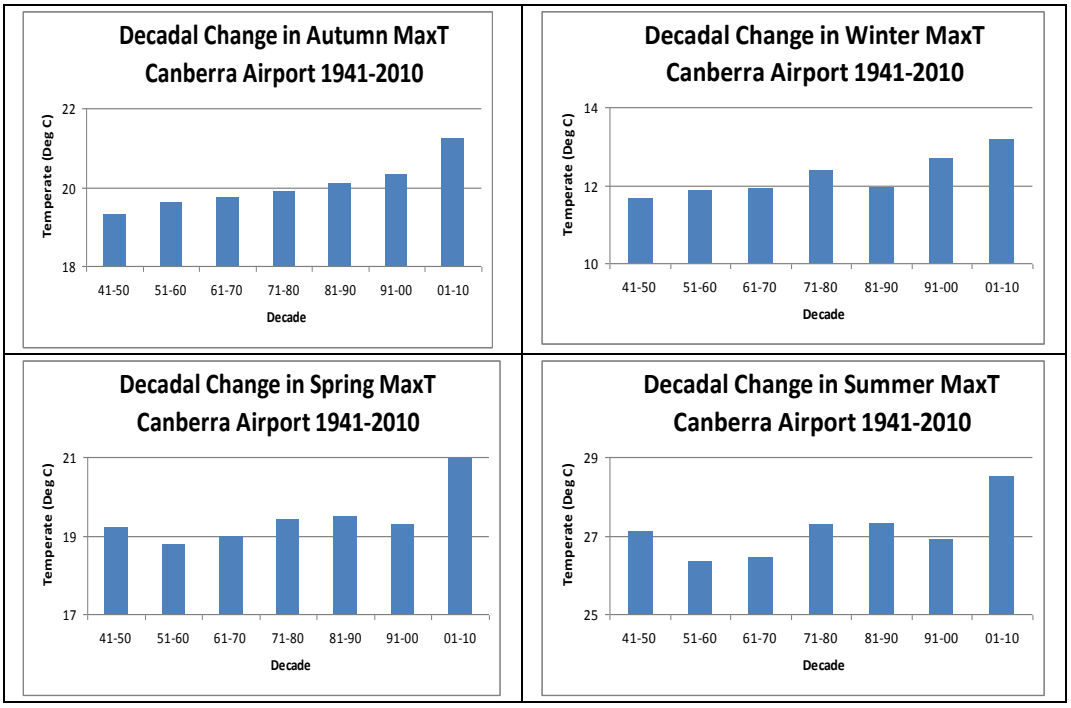
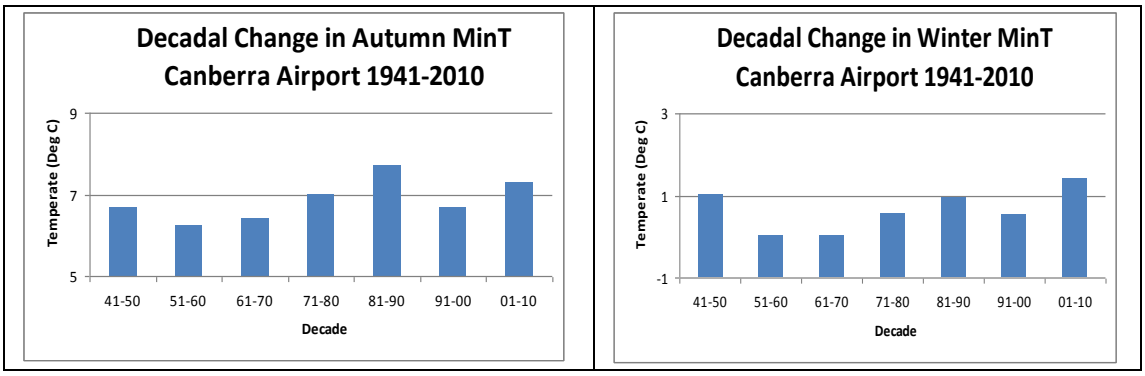


Figure 14: Trends in seasonal maximum temperatures at Canberra Airport.



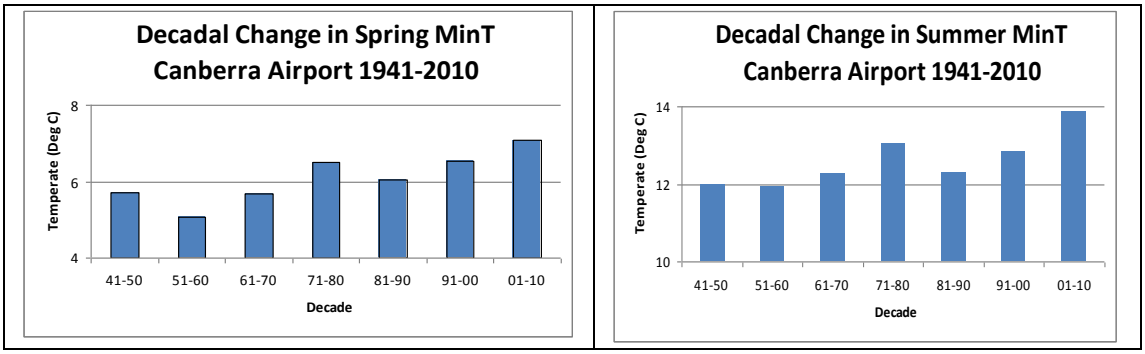


Figure 15: Trends in seasonal minimum temperatures at Canberra Airport.

Sunshine

Mean daily sunshine hours in the period 2008-2010 at Canberra Airport are shown in Figure 16. While 2008 and 2009 were sunnier than normal, 2010 had close to average sunshine hours despite being a very wet year. On a monthly basis, while the summers of 2008/09 and 2009/10 were considerable sunnier than average, the period October 2010-Mar 2011 had fewer sunshine hours. This is consistent with the wetter conditions and associate increased cloud cover during these months.

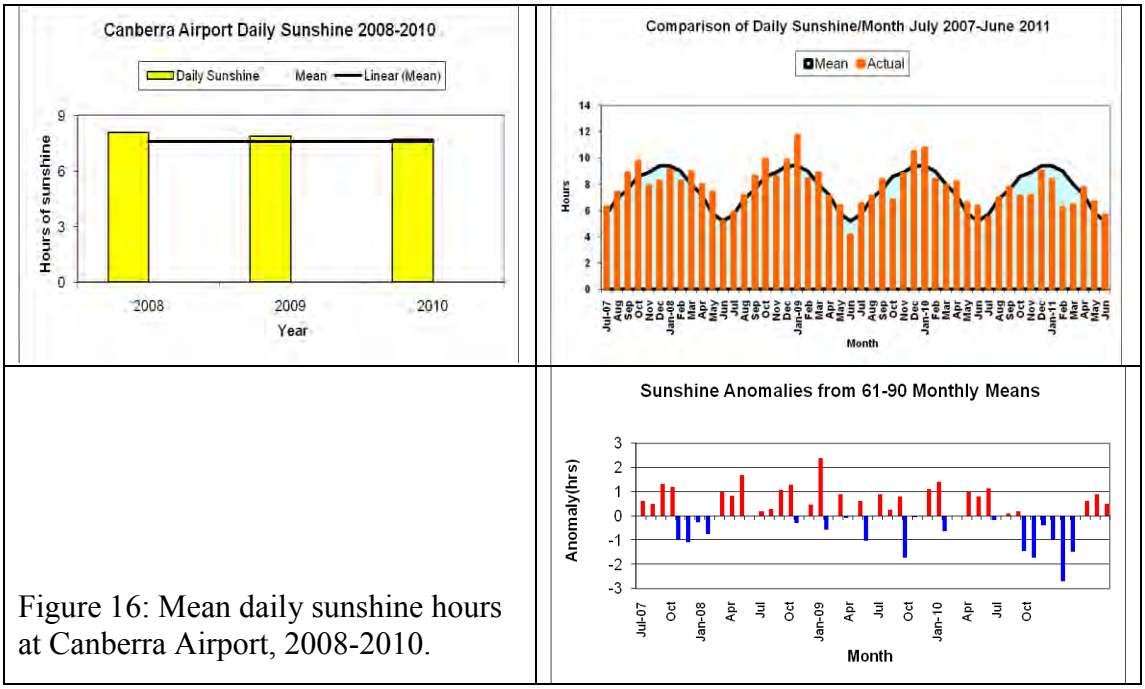


Figure 16: Mean daily sunshine hours at Canberra Airport, 2008-2010.

Long Term Trend

Annual and decadal values of mean daily sunshine hours over the longer term (1981-2010) are illustrated in Figure 17. Annual sunshine hours have generally increased during this period, which is consistent with the overall increase in daytime maximum temperatures during the same period. The dip towards average conditions in 2010 reflects the impact of the La Niña event on rainfall and associated cloudiness. The

upward trend in decadal average sunshine hours is also consistent with the warm and dry conditions experienced in Canberra during the last decade.

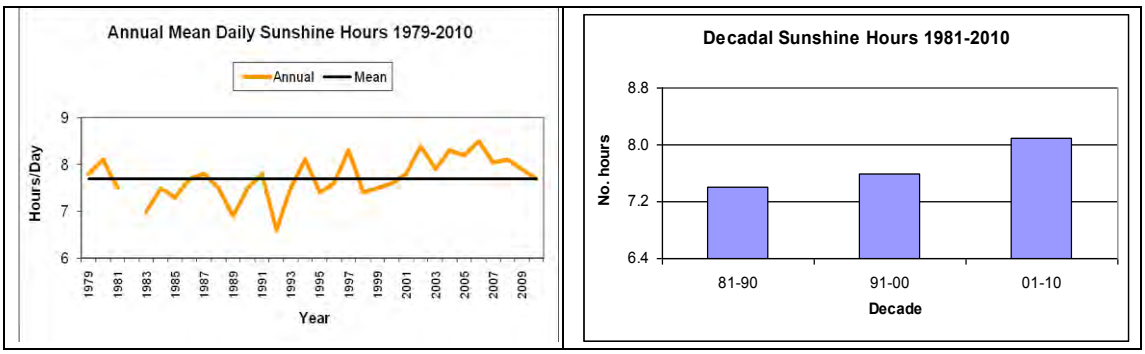


Figure 17: Long term trends in mean daily sunshine hours, Canberra Airport, 1979-2010.

Wind

Wind run is a measure of the wind speed at a place, recorded at 2 m above the surface as hourly values that are presented here as monthly averages (Figure 18). While wind speeds in 2008 and 2010 were near average, 2009 had higher wind speeds. However, wind speeds were lower in the period May 2010-February 2011 except during August-September 2010.

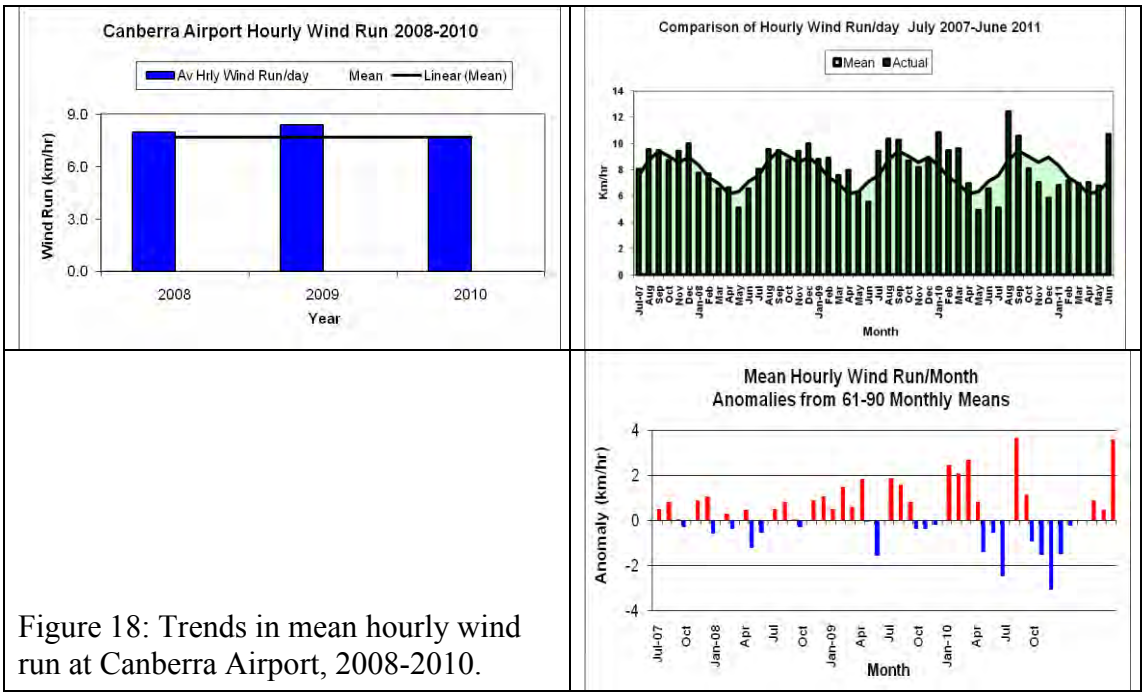


Figure 18: Trends in mean hourly wind run at Canberra Airport, 2008-2010.

Long Term Trend

Trends in wind run at Canberra Airport in the period 1970-2010 are illustrated in Figure 19. There is no apparent overall trend in wind run on an annual basis. Decadal

average wind run was approximately the same in the earliest decade analysed (1971-1980) as in 2001-2010, but was lower in the 1990s.

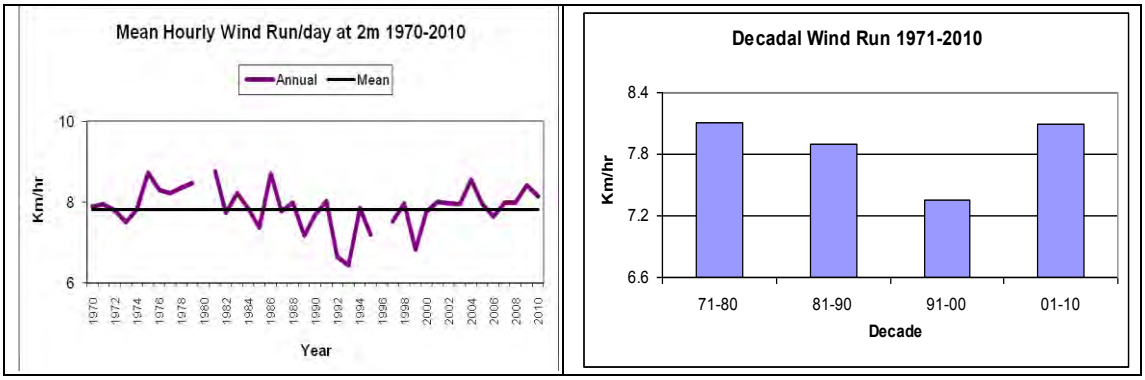


Figure 19: Long term trends in mean daily wind run at Canberra Airport, 1970-2010.

Relative Humidity

Monthly averages of relative humidity at 3 pm over the period 2008-2010 are illustrated in Figure 20. As relative humidity is temperature dependent and changes during the day, the 3 pm value has been selected as it is measured at the time closest to when the maximum temperature is usually observed; this is when the greatest difference between temperature and humidity tends to occur. While relative humidity in 2008 and 2009 reflects the drier than average conditions experienced in those years, humidity in 2010 was slightly above average which is consistent with the higher rainfall during that year. The monthly time series clearly shows the dry and wet spells that occurred during the reporting period.

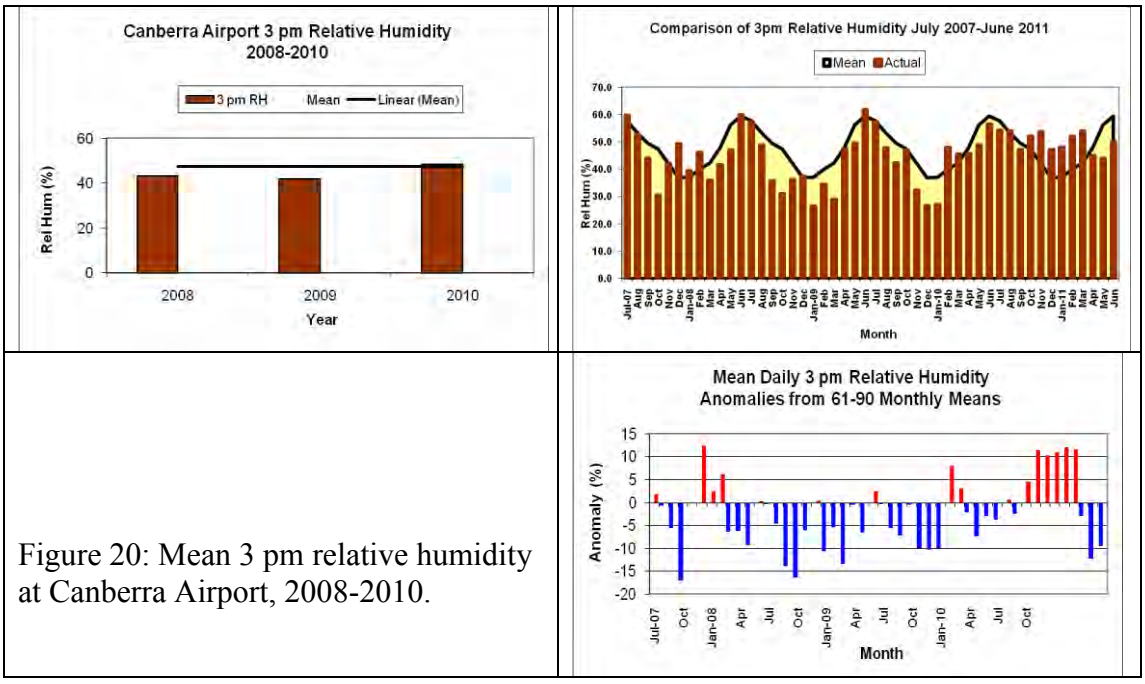


Figure 20: Mean 3 pm relative humidity at Canberra Airport, 2008-2010.

Long Term Trend

The general decrease in relative humidity in recent years (Figure 21) is also consistent with the lack of rainfall experienced over this period, while the increase in 2010 reflects the wetter conditions then. The relatively wet period during the 1970s and 1980s and the dry period during the last decade are particularly evident in the decadal averages.

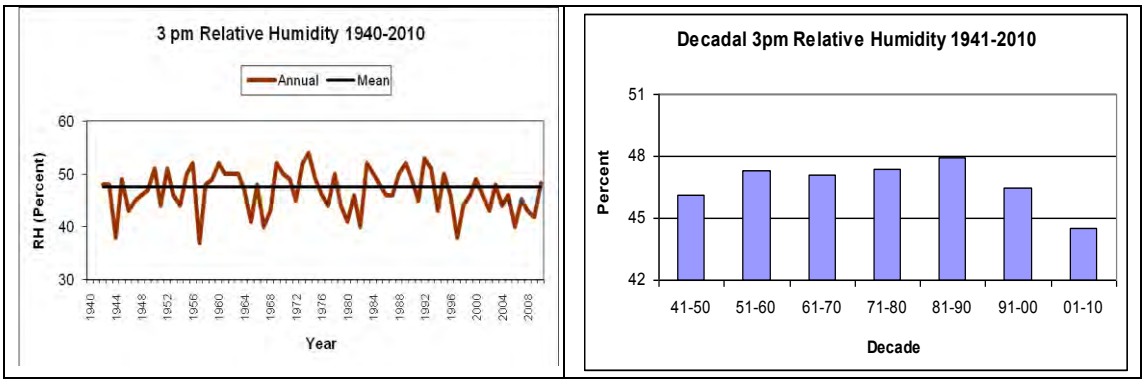


Figure 21: Long term trends in mean 3 pm relative humidity at Canberra Airport, 1940-2010.

Evaporation

Annual and monthly averages of daily potential evaporation measurements at Canberra Airport during the period 2008-2010 are presented in Figure 22. The effects of the drier and warmer conditions experienced during 2009 are evident in higher than average evaporation, and the wetter period in 2010 in lower than average evaporation. In the monthly time series the low evaporation/wetter periods in the summers of 2007/08 and 2010/11 contrast with the high evaporation/drier periods in 2008 and 2009. Potential evaporation is influenced by a range of factors including solar radiation, temperature, humidity and wind speed, all of which need to be considered in a thorough analysis of this variable.

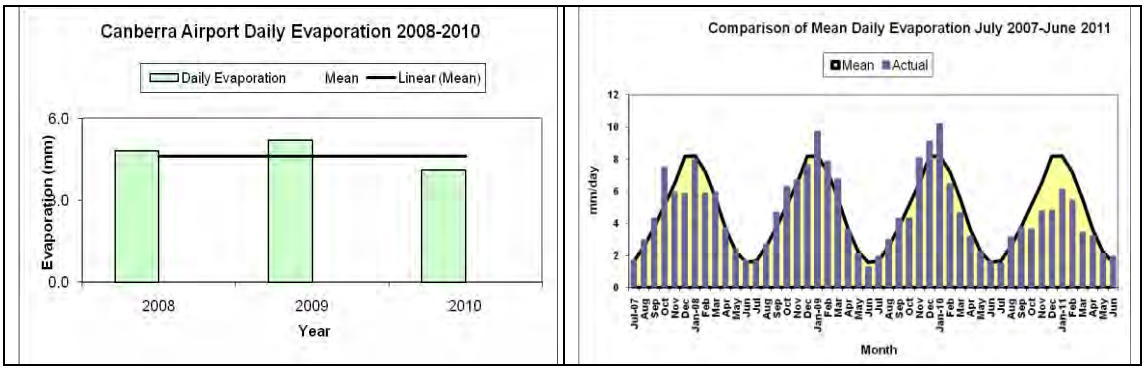
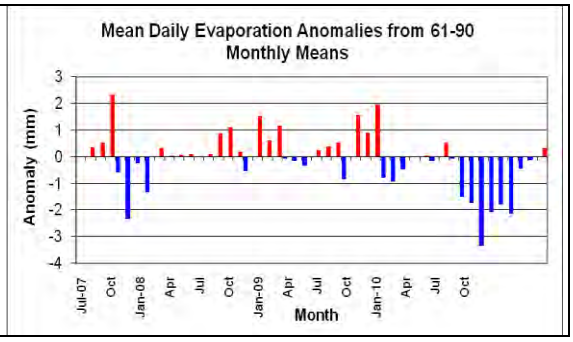
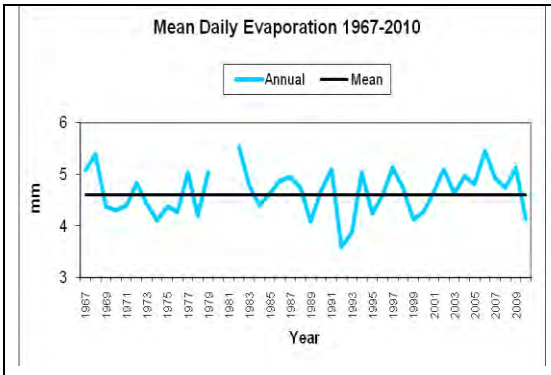


Figure 22: Mean daily evaporation at Canberra Airport, 2008-2010.



Long Term Trend

During the longer period 1967-2010 there appears to be little overall trend in potential evaporation, although there is an increase over several years in the 2000s reflecting both the below average rainfall and increase in temperature during this period. In 2010 the lower potential evaporation values reflect the wetter, lower temperature conditions.



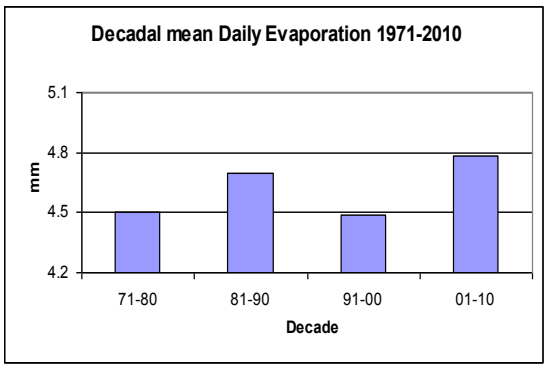
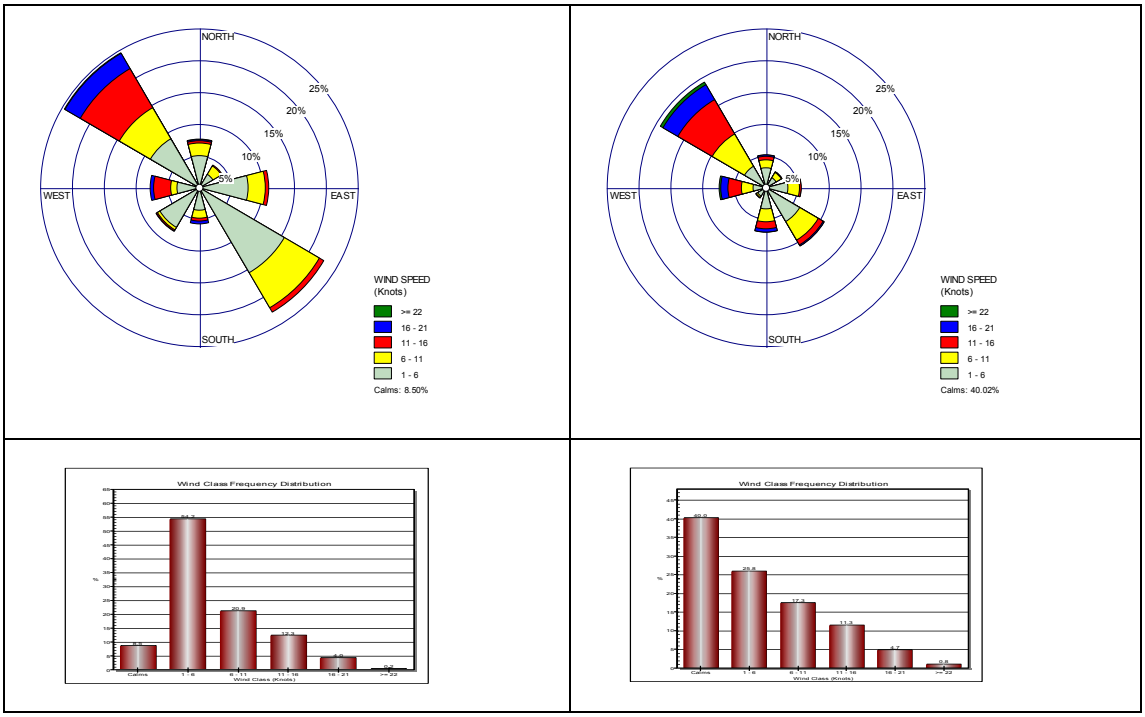


Figure 23: Long term trends in mean daily evaporation at Canberra Airport, 1967-2010.

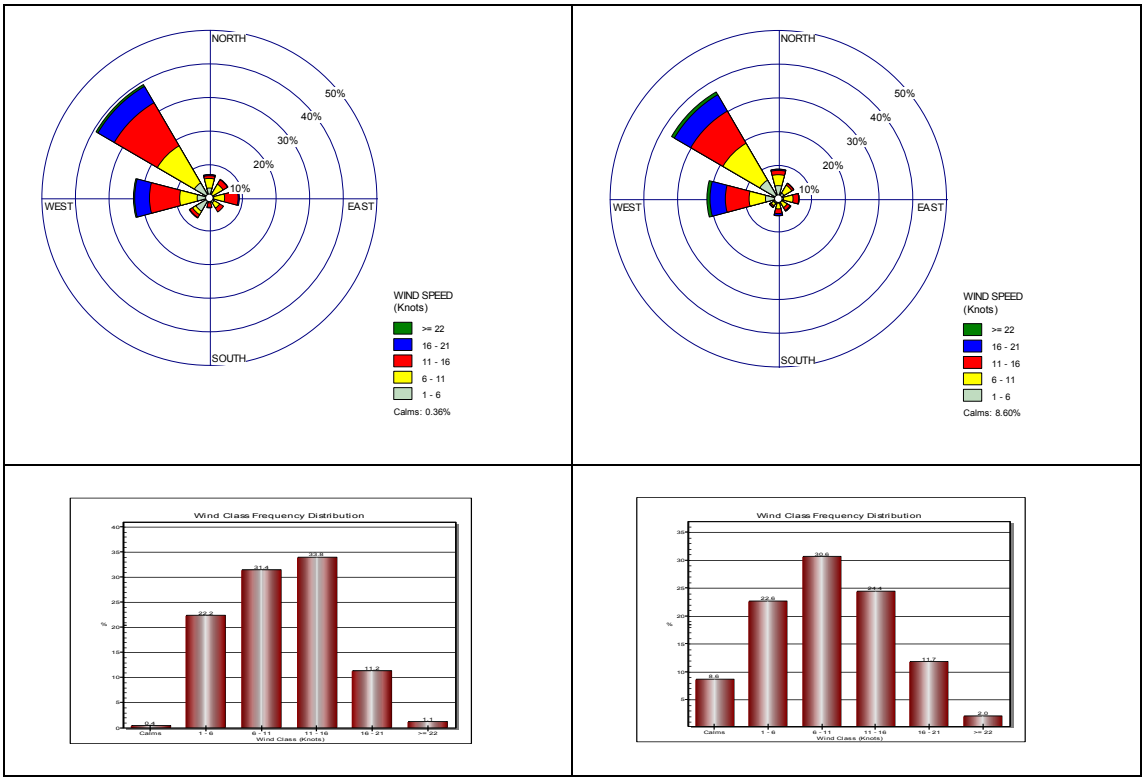
Wind Data

Wind roses are a way of presenting data for both wind speed and direction on the same chart. They are circular plots that show the wind direction (direction from which the wind is blowing) and wind speed ranges. The percentage of wind from a particular direction is indicated by the total length of each segment aligned with that direction. The wind speed ranges are expressed as percentages of the total wind, indicated by the relative size of each coloured segment in the wind rose. The wind frequency chart sets out the total percentage of wind in defined wind speed ranges. The two diagrams below show the 9 am and 3 pm wind data from Canberra Airport for the reporting period, together with the long term data at the site. Note that for the 2007-2011 period wind speed is expressed in knots, whereas the long term averages are expressed in km/h; the wind ranges have been scaled so that the wind roses are directly comparable.



a. July 2007-June 2011 b. March 1939-June 2011

Figure 24: Wind data for 9 am for the period July 2007–June 2011 in comparison with 9 am data for the period March 1939-June 2011.



a. July 2007-June 2011 b. March 1939-June 2011

Figure 25: Wind data for 3pm for the period July 2007 – June 2011 in comparison with 3pm for period March 1939-June 2011

Overall the winds during the last three years were close to the long term averages, although at 9 am there was a significant decrease in the numbers of calm events (reduced to 9.5% from 42%) and an increase in winds from both the W/NW and E/SE directions. At 3 pm almost no calm conditions were recorded, and there was an increase in westerly winds in comparison to the long term average.

As the position of the anemometer at Canberra Airport has not changed during this period, these results indicate that there has either been a change in weather patterns or that the instrumentation currently used for wind measurement may be more sensitive in light wind conditions than previous instruments. Further investigation is required to determine the reasons for the observed changes in wind speeds.

Seasonal Wind Roses

Wind rose data and frequency of occurrence at 9 am and 3 pm for each month, grouped by season, are presented for the period 2007-2011 in comparison with the 1939-2011 period in Figures 26-29.

Summer: there has been a reduction in calm conditions in all three months. In December, there has been an increase in NW winds and E/SE winds at 9 am and W/NW and NE winds at 3 pm. In January, the increase has been in W/NW winds and E/SE winds at 9 am and in W and NE winds at 3 pm. In February the increase has been in SE winds at 9 am and E/SE winds at 3 pm.

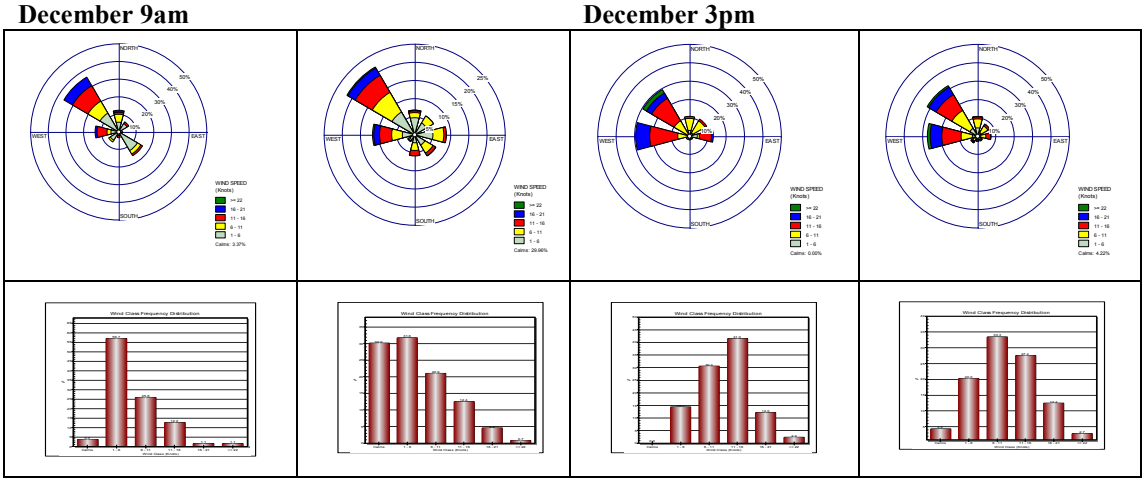
Autumn: there has been a general decrease in calm conditions. In both March and April there has been a significant increase in SE winds at 9 am and W and E/NE winds at 3 pm. In May the increase has been in SW winds and SE/E winds at 9 am and in NW/SW winds at 3 pm.

Winter: a reduction in calm conditions is observed. In June winds increased from the N/NW and E/SE at 9 am and NE/SE at 3 pm. In July the increase was from NW/SW at 9 am and E/SE at 3 pm. In August the increase was from W/NW and E/SE at 9 am and W at 3 pm.

Spring: in September the winds increased from the NW and from the SE at 9 am, and from the W/NW and East at 3 pm. Winds decreased from the S/SE. In October the winds increased from NE/SE and SW at 9 am and from the N and W and E/NE at 3 pm. In November winds decreased from the NW and increased in all other directions at 9 am, and increased from the E/NE and W at 3 pm.

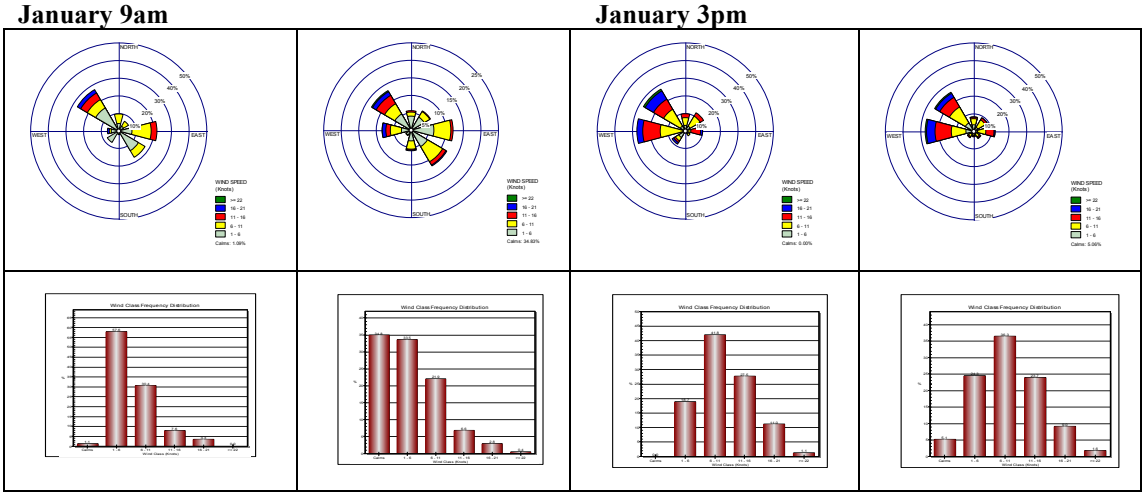
Seasonal Wind Rose Data – Summer

December 9am **December 3pm**



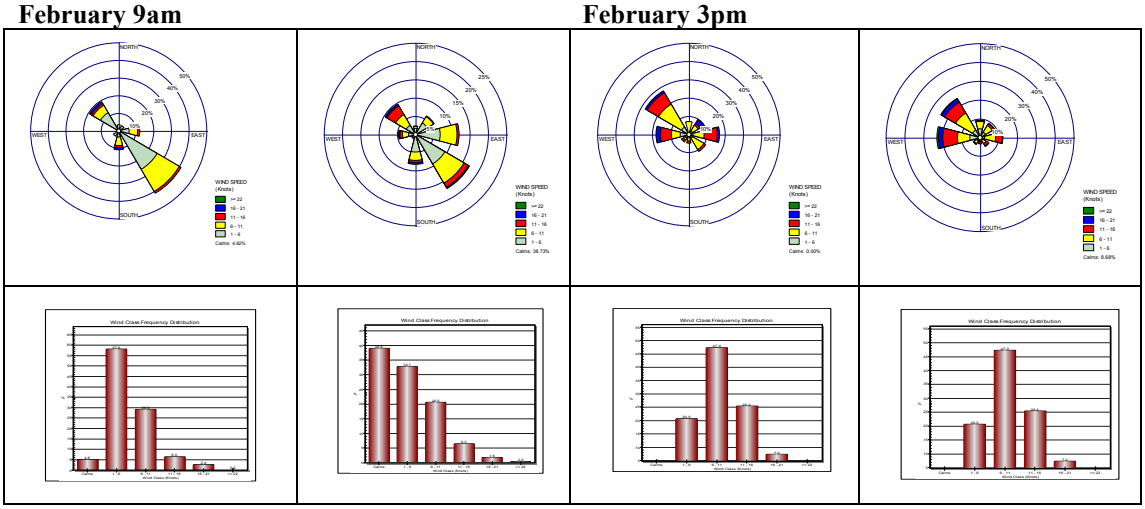
2007-2011 1939-2011 2007-2011 1939-2011

January 9am **January 3pm**



2007-2011 1939-2011 2007-2011 1939-2011

February 9am **February 3pm**

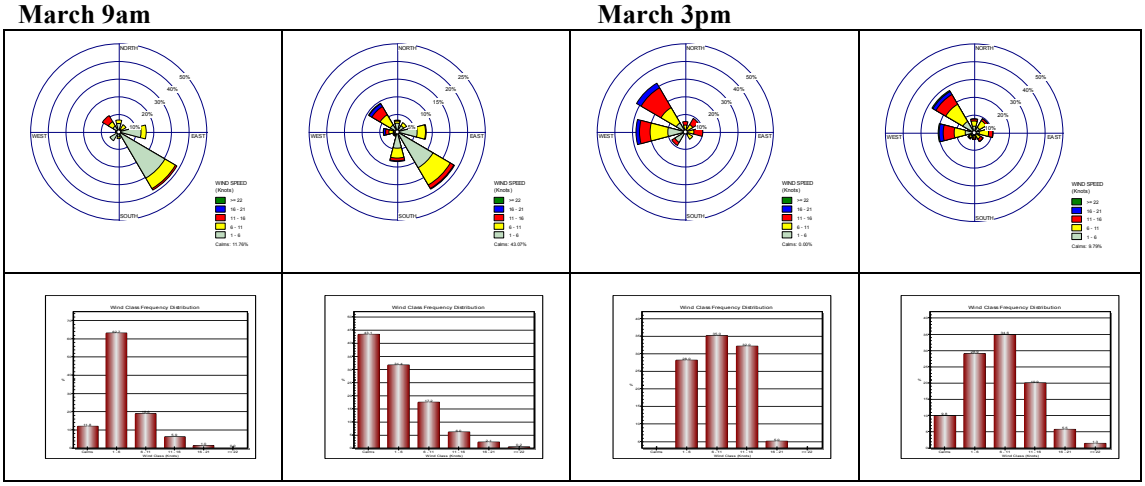


2007-2011 1939-2011 2007-2011 1939-2011

Figure 26: Summer wind roses for 2007-2011, compared to 1939-2011.

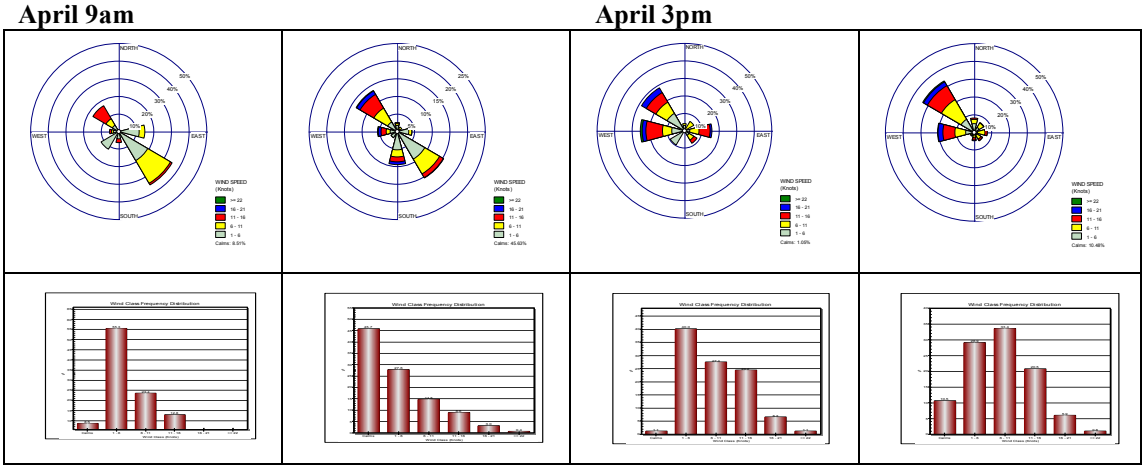
Seasonal Wind Rose Data – Autumn

March 9am **March 3pm**



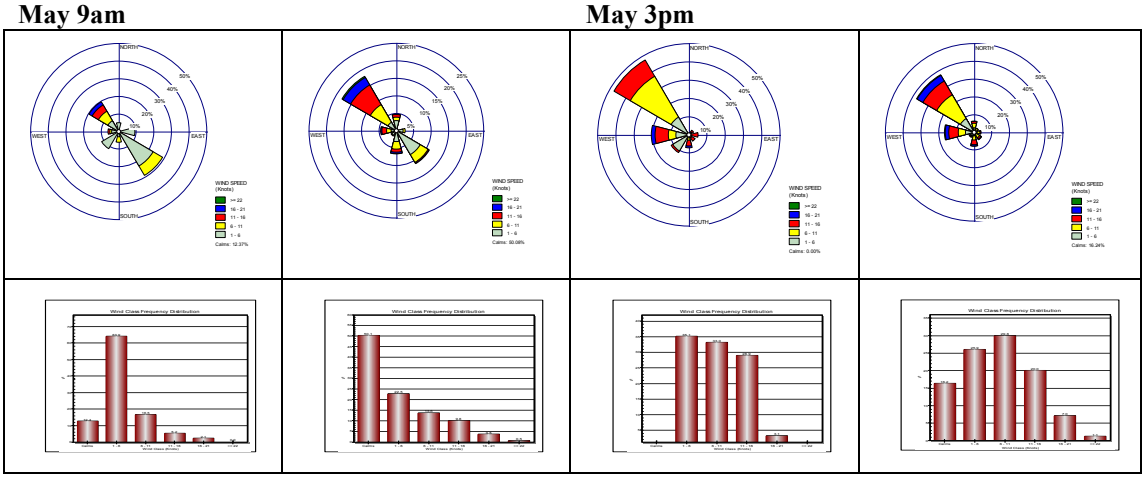
2007-2011 1939-2011 2007-2011 1939-2011

April 9am **April 3pm**



2007-2011 1939-2011 2007-2011 1939-2011

May 9am **May 3pm**

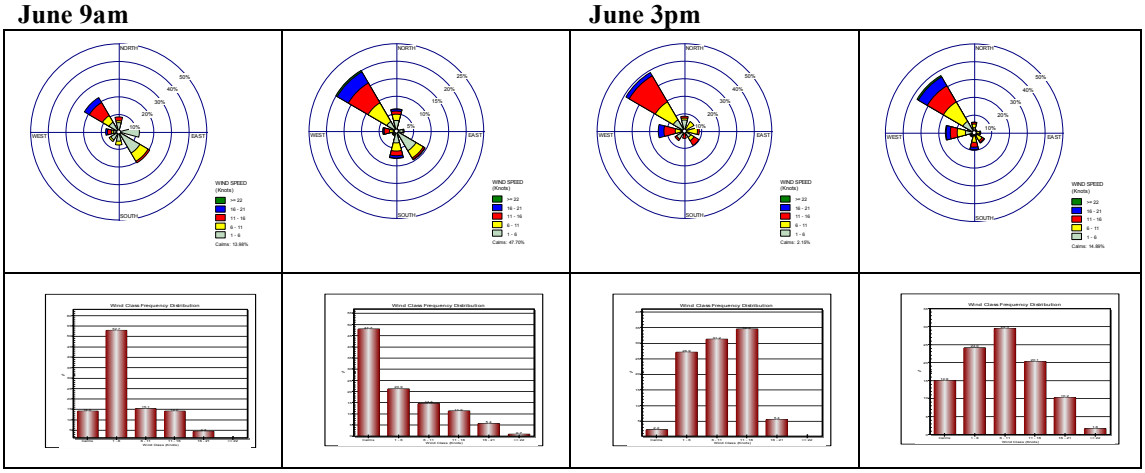


2007-2011 1939-2011 2007-2011 1939-2011

Figure 27: Autumn wind roses for 2007-2011, compared to 1939-2011.

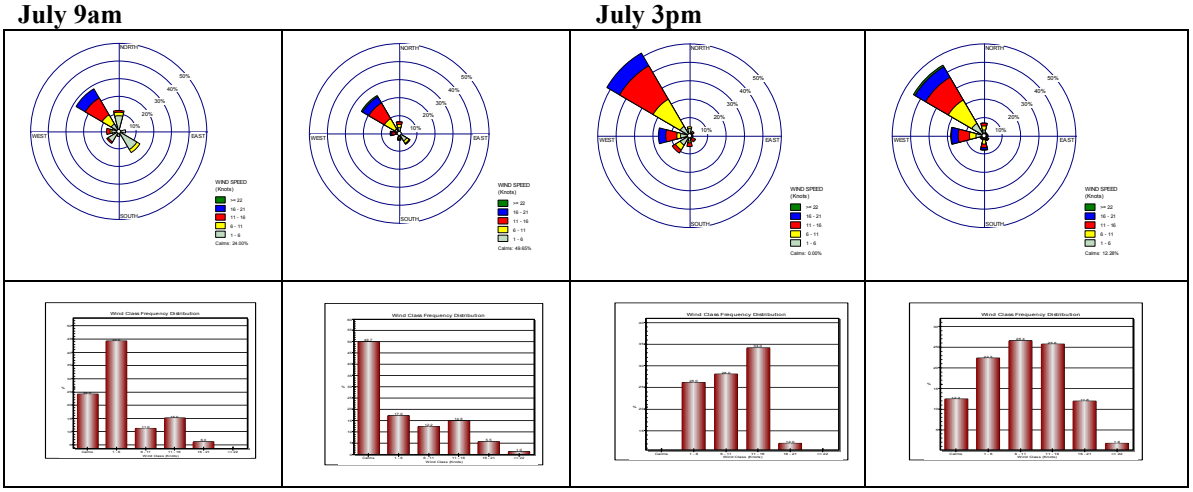
Seasonal Wind Rose Data – Winter

June 9am **June 3pm**



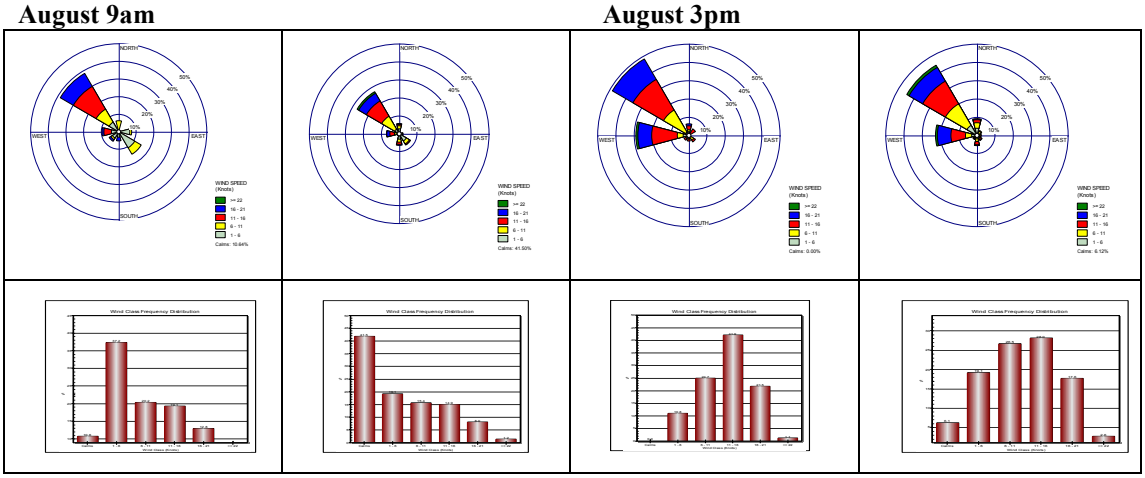
2007-2011 1939-2011 2007-2011 1939-2011

July 9am **July 3pm**



2007-2011 1939-2011 2007-2011 1939-2011

August 9am **August 3pm**

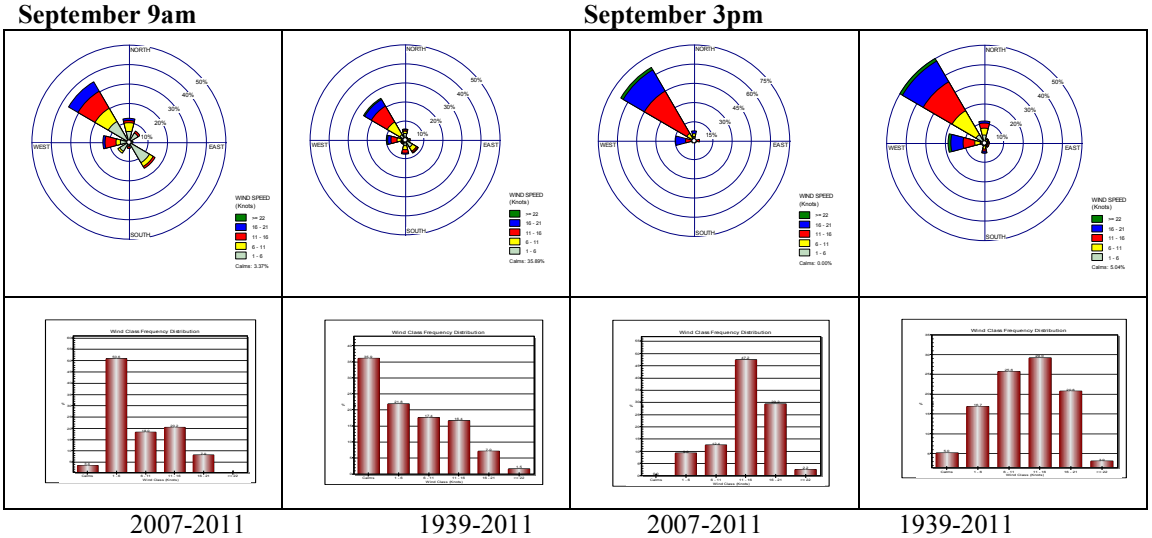


2007-2011 1939-2011 2007-2011 1939-2011

Figure 28: Winter wind roses for 2007-2011, compared to 1939-2011.

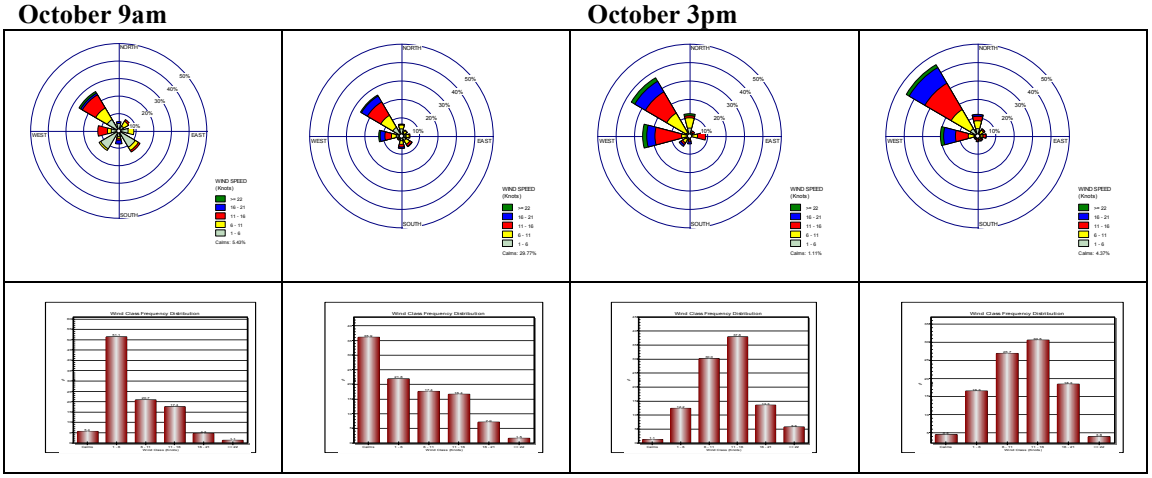
Seasonal Wind Rose Data – Spring

September 9am **September 3pm**



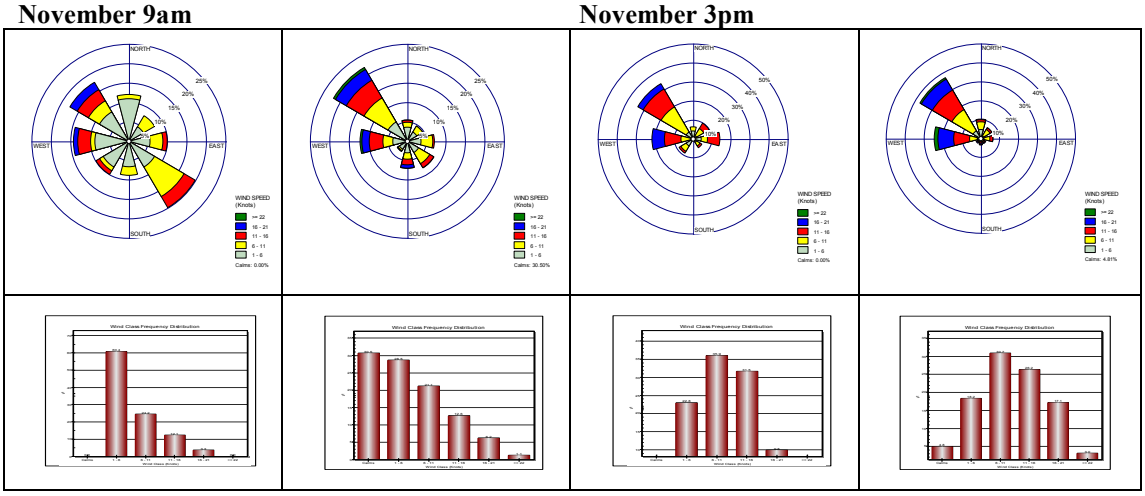
2007-2011 1939-2011 2007-2011 1939-2011

October 9am **October 3pm**



2007-2011 1939-2011 2007-2011 1939-2011

November 9am **November 3pm**



2007-2011 1939-2011 2007-2011 1939-2011

Figure 29: Spring wind roses for 2007-2011, compared to 1939-2011.

Significant Weather Events July 2007-June 2011

1. Dust Storms

Two dust storms were recorded in the ACT during 2009, on 15/4/2009 and 22/9/2009. During these events visibility was reduced to 3-4 km. Both were a result of markedly dry conditions over inland Australia preceding the passage of a significant cold front from the west. The dust was raised by strong W/NW winds ahead of the front and carried over the ACT and region as the frontal weather system moved eastward (Figures 29 and 30).

15/4/2009
A fast moving front moving over southern Australia picked up dust from western NSW in the strong W/NW airstream

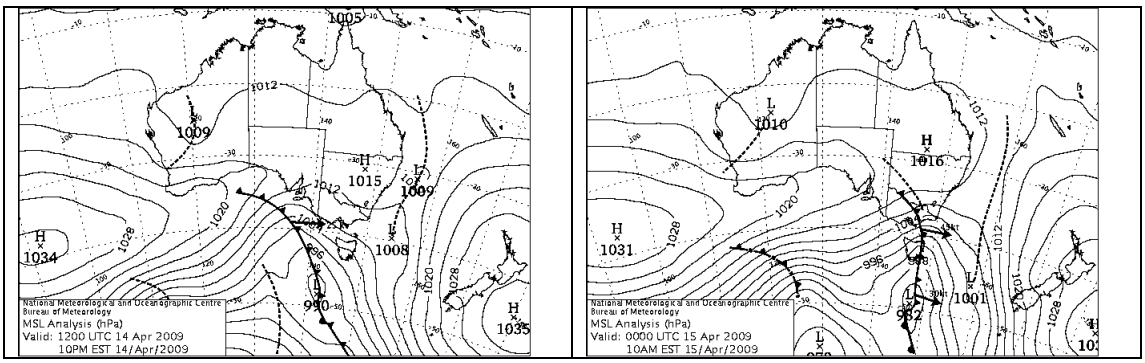


Figure 30: Surface synoptic charts for 9 pm on 14/4/2009 and 9 am on 15/5/2009.

22/9/2009
A deep low pressure system with a front extending to the north picked up dust from northern SA and SW Queensland and advected it over most of eastern and southern NSW and ACT in a NWly airstream.

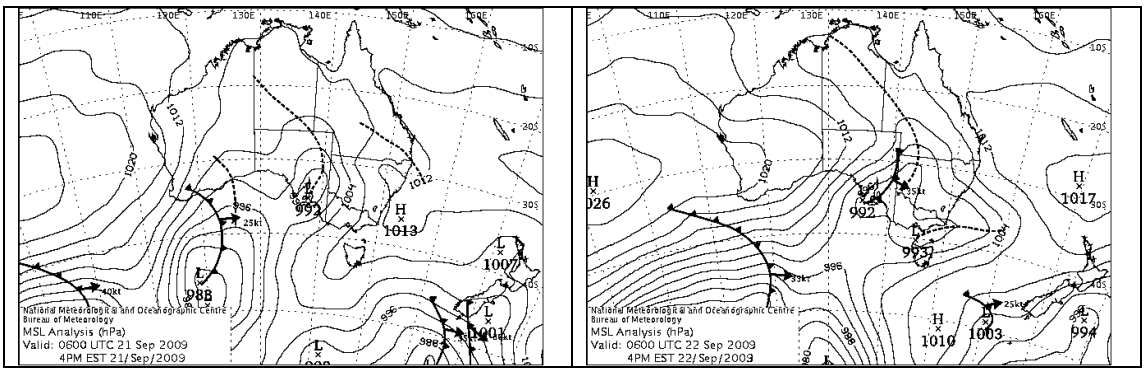


Figure 31: Surface synoptic charts for 3 pm on 22/9/2009 and 22/9/2009.

2. Rainfall Events

Table 3 lists the definitions used for this analysis while Tables 4 and 5 provide a summary of the significant and heavy rain days and rain events for the period.

Table 3: Definitions of Significant and Heavy rain days and Events

Definitions	**Rainfall**
Significant rain day	25 mm or more
Heavy rain day	50 mm or more
Heavy rain events where day 1 = 10 mm or more	
4 consecutive days	75 mm or more
5 consecutive days	100 mm or more
6 consecutive days	125 mm or more
7 consecutive days	150 mm or more

Table 4: Summary of significant and heavy rain days for the period July 2007-June 2011

	Jul-Dec				**Jan-Jun**	
Canberra Airport	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
Significant rain days	2	2	3	9	2	18
Heavy rain days	0	1	0	2	1	4

Table 5: Heavy rain events and rain days for the period July 2007-June 2011

Canberra Airport July 2007- June 2011		
Heavy Rainfall events	**No. Days**	**Rainfall**
13/2-16/2/2010	4	111.2
13-16/10/2010	4	84.6
29/11-5/12/2010	7	191
3/2-6/2/2011	4	100.2
Heavy Rainfall days	**Total**	**Thunderstorm?**
3/12/2010	87.6	Y
13/12/2008	55.4	N
14/02/2008	55.2	N
3/02/2011	50	Y

*Record daily total for December

There was a considerable increase in significant and heavy rain days during 2010, reflecting the impact of the La Niña event. The high rainfall total in 2010 was the result of rainfall on a relatively small number of rain days (there was only a slight increase in rain days in 2010), which means that the rainfall tended to be heavier during those rain days. The heavy rainfall event of 29/11-5/12/2010 was significant in that it led to flooding in the ACT and Queanbeyan; this was the heaviest flooding experienced there since 1974 (the last strong La Niña event). The high rainfall recorded to 9 am on 3 December 2010 meant that this was the wettest December day recorded at Canberra Airport; it was associated with a thunderstorm that also produced hail.

3. Heat Waves and Hot events

The overall numbers of days of 30°C or more and days of 35°C or more are listed in Table 1. The definitions of heat waves and hot events used for this analysis are as follows:

Heat Wave: At least three consecutive days of 33.5°C or more or at least three days of 33.5°C or more separated by one day of between 31.5°C to 33.4°C.

Hot Event: At least two consecutive days of 31.5°C or more.

These threshold temperatures reflect the 90th percentile level of summer maximum temperatures (33.5°C) and the 80th percentile level (31.5°C) for Canberra respectively.

During the summers of 2007/8-2010/11 nine heat waves (37 days) and 20 hot events (60 days) were recorded at Canberra Airport. A summary of these events is shown in Table 6.

There was one particularly long hot period of 12 days experienced between 28/1/2009 and 8/2/2009, during which the maximum temperature dropped below 33.5°C on only two occasions, with neither of these days being below 31°C. As can be seen in Table 6 the summer of 2009/10 was particularly hot, whilst 2010 was considerably cooler than has been experienced in recent times.

Table 6: Heat Waves and Hot Events for Canberra Airport 2007/8-2010/11

Summer Period	2007/08	2008/09	2009/10	2010/11	Total
Heat Wave Events	2	4	3	1	10
Heat Wave days	8	15	11	4	38
Hot Events	5	4	8	4	21
Hot Event days	17	8	30	9	64

Longest Heat Wave 5 consecutive days (twice)

Longest Heat Event 13 consecutive days >31.4°C (9 heat wave days + 4 hot days)

During this period (27/1/2009-8/2/2009) there were 10 days of 33.5°C or more and 3 single days between 31.5°C and 33.4°C

Summer with largest number of events	2009/10
Summer with the largest number of hot days	2009/10
Summer with largest number of heat wave days	2009/10
Summer with the least number of heat wave days	2010/11

Long term trends

Given the small numbers of heat waves overall, the analysis of these trends is limited to full decadal data; the last two summers have not been included in the decadal trends, but are included in the analysis of impacts of ENSO on heat events. Figure 32

provides a decadal analysis of heat waves in Canberra. There have been increases in both heat wave events and the number of heat wave days in the most recent decade (2001-2010). Table 7 shows the considerable influence of ENSO events on Canberra high temperature events, with El Niño years being considerably hotter with more heat waves, while La Niña years are cooler with very few heat waves occurring. There are almost three times as many heat waves in El Niño years than La Niña years.

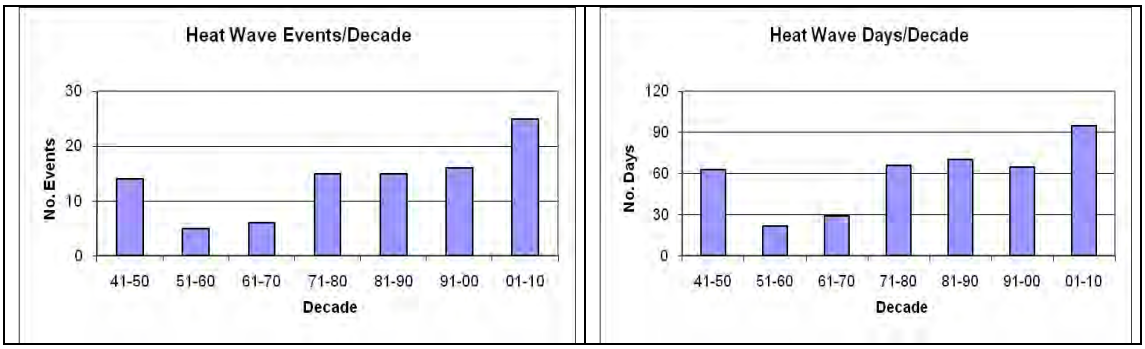


Figure 32: Decadal trends in heat wave events and heat wave days in Canberra, 1941-2010.

Table 7: Comparison of heat waves in Canberra between ENSO and non-ENSO events (based on the 20th and 80th percentile Jun/Nov SOI and Sept/Nov SOI values)

Period 1939-2010	El Nino	La Nina	Non Enso	Total
No. Years	17	16	39	72
No. Heat wave events	32	11	56	99
No. Heat wave days	143	44	232	419
Longest Sequence	10 days (twice)	6 days (once)	8 days (twice)	
Most HW events in 1 year	6	3	5	
Most HW days in 1 year	27	12	21	

Appendix A: Comparison of the Canberra Airport Observation Sites

In September 2008 the Bureau of Meteorology established a new site at Canberra Airport in response to the possible impact on the old site from development that had occurred during 2006-2008 around it. The old site was subsequently closed in November 2010. The new site is located around 400m further to the south.

This analysis is based on the two years of overlapping data that was downloaded from the Bureau of Meteorology website.

Results:

1. Rainfall

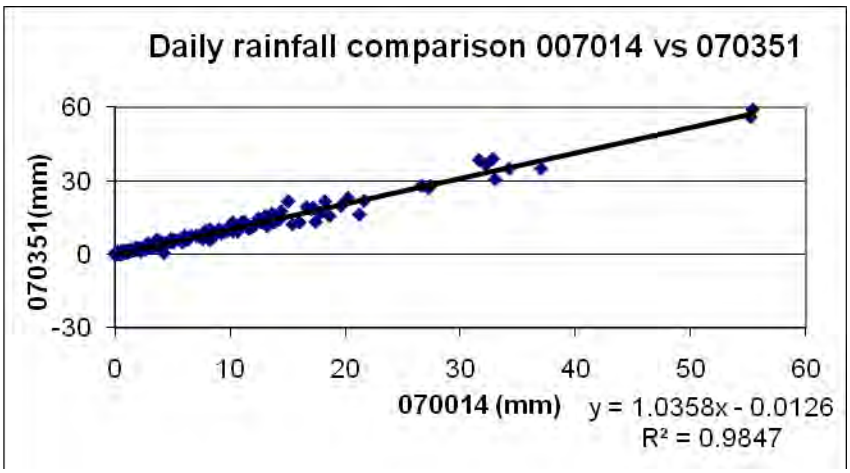


Figure 1: Comparison of 24 hour daily rainfall totals between the old (070014) and new (070351) observation sites at Canberra Airport

Table 1: Comparison between specified daily rainfall ranges of the two sites at Canberra Airport

Range	70014	70351	Difference	%Diff	Average/event
<1mm	32.2	32	-0.2	-1%	0
1-9.9mm	402.6	410.2	7.6	2%	0.1
10-19.9mm	471.2	484	12.8	3%	0.4
+>20mm	455.6	474.2	18.6	4%	1.3
Total	1361.6	1400.4	38.8	3%	

Table 2: Comparison between events of 0.2mm and no rain between the 2 sites at Canberra Airport

		70014	
		No Rain	0.2mm
70351	No Rain	538	30
	0.2mm	9	17

Development around the old site at Canberra Airport appears to be impacting on daily rainfall in two ways. There are many more days of 0.2mm being recorded at the old site. This change may be related to increased dew developing as a result of changes in

overnight temperatures or in the fact that overnight watering of grass in the development occurred . There is also increasing rainfall amounts being observed at the new site for totals above 10mm with increasing amounts for higher totals. This could be due to possible wind flow effects and/or sheltering as a result of the development around the old site impacting on rainfall.

2. Temperatures
a. Comparison of Canberra Airport Sites

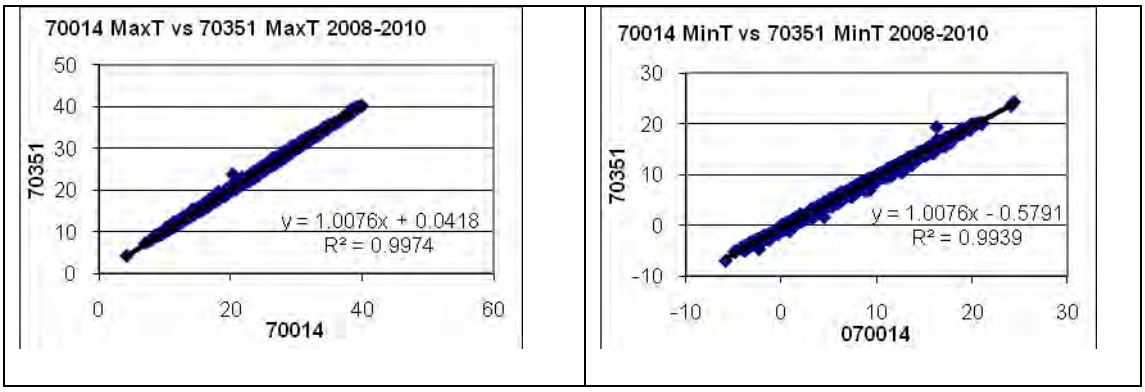


Figure 2: Comparison of the daily maximum and minimum temperatures between the old site (070014) and new site (070351) at Canberra Airport

Figure 2 indicates that there is an extremely high degree of correlation between both maximum and minimum temperatures between the old and new sites at Canberra Airport and as a result we can determine correction factors that can be applied to the data to ensure that the observations are comparable.

Table 3: Difference between the daily maximum and minimum temperatures at Canberra Airport (Old Site-New Site) by specified range

MaxT	Range	Average Difference
	<29.4	-0.2
	=>29.5	-0.4
MinT	Range	Average Difference
	<5	0.6
	5-14.9	0.5
	=>15	0.4

This comparison indicates that the new site is warmer for maximum temperatures above 29.4°C and cooler for minimum temperatures across all temperature ranges with a greater difference occurring for lower temperatures. Applying these differences to the data sets enables adjusted data sets to be developed that can allow us to continue to use the site for climate analysis.

Table 4: Adjusted occurrences of the numbers of days where maximum and minimum temperatures have been above or below specified temperatures using differences from Table 3

		70014	70351	Adjusted 70351
MaxT	Days=>30C	94	102	94
	Days=>33.5C	39	42	39
	Days=>35C	23	26	23
	Days=>36.5C	17	18	16

		70014	70351	Adjusted 70014
MinT	Days<=-3C	21	32	32
	Days<=0C	84	102	113
	Days<=2.2C	154	184	177

As can be seen in Table 4 the application of these correction values to the new site (070351) indicates that only very minimal changes have occurred in maximum temperatures whilst the application of the correction values for minimum temperatures at the old site (070014) has resulted in a considerable increase across all temperature ranges and more in line with the new site.

Summary:

Rainfall analysis suggests that there were more days of 0.2mm being recorded at the old site compared to the new site while the new site recorded around 3-4% more rainfall in heavier rainfall events. Suggested causes for these differences may include the impact of watering of grass in the development close to the old site in the development or the impact of an increase in dew point due to the change in minimum temperatures. Increased rainfall may be due to wind effects in a more exposed area at the new site or sheltering at the old site from buildings to the east.

Temperature analysis between the old and new sites indicates that they are very highly correlated to the extent that correction factors can be derived which can be applied to the data sets to ensure they are comparable and as such the site can be continued to be used as a climate reference station. The main areas where correction factors are required are for the maximum temperatures of 29.5°C or more where the new site appears to be on average 0.4°C warmer and for all minimum temperatures where the new site appears to range between 0.6C and 0.4°C cooler than the old site with the larger difference applying to colder temperatures and the smaller difference to warmer temperatures.

The Bureau of Meteorology considers that the lower minimum temperatures being recorded at the new site is in fact just returning these temperatures to those that were experienced prior to development so any adjustment only needs to be applied to the old site from the commencement of development to September 2008 (B.Trewin (pers comm.)). For maximum temperatures, however, as the new site does appear to be warmer, adjustments should continue to be made for temperatures of 29.5°C or more to maintain consistency across the 2 sites for climate trend purposes.

"the future is not somewhere we are going, it is something we are creating."

Professor Ian Lowe

ACT Government

The Office is independent of, but funded by, the ACT Government