Global Footprint Network
Advancing the Science of Sustainability

The University of Sydney
AUSTRALIA

The Ecological Footprint of Victoria
Assessing Victoria's Demand on Nature

Prepared for EPA Victoria
by Global Footprint Network and the University of Sydney
October 2005

State Government Victoria

EPA VICTORIA

Global Footprint Network *increases the effectiveness and reach of the Ecological Footprint by strengthening the Footprint community, standardizing the tool, and building wide support for bringing human demands in line with Earth's limited resources. More on Ecological Footprint can be found on the website www.footprintnetwork.org.*

ISA *is a research team at* ***the University of Sydney****, bringing together expertise from many academic disciplines. ISA develops research and applications for environmental and broader sustainability issues, and offers consultancy to organisations in a broad range of areas. ISA's aim is to continuously develop and improve scientifically rigorous, quantitative, consistent and comprehensive approaches for Integrated Sustainability Analysis.*
http://www.isa.org.usyd.edu.au

Table of contents

Executive summary

EPA Victoria commissioned Global Footprint Network and the University of Sydney to jointly produce a robust assessment of the State of Victoria's Ecological Footprint. The purpose of this study is two-fold:

1. Calculate Victoria's Footprint using two different methods;
2. Assess the relative strengths and weaknesses of both approaches, with the ultimate goal of making the two methods compatible and consistent.

The Ecological Footprint considers a particular set of research questions: What is Victoria's demand on renewable resources and the biosphere's CO_2 assimilation capacity, and how much ecological capacity is available in Victoria, Australia, or the world to provide these services? While these research questions do not consider depletion of non-renewable resources, such as ores and oil, or capture the environmental impact of many pollutant emissions, they measure the human economy's dependence on biological productivity.

To answer this set of research questions, both methods rely on the National Footprint and Biocapacity Accounts, detailed databases for over 150 countries which provide national averages of consumption and supply based on widely available statistical data compiled by national governments, the United Nations and other expert agencies. Global Footprint Network serves as the steward of these accounts, and updates the results annually. The University of Sydney tested the Australian findings using a different, simplified approach, which confirmed the results found in the National Accounts.

The Australian national Footprint and biocapacity results serve as the starting point for both of the methods. Global Footprint Network's analysis determines Victoria's Footprint using the ratio of Victorian's consumption patterns to Australian consumption patterns (Sec. 2.2.1, Table 2.4). In contrast, the University of Sydney approach uses data on household expenditures, and allocates Ecological Footprints to consumption categories using input-output analysis (Sec. 3). Global Footprint Network's approach produces up-to-date results and uses descriptive and flexible consumption categories. However, the allocation of Footprints to these categories uses a variety of approaches rather than a single systematic approach and results do not cover the full supply chain of consumer items. The University of Sydney's input-output analysis provides significantly finer detail, covers the full supply chain, and uses consumption categories consistent with standard economic analysis. However, lags in data availability means that the results are for a more distant point in time, and analytical complexity increases.

Using two methods instead of one increases confidence in the results, and, because of differences in the methodologies, provides greater insight into factors contributing to Victoria's Footprint. For both methods, the Victorian resident's Footprint of about 8 global hectares is 4.5 to 6.5 per cent larger than the Australian's average Footprint of 7.7 global hectares. (4.5 per cent is from University of Sydney's analysis, 6.5 per cent from Global Footprint Network's).

Both analyses show that the Victorian Footprint exceeds the State's biocapacity. Even though the cropland and grazing land productivities in Victoria are significantly greater than the Australian average, Victoria's higher population density results in a per capita biocapacity below the Australian average. With a biocapacity of 5.4 global hectares per resident, Victoria

has three times, per capita, the global average. Still, Victoria's biocapacity is one third smaller than the Victorian consumption Footprint of 8 global hectares per resident.

Chapter 4 of the study compares the two approaches and reaches the following conclusions: A manual allocation of the national Footprint to key sectors and activities, the approach used by Global Footprint Network, gives more flexibility in the choice of categories and is easier to explain to lay people. It also relies more directly on physical data, whereas input-output analysis uses financial data (prices) as proxies for physical quantities. On the other hand, the University of Sydney's input-output analysis provides a more complete and generally reproducible way to allocate impacts to consumption categories, covering the entire upstream supply chain. Input-output analysis provides more detailed insights into Footprint components, informing organisations about maximum-leverage points for abatement action. Finally, input-output analysis adheres to UN Standards for National Accounting, offering an alignment of the Ecological Footprint with other key indicators such as GDP, unemployment rate, etc.

This study also informs the development of standards for conducting Ecological Footprint analyses, a formal process Global Footprint Network is currently coordinating among the organisations, government agencies and others who apply the methodology. Comparison of the two allocation methods used in this study provides important insights into the strengths and weaknesses of both approaches. Addressing these will enable future Footprint studies to produce the most robust, reliable and relevant results possible.

1 Measuring Victoria's Ecological Footprint

1.1 Project Purpose

The purpose of this study is to provide a robust assessment of the State of Victoria's Ecological Footprint. To this end, EPA Victoria commissioned Global Footprint Network and the University of Sydney (USyd) to jointly produce such a study.

Since both organisations use different methods, the joint collaboration also investigated the consistency between the methods in order to find ways to potentially harmonize them and secure the highest possible assessment quality for Victoria's Footprint.

This report gives an introduction to the Ecological Footprint concept and its underlying research question (chapter 1). It then documents the approaches used by each organisation (chapter 2 and 3). Finally it compares and contrasts the two methods, documents the level of consistency between them, and investigates options for tying them even closer together (chapter 4).

1.2 Introduction to the Footprint Concept

1.2.1 Why Track Resource Consumption and Natural Capital?

Sustainability promises flourishing lives for all, now and in the future. Hence, a sustainable society is one that lives off the planet's natural resources and ecological services without depleting the natural capital stock that provides these goods. The core goods that nurture human beings – food, energy, timber, fish, fresh air and clean water – are provided by healthy farmlands, well-managed forests and fisheries, and natural ecological cycles. When we deplete the soil, over harvest forests and fisheries, and unbalance ecological cycles, we not only diminish our present supply of available natural resources, we erode nature's capacity to supply them in the future. Sustainability depends on protecting natural capital from systematic overuse; otherwise nature will no longer be able to provide us with these basic services.

How many natural resources and ecological services do we use? How well are we managing our natural capital? Without reliable, consistent measurements, we are blind and cannot effectively manage essential natural resources. To wisely manage our natural capital, we must know how much we have and how much we use i.e. to protect our natural assets we must use accounts that keep track of both our demands on nature and nature's supply of ecological resources. In the same way, financially responsible households, businesses, and governments use accounts to keep track of their income and spending

1.2.2 Ecological Footprint Accounts

Ecological Footprint accounts track our supply and use of natural capital. They document the area of biologically productive land and sea a given population requires to produce the resources it consumes and to assimilate the waste it generates, using prevailing technology. In other words, Ecological Footprints document the extent to which human economies stay within the regenerative capacity of the biosphere, and who uses what portion of this capacity. The Footprint uses productive area as a basis of measurement because to achieve long-term sustainability, we must not deplete renewable resources and services from the biosphere. These resources and services are powered by energy from the sun.

In other words, the biosphere is a sophisticated solar collector that transforms solar power into resources for life. The Footprint represents the portion of that solar collector necessary for maintaining humanity's activities.

The Ecological Footprint's biophysical resource accounting is possible because resource and waste flows can be tracked, and most of these flows can be associated with a biologically productive area required to maintain them. This area is expressed in *global hectares*—hectares adjusted to represent the average yield of all bioproductive areas on Earth. Since people increasingly use resources from all over the world and pollute far away places with their waste, the Ecological Footprint accounts for these areas wherever they happen to be located—a unique and important aspect of measuring and tracking resource flows in today's global economy.

1.2.3 Ecological Footprint Results

Ecological Footprints compare, for any given year, human demand on nature's bioproductivity with nature's regenerative capacity. Recent calculations, published in the *Living Planet Report 2004* (WWF 2004), show that the average Australian resident uses 7.7 global hectares to produce the goods they consume and absorb the waste they produce. Using the common unit of global hectares makes results comparable to all regions in the world (a hectare, or 10,000 m^2, is about the size of a football field. A "global hectare" is a hectare of biologically productive space with world-average productivity). The average US resident lives on an Ecological Footprint 24 percent larger than the average Australian resident (9.5 global hectares), whereas the average Italian lives on 3.8 global hectares. The average Mexican occupies 2.5 global hectares, and the average Indian lives on about one-quarter of that. Worldwide, the average Footprint is 2.2 global hectares per person (for more countries, see Table 1.1).

In contrast, dividing the total amount of biologically productive land and sea on the planet by the current world population reveals that there are 1.8 productive hectares available per person. The average Australian's Footprint is approximately four times this area. This amount of area per person is even less if we allocate some to the other species that also depend on it. Providing space for other species is necessary if we want to maintain the biodiversity that is essential for the health and stability of the biosphere.

1.2.4 Overshoot and Ecological Deficit

In 2001, humanity's Ecological Footprint exceeded the Earth's biocapacity by over 20 percent (2.2 [gha/pers] / 1.8 [gha/pers] = 1.2). In other words, it takes more than one year and two months to regenerate the resources humanity consumed in that one year. Global demand began outpacing supply only recently, beginning in the 1980s. In 1961, for example (the earliest year for which consistent data are available), humans only used approximately half of the natural resources and services generated in that year.

It is possible to overuse the global biocapacity. Trees can be harvested faster than they regrow, fisheries can be depleted more rapidly than they restock, and CO_2 can be emitted more quickly than ecosystems can absorb it. With humanity's current demand on nature, *overshoot* – using resources more quickly than they are provided – is no longer merely a local, but a global phenomenon.

	Population	Ecological Footprint	Biological Capacity	Ecological Deficit (-) or Reserve (+)
	[million]	[global ha/cap]	[global ha/cap]	[global ha/cap]
WORLD	6,148	2.2	1.8	-0.4
Argentina	38	2.6	6.7	4.2
Australia	19	7.7	12.7*	11.5
Brazil	174	2.2	10.2	8.0
Canada	31	6.4	14.4	8.0
China	1,293	1.5	0.8	-0.8
Egypt	69	1.5	0.5	-1.0
France	60	5.8	3.1	-2.8
Germany	82	4.8	1.9	-2.9
India	1,033	0.8	0.4	-0.4
Indonesia	214	1.2	1.0	-0.2
Italy	58	3.8	1.1	-2.7
Japan	127	4.3	0.8	-3.6
Korea Republic	47	3.4	0.6	-2.8
Mexico	101	2.5	1.7	-0.8
Netherlands	16	4.7	0.8	-4.0
Pakistan	146	0.7	0.4	-0.3
Philippines	77	1.2	0.6	-0.6
Russia	145	4.4	6.9	2.6
Sweden	9	7.0	9.8	2.7
Thailand	62	1.6	1.0	-0.6
United Kingdom	59	5.4	1.5	-3.9
USA	288	9.5	4.9	-4.7
Combined	4,148	2.4	1.9	-0.5

In the last column, negative numbers indicate an ecological *deficit,* positive numbers an ecological *reserve.* All results are expressed in *global hectares*, hectares of biologically productive space with world-average productivity.

Note that numbers may not always add up due to rounding. These Ecological Footprint results are based on 2001 data, the most recent available (as published in WWF, *Living Planet Report 2004*).

*Australia's biocapacity has been adjusted to reflect new data that became available after the publication of the *Living Planet Report 2004*. See Section 2.2 of this report for additional explanations.

Table 1.1: *The Ecological Footprint and biocapacity of selected countries*

Overshoot causes the liquidation of the biological natural capital. For example, harvesting timber faster than the forest regrows means the forest will shrink. Efficiency gains have led our Footprint to grow more slowly than our economic activities. Still, human demand on nature has steadily risen to a level where humans have put the planet in ecological overshoot (Figure 1). We are not just living on nature's interest, but we are also depleting the capital.

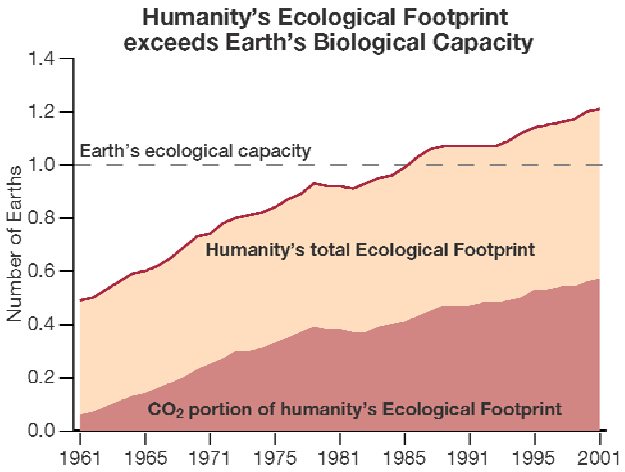

Figure 1.1: *The Footprint allows the comparison of human demand against the regenerative capacity of the biosphere. The global trend of the last 40 years is depicted here: an increase from using half of the biosphere's capacity in 1961 to using 120% capacity in 2001. Source: WWF 2004.*

1.2.5 Robustness of the Footprint Accounts

The Ecological Footprint is a conservative measure of human demand on the planet. The National Footprint and Biocapacity Accounts, which are the foundation for regional Footprint assessments such as the one for Victoria, build on publicly available statistics from United Nations agencies. They take the UN data at face value, and since they document ecological performance of the past, they do not depend on either extrapolation or dynamic modelling.

The accounts are designed to be conservative: when data is contradictory the accounts use the data that result in a lower estimate of human demand and higher estimates for biocapacity. In addition, the accounts leave out impacts that are not conclusively documented, such as the use of freshwater with locally specific impacts, or the emission of a variety of pollutants. When there is uncertainty about the yields of a given bioproductive space an optimistic figure is used, favouring overestimation of global biocapacity. For instance, the Footprint of emitting CO_2 (mostly from burning fossil fuel) is taken as the area of world-average forest required to sequester the CO_2, after the amount absorbed by the oceans is subtracted. Other methods for calculating a CO_2 or fossil fuel replacement Footprint return larger Footprint results.

The reason we use a conservative approach is to make our claim of global overshoot as robust as possible. Still, because of the conservative nature of the Ecological Footprint measure, human demand on the biosphere is likely to be even greater than the results indicate.

1.2.6 Other Ecological Impacts

The Ecological Footprint does not document our entire impact on nature. It only addresses one particular question: how much of the regenerative capacity of the biosphere is occupied by a given activity. Hence, it does not directly assess degradation, risk, visual impacts or intensity of use since this is not part of the research question. Nevertheless, degradation will show up in future accounts as declining biocapacity.

Primarily, Footprint accounts include those aspects of our resource consumption and waste production that are potentially sustainable. In other words, it shows those resources that within given limits can be regenerated and broken down into waste. All activities that are systematically in contradiction with sustainability have no Footprint since nature cannot cope

with them. For instance, there is no significant natural absorptive capacity for substances such as heavy metals, persistent organic and inorganic toxins, radioactive materials, or mismanaged biohazardous waste. For a sustainable world, their use must be phased out.

1.3 Ecological Footprint assessments: Component-based and compound approaches

Two distinct approaches exist for calculating Ecological Footprints: component-based and compound Footprinting (Simmons et al., 2000). The component-based approach is bottom-up, summing the Ecological Footprints of all relevant components of a population's resource consumption and waste production. This is achieved by first identifying all the individual items, and amounts thereof, that a given population consumes, and second, assessing the Ecological Footprint of each component using life-cycle data.

The overall accuracy of the final result depends on the completeness of the component list as well as on the reliability of the life-cycle assessment (LCA) of each identified component. The challenges of this approach include: measurement boundary problems associated with LCA, lack of accurate and complete information about products' life-cycles, problems of double-counting in the case of complex chains of production with many primary products and by-products, and the large amount of detailed knowledge necessary for each analysed process. In addition, there may be significant differences in the resource requirements of similar products, depending on how they are produced. Still, judging from the hundreds of projects employing this approach worldwide, the process of detecting all components and analysing their respective resource demands has heuristic/pedagogical value.

Compound Footprinting, in contrast, starts with aggregate Ecological Footprint data, and then determines how this is distributed across the various activities engaged in by a population or an economy. Input-output assessment is a compound approach, as are the national Footprint calculations performed by Global Footprint Network. In essence, they start from a whole, before divvying up the whole into pieces. This top-down approach ensures that the resulting Footprint analysis is complete, and avoids the problem of double counting.

Since the National Footprint and Biocapacity Accounts serve as the starting point for both input-output and Global Footprint Network allocations of national Footprints to sectors or consumption categories, we provide here a brief introduction. More detailed descriptions of how the national Footprint accounts work can be found on Global Footprint Network's website at www.footprintnetwork.org.[1]

The national Footprint accounts use aggregate data that captures a country's resource demand without requiring information about every single end use, and is therefore more complete than data used in the component-based approach. For instance, to calculate the paper Footprint of a country, information about the total amount consumed is typically available and sufficient for the task. In contrast to the component method, there is no need to know which portions of the overall paper consumption were used for which purposes, aspects that are poorly documented in statistical data collections. Similarly, the national Footprint calculation only requires data on the overall CO_2 emissions of a country, not a breakdown of which activity is associated with which portion of the total emissions. A compound Footprint approach yields accurate, robust results at a national scale, but does not provide information about all the details, nor does it necessarily show results in categories that may be the most policy relevant.

[1] Method paper is available at http://www.footprintnetwork.org/gfn_sub.php?content=download

In order to combine the utility of the component method with the accuracy of the compound method, a hybrid approach is used. This approach offers an intuitive presentation of the results with details about the activities that generate the Footprint. The hybrid approach is useful for national applications if more details are required, but also for input-output studies that break down national data into more detailed categories. In the case of input-output studies, the hybrid method allows us to add further resolution to the predefined categories of an input-output study.

1.3.1 Applications of Ecological Footprint Accounts

The Ecological Footprint can be applied at scales ranging from single products to organisations, cities, regions, nations, and humanity as a whole. It can be used to help budget our limited natural capital. It also makes clear the four complementary ways in which ecological deficits can be reduced or eliminated:

(1) Use resource-efficient technology that reduces the demand on natural capital;

(2) Reduce human consumption while preserving people's quality of life (for example reducing the need for fossil fuels by making cities pedestrian-friendly);

(3) Lower the size of the human family in equitable and humane ways so that total consumption decreases even if per capita demand remains unchanged; and

(4) Invest in natural capital, for example by implementing resource extraction methods that increase rather than compromise the land's biological productivity, thereby increasing supply.

There have been Footprint applications on every continent, with the possible exception of Antarctica. Global and national accounts have been reported in headlines worldwide, and over 100 cities or regions have assessed their Ecological Footprint (see some examples in Table 2). In California, Sonoma County's Footprint project *Time to Lighten Up* has inspired all cities of the county to sign up for the Climate Saver Initiative of the International Council for Local Environmental Initiatives (ICLEI). Wales has adopted the Ecological Footprint as its headline indicator.

WWF International, one of the world's most influential conservation organisations, uses the Ecological Footprint in its communication and policy work for advancing conservation and sustainability. Government agencies, particularly in Europe, have studied the implications of Ecological Footprint results and have re-examined the significance of carrying capacity. A number of national ministers have repeatedly used the concept, including French President Jacques Chirac in his speech to the World Summit on Sustainable Development in Johannesburg. Even large media outlets are picking up the idea: *The Economist* titled its July 2002 insert on the global environment "How many planets?" based on a Footprint assessment that showed it would take three planet Earths if all people lived lifestyles similar to those in OECD countries.[2]

[2] OECD stands for Organisation for Economic Cooperation and Development, whose members are the wealthiest nations in the world.

Table 1.2: *Footprint Applications in Public Policy*

Municipal Applications

There may well be over one hundred Ecological Footprint studies for cities, ranging from student projects to comprehensive analyses of a metropolitan area's demand on nature. *London*, for instance, has already gone through three rounds. In 1995, urban sustainability expert Herbert Girardet estimated that the UK capital's Footprint was 125 times the size of the city itself. In other words, in order to function, London required an area the size of the entire productive land surface of the UK to provide all the resources the city uses and to dispose of its pollutants and waste.

In 2000, under the leadership of Mayor Ken Livingstone, London commissioned a more detailed Ecological Footprint study called *City Limits*. The report, sponsored by organisations including the Chartered Institution of Wastes Management, the Institution of Civil Engineers (ICE), and the Biffaward Programme on Sustainable Resource Use, was produced by Best Foot Forward and launched in September 2002. Results for this city and its 7 million inhabitants are available at: http://www.citylimitslondon.com.

To respond to the challenges identified by the *City Limits* report, London Remade, a business membership organisation supported by over 300 of the capital's major businesses and higher education institutions, wanted to analyse possible steps for reducing London's Footprint. In collaboration with London First, a waste management partnership, it commissioned consulting companies WSP Environmental and Natural Strategies to identify the reduction potential in a project called *Toward Sustainable London: Reducing the Capital's Ecological Footprint*. The first of four reports, *Determining London's Ecological Footprint and Priority Impact Areas for Action*, is available at: http://www.londonremade.com/lr_footprinting.asp

Others have studied aspects of city living using the Ecological Footprint. For instance, the sustainable consumption unit of the Stockholm Environment Institute-York has led a number of studies of cities or regions (http://www.york.ac.uk/inst/sei/IS/sustain.html). They also contributed, with BioRegional, to a WWF-UK report called *One Planet Living in the Thames Gateway*, which identifies Footprint savings potential for greener urban developments. The report is available at: http://www.wwf.org.uk/filelibrary/pdf/thamesgateway.pdf.

Bill Dunster, UK's leading ecological architect, uses the Footprint as the context for his designs. More on his work can be found at http://www.zedfactory.com.

National & Regional Applications

A number of national and regional Footprint studies have contributed to policy discussions, some in close cooperation with government agencies. For example:

Wales (pop. 2,900,000). The National Assembly for Wales adopted the Ecological Footprint as their headline indicator for sustainability in March of 2001, making Wales the first nation to do so. The first report was commissioned through WWF-Cymru and executed by Best Foot Forward. This report details Welsh energy, transportation, and materials management. It can be found at: http://www.wwf-uk.org/filelibrary/pdf/walesfootprint.pdf.

The State of Victoria, Australia (pop. 4,650,000). EPA Victoria, the lead state agency responsible for protecting the environment, established a series of pilot projects in 2002 in

partnership with a wide range of organisations and businesses to further investigate the practical applications of the Ecological Footprint to promote sustainability. See http://www.epa.vic.gov.au/eco-footprint. The campaign is expanding its reach for 2005-06.

Sonoma County, California (30 miles north of San Francisco, pop. 495,000). Under a grant from the U.S. EPA, Sustainable Sonoma County, a local NGO, used the Ecological Footprint as the foundation of a 2002 campaign. By inviting wide public participation and comment on the study before it was released, it was able to generate strong local buy-in. As a result, the launch of the study got county-wide media coverage and built the groundwork for a subsequent campaign. The latter resulted in all municipalities of Sonoma County committing simultaneously to reduce their CO_2 emissions by 20 percent, making it the first U.S. county to do so. To meet this commitment, they established programs that track progress towards meeting their reduction goal. The Sonoma Footprint study is available at: http://www.sustainablesonoma.org/projects/scefootprint.html

Six southern regions of Italy. Commissioned by WWF Italy, CRAS produced a Footprint study comparing the 6 southern regions of Italy. The study is available at: http://www.cras-srl.it/pubblicazioni/32.pdf

International Applications

The European Parliament commissioned a comparative study on the application of Ecological Footprinting to sustainability. This project included case studies exploring potential uses of the Footprint in international legislation. The study, completed in 2001, was supervised by the Directorate General for Research, Division Industry, Research, Energy, Environment, and Scientific and Technological Options Assessment (STOA). It is available at http://www.europarl.eu.int/stoa/publi/pdf/00-09-03_en.pdf or as 10-page summaries in 11 European languages at http://www.europarl.eu.int/stoa/publi/default_en.htm.

The United Nations Population Fund (UNFPA) report, State of World Population 2001 - Footprints and Milestones: Population and Environmental Change, builds on Ecological Footprint concepts. See http://www.unfpa.org/swp/2001/english/ch03.html#5

1.3.2 An Indicator for 'Strong' and 'Weak' Sustainability

By monitoring human use of renewable natural capital, Ecological Footprint accounts provide guidance for sustainability: a Footprint smaller than the available biocapacity is a necessary condition for 'strong sustainability,' a stance which asserts that securing people's well-being necessitates maintaining natural capital.

Some argue that 'strong sustainability' is too stringent, since technology and knowledge can compensate for lost ecological assets. While this can be debated, even managing for 'weak sustainability' requires reliable accounting of assets. Hence, by measuring the overall supply of, and human demand on regenerative capacity, the Ecological Footprint serves as an ideal tool for tracking progress, setting targets, and driving policies for sustainability.

1.3.3 What's in it for Governments and Regions?

Ecological Footprint accounts allow governments to track a region's demand on natural capital and to compare this demand with the amount of natural capital actually available. The accounts also give regions or countries the ability to answer more specific questions about the distribution of these demands within their economic systems. For example, Footprint accounts can reveal the ecological demand associated with residential consumption, the production of value-added products, or the generation of exports, or they might be used to assess the ecological capacity embodied in the imports upon which a region depends. This can help in understanding a region's constraints or future liabilities in comparison with other regions of the world, and in identifying opportunities to defend or improve the quality of life within the region.

Footprint accounts help governments become more specific about sustainability in a number of different ways. The accounts provide a common language and a clearly defined methodology that can be used to support training of staff and to communicate sustainability issues with other levels of government or with the public. Footprint accounts add value to existing data on production, trade, and environmental performance by providing a comprehensive way to interpret them. For instance, the accounts can help guide 'environmental management systems' by offering a framework for gathering and organizing data, setting targets, and tracking progress. The accounts can also serve environmental reporting requirements, and can inform strategic decision-making for regional economic development.

In addition, monitoring demand and supply of natural capital allows governments to:

- Build a region's competitiveness by monitoring ecological deficits, since over time these deficits will become an increasing economic liability;
- Stay aligned with the business community's increasing focus on sustainability as a way to decrease future vulnerability (see for example BP or Toyota);
- Manage common assets more effectively. Without an effective metric, these assets are typically valued at zero or less and their contribution to society is not systematically assessed nor included in strategic planning;
- Have access to an early warning device for economic and military long-term security that recognises emerging ecological scarcities and identifies global trends;
- Monitor the combined impact of ecological pressures that are more typically evaluated independently, such as climate change, fisheries collapse, loss of cropland, forest overharvesting, and urban sprawl;
- Identify local and global possibilities for the mitigation of climate change, and examine the tradeoffs between different approaches to atmospheric CO_2 reduction; and
- Test policy options for future viability and possible unintended consequences.

Without regional resource accounting, countries can easily overlook or fail to realise the extent of these kinds of opportunities and threats. The Ecological Footprint, a comprehensive, science-based resource accounting system that compares people's use of nature with nature's ability to regenerate, helps eliminate this blind spot.

1.4 Laying the groundwork for a sustainable future

Achieving a sustainable society depends on abandoning vague concepts, and becoming specific about the core requirements of sustainability. These requirements can be spelled out

in explicit terms; a key one is avoiding ecological overshoot. Today, global ecological overshoot is an increasingly recognised concern. By becoming specific about sustainability and using tools such as the Ecological Footprint, we can measure and manage our use of natural resources and rectify overshoot. The Ecological Footprint can track a region's ecological performance and be used to communicate the results effectively to policymakers and the public. The Footprint's synthesis of environmental pressures provides a platform for comparing a wide variety of ecological challenges facing a region.

Wealthy cities, regions, and countries not only generate a disproportionate share of human pressure on the biosphere. Many of these regions also exceed their own, local biological capacity. Yet at the same time as these groups exert the greatest environmental pressure, they also have the greatest power to effect change.

Regions like Victoria can help humanity end overshoot and also protect themselves from the fallout of overshoot by developing ecological accounts that are able to track the use of valuable ecological assets. Victoria can also run social marketing campaigns that create public movement towards reducing human pressure on the environment. A more resource efficient Victoria will stand a better chance to be competitive in the future. By starting to manage society's metabolism and by avoiding local or global ecological deficits, Victoria can move towards sustainability within its own borders while also becoming more ecologically responsible to the world as a whole.

2 Global Footprint Network Approach: Victoria's Ecological Footprint

The focus of this study was to compare two different "Footprint allocation" methods. Both methods start from the same baseline: the results calculated by both Global Footprint Network and USyd are based on the same bioproductivity data and start from the same research question. The allocation methods – the way the overall demand on nature is allocated to specific activities – differ in two respects:

1) Production accounts are derived from either apparent consumed quantity (Global Footprint Network) or apparent used areas (USyd, with Footprint Network yield and equivalence factors applied), and

2) Productivity used by humans is distributed across consumption categories manually using auxiliary data (Global Footprint Network) or analytically using input-output analysis (USyd).

The emphasis of the USyd part of the project was to demonstrate the features of the input-output technique in distributing bioproductivity uses across consumption categories, not to produce alternative national bioproductivity measures. The strategy pursued was therefore to make sure that USyd and Global Footprint Network production-side bioproductivity accounts were aligned as much as possible, so that differences in the consumption-side accounts between USyd and Global Footprint Network highlight the features of the respective distribution methods. As a result, their differences and complementarities could be identified.

2.1 Introduction to Global Footprint Network Analysis

2.1.1 Summary

This section documents the results of a study conducted by Global Footprint Network to provide EPA Victoria with first-order calculations of Victoria's Ecological Footprint for consumption and of the region's biocapacity. As the research project also aims to clarify the methodological challenges and opportunities for standardizing Ecological Footprint accounts, these results are compared in the following sections of this report with the University of Sydney's Footprint results for Victoria and Australia. The University of Sydney's Footprint of Victoria was developed simultaneously using a different methodological approach (see chapters 3 and 4).

Global Footprint Network's analysis shows that the average consumption Footprint of Victoria's residents is 8.1 global hectares (gha) per person, approximately 6% above the Australian average. Victoria's demand on resources is apportioned as follows:

Activity Area	Percent of Total		Landuse Type	Percent of Total
Food	37%		Energy Total	58%
Housing	19%		Cropland	14%
Mobility	10%		Pasture	10%
Goods	23%		Forest	9%
Services	11%		Built area	2%
Unidentified	0%		Fishing grounds	6%
TOTAL	100%		TOTAL	100%

Table 2.1: *Breakdown of Victoria Footprint by Activity Area and Land-use Type. For example, out of the 8.1 global hectares of Footprint per Victoria resident, 10 percent occupy*

pasture areas, and 11 percent are used to provide services. Columns may not sum to 100% due to rounding.

This analysis provides useful information for determining specific practical steps that Victoria's residents and local governments can take to reduce their Ecological Footprint. The Ecological Footprint can track Victoria's ecological performance, effectively communicate the results to policymakers and the public, and systematically compare a wide variety of ecological challenges facing the region.

2.1.2 Setting the Boundaries

Choosing specific and policy-relevant study boundaries is a critical step for any resource flow assessment. Without clear definitions of what is and is not measured in a given Footprint, the analysis is not specific and the results are difficult to interpret. This is as true for Ecological Footprint assessments as it is for any other resource accounting, be it of CO_2, water, or energy consumption.

To make the analysis transparent and comparable, it is important to choose boundaries that ensure there is no double counting. More explicitly, if we applied the identical boundary principle to all other similar entities on earth and added up each entity's resource consumption, the sum would be equal to the total global resource consumption.

For Ecological Footprint studies, there are two standard ways of drawing boundaries:

1. *Consumption Footprint*: The Footprint of a population's final consumption. In the case of Victoria, the Footprint would include all the consumption of the region's residents, including goods and services while a resident is not physically present in Victoria, as well as consumed goods and services imported from elsewhere. This provides an insight into the resource intensity of the population's lifestyle and how it can be influenced. For example, the Consumption Footprint would include the resources used to produce the cars the population drives, the jet fuel used for their vacation travel, and the imported food they purchase, no matter whether these resources are used or originate inside or outside Victoria. Also, the Consumption Footprint would not include the energy used to power their computers at work because this energy is not part of their household consumption. Instead, this energy is assigned to the Consumption Footprint of the person who purchases the products of that office or company.

2. *Primary Production and Secondary Production Footprint*: The Footprint associated with all economic activity within a given area or population. This Footprint can be measured either at the primary production level (for example, agriculture) (the primary production Footprint), or at the stage of the commercial activities that transform primary resources and provide them to the final user (for example, the grocery store) (the secondary production or commercial Footprint). For Victoria, the commercial Production Footprint (the second possibility of the two production Footprint approaches) would include all the resources spent (and turned into waste) in producing the value added by the region's economy. This Footprint would include, for example, the timber supplied to a woodworking shop in Victoria (materials wasted in the production process and materials in the final product), the paper and electricity used by banks and offices located within Victoria, and the transportation energy for commuting to work, no matter where the products/services that they produced are consumed.

In summary, the two Footprint formulations are:

- Consumption Footprint: "Consumed in Victoria, no matter where produced"
- Production Footprint: "Produced in Victoria, no matter where consumed"

Some studies refer to a third way of setting boundaries, "the geography principle." This would capture the resources that are being turned into waste within the boundaries of Victoria. This approach, as intuitively attractive as it may initially seem, does not work for this task since it would lead to indefensible exclusions. For example, the CO_2 emitted in power plants that provide electric power to Victoria but are not located within its geographic territory would not be captured by this approach.

None of these three boundary approaches, if used correctly, would result in double counting as long as they are kept separate. Further, the sum of all the Footprints of the human population (strictly following either the consumption approach, a production approach, or a geography principle) would add up to the total global Footprint.

In this study, we used the Consumption Footprint approach. Victoria's Ecological Footprint is therefore defined here as the consumption Footprint of all people living within the geographic boundaries of Victoria. This consumption Footprint can be compared, on a per capita basis, to other municipal, national, or international consumption Footprints.

2.1.3 Defining the Footprint Activity Areas

The Victorian Ecological Footprint analysis is organised around the major human activities that place demands on the environment. These categories offer a basis for both analysing the Victoria Footprint and for developing practical steps to reduce it, and are intended to:

1. Establish clear boundaries for the study;
2. Be mutually exclusive to eliminate double counting;
3. Cover the whole scope of Victoria's resource use;
4. Be specific, measurable, and in line with the Ecological Footprint's research question: "How much of the biosphere's regenerative capacity is necessary to maintain given activities or processes;" and
5. Be meaningful to different stakeholders and clearly communicate the key issues that need to be addressed in order to reduce Victoria's Ecological Footprint.

The Ecological Footprint is divided into the following categories:

Activity	**Sub categories**
Food	Plant-based Animal-based
Housing	New construction Maintenance Residential energy use
Mobility	Passenger cars and trucks Motorcycles Buses Passenger rail Passenger air

	Passenger boat
Goods	Appliances Furnishings Computers and electrical equipment Clothing and shoes Cleaning products Paper products Tobacco Other miscellaneous goods
Services	Water and sewage Telephone and cable Solid waste Financial and legal Medical Real estate and rental lodging Entertainment Government Other miscellaneous services

Table 2.2: *Footprint activities*

2.2 Calculating Victoria's Footprint and Biocapacity

2.2.1 Victoria's Consumption Footprint

The calculation of Victoria's Ecological Footprint is based on Australia's National Footprint and Biocapacity Accounts for 2001. These detailed national accounts, as featured in the *Living Planet Report 2004* (WWF et al., 2004), provide information about the various land areas used to support Australian consumption. More detail on how they are calculated is available in Wackernagel et al. (2005, extended and updated from Monfreda et al. 2004). However, they do not identify which human activity occupies which part of the overall Footprint.

To assign these land uses to human activities, we established a "consumption-land use" matrix for Australia. Using Australian statistics, we distributed the average Australian Footprint over the five main human activity categories: Food, Housing, Mobility, Goods, and Services.

Table 2.3 shows the consumption-land use matrix for Australia. Consistent with the national accounts, it shows the total Ecological Footprint per Australian resident of 7.7 global hectares per person distributed over the Footprint categories of energy land, cropland, pasture, forest, built area, and fishing grounds. In addition, the matrix links these demands to the five categories of human activities, and their subcategories.

Final demand of energy land, cropland, pasture, forest, built up area and fishing grounds was distributed to the consumption categories using a variety of statistics that provide information about the use of certain materials in the Australian economy. For instance, the total amount of rubber use, which is known from the Footprint accounts, can be distributed over activities which use rubber: medical services, hygiene, transport etc. Statistical information about these kinds of uses was applied to allocate the average national Footprint to the corresponding

activities. For more detail, contact Global Footprint Network to obtain a copy of the calculation sheet.

[gha/cap]	Energy Total	Cropland	Pasture	Forest	Built area	Fishing Grounds	Total
Food	0.5	1.1	0.7	0.0		0.3	**2.7**
.plant-based	0.3	0.3		0.0			0.6
.animal-based	0.3	0.7	0.7	0.0		0.3	2.1
Housing	1.1	0.0		0.3	0.1		1.4
.new construction	0.1	0.0		0.3	0.0		0.4
.maintenance	0.0	0.0		0.0	0.1		0.1
.residential energy use	0.9						0.9
..electricity	*0.8*						*0.8*
..natural gas	*0.1*						*0.1*
..fuelwood	*0.1*						*0.1*
..fuel oil, kerosene, LPG, coal	*0.0*						*0.0*
Mobility	0.7	0.0			0.1		**0.8**
.passenger cars and trucks	0.5	0.0			0.1		0.6
.motorcycles	0.0	0.0			0.0		0.0
.buses	0.0	0.0			0.0		0.0
.passenger rail transport	0.0	0.0			0.0		0.0
.passenger air transport	0.1	0.0			0.0		0.1
.passenger boats							
Goods	1.4	0.0	0.0	0.4	0.0		**1.9**
.appliances (not including operation energy)	0.0			0.0	0.0		0.0
.furnishing	0.0	0.0	0.0	0.0	0.0		0.1
.computers and electrical equipment (not inclu	0.0			0.0	0.0		0.0
.clothing and shoes	0.0	0.0	0.0	0.0	0.0		0.1
.cleaning products	0.0			0.0	0.0		0.1
.paper products	0.1			0.2	0.0		0.3
.tobacco	0.0	0.0		0.0	0.0		0.0
.other misc. goods	1.2	0.0		0.1	0.0		1.3
Services	0.7	0.0		0.1	0.0		**0.9**
.water and sewage	0.0			0.0	0.0		0.0
.telephone and cable service	0.0			0.0	0.0		0.0
.solid waste	0.0			0.0	0.0		0.0
.financial and legal	0.0			0.0	0.0		0.1
.medical	0.2	0.0		0.0	0.0		0.2
.real estate and rental lodging	0.1	0.0		0.0	0.0		0.1
.entertainment	0.0			0.0	0.0		0.1
.Government	0.1	0.0		0.0	0.0		0.2
..non-military, non-road	*0.1*	*0.0*		*0.0*	*0.0*		*0.1*
..military	*0.1*	*0.0*		*0.0*	*0.0*		*0.1*
.other misc. services	0.1	0.0		0.0	0.0		0.2
		0.0			0.0		0.0
Total (gha/cap)	**4.4**	**1.1**	**0.8**	**0.8**	**0.3**	**0.3**	**7.7**

Table 2.3: *Consumption–land use matrix for Australia showing the Ecological Footprint of the average Australian resident, in global hectares per person.*

Blank cells indicate that cells are either not applicable to the calculation for that land use category, or in some cases that there is insufficient data to calculate sub-categories. Cells that appear as zeroes contain actual values that are smaller than 0.005 [gha/cap]. Columns may not sum to 100% due to rounding.

As data on resource consumption and trade are only available for Australia as a whole, and not specifically for Victoria, we determined Victoria's Footprint by comparing Victorian and Australian consumption patterns. Table 2.4 contains key ratios used to compare Victorian and Australian per capita consumption.

	Victoria	Australia	Ratio
DEMOGRAPHIC DATA			
Population	4,854,100	19,352,000	
Individuals per household	2.66	2.60	
ECONOMIC DATA			
Total household expenditures per week	$ 718.19	$ 698.98	
Household expenditures per week, minus for housing, food, fuel, and transport	$ 342.00	$ 338.87	
Per capita expenditures per week	$ 128.57	$ 130.33	99%
TRANSPORTATION			
Road km per person travelled, 2002			
Passenger vehicles	8,297	7,476	111%
Motorcycles	67	87	77%
Buses	68	92	74%
Airplane			
Passenger km per person	1,351	1,767	76%
Rail			
Passenger km per person	602	575	105%
ENERGY CONSUMPTION			
Residential energy consumption			
Electricity [kWh per capita]	2,118	2,440	87%
Gas [kWh per capita]	4,384	1,480	296%
Carbon intensity of electricity [t C/Gj]	0.0255	0.0245	104%
FOOD			
Apparent per capita consumption [kg]:			
Seafood	15	10.9	138%

Table 2.4: *Comparison of Victoria and Australia residents' per capita consumption. Some examples*

Using these ratios, we were able to determine, for example, that per capita car travel in Victoria is greater than the Australian average, and Victoria's car Footprint was adjusted proportionally. Applying these ratios across the Australian consumption-land use matrix, we constructed the equivalent matrix for Victoria.

The consumption–land use matrix for Victoria, displayed in Table 2.5 below, shows that the average Victoria resident's total Ecological Footprint is 6 percent larger than that of the average Australia resident. However, this is not distributed uniformly across all categories. For instance, residential electricity consumption and aeroplane travel in Victoria are well below the Australian average (87% and 76%, respectively).

in [gha/cap]	Energy Total	Crop land	Pasture	Forest	Built Area	Fishing Grounds	Total
Food	0.6	1.1	0.8	0.0		0.5	**3.0**
.plant-based	0.3	0.3		0.0			0.6
.animal-based	0.3	0.8	0.8	0.0		0.5	2.3
Housing	1.3	0.0		0.2	0.1		1.5
.new construction	0.1	0.0		0.2			0.3
.maintenance	0.0	0.0		0.0			0.0
.residential energy use	1.1						1.1
..electricity	*0.8*						*0.8*
..natural gas	*0.2*						*0.2*
..fuelwood	*0.1*						*0.1*
..fuel oil, kerosene, LPG, coal	*0.0*						*0.0*
Mobility	0.7	0.0			0.1		**0.8**
.passenger cars and trucks	0.6	0.0					0.6
.motorcycles	0.0	0.0					0.0
.buses	0.0	0.0					0.0
.passenger rail transport	0.0	0.0					0.0
.passenger air transport	0.1	0.0					0.1
.passenger boats							
Goods	1.5	0.0	0.0	0.4	0.0		**1.9**
.appliances (not including operation energy)	0.0			0.0			0.0
.furnishing	0.0	0.0	0.0	0.0			0.1
.computers and electrical equipment (not inclu	0.0			0.0			0.0
.clothing and shoes	0.0	0.0	0.0	0.0			0.1
.cleaning products	0.0			0.0			0.0
.paper products	0.1			0.2			0.3
.tobacco	0.0	0.0		0.0			0.0
.other misc. goods	1.2	0.0		0.1			1.3
Services	0.8	0.0		0.1	0.0		**0.9**
.water and sewage	0.0			0.0			0.0
.telephone and cable service	0.0			0.0			0.0
.solid waste	0.0			0.0			0.0
.financial and legal	0.0			0.0			0.1
.medical	0.2	0.0		0.0			0.2
.real estate and rental lodging	0.1	0.0		0.0			0.1
.entertainment	0.0			0.0			0.1
.government	0.2	0.0		0.0			0.2
..non-military, non-road	*0.1*	*0.0*		*0.0*			*0.1*
..military	*0.1*	*0.0*		*0.0*			*0.1*
.other misc. services	0.1	0.0		0.0			0.1
Total (gha/cap)	**4.7**	**1.1**	**0.8**	**0.7**	**0.2**	**0.5**	**8.1**

Table 2.5: *Consumption–land use matrix for Victoria showing the Ecological Footprint of an average resident of Victoria, in global hectares per person.*

Blank cells indicate that cells are either not applicable to the calculation for that land use category, or in some cases that there is insufficient data to calculate sub-categories. Cells that appear as zeroes contain actual values that are smaller than 0.005 [gha/cap]. Also, numbers may not sum due to rounding.

2.3 Victoria's Biocapacity

Victoria's demand for resources can be compared to what is available globally, nationally or locally. To compare Victoria's Footprint with its own supply, or the region's biocapacity, we assembled ecosystem and land use data for Victoria. These figures were then converted to global hectares to make results consistent with and comparable to the Footprint and biocapacity estimates elsewhere. Results are shown in Table 2.6 below.

Biocapacity available worldwide adds up to 1.8 global hectares (assuming no area is set aside for wild species who are competing with the human enterprise for ecological services). Victoria's biocapacity is 5.4 global hectares per person, or three times more than world

average since it is less densely populated than the world as a whole. Half of Victoria's biocapacity stems from marine areas. (This marine capacity was calculated by allocating to Victoria a piece of Australia's marine capacity proportional to the size of Victoria's population). Note that actual hectares and global hectares can diverge since not every hectare is equally productive (but every global hectare represents the same amount of biocapacity).

Even though Victoria's territory contains three times more biocapacity per person than world average, its Ecological Footprint still exceeds its biocapacity. Victoria's average per-person Footprint of 8.1 global hectares is 50 percent greater than its calculated 5.4 global hectare biocapacity per person. In other words, to balance this ecological deficit, Victoria must either import an extra 50 percent of the ecological capacity it uses from other regions, or it must deplete its own natural capital.

Australia, by contrast, has a biocapacity of 12.7 global hectares per person, and a Footprint of 7.7 global hectares per person. Thus the average Australian Footprint measures only 61 percent of the country's available biocapacity per person. (The value of the Australian biocapacity given here differs from that shown in LPR 2004. Newly available data indicates that the limitation on pasture biocapacity is not the available net primary productivity, but rather, the lack of freshwater. The value shown in LPR 2004 therefore overestimates Australia's biocapacity).

Global Biocapacity per person	1.8	global hectares
Humanity's Footprint per person	2.2	global hectares
Ratio of Humanity's Footprint to Global Biocapacity	121%	

Biocapacity of Australia per person

	Area [1000 ha]	Equivalence factor [gha/ha]	Yield factor [-]	Biocapacity [1000 gha]	Biocapacity per person [gha/cap]
Cropland	47,329			81,304	4.2
primary	21,430	2.19	0.90	42,268	
marginal	25,899	1.80	0.84	39,036	
Grazing land	430,101	0.48	0.18	36,115	1.9
Forest area	164,290	1.38	0.31	69,822	3.6
Fishing grounds	212,392			52,797	2.7
marine	206,500	0.36	0.71	52,736	
inland water	5,892	0.36	0.03	61	
Built-up land	2,583	2.19	0.90	5,095	0.3
Total	856,695			245,134	**12.7**
Australia Footprint per person		7.7	global hectares		
Ratio of Australian Footprint to Australian Biocapacit		61%			

Biocapacity of Victoria per person

	Area [1000 ha]	Equivalence factor [gha/ha]	Yield factor [-]	Biocapacity [1000 gha]	Biocapacity per person [gha/cap]
Cropland	5,916	1.98	1.02	10,301	2.1
Grazing land	7,282	0.48	1.09	666	0.1
Forest area	8,295	1.38	0.30	1,050	0.2
Fishing grounds (assumed national average)				13,243	2.7
Built-up land	449	2.19	1.02	901	0.2
Total	21,942			26,162	**5.4**
Victoria Footprint per person		8.1	global hectares		
Ratio of Victorian Footprint to Victorian Biocapacity		150%			

Table 2.6: *Biocapacity of Victoria and Australia, in global hectares per person.*

2.4 Evaluating the results

An analysis of Victoria's Footprint results shows that the largest contributor to the total Footprint is Food, followed by Goods, and then Housing. On the basis of their contribution to the total Victorian Footprint, the Footprint activity categories are ranked in the following order:

1. **Food (37%):**

The consumption of plant-based and animal-based food products, including the Footprint associated with food production, processing, packaging, storage, and transport.

2. **Goods (23%):**

The consumption of products and materials and their associated end-of-life disposal.

3. **Housing (19%):**

The consumption of land and resources for the construction and maintenance of housing, and the residential consumption of electricity, natural gas, and other fuels.

4. **Services (11%):**

The consumption of services and their associated resource costs.

5. **Mobility (10%):**

The consumption of fuel for personal transport and the associated energy and built area Footprints of transport infrastructure. These results are provided in more detail in Table 2.7, and illustrated in Figure 2.1.

Activity	Percent of Total Footprint
Food	**36%**
.plant-based	8%
.animal-based	28%
Housing	**18%**
.new construction	5%
.maintenance	1%
.residential energy use	12%
..electricity	*10%*
..natural gas	*1%*
..fuelwood	*1%*
..fuel oil, kerosene, LPG, coal	*0%*
Mobility	**11%**
.passenger cars and trucks	8%
.motorcycles	0%
.buses	0%
.passenger rail transport	0%
.passenger air transport	2%
.passenger boats	
Goods	**24%**
.appliances (not including operation energy)	1%
.furnishing	1%
.computers and electrical equipment (not including operatic	0%
.clothing and shoes	1%
.cleaning products	1%
.paper products	4%
.tobacco	0%
.other misc. goods	17%
Services	**11%**
.water and sewage	0%
.telephone and cable service	1%
.solid waste	0%
.financial and legal	1%
.medical	3%
.real estate and rental lodging	1%
.entertainment	1%
.Government	2%
..non-military, non-road	*1%*
..military	*1%*
.other misc. services	2%
Unidentified	0%
Total (gha/cap)	**100%**

Table 2.7: *Activity contributions to the Victoria Footprint*

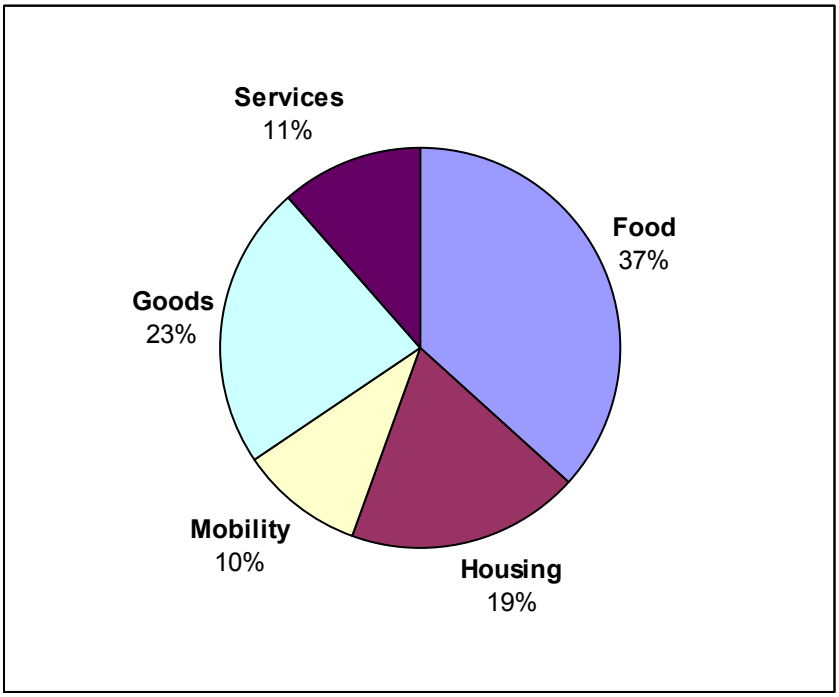

Figure 2.1: *Activity contributions to the Victoria Footprint.*

Of the six Footprint area types, Energy land makes up more than half the total Victoria Footprint, followed by Cropland and Pasture (see Figure 2.2). Table 2.8 provides more detail about each area requirement, as shown in a matrix with the activity categories, and Figure 2 further illustrates this breakdown.

	Energy Total	Cropland	Pasture	Forest	Built area	Fishing grounds	Total Footprint, Victoria	% of total Victoria EF
	[gha/cap]	[gha/cap]	[gha/cap]	[gha/cap]	[gha/cap]	[gha/cap]	[gha/cap]	
Food	0.6	1.1	0.8	0.0	0.0	0.5	**3.0**	**37%**
Housing	1.3	0.0	0.0	0.2	0.1	0.0	**1.5**	**19%**
Mobility	0.7	0.0	0.0	0.0	0.1	0.0	**0.8**	**10%**
Goods	1.5	0.0	0.0	0.4	0.0	0.0	**1.9**	**23%**
Services	0.8	0.0	0.0	0.1	0.0	0.0	**0.9**	**11%**
Unidentified	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0%**
Total (gha/cap)	**4.7**	**1.1**	**0.8**	**0.7**	**0.2**	**0.5**	**8.1**	**100%**
	58%	**14%**	**10%**	**9%**	**2%**	**6%**	**100%**	

Table 2.8: *Area Requirements of the Victoria Footprint*

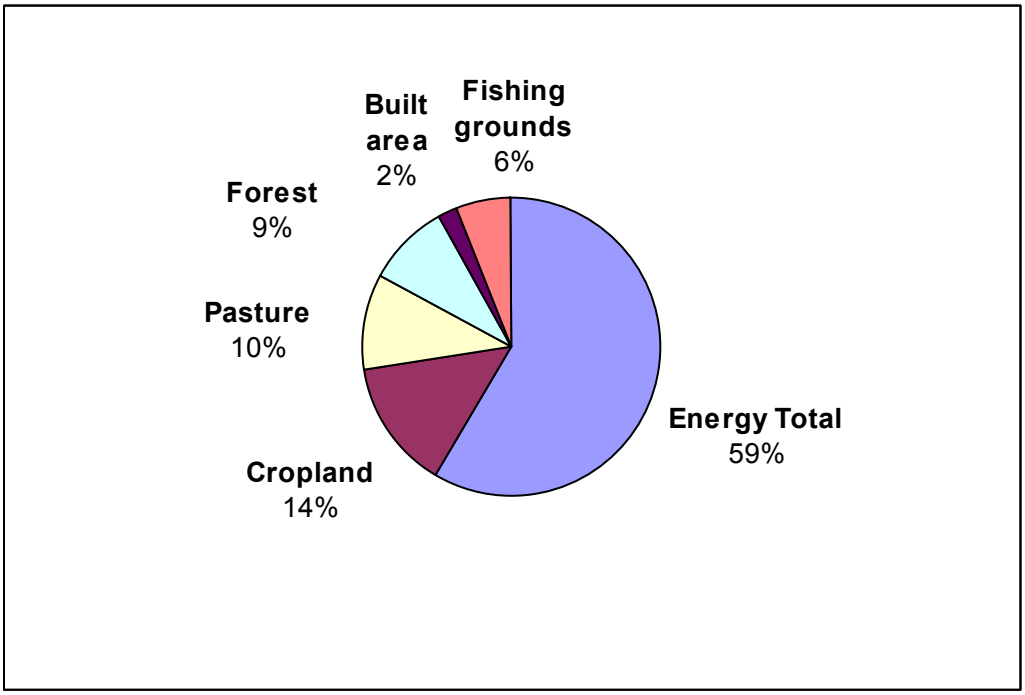

***Figure 2.2**: Area requirements of the Victoria Footprint by land-use area.*

For access to the underlying calculation sheets that were used to generate these results, please contact Global Footprint Network at www.footprintnetwork.org or info@footprintnetwork.org.

3 The University of Sydney Approach: Victoria's Ecological Footprint

The emphasis of the USyd part of the project was mainly to demonstrate the features of the input-output technique in distributing bioproductivity uses across consumption categories, and not to produce an alternative national assessment of bioproductivity and its use. The strategy pursued was therefore to make sure that USyd and Global Footprint Network production-side Footprint and bioproductivity accounts were aligned as much as possible, so that differences in the consumption-side accounts between USyd and Global Footprint Network highlight the features of the respective distribution methods.

USyd uses a sectoral land-use approach for calculating the national reference Footprint, and used this as a basis. The main aim of USyd's approach is to showcase how to distribute the total Footprint to various regions, industry sectors, and consumer items. USyd's sectoral land-use approach produced a result of 6.8 global hectares per Australian for 1998-99, slightly lower than the production-based assessment of Global Footprint Network of 7.7 global hectares per Australian for 2001. In this chapter 6.8 global hectares is referred to as a reference point. The fact that this 1998-99 land-use-based reference differs from the Global Footprint Network's production-based reference does not affect the overall result of this study, since the relative difference between Australia and Victoria – percentage wise, and by detailed component – is the key item for comparison between the two methods.

Applying input-output analysis to Household Expenditure Surveys of the Australian and Victorian populations, the USyd team finds that, per capita, Victoria's 1998-99 Ecological Footprint is 4.5 percent higher than Australia's 1998-99 Ecological Footprint. The difference is mainly due to higher per-capita income and expenditure in Victoria, and because the predominant fossil fuel for electricity (brown coal in Victoria) is more emissions-intensive. The main components of the Ecological Footprint are electricity use (emissions component) and food consumption (land component). The results obtained by the USyd team show that production layers of 3rd and higher orders have to be considered in order to ensure that Ecological Footprint results are complete at the detailed commodity level. Moreover, Structural Path Analysis reveals detailed supply-chains that carry dominant Ecological Footprint contributions, and that can be identified as the best leverage points for initiating changes. Both production layer decomposition and Structural Path Analysis are only possible when using input-output analysis.

The following Sections describe in detail the methodology employed by the USyd team, and the results for Australia and Victoria.

3.1 Methodology

Using input-output analysis, monetary data y_i on regional household expenditure on commodities i=1,…,N in units of Australian Dollars (A$) is converted into Ecological Footprint contributions F_i in units of global hectares (gha) by multiplication with *intensities* m_i in units of global hectares per dollar (gha/A$) for the same set of commodities:

$$F_i = m_i y_i .$$

The total Ecological Footprint EF is then calculated by simply adding up over commodities:

$$EF = \sum_{i=1}^{N} F_i = \sum_{i=1}^{N} m_i y_i .$$

While the consumption data y can be taken from statistical data (Australian Bureau of Statistics 2000b), the intensities m are derived from input-output theory, by a series of matrix calculations involving land and energy intensities, and direct requirements coefficients from input-output tables (for further details see Lenzen 2001). Considering that intensities m are expressed on a per-dollar basis, they can be said to contain *structural* information. In contrast, y contains *absolute* information.

While both types of information are specific for any one year, structural quantities often change more slowly than absolute quantities. For example, while absolute energy consumption in Australia increases by a few percent each year, the energy intensity (energy consumption per dollar of industry output) shows annual changes of less than one percent (Wood 2003).

In this study, structural information relating to 1994-95 was used (see Section 3.2 for further details), while absolute expenditure information refers to the most recent ABS Household Expenditure Survey of 1998-99. Considering that structural quantities (energy and land intensities and industrial interdependence, in short the *production recipe*) change relatively slowly, only a small uncertainty (in the order of less than 5%) is introduced into absolute Ecological Footprint figures by assuming that the 1995 production recipe applies to 1998.

Because of the above assumptions, the (absolute or per-capita) primary production accounts (Section 3.3) calculated using the University of Sydney (USyd) and Global Footprint Network (Global Footprint Network) methods should be compared as referring to 1994-95 and 2001, respectively. The more important consumption accounts (Section 3.5) should be compared as referring to 1998-99 and 2001, respectively. Nevertheless, an attempt was made to extrapolate USyd accounts towards the year 2001, using simplified assumptions of homogeneous inflation, economic growth and population growth rates.

3.2 Data and disaggregation

Since the Ecological Footprint of consumption measures demand consumption inputs on the biosphere, an Ecological Footprint calculation for Australia and Victoria is based on consumption data. The data underpinning this work are hence the most recent Household Expenditure Survey (HES) conducted by the Australian Bureau of Statistics 2000a) in 1998-99. These data comprise estimates of expenditure on about 500 consumer items, collected from 6,893 Australian households, 1,369 of which are located in Victoria.

3.2.1 Household Expenditure Survey

The commodity classification used in the Household Expenditure Survey differs somewhat from the input-output product classification (IOPC) used in the Australian input-output tables used for calculating Ecological Footprints embodied in consumer goods. Therefore, a re-classification had to be carried out between Household Expenditure Survey and IOPC. The agreement between the Household Expenditure Survey and input-output data was examined for total Australian private final consumption (Tab. 3.1). Note that the 1998-99 input-output tables have been released only in late 2004 (Australian Bureau of Statistics 2004b), so that for the first time a calibration of the 1998-99 Household Expenditure Survey (HES) against the 'reconciliation of flows' data in the input-output tables is possible. The comparison shows that:

- the HES under-reports total expenditure of commodities by 12%, which may be due to a conscious under-reporting of alcohol, tobacco, and gambling (for obvious reasons), and under-reporting of ownership of dwellings, maybe for taxation reasons. Maybe also oils and fats are under-reported (more than 40%) because of respondents being reluctant to reveal adverse dietary habits;
- other differences of more than 30% could be due to discrepancies in classification definitions, such as
  - some fish could be in input-output item 'other food', some leather could be in input-output item 'clothing' or 'miscellaneous manufacturing';
  - plastic products could be hidden in many other sectors;
  - fabricated metal products could also be 'other machinery' or 'sheet metal';
  - retail trade is a vaguely defined sector, products could be virtually everywhere in other sectors;
- we have consciously defined expenditure on sheep meat and pig meat as coming from sectors sheep and pigs, in order to make the input-output item 'meat' contain only of beef, so that we can more clearly see the differences between the meat types, hence differences are artificial for these categories;
- we cannot explain the differences in gas supply expenditure, a conjecture being that urban households are over-represented in the HES.

However, overall expenditure discrepancies could cancel in Ecological Footprint results because products may be located in other sectors with similar Footprint intensities, and then the allocation is not so critical. In summary, given that the 1998-99 HES sampling rate was 0.1%, the correspondence between the Household Expenditure Survey and input-output tables is surprisingly good.

IOPC code	Commodity description	IO table ($ mill)	HES ($ mill)
0101	Sheep	26	387
0102	Grains	0	0
0103	Beef cattle	36	0
0104	Dairy cattle	2	0
0105	Pigs	5	696
0106	Poultry	403	684
0107	Other agriculture	5352	6336
0200	Services to agriculture; hunting and trapping	32	2
0300	Forestry and logging	26	19
0400	Commercial fishing	1336	1180
1100	Coal, oil and gas	798	676
1301	Iron ores	-	0
1302	Non-ferrous metal ores	-	0
1400	Other mining	3	0
1500	Services to mining	n.a	0
2101	Meat and meat products	6126	4285
2102	Dairy products	4766	5396
2103	Fruit and vegetable products	4188	3600
2104	Oils and fats	884	524
2105	Flour mill products and cereal foods	1608	1460
2106	Bakery products	4297	4600
2107	Confectionery	1812	1856
2108	Other food products	6192	5444
2109	Soft drinks, cordials and syrups	3171	2688
2110	Beer and malt	3722	2084
2111	Wine and spirits	3038	2640
2112	Tobacco products	7043	4296
2201	Textile fibres, yarns and woven fabrics	1029	928
2202	Textile products	2359	2056
2203	Knitting mill products	1533	1232
2204	Clothing	10688	8792
2205	Footwear	2548	2128
2206	Leather and leather products	475	244
2301	Sawmill products	2	15
2302	Other wood products	110	122
2303	Pulp, paper and paperboard	230	178
2304	Paper containers and products	829	711
2401	Printing and services to printing	1396	1167
2402	Publishing; recorded media etc	5265	3031
2501	Petroleum and coal products	8789	10901
2502	Basic chemicals	1244	1077
2503	Paints	2	47
2504	Medicinal and pharmaceutical products, pesticides	5190	3400
2505	Soap and detergents	1422	1445
2506	Cosmetics and toiletry preparations	2749	2948
2507	Other chemical products	172	171
2508	Rubber products	1122	1033
2509	Plastic products	1698	821
2601	Glass and glass products	95	78
2602	Ceramic products	538	577
2603	Cement, lime and concrete slurry	-	213
2604	Plaster and other concrete products	0	283
2605	Other non-metallic mineral products	0	52
2701	Iron and steel	-	65
2702	Basic non-ferrous metal and products	64	6
2703	Structural metal products	-	354
2704	Sheet metal products	150	28
2705	Fabricated metal products	861	1785
2801	Motor vehicles and parts; other transport equipment	16498	18964

2802	Ships and boats	649	556
2803	Railway equipment	-	0
2804	Aircraft	120	0
2805	Photographic and scientific equipment	3108	2988
2806	Electronic equipment	4702	3184
2807	Household appliances	4816	5106
2808	Other electrical equipment	612	456
2809	Agricultural, mining and construction equipment	299	243
2810	Other machinery and equipment	83	111
2901	Prefabricated buildings	-	0
2902	Furniture	5534	5152
2903	Other manufacturing	4855	6824
3601	Electricity supply	4975	5200
3602	Gas supply	565	1376
3701	Water supply; sewerage and drainage services	3310	2444
4101	Residential building	-	0
4102	Other construction	-	0
4501	Wholesale trade	0	0
5101	Retail trade	8235	68
5401	Mechanical repairs	7058	4128
5402	Other repairs	1143	1044
5701	Accommodation, cafes and restaurants	23576	22694
6101	Road transport	2135	1736
6201	Rail, pipeline and other transport	1008	817
6301	Water transport	n.a	63
6401	Air and space transport	n.a	4958
6601	Services to transport; storage	606	888
7101	Communication services	8436	7968
7301	Banking	10016	11172
7302	Non-bank finance	2517	2704
7401	Insurance	8889	8104
7501	Services to finance, investment and insurance	1584	1036
7701	Ownership of dwellings	63674	55132
7702	Other property services	920	644
7801	Scientific research, technical and computer services	17	0
7802	Legal, accounting, marketing and business management services	2193	2098
7803	Other business services	726	486
8101	Government administration	846	2095
8201	Defence	-	0
8401	Education	8289	5980
8601	Health services	10473	10740
8701	Community services	2098	2512
9101	Motion picture, radio and television services	1110	672
9201	Libraries, museums and the arts	1242	1776
9301	Sport, gambling and recreational services	11782	4044
9501	Personal services	6145	4796
9601	Other services	7749	5133
	Sum	348,019	305,814

Tab. 3.1: *Comparison between Australian final consumption data from 1998-99 HES and input-output tables.*

3.2.2 Concordance of IOPC and Global Footprint Network Classifications

In order to translate input-output-classified results into the Global Footprint Network classification, a concordance had to be constructed between reporting categories. This was carried out using informed knowledge about Australian input-output tables, aided by definitions in the ABS publication 5215.0 (Australian Bureau of Statistics 1999c).

Concordance table
IOPC^{+} - GFN

	Food	.plant-based	.animal-based	Housing	.new construction	.maintenance	.residential energy use	..electricity	..natural gas	..fuelwood	..fuel oil, kerosene, LPG, coal	Mobility	.passenger cars and trucks	.transit infrastructure	.motorcycles	.passenger air	.passenger public transit	Goods	.appliance manufacturing	.furniture	.computers and electrical equipment	.clothing and shoes	.cleaning products and services	.other household products	.paper products	.tobacco
Sheep, lambs and shorn wool	*1*	1		*0*			*0*					*0*						*0*								
Barley, unmilled	*1*	1		*0*			*0*					*0*						*0*								
Rice, in the husk	*1*	1		*0*			*0*					*0*						*0*								
Wheat, legumes for grain, oilseeds, oats and	*1*	1		*0*			*0*					*0*						*0*								
Beef cattle	*1*		1	*0*			*0*					*0*						*0*								
Dairy cattle and untreated whole milk	*1*		1	*0*			*0*					*0*						*0*								
Pigs	*1*		1	*0*			*0*					*0*						*0*								
Poultry and eggs	*1*		1	*0*			*0*					*0*						*0*								
Sugar cane for planting and crushing	*1*	1		*0*			*0*					*0*						*0*								
Cotton (excl ginned)	*0*			*0*			*0*					*0*						*1*								
Vegetable and fruit growing, hay, plant nurse	*1*	1		*0*			*0*					*0*						*0*								
Services to agriculture, ginned cotton, cotton	*1*		1	*0*			*0*					*0*						*0*								
Softwoods, conifers	*0*			*1*			*1*			1		*0*						*0*								
Hardwoods, brushwoods, scrubwoods, hewn	*0*			*1*			*1*			1		*0*						*0*								
Forestry and services to forestry	*0*			*1*			*1*			1		*0*						*0*								
Commercial fishing, fresh seafood	*1*		1	*0*			*0*					*0*						*0*								
Black coal (all types incl briquettes)	*0*			*1*			*1*				1	*0*						*0*								
Crude oil (incl condensate)	*0*			*1*			*1*				1	*0*						*0*								
Natural gas (in the gaseous state)	*0*			*1*			*1*		1			*0*						*0*								
Liquefied natural gas, liquefied petroleum ga	*0*			*1*			*1*		1			*0*						*0*								
Brown coal, lignite (all types incl briquettes)	*0*			*1*			*1*				1	*0*						*0*								
Iron ores (jncl tratment; excl pelletising)	*0*			*0*			*0*					*0*						*1*								
Bauxite	*0*			*0*			*0*					*0*						*1*								
Copper concentrates, oxides, precipitates ar	*0*			*0*			*0*					*0*						*1*								
Gold bullion and ores; lead ores and concen	*0*			*0*			*0*					*0*						*1*								
Silver and zinc ores	*0*			*0*			*0*					*0*						*1*								
Uranium, nickel, tin, manganese and other r	*0*			*0*			*0*					*0*						*1*								
Sand, gravel, limestones, clay, gypsum and	*0*			*1*	1		*0*					*0*						*0*								
Petroleum and mineral exploration and serv	*0*			*0*			*0*					*0*						*0*								
Meat and meat products	*1*		1	*0*			*0*					*0*						*0*								
Milk, cream, butter, cheese, whole milk drink	*1*		1	*0*			*0*					*0*						*0*								
Vegetables, fruit, juices, jams, salads, canne	*1*	1		*0*			*0*					*0*						*0*								
Oils and fats, margarine	*1*	0.45	0.55	*0*			*0*					*0*						*0*								
Flour, cereal foods, rice, pasta and other flo	*1*	1		*0*			*0*					*0*						*0*								
Bread, cakes, biscuits, meat pies and other	*1*	1		*0*			*0*					*0*						*0*								
Confectionery	*1*	1		*0*			*0*					*0*						*0*								
Raw and refined sugar, animal feeds, frozen	*1*	1		*0*			*0*					*0*						*0*								
Soft drinks, mineral and aerated waters, cor	*1*	1		*0*			*0*					*0*						*0*								
Beer and malt	*1*	1		*0*			*0*					*0*						*0*								
Wine and spirits	*1*	1		*0*			*0*					*0*						*0*								
Tobacco products	*0*			*0*			*0*					*0*						*1*								1
Processed wool, textile fibres, yarns, towels	*0*			*0*			*0*					*0*						*1*						1		
Carpets, felt, curtains, tarpaulins, belts, sails	*0*			*0*			*0*					*0*						*1*		1						
Hosiery, jumpers and knitting mill products	*0*			*0*			*0*					*0*						*1*				1				
Clothing and safety headgear and eyewear	*0*			*0*			*0*					*0*						*1*				1				
Footwear, soles and other parts, repairing	*0*			*0*			*0*					*0*						*1*				1				
Leather, hides, skins, handbags, suitcases, v	*0*			*0*			*0*					*0*						*1*				1				
Sawn and dressed timber, treated wood, gro	*0*			*1*			*1*			1		*0*						*0*								
Plywood, veneers, fibreboard, panels, partic	*0*			*1*	1		*0*					*0*						*0*								
Pulp, newsprint, paper and paperboard	*0*			*0*			*0*					*0*						*1*							1	
Paper and paperboard containers, corrugate	*0*			*0*			*0*					*0*						*1*							1	
Stationery, envelopes, labels, cards, diaries,	*0*			*0*			*0*					*0*						*1*							1	
Newspapers, magazines, books, periodicals	*0*			*0*			*0*					*0*						*0*								
Automotive petrol, gasolene refining or blen	*0*			*0*			*0*					*1*	1					*0*								
Kerosene and kerosene-type jet fuel	*0*			*1*			*1*				1	*0*						*0*								
Gas oil, fuel oil	*0*			*1*			*1*				1	*0*						*0*								
Petroleum bitumen, petroleum coke, refinery	*0*			*1*			*1*				1	*0*						*0*								
Mixed fertilisers	*0*			*0*			*0*					*0*						*1*								
Phosphate, nitrate and other fertilisers, acet	*0*			*0*			*0*					*0*						*1*								
Paints, primers, filler, putty	*0*			*1*	1		*0*					*0*						*0*								

Fig. 3.1: *Extract from IOPC-Global Footprint Network concordance table. Note: Global Footprint Network categories contain intermediate totals and final totals, while IOPC categories are disjunct.*

3.2.3 Distribution of Expenditure Across Global Footprint Network Categories

Differences in the Ecological Footprint can be caused by differences in expenditure patterns. We have therefore examined such patterns for the average Australian and Victorian consumer, but we have also given some examples for different regions within Victoria, and different population segments.

Consumption patterns vary significantly depending on the geographical location within Victoria. For example, in inner Melbourne services dominate whereas in the Western District (a rural area of Victoria) mobility and housing accounts for a larger portion of consumption. Moreover, differences appear between small wealthy households and large poor households, as demonstrated by the bars representing Victorian lone person households and single parents with more than one child, with wealthy households spending more on luxuries (such as services, air travel).

It appears that consumption patterns are fairly similar in Victoria and Australia. Therefore, differences in Ecological Footprints can largely be caused by differences in production structures (beef, dairy, electricity etc).

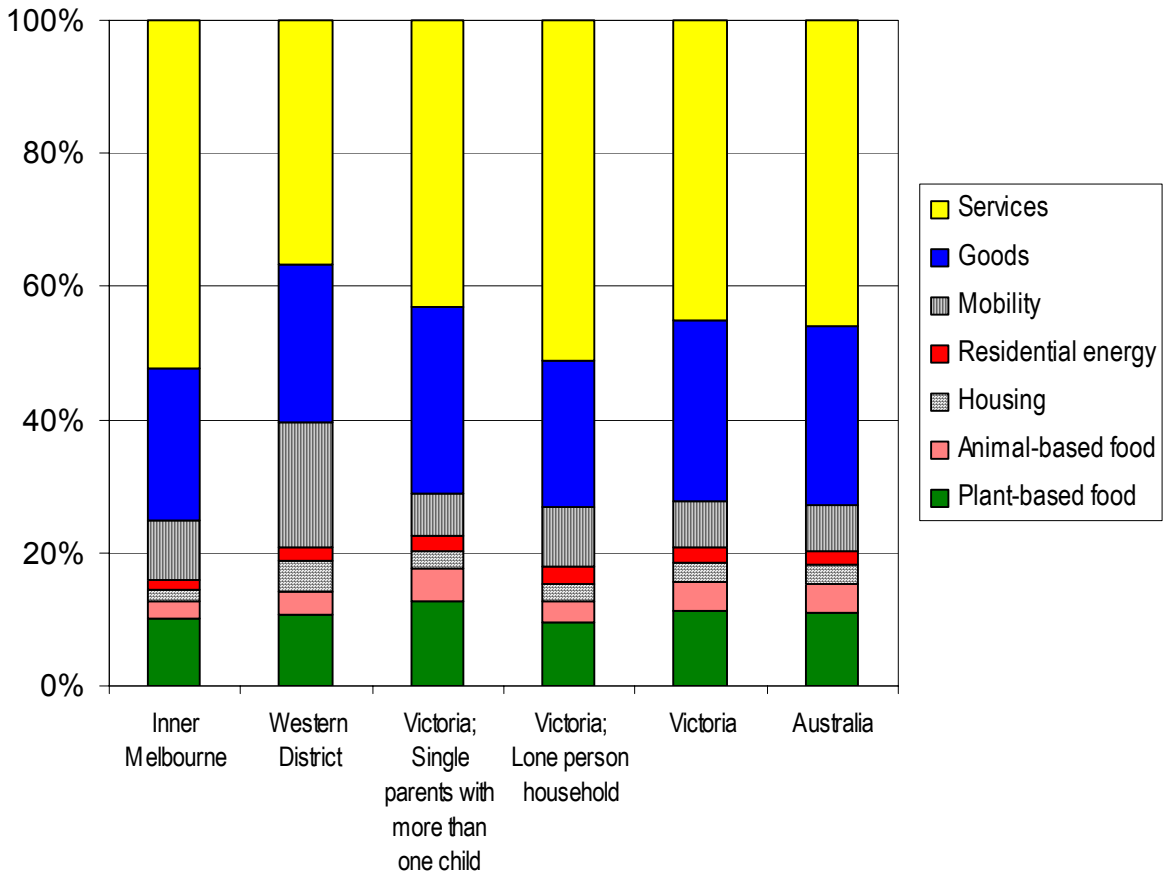

Fig. 3.2: *Consumption patterns of various regional and population segments in Australia (from Australian Bureau of Statistics 2000b).*

3.2.4 Data on Land Use

The following data on land use (Fig. 3.3) was extracted from various data sources as documented in Lenzen and Murray (2001), and shows how the Australian continent is used or owned by various industries, groups of people, and the government:

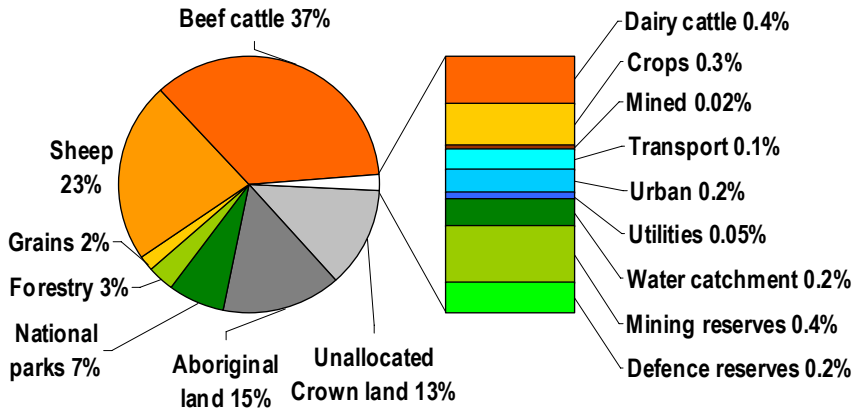

Fig. 3.3: *Land use in Australia by using entity.*

It is a remarkable fact that 60% of Australia is used for sheep and beef cattle grazing. Furthermore, mines – which are commonly perceived as strongly impacting on land – occupy only 0.02%.

Global Footprint Network land category	Yield factor	Equivalence factor	Included in bio-capacity	Included in EF	Comment
Cropland	0.870	1.995	yes	yes	Average of primary and marginal
Permanent pasture	0.770	0.480	yes	yes	Includes arid pasture
Forest AWS	1.180	1.380	yes	yes	State forest
Forest NAWS	0.210	1.380	yes	no	National Parks, defence, mining and water supply reserves
"Unproductive" areas	0.000	0.000	no	no	Crown land, Aboriginal land
Marine	0.710	0.360	yes	yes	
Inland water	0.030	0.300	yes	yes	
Built	0.900	2.190	yes	yes	Homes, parks, roads, railways, runways, factories, offices, shops, mines, reservoirs, pipelines, overhead lines, landfills, etc
Energy land	0.267	-	no	yes	

Tab. 3.2: *Yield and equivalence factors used in this study.*

In order to calculate bioproductivity-based Ecological Footprints from these data, land use figures expressed in actual Australian hectares used by Australian producing industries (a production-land account) were first converted into global hectares using Global Footprint Network yield and equivalence factors (Tab. 3.2), thus arriving at a production-bioproductivity account (Fig. 3.4). Subsequently, these derived data were subjected to the input-output formalism (Lenzen 2001), to yield a consumption-bioproductivity account.

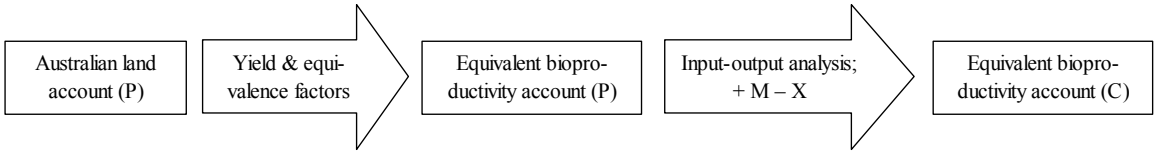

Fig.3.4: *Conversion of land data for calculating bioproductivity-based Ecological Footprints.*

While accounts calculated by either organisation are based on the original bioproductivity metric, they differ in two respects: 1) production accounts are derived from either apparent consumed quantity (Global Footprint Network) or apparent used areas (USyd), and 2) productivity used by humans is distributed across consumption categories manually using auxiliary data (Global Footprint Network) or analytically using input-output analysis (USyd). Since the emphasis of the USyd part of the project was to apply the input-output technique to bioproductivity data, the strategy pursued was to make sure that bioproductivity accounts (production side) were aligned as much as possible. This was achieved through discussions between members of the project team, so that differences in the consumption-side accounts highlight the features of either distribution method.

3.2.5 Data on Energy Use and Greenhouse Gas Emissions

Data on Australian energy consumption was taken from Australian Bureau of Agricultural and Resource Economics (1999). Australian greenhouse gas emissions are reported regularly by the National Greenhouse Gas Inventory Committee (1998). These items were converted into bioproductivity equivalence using factors supplied by the Global Footprint Network team. Note that at present, CO_2 emissions from non-energy uses (industrial processes or land use changes) as well as non-CO_2 emissions are excluded from Global Footprint Network accounts. In this work, figures excluding and including these components will be given to indicate the range of uncertainty (see Section 3.6).

3.2.6 Further Possible Disaggregation

It is also possible to calculate the Ecological Footprint for the spatial and socio-economic disaggregation listed in Appendix A (Australian Bureau of Statistics 2000b). Because of varying sample sizes, this disaggregation roughly follows Statistical Divisions (SDs) within Victoria, and Statistical Subdivisions (SSDs) within Melbourne.

Due to low population density in some SDs, and confidentiality restrictions on sample size imposed by the ABS, data are released for aggregates only in the case of SDs Wimmera and Mallee, and SDs Ovens-Murray and East Gippsland. A list and maps of all SDs and SSDs follows (Tab. 3.3, Figs. 3.5 and 3.6).

	Melbourne SSDs		Victoria SDs
1	Inner Melbourne	1	Melbourne
2	Western Melbourne	2	Barwon
3	Melton-Wyndham	3	Western District
4	Moreland	4	Central Highlands
5	Northern Middle Melbourne	5	Wimmera & Mallee
6	Hume City	6	Loddon
7	Northern Outer Melbourne	7	Goulburn
8	Boroondara	8	Ovens-Murray & East Gippsland
9	Eastern Middle Melbourne	9	Gippsland
10	Eastern Outer Melbourne		
11	Yarra Ranges		
12	Southern Melbourne		
13	Greater Dandenong City		
14	South East Outer Melbourne		
15	Frankston		
16	Mornington Peninsula		

***Tab. 3.3**: Melbourne SSDs and Victoria SDs available for further disaggregation.*

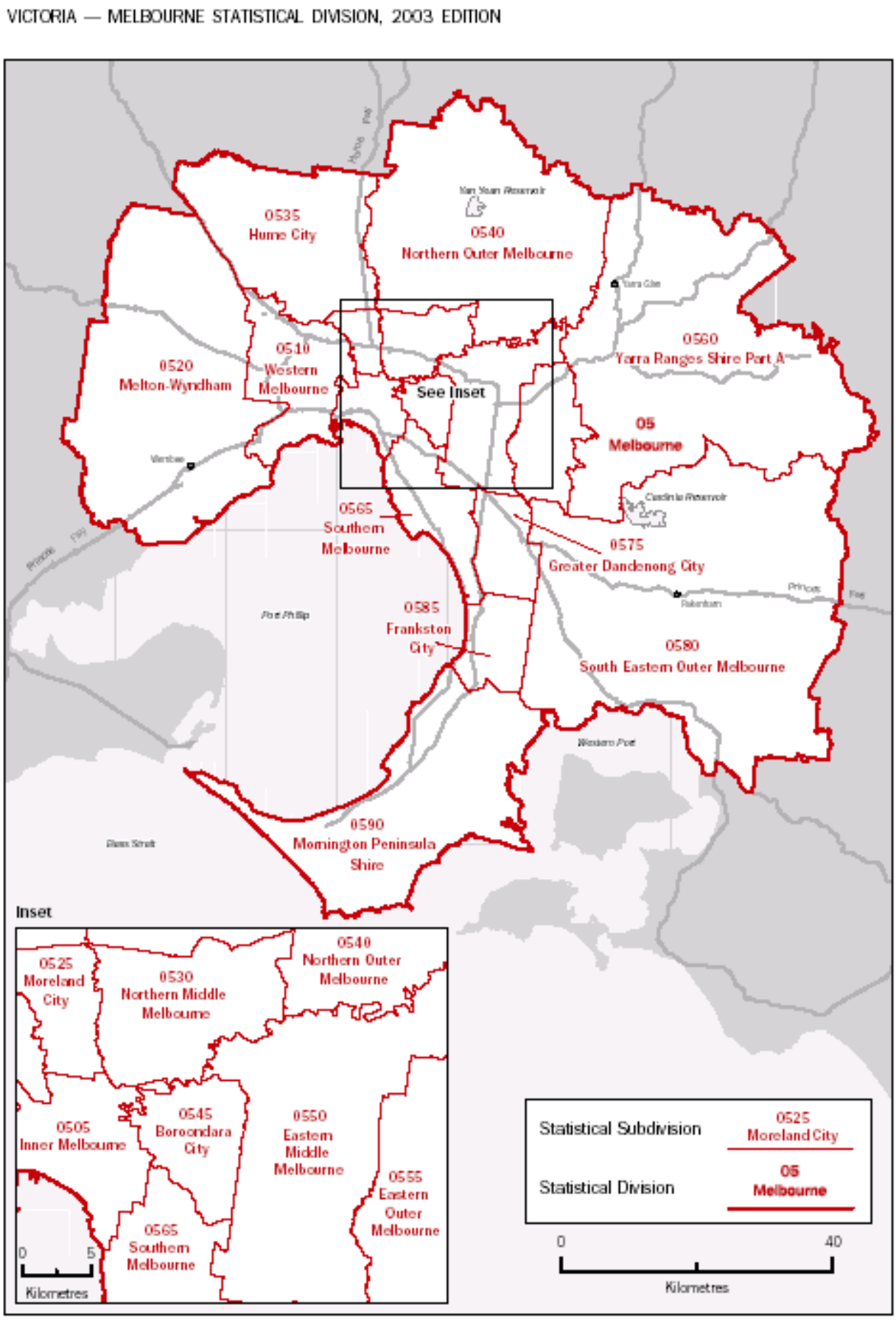

Fig. 3.5: *Melbourne Statistical Sub-Divisions (from ABS 1216.0)*

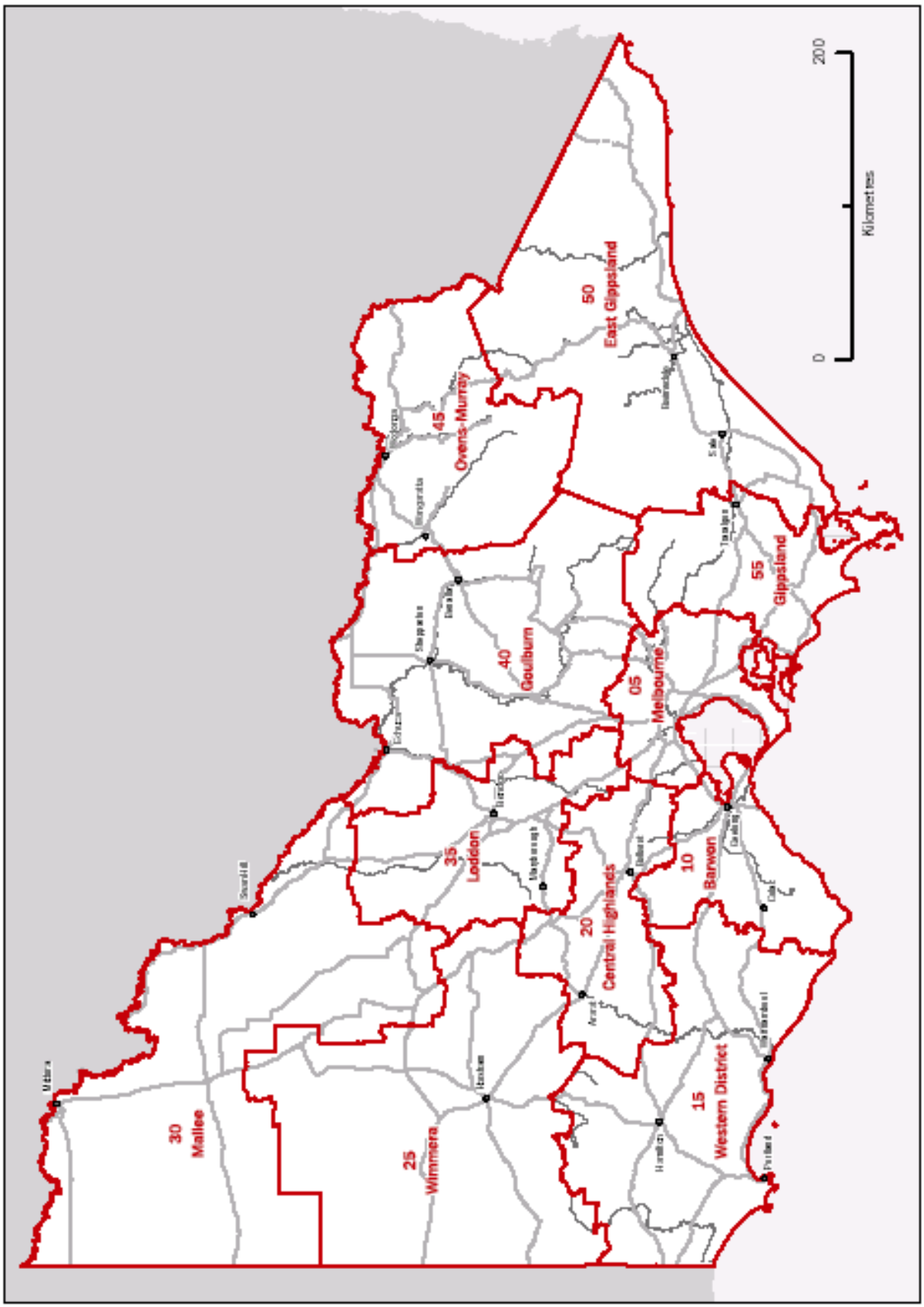

Fig. 3.6: *Victorian Statistical Divisions (from ABS 1216.0)*

3.3 Australia's production accounts

3.3.1 Australia's Biocapacity

Based on area data compiled in Lenzen and Murray (2001), and marine areas supplied by the Global Footprint Network team, and using yield and equivalence factors listed in Tab. 3.2, we arrive at the following 1995 biocapacity account (Tab. 3.4):

Land type Industry	Cropland	Forest AWS	Forest NAWS	Permanent pasture	Marine	Inland water	Built	Equivalent biocapacity
Sheep	523	0	0	64,979	0	0	1	65,503
Beef cattle	1,233	0	0	102,758	0	0	1	103,992
Dairy cattle	504	0	0	1,014	0	0	0	1,519
Crops and other agriculture	27,159	0	0	0	0	0	5	27,164
Forestry	0	12,783	5,225	0	0	0	0	18,008
Fishing	0	0	0	0	52,781	0.012	1	52,783
Mining	0	0	937	0	0	0	338	1,275
Manufacturing	100	0	0	0	0	0	366	466
Utilities (El, Gas & Wat)	0	0	433	0	0	0	652	1,084
Services	0	0	0	0	0	0	1,630	1,630
Government / public	0	0	15,666	0	0	0	266	15,932
Private	0	0	0	0	0	0	2,189	2,189
All industries	29,520	12,783	22,261	168,750	52,781	0.012	5,450	291,545

Tab. 3.4: *Australian production account (in '000 global hectares, '000 gha).*

As expected, most of Australia's biocapacity lies in its pastures, followed by marine areas, cropland and forests. Figs. 3.7 and 3.8 give pie chart breakdowns by industry and land type.

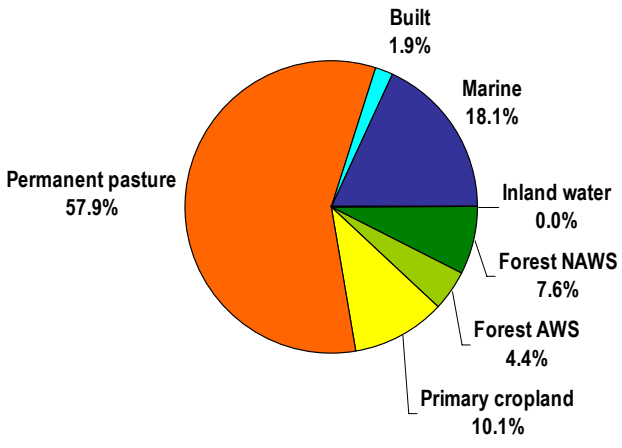

Fig. 3.7: *Biocapacity by land type.*

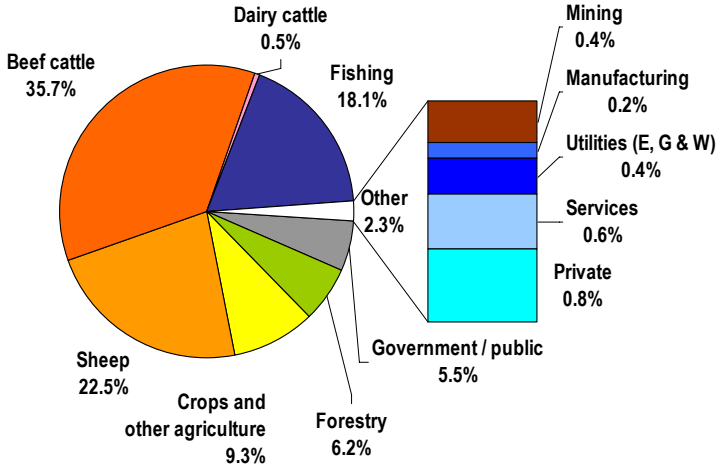

Fig. 3.8: *Biocapacity by using industry.*

3.3.2 Australia's Primary Production Account

Instead of biocapacity data (Section 3.3.1), Ecological Footprints are based on primary production accounts (Section 3.3.2.4). The difference between biocapacity and primary production is that some capacity is not used for human purposes, while primary production is fully utilised. Therefore, in order to calculate Ecological Footprint accounts, the portion of the biocapacity that is actually used in Australia had to be determined. This applies to the following land types: cropland (3.3.2.1), grazing land (3.3.2.2), and marine areas (3.3.2.3).

3.3.2.1 Adjustments to Primary Production Data; cropland

1) A discrepancy exists in the primary production account for cropland (1.59 versus 2.34 gha/cap, USyd and Global Footprint Network, respectively), which is mainly due to the fact that the Sydney University study uses the land, energy and structural data for the year 1995.

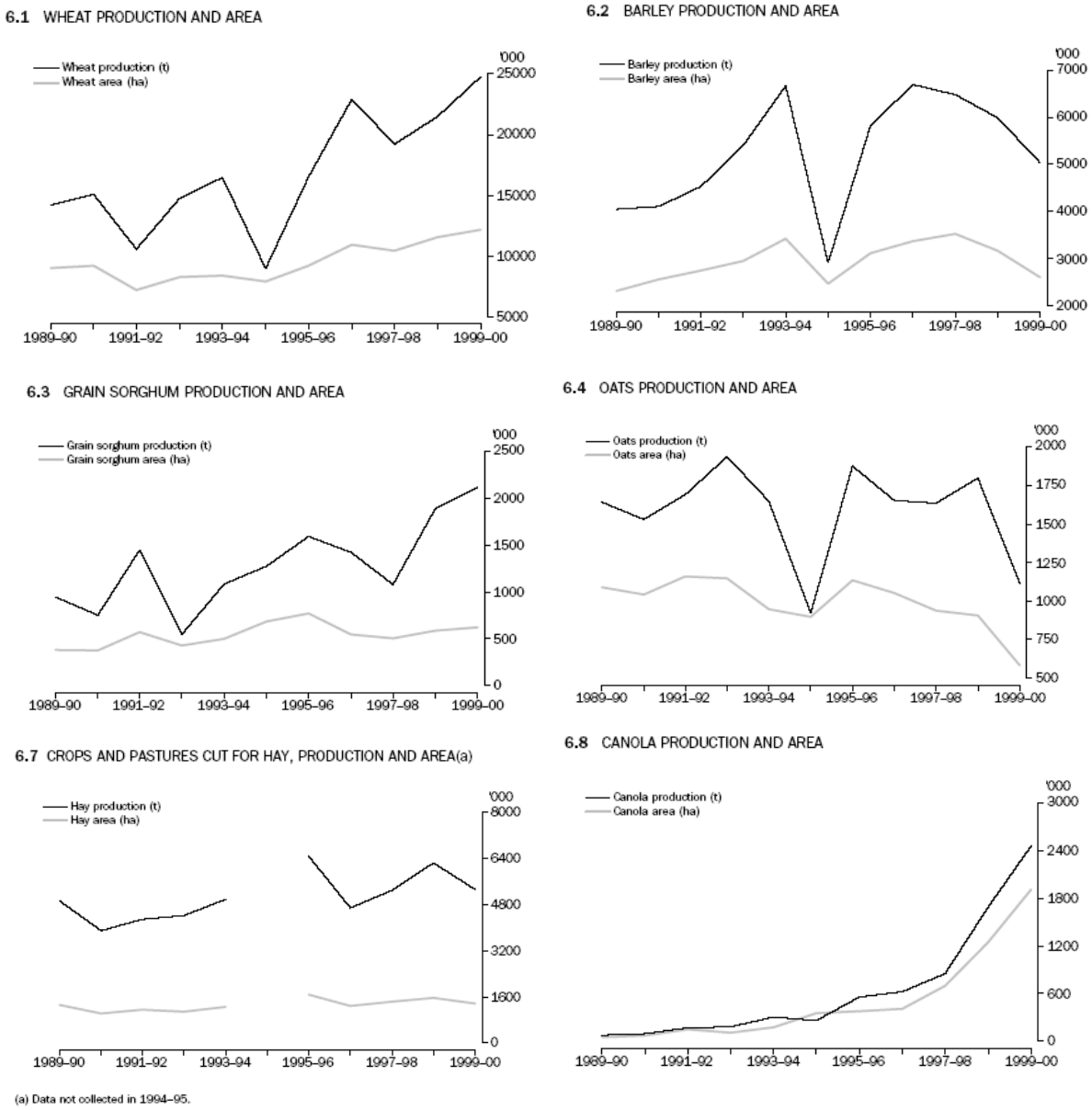

Fig. 3.9: *Trends in grain area and production (Australian Bureau of Statistics 1997).*

Since then, cropland has increased significantly in Australia (see Fig. 3.9), mainly for providing exports (see Fig. 3.10). On the other hand, data on agricultural production shows that yields have fluctuated substantially, and that 1994-95 was a year featuring particularly low yields (Fig. 3.9), except for irrigation-based rice (not shown).

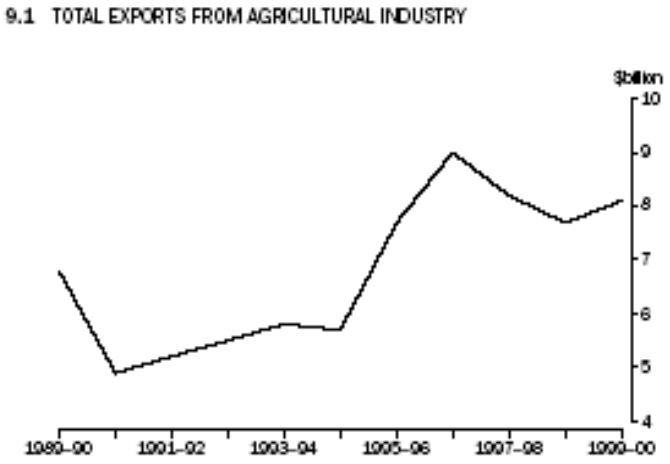

Fig. 3.10: *Exports from agricultural industry (Australian Bureau of Statistics 1997; 2004a).*

Rather than absolute figures, the input-output framework relies on the *production recipe*: the land intensities resulting from an input-output analysis are scale-invariant as long as output and land input vary proportionally. Hectare-input per unit of wheat output was particularly high in 1994-95 (Fig. 3.11). In this respect, Australia uses less land per unit of wheat in 2001 than it did in 1994-95. Therefore, if comparisons with 2001 were to be made, the yield factor applied in this study ($\frac{\text{global ha} / \text{wheat output}}{\text{Australian ha} / \text{wheat output}}$, 0.9) would have to be scaled down to match 1994-95 data, leading to a larger discrepancy.

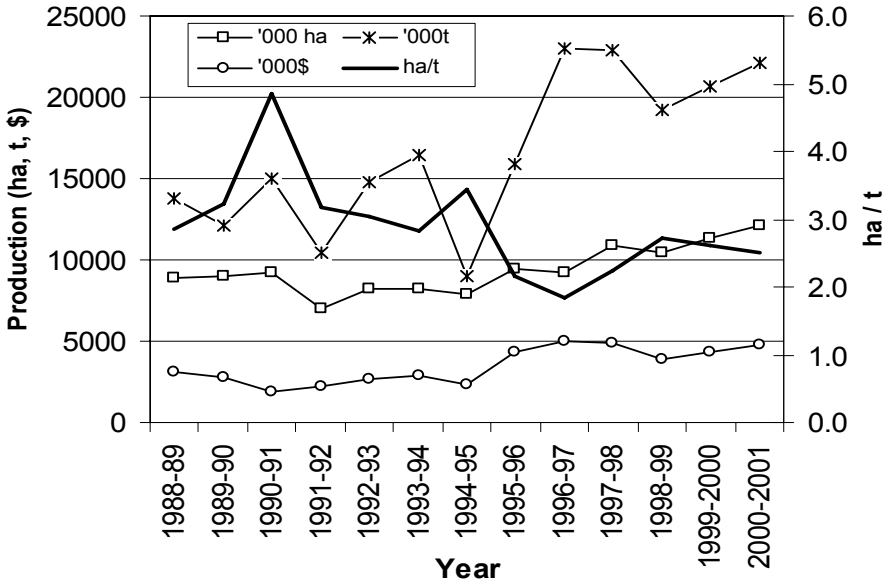

Fig. 3.11: *Wheat production area, tonnage, sales and yield (data from Australian Bureau of Statistics 1997; 2004a).*

3.3.2.2 Grazing land

As in Simpson *et al.* 1998; Simpson *et al.* 2000, arid pastures were taken into account at given yield and equivalence factors, resulting in a large discrepancy of grazing land between USyd and Global Footprint Network accounts. Given that the Global Footprint Network bioproductivity measure covers only land according to its productivity for human purposes, the amounts of meat extracted from these arid areas has to be taken as a base for calculating the global-hectare equivalent of Australian arid pastures. In the USyd calculations, a 'non-fallow' factor was applied to Australian grazing areas in order to match these with Global Footprint Network primary productivity figures. This procedure is probably realistic, given that the number of meat cattle slaughtered has not changed significantly (see Fig. 3.12).

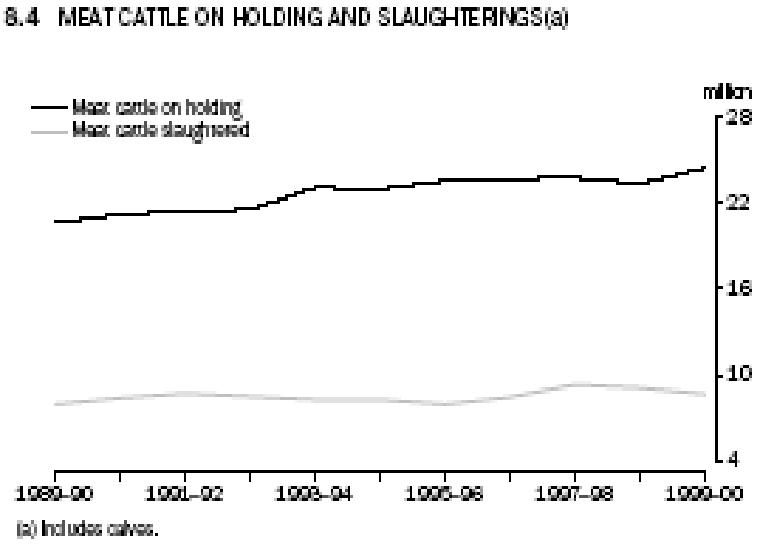

Fig. 3.12: *Meat cattle production characteristics (Australian Bureau of Statistics 2004a).*

Similar conditions hold for the sheep industry, where slaughterings have been fairly constant, but wool and sheep meat production have even decreased.

3.3.2.3 Marine Areas

Similarly to grazing area, a 'non-use' factor was applied to marine areas in order to match marine biocapacity with the primary production figure used by the Global Footprint Network.

3.3.2.4 Primary Production Account

A final post-adjustment comparison of primary production figures is shown below. This production account represents the *input data* for the calculus carried out at the University of Sydney, in the sense that these primary production amounts are distributed, first across downstream using industries, and ultimately to final demand items (private final consumption, government final consumption, changes in inventories, and exports).

	USyd total gha/cap	Non-fallow factor	USyd 'used' gha/cap	Global Footprint Network gha/cap
Cropland	1.59	100%	1.59	2.60
Forest AWS	0.69	100%	0.69	0.85
Permanent pasture	9.07	21%	1.94	1.87
Marine	2.84	6%	0.17	0.16
Inland water	0.00	100%	0.00	0.00
Built	0.29	100%	0.29	0.26

Tab. 3.5: *Australian production account (in '000 global hectares, '000 gha).*

Remaining differences between USyd and Global Footprint Network per-capita figures for marine areas and pastures are due to slightly differing populations in 1995 (18.3 million) and 2001 (19.4 million).

3.4 A first impression: The Ecological Footprint account for Australia's consumption

National accounts are usually arranged according to the National Accounting Identity stating that Gross National Turnover (GNT) breaks down into

GNT = GDP + Imports = GNE + Exports

with Gross National Exp (GNE) being

GNE = Private Final Consumption + Government Final Consumption
+ Gross Fixed Capital Exp + Changes in Inventories .

In input-output terms, GDP + imports is sometimes referred to as 'primary inputs', while GNE + exports is called 'final demand'. Using generalised input-output analysis, conventional financial accounts can be translated into accounts expressed in physical units, for example global hectares. The results of such a conversion (see Fig. 3.4) of Australia's 1994-95 financial accounts is shown in Tab. 3.6.

gha/cap	Production	Imports	Other final demand	Exports	Consumption
Cropland	1.59	0.10	0.05	0.96	0.67
Grazing land	1.94	0.09	0.09	1.10	0.85
Marine waters	0.17	0.00	0.01	0.04	0.11
Inland water	0.00	0.00	0.00	0.00	0.00
Forest AWS	0.69	0.15	0.45	0.12	0.26
Built	0.29	0.11	0.04	0.15	0.22
Fossil fuels – CO_2	4.46	1.05	0.73	1.49	3.29
Sum	9.14	1.50	1.38	3.86	5.39

Tab. 3.6: *Australia's national Ecological Footprint account 1994-95 (in global hectares per capita, gha/cap).*

The first value column is identical to the third column in Tab. 3.5, with the addition of 'Fossil fuels – CO_2', giving a total of 9.1 global hectares per capita hectares for Australia's production in 1994-95. Including requirements of imports, this figure increases by 1.5 gha/cap to about 10.6 gha/cap. In analogy to the financial account, this figure could be called 'Gross National Turnover in Ecological Footprint terms'.

The expenditure-side breakdown of GNT identifies private final consumption as the major Footprint cause, with 5.4 gha/cap, followed by exports (3.9 gha/cap) and government final consumption and changes in inventories (1.4 gha/cap). Note that gross fixed capital expenditure is consistently allocated to all components, since it was internalised into intermediate production in the input-output formalism.

3.4.1 Extrapolation to 2001

The figures in Tab. 3.6 refer to the financial year 1994-95. Since then, economic output, land use patterns and population have changed. In order to verify that the 1994-95 USyd account and the 2001 Global Footprint Network account are of comparable magnitude, we have made the following simplified assumptions:

- cropland use in Australia has grown by 63% (Fig. 3.9);
- grain exports have grown by 82% (Fig. 3.10);
- grazing land has not been expanded (Fig. 3.12);
- energy use in production has grown by 3%/annum or by 19 % in 6 years (Australian Bureau of Agricultural and Resource Economics 1999);
- real economic growth is 2%/annum (based on a nominal economic growth of about 5.6%/annum, minus population growth (about 1%/annum) minus inflation (about 2.7%/annum), so that over six years, the remaining quantities are assumed to have grown to $1.02^6 = 112.5\%$.

gha/cap	Production	Imports	Other final demand	Exports	Consumption
Cropland	63.4%	12.5%	12.5%	114.3%	12.5%
Grazing land	0.0%	0.0%	0.0%	0.0%	0.0%
Marine waters	0.0%	12.5%	12.5%	12.5%	12.5%
Inland water	12.5%	12.5%	12.5%	12.5%	12.5%
Forest AWS	12.5%	12.5%	12.5%	12.5%	12.5%
Built	12.5%	12.5%	12.5%	12.5%	12.5%

Fossil fuels – CO_2	19.4%	12.5%	12.5%	12.5%	12.5%

***Tab. 3.7**: Scaling factors for extrapolation to 2001.*

The result of scaling figures in Tab. 3.6 with factors in Tab. 3.7 is the extrapolated Ecological Footprint account in Tab. 3.8.

gha/cap	Production	Imports	Other final demand	Exports	Consumption
Cropland	2.59	0.11	0.06	2.06	0.75
Grazing land	1.94	0.09	0.09	1.10	0.85
Marine waters	0.17	0.00	0.01	0.05	0.12
Inland water	0.00	0.00	0.00	0.00	0.00
Forest AWS	0.77	0.16	0.51	0.13	0.29
Built	0.33	0.12	0.04	0.17	0.24
Fossil fuels – CO_2	5.33	1.18	0.82	1.68	3.70
Sum	11.13	1.67	1.54	5.19	5.96

***Tab. 3.8:** Australia's national Ecological Footprint account, extrapolated to 2001 (in global hectares per capita, gha/cap).*

Australia's consumption Ecological Footprint is now projected to be 6 global hectares per capita. This can be compared with the Ecological Footprint account calculated according to the Global Footprint Network method (Tab. 3.9).

gha/cap	Production	Imports	Other final demand	Exports	Consumption
Cropland	2.60	0.11	0.12	1.74	1.09
Grazing land	1.87	0.01	0.00	1.09	0.78
Marine waters	0.16	0.19	0.00	0.07	0.33
Inland water	0.00	0.01	0.00	0.00	0.01
Forest AWS	0.85	0.13	0.00	0.14	0.84
Built	0.26	0.00	0.00	0.00	0.26
Fossil fuels – CO_2	5.25	0.95	0.00	1.86	4.34
Sum	11.00	1.39	0.12	4.90	7.65

***Tab. 3.9:** Australia's national Ecological Footprint account for 2001, Global Footprint Network data (global hectares per capita, gha/cap).*

3.5 Detailed Ecological Footprint accounts for Australia, 1998-99

Tab. 3.10 shows Australia's consumption-land-use matrix, obtained from HES data and USyd input-output results by conversion into Global Footprint Network categories (see Section 3.2.2). Differences with respect to Tabs. 3.6 and 3.9 arise because base years and data sources differ. Note that this matrix contains government final consumption in the respective rows. 'Housing maintenance' contains the physical area of the building, while 'New construction' contains construction materials. 'Transit infrastructure' is contained in 'Government services'. 'Motorcycles' includes ships.

	Primary cropland (gha)	Forest AWS (gha)	Permanent pasture (gha)	Marine (gha)	Inland water (gha)	Built (gha)	CO2 land (gha)	Sum
Food	0.44	0.05	0.44	0.07		0.01	0.40	1.42
.plant-based	0.33	0.04	0.11	0.00		0.01	0.28	0.76
.animal-based	0.11	0.02	0.32	0.07		0.00	0.12	0.65
Housing	0.00	0.02	0.00			0.11	0.97	1.10
.new construction		0.00					0.02	0.02
.maintenance						0.10		0.10
.residential energy use	0.00	0.01	0.00			0.01	0.94	0.97
..electricity		0.00	0.00			0.01	0.77	0.79
..natural gas							0.14	0.14
..fuelwood		0.01					0.00	0.01
..fuel oil, kerosene, LPG, coal							0.03	0.03
Mobility	0.01	0.01	0.01			0.02	0.55	0.60
.passenger cars and trucks	0.00	0.01	0.01			0.00	0.40	0.42
.transit infrastructure								
.motorcycles							0.01	0.01
.passenger air	0.00	0.00	0.00			0.01	0.10	0.11
.passenger public transit		0.00	0.00			0.01	0.05	0.06
Goods	0.05	0.08	0.26	0.00		0.03	0.71	1.12
.appliance manufacturing		0.00	0.00			0.00	0.06	0.07
.furniture	0.00	0.02	0.03			0.00	0.04	0.09
.computers and electrical equipment		0.00					0.03	0.03
.clothing and shoes	0.01	0.00	0.15			0.00	0.05	0.23
.cleaning products and services	0.01	0.00	0.00				0.03	0.04
.other household products	0.00	0.00	0.04			0.00	0.04	0.09
.paper products		0.01					0.02	0.03
.tobacco	0.00	0.00	0.00				0.01	0.02
.other misc. goods	0.02	0.04	0.03	0.00		0.02	0.43	0.54
Services	0.20	0.54	0.16	0.04		0.08	1.53	2.57
.water and sewage		0.00	0.00			0.00	0.03	0.04
.telephone and cable service	0.00	0.01	0.00			0.00	0.07	0.08
.solid waste						0.00	0.00	0.00
.financial and legal	0.01	0.01	0.01			0.00	0.08	0.11
.medical	0.00	0.00	0.00			0.00	0.03	0.04
.real estate and rental lodging	0.01	0.04	0.01			0.01	0.21	0.27
.entertainment	0.13	0.02	0.08	0.03		0.02	0.26	0.55
.Government	0.05	0.45	0.05	0.01		0.04	0.71	1.31
..non-military, non-road	0.05	0.45	0.04	0.01		0.04	0.62	1.20
..military	0.00	0.01	0.01			0.00	0.09	0.11
.other misc. services	0.00	0.01	0.01			0.01	0.14	0.17
Sum	0.71	0.70	0.87	0.12		0.25	4.16	6.80

Tab. 3.10: *Consumption-land-use matrix of Australia's Ecological Footprint, 1998-99. Cells containing values of less than 0.001 gha/cap are empty.*

In the following, the detailed results of this Ecological Footprint study are presented for Australia's households in the order of

1. Commodity breakdown,
2. Commodity spiders,
3. Production layer decomposition,
4. Structural path analysis, and
5. Commodity and path summary.

In contrast to the national account (Section 3.4), these results are calculated based on consumer purchase data taken from the 1998-99 Household Expenditure Survey.

3.5.1 Commodity Breakdown

As a first step in providing more detail, aggregate total figures for Australia's Ecological Footprint are broken down into expenditures on purchased commodities.

Rank	Commodity	Impact	% of total
1	Electricity supply	0.79	14.24%
2	Accommodation, cafes and restaurants	0.47	8.56%
3	Beef products	0.37	6.67%
4	Ownership of dwellings	0.35	6.26%
5	Retail trade	0.32	5.79%
6	Petrol	0.28	5.10%
7	Raw sugar, animal feeds, processed seafoods and other food products	0.22	4.05%
8	Clothing	0.18	3.19%
9	Wholesale trade	0.12	2.26%
10	Motor vehicles and parts, other transport equipment	0.12	2.25%
11	Dairy products	0.12	2.21%
12	Air transport	0.11	2.03%
13	Flour, cereal foods, rice, pasta and other flour mill products	0.10	1.81%
14	Vegetable and fruit growing, hay, plant nurseries, flowers	0.10	1.72%
15	Gas production and distribution	0.09	1.66%
16	Bread, cakes, biscuits and other bakery products	0.09	1.59%
17	Commercial fishing	0.09	1.56%
18	Communication services	0.08	1.52%
19	Sheep, lambs, wool	0.08	1.42%
20	Household appliances and hot water systems	0.07	1.22%
21	Vegetables, fruit, juices, jams and other fruit and vegetable products	0.06	1.09%
22	Banking	0.05	0.93%
23	Furniture	0.05	0.90%
24	Liquefied natural gas, liquefied natural petrol	0.05	0.89%
25	Hairdressing, goods hiring, film processing, laundry and other personal services	0.05	0.83%
26	Coins, jewellery, sporting goods, toys, signs, brushes and other manufacturing	0.05	0.82%
27	Health services	0.04	0.77%
28	Processed wool, textile fibres, yarns and woven fabrics	0.04	0.77%
29	Soft drinks, cordials and syrups	0.04	0.76%
30	Sport, gambling and recreational services	0.04	0.73%

***Tab. 3.11**: Commodity breakdown of Australia's population's Ecological Footprint, 1998-99.*

Tab. 3.11 shows a ranked breakdown of Australians' Ecological Footprint into the most important commodities needed for living. The Footprint figures in the second column include all upstream impacts, and the figures in the third column give the percentage of the commodity in the total Footprint. All figures reported are in per-capita terms. Error margins for values quoted are in the order of 10-20%.

By far the most important commodity is electricity used in the household, accounting for nearly 0.8 gha/cap or 15% of the total consumption-based Ecological Footprint. Australians spend a relatively high proportion of their expenditure on meals out, so that this commodity ranks second at almost 0.5 gha/cap or 9% of the total. Beef follows with about 7%. The commodity 'ownership of dwellings' comprises all requirements to either maintain rental accommodation, or to build, renovate and maintain owned apartments and houses. 'Retail trade' includes a whole range of services related to bringing goods from the point of wholesale to the consumer, and storing, and selling them. 'Petrol' is almost exclusively combusted in private cars. Rank 7 comprises a large range of food items not included elsewhere. Amongst the lower ranks, cotton land embodied in clothing (8^{th}), grazing land in dairy products (11^{th}), and aviation turbine fuel embodied in air tickets (12^{th}) can be found. The remainder is largely self-explanatory, but will be "unravelled" in the more detailed breakdowns in the Sections to follow.

3.5.2 Spider Diagrams

As a second step, spider diagrams provide an elegant way of depicting multi-faceted information in one compressed visual representation. The spider diagrams support multi-criteria decision-making by making trade-offs between Ecological Footprint components (land types and CO_2 emissions) visible.

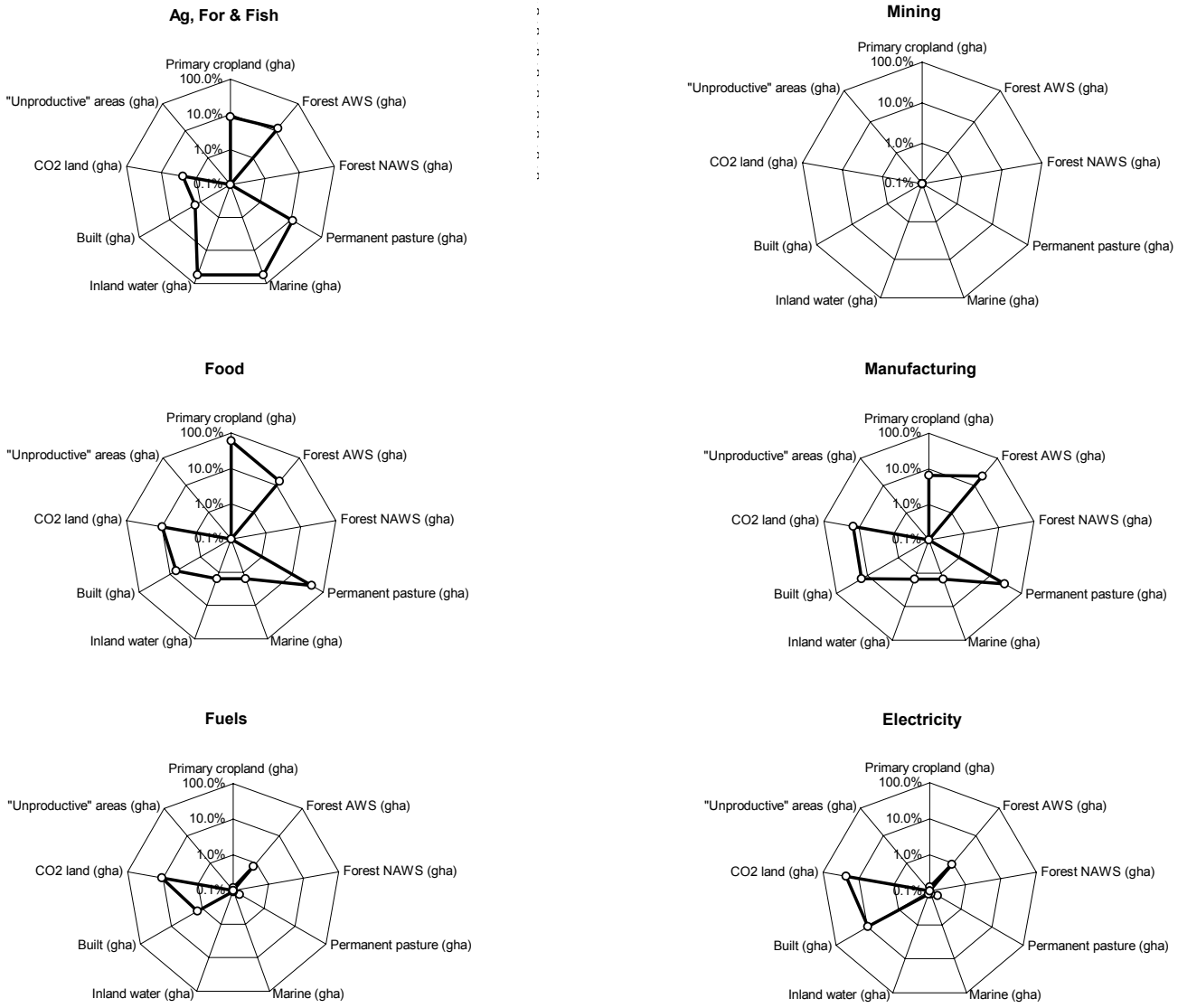

Fig. 3.13: *Spider diagrams for various consumer item groups purchased by the Australian population, 1998-99.*

In the upper left diagram, for example, the population's purchases directly from agricultural, forestry and fishing sectors are analysed. The importance of food in terms of Ecological Footprint components is depicted as a percentage of the Australian population's total Ecological Footprint. The central element is the bold polygon. The further outwards it extends, the higher the relative impact of the consumer item on the respective component. Note that the radial scale is logarithmic, that is, a step from one concentric line to the other represents a factor of ten.

For example, in terms of marine and inland waters, purchases from agriculture, forestry and fisheries (for example fresh fish) is responsible for more than 50% of the Australian

population's total impact on these Ecological Footprint categories. In terms of crop and grazing land however, the proportion is only about 10%, because most meat, vegetables and fruit are bought from food-processing industries, and not directly from farms. The corresponding retail purchases then appear in the middle left diagram, under 'food' industries. The 'Mining' diagram is empty, because households don't purchase mining commodities. The spider diagrams in the figures above and below represent a complete breakdown of the Australian economy.

The diagram for water can illustrate trade-offs in changes of consumption patterns. A long-term increase in water purchases would affect mainly the built land component (more dams, pipelines etc) and the CO_2 land (more electricity for pumping). Other Ecological Footprint components would be less affected.

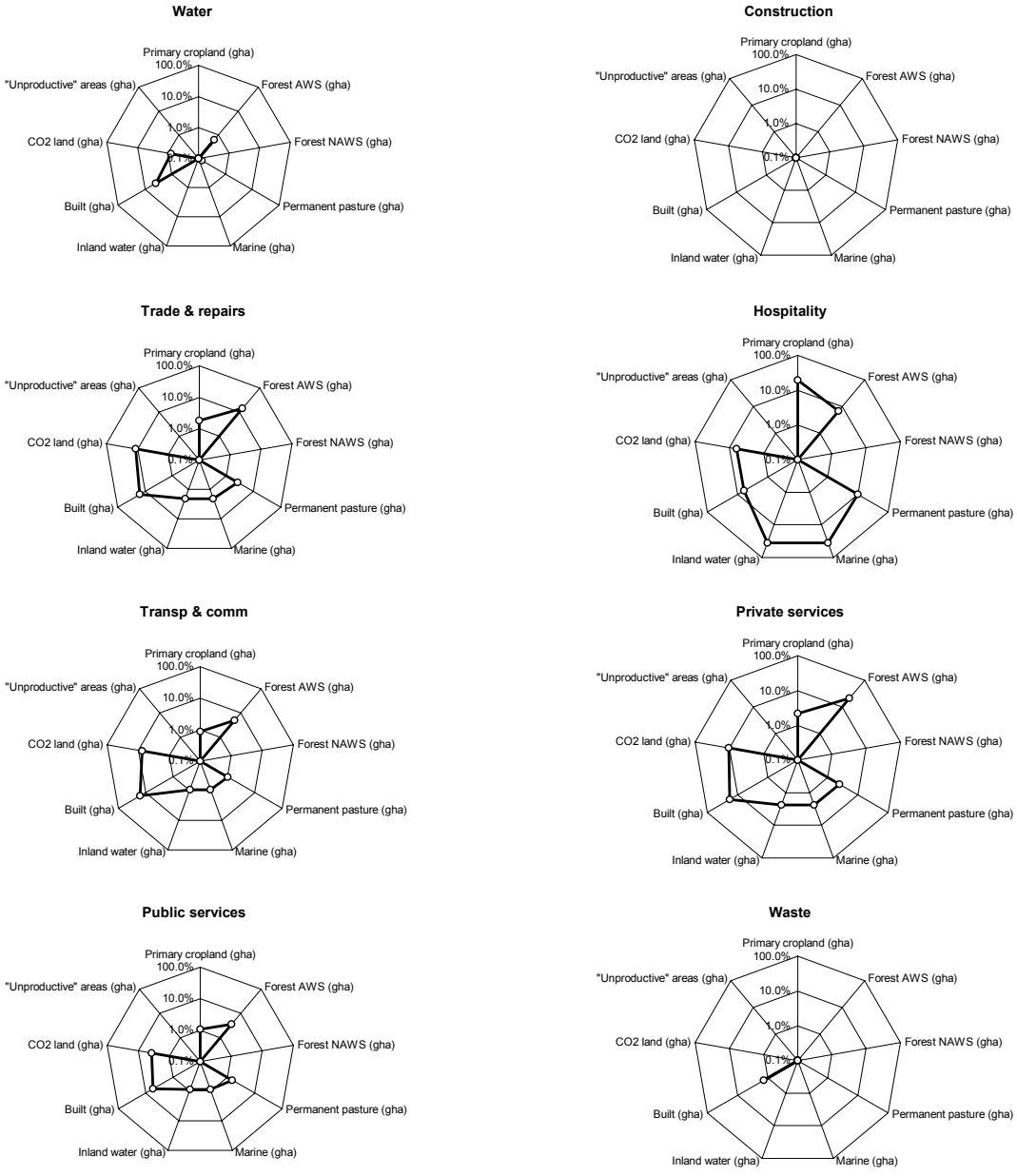

Fig. 3.14*: Spider diagrams for various consumer item groups purchased by the Australian population, 1998-99 (continued).*

3.5.3 Production Layer Decomposition

As a third step, the commodity spiders can be decomposed into contributions originating in different production layers. As an example, Fig. 3.15 shows a production layer decomposition (PLD) for the Australian population's Ecological Footprint, excluding government final consumption.

The Ecological Footprint caused directly by the population (order zero; for example from car travel, or on-site gas combustion) is low. Order 1 includes all suppliers of commodities purchased by the population. The 1st-order (embodied) Ecological Footprint includes for example fossil energy combusted in power plants supplying Australians with electricity, or energy used during extraction, refining and distribution of fuels purchased by Australians. 2nd-order contributions originate from suppliers of suppliers. An example here is land used in agriculture for food, or emissions from steel sheet manufacturing for cars.

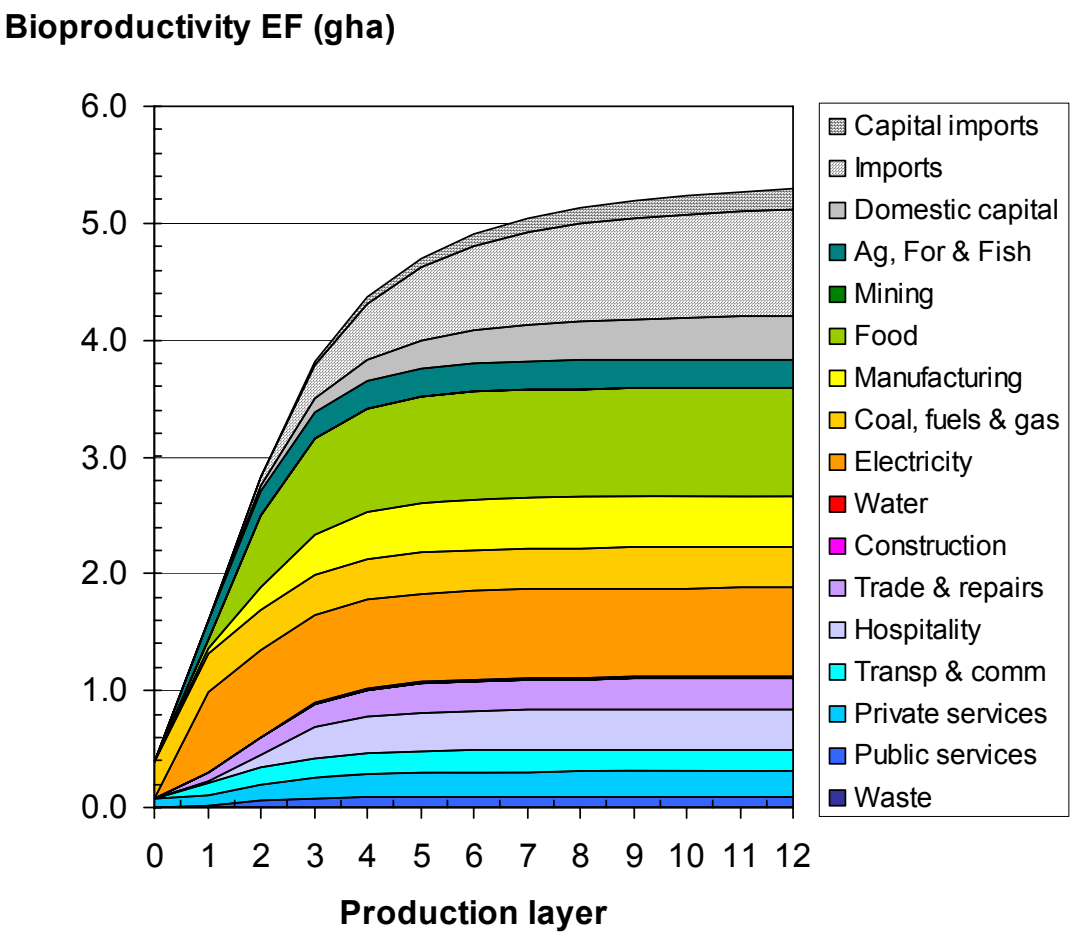

Fig. 3.15: *Production layer decomposition for the Australian population's Ecological Footprint, 1998-99.*

The "suppliers of the suppliers of the suppliers" of the population are in production layer 3, and so on. Fig. 3.15 shows that even though supply chains become more and more remote and complex, they contribute significantly up to higher orders. Therefore, omitting these upstream impacts causes severe errors in an Ecological Footprint assessment.

3.5.4 Structural Path Analysis (SPA)

In a fourth step, the production layers are decomposed once more into their structural paths. Each path is characterised by a code, consisting of (1) the path rank, (2) the path value, (3) a description of the path nodes, and in the first brackets (4) the path order, and (5) the path coverage in % of the respective Footprint component, and finally in the second brackets (6), the relative contribution in % to the total Ecological Footprint.

Rank	gha	Ecological footprint	% of total
1	0.67	CO2 land > Electricity supply : (1; 19.%)	(19.2%)
2	0.24	Pasture > Beef cattle > Meat products : (2; 28.%)	(6.9%)
3	0.23	CO2 land > Automotive petrol : (0; 6.7%)	(6.6%)
4	0.10	Built > Ownership of dwellings : (0; 46.%)	(2.8%)
5	0.08	CO2 land > Gas production and distribution : (0; 2.3%)	(2.3%)
6	0.07	Pasture > Sheep and shorn wool : (1; 8.2%)	(1.9%)
7	0.07	Marine > Commercial fishing : (1; 64.%)	(1.9%)
8	0.06	Cropland > Wheat & other grains > Flour and cereal foods : (2; 9.%)	(1.7%)
9	0.06	CO2 land > Air transport : (1; 1.6%)	(1.6%)
10	0.06	Cropland > Wheat & other grains > Other food products : (2; 8.3%)	(1.6%)
11	0.05	CO2 land > Other food products : (1; 1.5%)	(1.5%)
12	0.05	Pasture > Beef cattle > Meat products > Accomm, cafes and restaurants : (3; 6.%)	(1.4%)
13	0.05	CO2 land > Electricity supply > Accomm, cafes and restaurants : (2; 1.4%)	(1.4%)
14	0.05	CO2 land > Retail trade : (1; 1.4%)	(1.4%)
15	0.05	Cropland > Barley > Beer and malt > Accomm, cafes and restaurants : (3; 7.3%)	(1.4%)
16	0.05	CO2 land > LNG, LPG : (0; 1.3%)	(1.3%)
17	0.04	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics > Clothing : (3; 5.%)	(1.2%)
18	0.04	CO2 land > Electricity supply > Retail trade : (2; 1.%)	(1.0%)
19	0.03	Marine > Commercial fishing > Accomm, cafes and restaurants : (2; 27.%)	(0.8%)
20	0.03	Pasture > Sheep and shorn wool > Meat products : (2; 3.1%)	(0.7%)
21	0.03	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics : (2; 3.1%)	(0.7%)
22	0.03	CO2 land > Diesel : (0; 0.74%)	(0.7%)
23	0.02	Cropland > Wheat & other grains > Flour and cereal foods > Bakery products : (3; 3.%)	(0.6%)
24	0.02	CO2 land > Wholesale trade : (1; 0.57%)	(0.6%)
25	0.02	CO2 land > Automotive petrol : (1; 0.55%)	(0.5%)
26	0.02	Cropland > Barley > Beer and malt : (2; 2.5%)	(0.5%)
27	0.02	Cropland > Dairy cattle & milk > Dairy products : (2; 2.4%)	(0.5%)
28	0.01	Cropland > Vegetable and fruit growing : (1; 2.1%)	(0.4%)
29	0.01	Cropland > Beef cattle > Meat products : (2; 2.%)	(0.4%)
30	0.01	Forest AWS > Forestry > Vegetable and fruit growing : (2; 5.2%)	(0.4%)

***Tab. 3.12**: Structural Path Analysis for Australia's Ecological Footprint.*

For example, the structural path ranking 23rd:

0.02 Cropland > Wheat & other grains > Flour and cereal foods > Bakery products (3; 3.%) (0.4%)

(boxed), describes cropland that is used to grow grains sold to flour mills producing flour for bakeries selling bread to Australians. The path value is 0.02 global hectares. The path is of 3rd order, and constitutes a coverage of 3.0% of the total cropland appropriated by Australians. It also represents 0.4% of Australians' total per-capita Ecological Footprint. In all Structural Path Analyses, the right-most commodity is the one that links back to the commodity breakdown table (Section 3.5.1) for each indicator. Not all commodities listed in a top-30 commodity breakdown appear amongst the top-30 structural paths. Note that the number of significant figures quoted in tables does not reflect accuracy.

3.5.5 Commodity and Path Summary

The commodity and path summary combines the commodity ranking (3.5.1) and structural path analysis (3.5.4) into one overview table, listing first the *commodity* rank and the commodity name. Following, for top-30 paths linking to that commodity, order, description, value (in global hectares per capita) and the percentage contribution to the total Footprint are listed. 'No dominant path' is listed if the most important path linking to a commodity is not amongst the top-30.

Commodity rank	Commodity	Path order	Path description	Value	Percentage of total impact
1	Electricity supply	1	CO2 land > Electricity supply > Australia	0.67	12.12%
2	Accommodation, cafes and restaurants	3	Pasture > Beef cattle > Meat products > Accomm, cafes and restaurants > Australia	0.05	0.90%
		2	CO2 land > Electricity supply > Accomm, cafes and restaurants > Australia	0.05	0.89%
		3	Cropland > Barley > Beer and malt > Accomm, cafes and restaurants > Australia	0.05	0.87%
		2	Marine > Commercial fishing > Accomm, cafes and restaurants > Australia	0.03	0.52%
3	Beef products	2	Pasture > Beef cattle > Meat products > Australia	0.24	4.34%
		2	Pasture > Sheep and shorn wool > Meat products > Australia	0.03	0.47%
		2	Cropland > Beef cattle > Meat products > Australia	0.01	0.24%
4	Ownership of dwellings	0	Built > Ownership of dwellings > Australia	0.10	1.79%
5	Retail trade	1	CO2 land > Retail trade > Australia	0.05	0.89%
		2	CO2 land > Electricity supply > Retail trade > Australia	0.04	0.65%
6	Petrol	0	CO2 land > Automotive petrol > Australia	0.23	4.16%
		1	CO2 land > Automotive petrol > Australia	0.02	0.34%
7	Raw sugar, animal feeds, processed seafoods and other food products	2	Cropland > Wheat & other grains > Other food products > Australia	0.06	1.00%
		1	CO2 land > Other food products > Australia	0.05	0.96%
8	Clothing	3	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics > Clothing > Australia	0.04	0.76%
9	Wholesale trade	1	CO2 land > Wholesale trade > Australia	0.02	0.36%
10	Motor vehicles and parts, other transport equipment	all	No dominant path	0.12	2.25%
11	Dairy products	2	Cropland > Dairy cattle & milk > Dairy products > Australia	0.02	0.29%
12	Air transport	1	CO2 land > Air transport > Australia	0.06	1.03%
13	Flour, cereal foods, rice, pasta and other flour mill products	2	Cropland > Wheat & other grains > Flour and cereal foods > Australia	0.06	1.07%
14	Vegetable and fruit growing, hay, plant nurseries, flowers	1	Cropland > Vegetable and fruit growing > Australia	0.01	0.25%
		2	Forest AWS > Forestry > Vegetable and fruit growing > Australia	0.01	0.24%
15	Gas production and distribution	0	CO2 land > Gas production and distribution > Australia	0.08	1.43%
16	Bread, cakes, biscuits and other bakery products	3	Cropland > Wheat & other grains > Flour and cereal foods > Bakery products > Australia	0.02	0.36%
17	Commercial fishing	1	Marine > Commercial fishing > Australia	0.07	1.23%
18	Communication services	all	No dominant path	0.08	1.52%
19	Sheep, lambs, wool	1	Pasture > Sheep and shorn wool > Australia	0.07	1.23%
20	Household appliances and hot water systems	all	No dominant path	0.07	1.22%

Tab. 3.13: *Commodity and path summary for Australia's Ecological Footprint.*

3.6 Detailed Ecological Footprint accounts for Victoria, 1998-99

Tab. 3.14 shows Victoria's consumption-land-use matrix, obtained from USyd results through conversion into Global Footprint Network categories (see Section 3.2.2). Victoria's Ecological Footprint is slightly higher than Australia's. Since the expenditure patterns are almost identical (Fig. 3.2), this is mainly due to generally higher levels of expenditure. Note that this matrix contains government final consumption in the respective rows. 'Housing maintenance' contains the physical area of the building, while 'New construction' contains construction materials. 'Transit infrastructure' is contained in 'Government services'. 'Motorcycles' includes ships.

	Primary cropland (gha)	Forest AWS (gha)	Permanent pasture (gha)	Marine (gha)	Inland water (gha)	Built (gha)	CO2 land (gha)	Sum
Food	0.45	0.05	0.45	0.07		0.01	0.42	1.46
.plant-based	0.34	0.04	0.04	0.00		0.01	0.28	0.71
.animal-based	0.12	0.02	0.41	0.07		0.00	0.13	0.75
Housing	0.00	0.02	0.00			0.11	1.15	1.28
.new construction		0.00					0.02	0.02
.maintenance						0.10		0.10
.residential energy use	0.00	0.02	0.00			0.01	1.13	1.16
..electricity		0.00	0.00			0.01	0.82	0.83
..natural gas		0.00				0.00	0.29	0.29
..fuelwood		0.02					0.00	0.02
..fuel oil, kerosene, LPG, coal							0.02	0.02
Mobility	0.01	0.01	0.01			0.02	0.58	0.63
.passenger cars and trucks	0.00	0.01	0.01			0.01	0.42	0.45
.transit infrastructure								
.motorcycles							0.00	0.01
.passenger air	0.00	0.00	0.00			0.01	0.10	0.12
.passenger public transit		0.00	0.00			0.01	0.05	0.06
Goods	0.05	0.08	0.26	0.00		0.03	0.71	1.13
.appliance manufacturing		0.00	0.00			0.00	0.06	0.06
.furniture	0.00	0.02	0.03			0.00	0.04	0.09
.computers and electrical equipment		0.00	0.00				0.03	0.04
.clothing and shoes	0.01	0.00	0.17			0.00	0.06	0.25
.cleaning products and services	0.01	0.00	0.00				0.03	0.04
.other household products	0.00	0.00	0.03			0.00	0.04	0.07
.paper products		0.01					0.02	0.03
.tobacco	0.00	0.00	0.00				0.01	0.02
.other misc. goods	0.02	0.04	0.03	0.00		0.02	0.44	0.54
Services	0.21	0.54	0.17	0.05		0.08	1.56	2.61
.water and sewage		0.00	0.00			0.01	0.03	0.04
.telephone and cable service	0.00	0.01	0.00			0.00	0.07	0.08
.solid waste						0.00	0.00	0.00
.financial and legal	0.00	0.01	0.01			0.00	0.08	0.10
.medical	0.00	0.00	0.00			0.00	0.04	0.05
.real estate and rental lodging	0.01	0.04	0.01			0.01	0.21	0.27
.entertainment	0.14	0.03	0.09	0.03		0.02	0.28	0.58
.Government	0.05	0.45	0.05	0.01		0.04	0.71	1.30
..non-military, non-road	0.05	0.45	0.04	0.01		0.04	0.62	1.19
..military	0.00	0.01	0.01			0.00	0.09	0.11
.other misc. services	0.00	0.01	0.01			0.01	0.15	0.18
Sum	0.72	0.70	0.89	0.12		0.25	4.42	7.11

Tab. 3.14: *Consumption-land-use matrix of Victoria's Ecological Footprint, 1998-99. Cells containing values of less than 0.001 gha/cap are empty.*

In the following, the detailed results of this Ecological Footprint study are presented for Victoria's households in the order of

1. Commodity breakdown,
2. Commodity spiders,
3. Production layer decomposition,
4. Structural path analysis, and
5. Commodity and path summary.

In contrast to the national account (Section 3.4), these results are calculated based on consumer purchase data taken from the 1998-99 Household Expenditure Survey. Since similar results have been presented for Australia (Section 3.5), comments are made in this Section only where results differ.

3.6.1 Commodity Breakdown

As a first step in providing more detail, aggregate figures (Section 3.4) for Victoria's Ecological Footprint are broken down into expenditures on purchased commodities.

Rank	Commodity	Impact	% of total
1	Electricity supply	0.83	14.29%
2	Accommodation, cafes and restaurants	0.50	8.60%
3	Beef products	0.38	6.45%
4	Ownership of dwellings	0.34	5.89%
5	Retail trade	0.33	5.71%
6	Petrol	0.29	4.99%
7	Raw sugar, animal feeds, processed seafoods and other	0.23	3.95%
8	Gas production and distribution	0.20	3.51%
9	Clothing	0.19	3.26%
10	Motor vehicles and parts, other transport equipment	0.14	2.47%
11	Wholesale trade	0.13	2.20%
12	Dairy products	0.13	2.15%
13	Air transport	0.12	2.00%
14	Flour, cereal foods, rice, pasta and other flour mill	0.11	1.82%
15	Vegetable and fruit growing, hay, plant nurseries, flowers	0.10	1.66%
16	Bread, cakes, biscuits and other bakery products	0.10	1.64%
17	Commercial fishing	0.09	1.50%
18	Sheep, lambs, wool	0.09	1.47%
19	Liquefied natural gas, liquefied natural petrol	0.09	1.47%
20	Communication services	0.08	1.38%
21	Vegetables, fruit, juices, jams and other fruit and vegetable	0.06	1.03%
22	Household appliances and hot water systems	0.06	1.02%
23	Banking	0.05	0.90%
24	Furniture	0.05	0.88%
25	Hairdressing, goods hiring, film processing, laundry and	0.05	0.88%
26	Health services	0.05	0.78%
27	Railway passenger transport services	0.05	0.78%
28	Sport, gambling and recreational services	0.04	0.71%
29	Soft drinks, cordials and syrups	0.04	0.69%
30	Water supply, sewerage and drainage services	0.04	0.69%

Tab. 3.15: *Commodity breakdown of Victoria's population's Ecological Footprint, 1998-99.*

By far the most important commodity is once again electricity used in the household, accounting for more than 0.7 gha/cap or 13% of the total consumption-based Ecological Footprint. As Australians, Victorians spend a relatively high proportion of their expenditure on meals out, so that this commodity ranks second at almost 0.5 gha/cap or 9% of the total. Beef follows with about 7%. The commodity 'ownership of dwellings' comprises all requirements to either maintain rental accommodation, or to build, renovate and maintain owned apartments and houses. 'retail trade' includes a whole range of services related to bringing goods from the point of wholesale to the consumer, and storing, and selling them. 'Petrol' is almost exclusively combusted in private cars. Rank 7 comprises a large range of food items not included elsewhere. The remainder is largely self-explanatory, but will be "unravelled" in the more detailed breakdowns in the Sections to follow.

The main difference between Victoria and Australia's breakdowns is that distributed and bottled gas is consumed to a larger extent in Victoria, probably due to higher space heating requirements. Corresponding rank shifts are 15^{th} to 8^{th} (distributed gas) and 24^{th} to 19^{th} (bottled gas). As a consequence, the Ecological Footprint due to electricity consumption is slightly lower in Victoria.

3.6.2 Spider Diagrams

As a second step, spider diagrams provide an elegant way of depicting multi-faceted information in one compressed visual representation. The spider diagrams support multi-criteria decision-making by making trade-offs between Ecological Footprint components (land types and CO_2 emissions) visible.

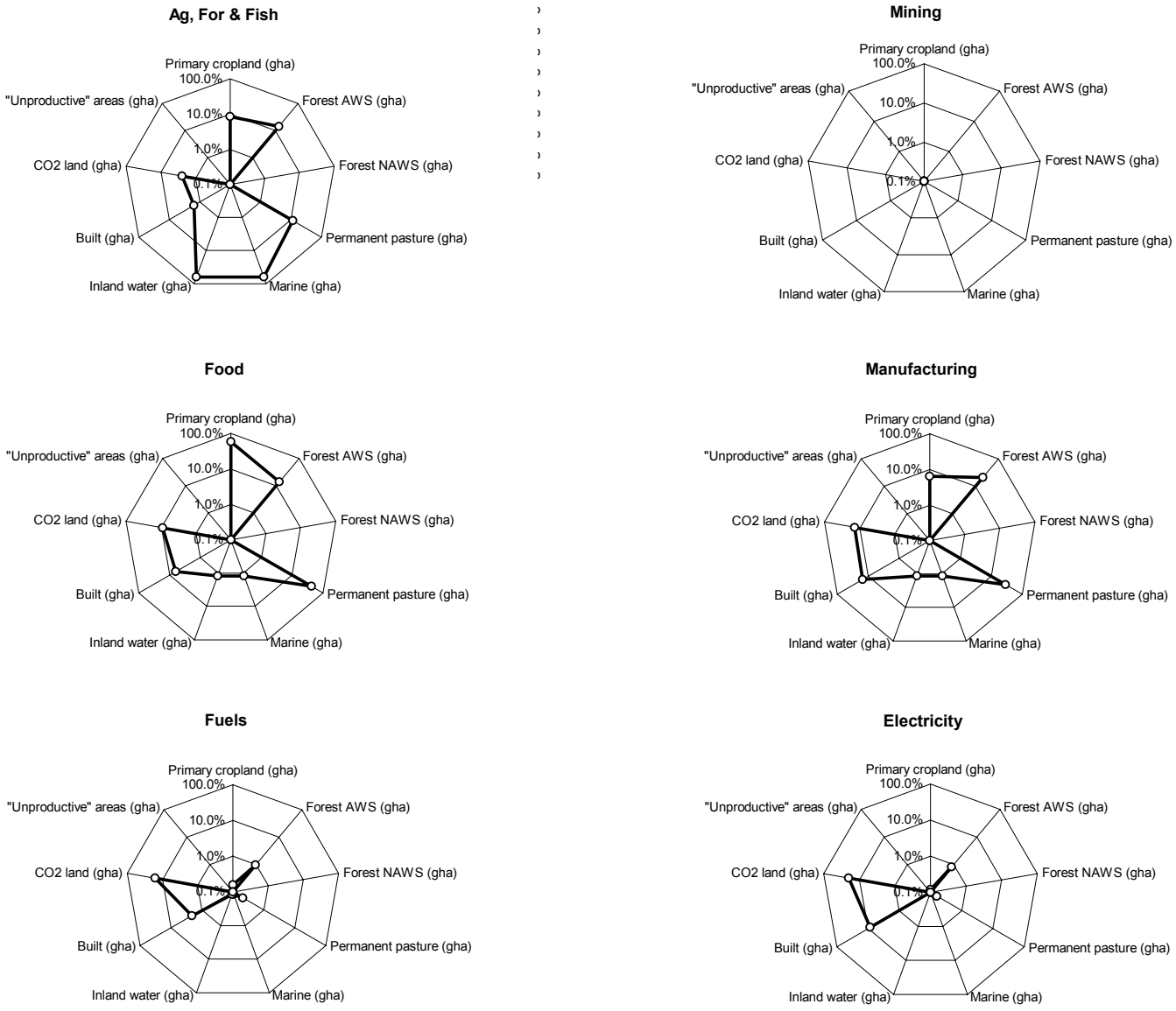

Fig. 3.16: *Spider diagrams for various consumer item groups purchased by the Victorian population, 1998-99.*

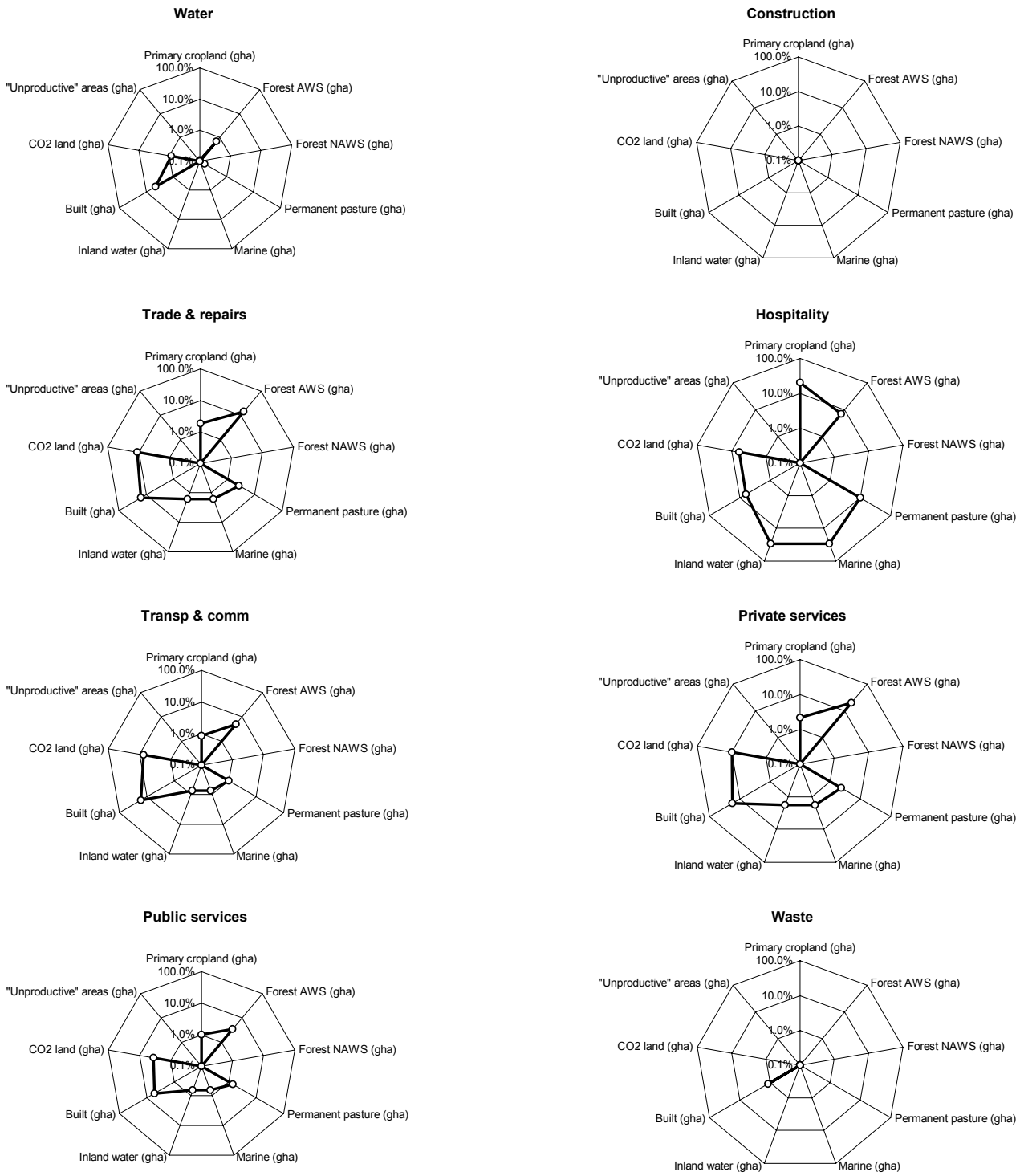

Fig. 3.17: *Spider diagrams for various consumer item groups purchased by the Victorian population, 1998-99 (continued).*

3.6.3 Production Layer Decomposition

As a third step, the commodity spiders can be decomposed into contributions originating in different production layers. As an example, Fig. 3.18 shows a production layer decomposition (PLD) for the Victorian population's Ecological Footprint, excluding government final consumption.

The Ecological Footprint caused directly by the population (order zero; for example from car travel, or on-site gas combustion) is low. Order 1 includes all suppliers of commodities purchased by the population. The 1st-order (embodied) Ecological Footprint includes for example fossil energy combusted in power plants supplying Australians with electricity, or energy used during extraction, refining and distribution of fuels purchased by Australians. 2nd-order contributions originate from suppliers of suppliers. An example here is land used in agriculture for food, or emissions from steel sheet manufacturing for cars.

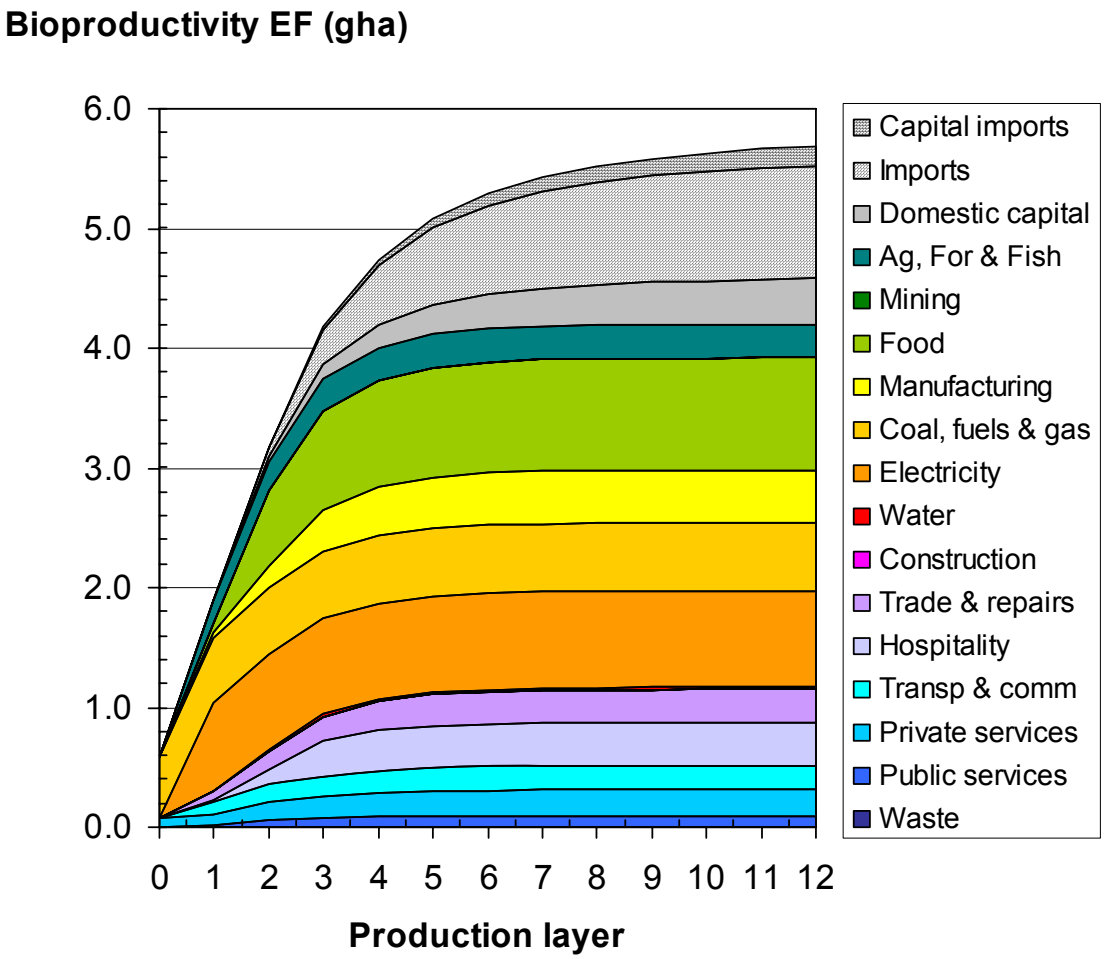

Fig. 3.18: *Production layer decomposition for the Victorian population's Ecological Footprint, 1998-99, excluding government final consumption.*

The "suppliers of the suppliers of the suppliers" of the population are in production layer 3, and so on. Fig. 18 shows that even though supply chains become more and more remote and complex, they contribute significantly up to higher orders. Therefore, omitting these upstream impacts causes severe errors in an Ecological Footprint assessment.

3.6.4 Structural Path Analysis (SPA)

In a fourth step, the production layers are decomposed once more into their structural paths. Each path is characterised by a code, consisting of (1) the path rank, (2) the path value, (3) a description of the path nodes, and in the first brackets (4) the path order, and (5) the path coverage in % of the respective Footprint component, and finally in the second brackets (6), the relative contribution in % to the total Ecological Footprint.

Rank	gha	Ecological footprint	% of total
1	0.72	CO2 land > Electricity supply : (1; 19.%)	(19.3%)
2	0.24	Pasture > Beef cattle > Meat products : (2; 28.%)	(6.4%)
3	0.24	CO2 land > Automotive petrol : (0; 6.4%)	(6.4%)
4	0.17	CO2 land > Gas production and distribution : (0; 4.7%)	(4.5%)
5	0.10	Built > Ownership of dwellings : (0; 46.%)	(2.6%)
6	0.08	CO2 land > LNG, LPG : (0; 2.1%)	(2.1%)
7	0.07	Pasture > Sheep and shorn wool : (1; 8.7%)	(2.0%)
8	0.07	Marine > Commercial fishing : (1; 63.%)	(1.8%)
9	0.06	Cropland > Wheat & other grains > Flour and cereal foods : (2; 9.2%)	(1.7%)
10	0.06	CO2 land > Air transport : (1; 1.6%)	(1.6%)
11	0.06	CO2 land > Electricity supply > Accomm, cafes and restaurants : (2; 1.6%)	(1.6%)
12	0.06	Cropland > Wheat & other grains > Other food products : (2; 8.3%)	(1.5%)
13	0.05	CO2 land > Other food products : (1; 1.5%)	(1.4%)
14	0.05	Pasture > Beef cattle > Meat products > Accomm, cafes and restaurants : (3; 6.1%)	(1.4%)
15	0.05	Cropland > Barley > Beer and malt > Accomm, cafes and restaurants : (3; 7.4%)	(1.3%)
16	0.05	CO2 land > Retail trade : (1; 1.3%)	(1.3%)
17	0.05	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics > Clothing : (3; 5.3%)	(1.2%)
18	0.04	CO2 land > Electricity supply > Retail trade : (2; 1.1%)	(1.1%)
19	0.03	Marine > Commercial fishing > Accomm, cafes and restaurants : (2; 28.%)	(0.8%)
20	0.03	Pasture > Sheep and shorn wool > Meat products : (2; 3.1%)	(0.7%)
21	0.02	Cropland > Wheat & other grains > Flour and cereal foods > Bakery products : (3; 3.2%)	(0.6%)
22	0.02	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics : (2; 2.5%)	(0.6%)
23	0.02	CO2 land > Wholesale trade : (1; 0.55%)	(0.5%)
24	0.02	CO2 land > Automotive petrol : (1; 0.53%)	(0.5%)
25	0.02	Cropland > Dairy cattle & milk > Dairy products : (2; 2.4%)	(0.4%)
26	0.02	CO2 land > Gas production and distribution : (1; 0.4%)	(0.4%)
27	0.02	CO2 land > Basic iron and steel > Motor vehicles and parts : (2; 0.39%)	(0.4%)
28	0.01	Cropland > Barley > Beer and malt : (2; 2.1%)	(0.4%)
29	0.01	Cropland > Vegetable and fruit growing : (1; 2.%)	(0.4%)
30	0.01	Cropland > Beef cattle > Meat products : (2; 2.%)	(0.4%)

***Tab. 3.16**: Structural Path Analysis for Victoria's Ecological Footprint.*

For example, the structural path ranking 21st:

0.02 Cropland > Wheat & other grains > Flour and cereal foods > Bakery products (3; 3.2%) (0.4%)

(boxed), describes cropland that is used to grow grains sold to flour mills producing flour for bakeries selling bread to Victorians. The path value is 0.02 global hectares. The path is of 3rd order, and constitutes a coverage of 3.2% of the total cropland appropriated by Victorians. It also represents 0.4% of Victorians' total per-capita Ecological Footprint. In all Structural Path Analyses, the right-most commodity is the one that links back to the commodity breakdown table (Section 3.6.1) for each indicator. Not all commodities listed in a top-30 commodity breakdown appear amongst the top-30 structural paths. Note that the number of significant figures quoted in tables is not reflective of the accuracy, but have been included for ease of reporting.

3.6.5 Commodity and Path Summary

The commodity and path summary combines the commodity ranking (3.6.1) and structural path analysis (3.6.4) into one overview table, listing first the *commodity* rank and the commodity name. Following, for top-30 paths linking to that commodity, order, description, value (in global hectares per capita) and the percentage contribution to the total Footprint are listed. 'No dominant path' is listed if the most important path linking to a commodity is not amongst the top-30.

Commodity rank	Commodity	Path order	Path description	Value	Percentage of total impact
1	Electricity supply	1	CO2 land > Electricity supply > Victoria	0.72	19.25%
2	Petrol	0	CO2 land > Automotive petrol > Victoria	0.24	6.42%
		1	CO2 land > Automotive petrol > Victoria	0.02	0.53%
3	Retail trade	1	CO2 land > Retail trade > Victoria	0.05	1.34%
		2	CO2 land > Electricity supply > Retail trade > Victoria	0.04	1.12%
4	Accommodation, cafes and restaurants	2	CO2 land > Electricity supply > Accomm, cafes and restaurants > Victoria	0.06	1.58%
		3	Pasture > Beef cattle > Meat products > Accomm, cafes and restaurants > Victoria	0.05	1.39%
		3	Cropland > Barley > Beer and malt > Accomm, cafes and restaurants > Victoria	0.05	1.34%
		2	Marine > Commercial fishing > Accomm, cafes and restaurants > Victoria	0.03	0.80%
5	Ownership of dwellings	0	Built > Ownership of dwellings > Victoria	0.10	2.65%
6	Gas production and distribution	0	CO2 land > Gas production and distribution > Victoria	0.17	4.55%
		1	CO2 land > Gas production and distribution > Victoria	0.02	0.40%
7	Motor vehicles and parts, other transport equipment	2	CO2 land > Basic iron and steel > Motor vehicles and parts > Victoria	0.02	0.40%
8	Wholesale trade	1	CO2 land > Wholesale trade > Victoria	0.02	0.53%
9	Air transport	1	CO2 land > Air transport > Victoria	0.06	1.58%
10	Raw sugar, animal feeds, processed seafoods and other food products	2	Cropland > Wheat & other grains > Other food products > Victoria	0.06	1.50%
		1	CO2 land > Other food products > Victoria	0.05	1.44%
11	Liquefied natural gas, liquefied natural petrol	0	CO2 land > LNG, LPG > Victoria	0.08	2.09%
12	Communication services	all	No dominant path	0.07	1.79%
13	Dairy products	2	Cropland > Dairy cattle & milk > Dairy products > Victoria	0.02	0.43%
14	Household appliances and hot water systems	all	No dominant path	0.05	1.44%
15	Vegetable and fruit growing, hay, plant nurseries, flowers	1	Cropland > Vegetable and fruit growing > Victoria	0.01	0.37%
16	Hairdressing, goods hiring, film processing, laundry and other personal services	all	No dominant path	0.04	1.10%
17	Banking	all	No dominant path	0.04	1.08%
18	Clothing	3	Pasture > Sheep and shorn wool > Fibres, yarns, fabrics > Clothing > Victoria	0.05	1.20%
19	Health services	all	No dominant path	0.04	0.97%
20	Railway passenger transport services	all	No dominant path	0.03	0.92%

Tab. 3.17: *Commodity and path summary for Victoria's Ecological Footprint.*

3.7 Variability

The Ecological Footprints in this study have been calculated using a national Australian input-output analysis framework developed at the University of Sydney, which guarantees a complete coverage of Footprint impacts over the entire supply chain of commodities purchased by a population, including an infinite amount of upstream production layers.

Within this framework, different system boundaries can be addressed, which include either

1. commodities produced only domestically;
2. domestic capital;
3. imported commodities;
4. imported capital.

Moving from 1 to 4 will consecutively increase the Ecological Footprint value, since more feedback loops and supply streams are included. An example is shown in Fig. 19 for Australia's Ecological Footprint. The various green curves relate to the different system boundaries, while the red curve represents the system chosen for this study in consultation with the Global Footprint Network team. The largest impact on the Ecological Footprint has the addition of imports.

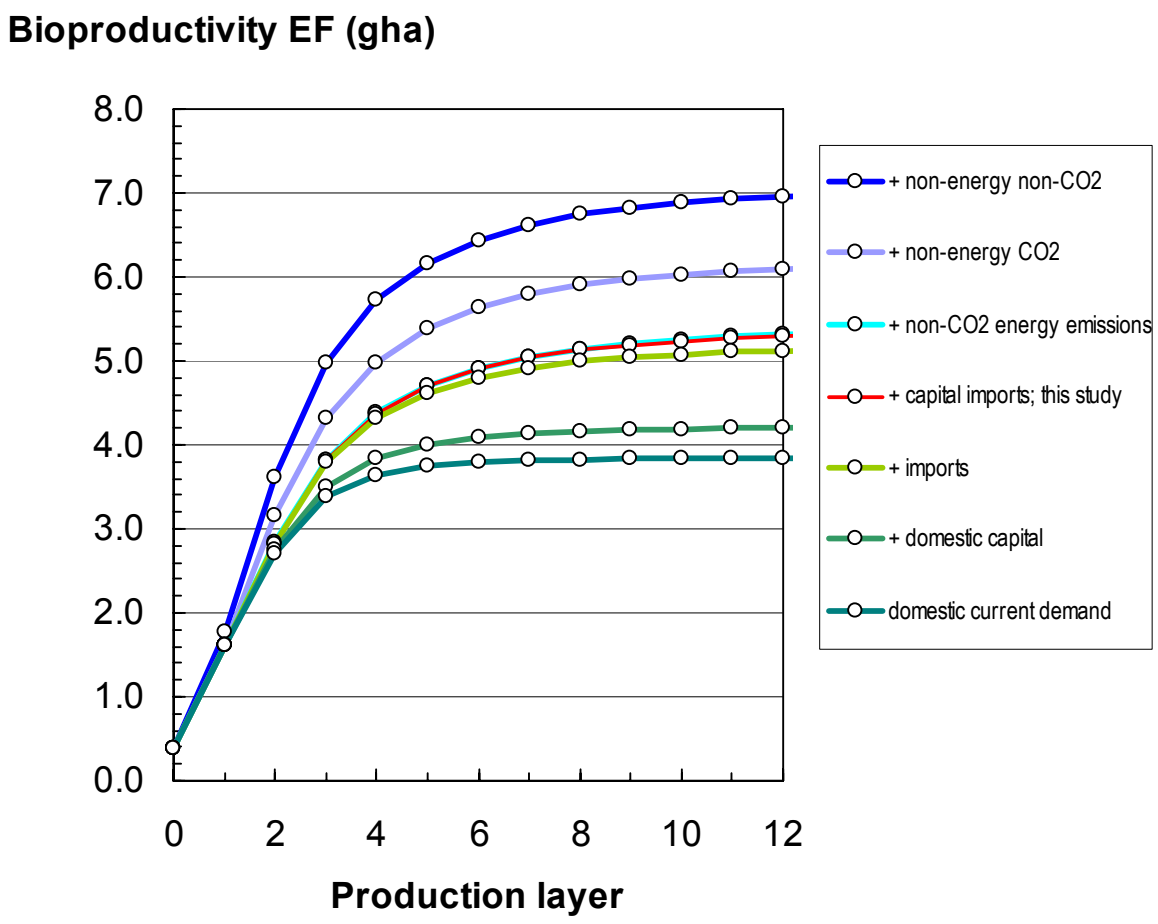

Fig. 3.19: *Production layer decomposition of various Ecological Footprint estimates.*

Furthermore additions can be made of

1. non-CO_2 greenhouse gases due to fuel combustion;
2. CO_2 from non-combustion sources;
3. non-CO_2 greenhouse gases from non-combustion sources.

Moving from 1 to 3 will consecutively increase the emissions land component of the Ecological Footprint (blue curves). During fuel combustion, the main greenhouse gas emitted is CO_2; therefore non-CO_2 gases add a minor amount. However, adding CO_2 from non-combustion sources (land clearing, flaring etc) increases the Ecological Footprint considerably, because these sources are large in Australia. Similarly, non-CO_2 non-energy emissions (CH_4 from coalmine seams, CH_4 from enteric fermentation in animals, etc) are significant in Australia. These sources could be included in future Ecological Footprint calculations.

3.8 Uncertainty

The data presented in this report is affected by scientific uncertainty originating from a range of sources. We can distinguish uncertainty related to

- the choice of model
- the scope of the chosen model
- discrepancies and errors in the underlying data
- variability.

The spread between the Ecological Footprint figures in Fig. 19 which relate to different **model scope** is considerable: about 4 to 7 gha/cap, or 75% of the baseline figure.

Differences between results obtained using input-output and manual methods of **imports and exports allocation** are expected to be up to 1 gha/cap. Similar differences can arise between nation-internal allocation of Ecological Footprint contributions across consumption categories, but these do not affect the national total.

Data-related variability exists with regard to different **sources and units of household consumption data** (monetary or mass).

Similarly, any consumption or production data may be affected by **sampling errors**, or the sample data may deviate from the true mean of the whole population.

Discrepancies due to different **proportionality assumptions** can lead to significant differences. While the USyd's input-output model assumes Ecological Footprint contributions to be proportional to expenditure, the Global Footprint Network method assumes proportionality to mass flows. Both may not necessarily hold. For example, the difference in value of an average and a luxury car may not be due to additional inputs that cause Ecological Footprints, but due to either additional labour input, or simply brand mark-ups. Similarly, an expensive car may possess the same mass as an average car, but could contain electronic and other accessories that required significant resource input from upstream suppliers (see also the striking example in Tab. 3.11). Remedies in both cases could be 1) to carry out more detailed follow-up analyses of items, where violations of proportionality assumptions are suspected, and 2) to dis-aggregate the accounting scheme, including underlying input-output tables. Work on 2) is under way at the University of Sydney.

Finally, there exists **temporal variability**: Ecological Footprints may increase or decrease over time both due to change in consumption or bio-productivity.

4 The Two Ecological Footprint Methods – How Are They Consistent and How Do They Differ?

This section of the report compares the two Ecological Footprint approaches used, one by Global Footprint Network and the other by the University of Sydney. The approaches differ most in one aspect: how they distribute the aggregate human resource demand across specified consumption categories. Global Footprint Network did this manually, using auxiliary data, while the University of Sydney performed this analytically using input-output analysis.

Calculating a region's Footprint involves four steps and the format of this Chapter follows this structure.

- Firstly, we clarify what the Footprint measures (Section 4.1).
- Secondly, we calculate the Footprint for the country the region is in--i.e. Australia (Section 4.2). This is because sub-national regions do not tend to have complete resource production and trade statistics and, therefore, must be based on extrapolations from national data.
- In the third stage, the national resource demand is allocated to human activities (Section 4.3). It is the comparison of the two Ecological Footprint methods at this stage (input-output vs manual), which is of particular interest in this report.
- Lastly, regional patterns are compared to national patterns by adjusting the national benchmark measure to local particularities (Section 4.3).
- To close the chapter, we present a commentary summarising the strengths and limitations of each Ecological Footprint approach at each of these stages (Section 4.4) before conclusions are drawn in Section 5.

The key result is that the two methods differ by only 1.5% in the ratio between the Victorian average Footprint and the national average Footprint (Global Footprint Network's calculations lead to conclusion that Victorian per capita Footprint is 6 percent larger than the national average, while University of Sydney's approach concludes that the Victorian per capita Footprint is 4.5 percent larger than the national average). In other words, the two approaches confirm one another because the difference is comparable to possible errors made in the calculations.

Differences in absolute Ecological Footprint values are larger. But these absolute values were not the focus of this report.[3]

[3] This study compared methods for allocating (or distributing) the national overall demand to particular activities or subpopulations. With the limited scope of the research project, each initiative used its standard assessment of the national Footprint. Global Footprint Network uses a resource balance with about 5000 data points per year from UN sources, University of Sydney based its assessment on Australian government data and estimated the Footprint with a simplified approach based on occupied land areas. Global Footprint Network calculated the average Australian's Footprint to be 7.7 gha and the University of Sydney 6.8 gha, a difference of 11 percent.

4.1 The Ecological Footprint Research Question

The name "Ecological Footprint" is shorthand for a particular research question. Originally, Wackernagel and Rees (1996) defined the question as: how much of the regenerative capacity of the planet is being occupied by human activities? This particular approach also allows researchers to address questions like: How much of this regenerative capacity is located in a particular place? Who uses what portion of the overall human demand on nature?

The method is limited in two ways. One is that the Ecological Footprint is not a complete sustainability measure, and was never designed to be. As stated, it only represents one research question, which we believe is highly relevant to sustainability. The second limitation is how well the question is being answered.

4.1.1 Limitations of the Footprint as a complete sustainability measure

The Footprint is not a complete sustainability measure. Having a Footprint smaller than the biosphere is a necessary minimum condition for humanity's sustainability, but is far from sufficient. For instance, while social well-being also needs to be tracked, the Footprint does not measure it. The Ecological Footprint also makes no attempt to evaluate the long-term viability of social structures, economic viability, or political systems. Nor does it identify the drivers of human demand on ecosystems – it merely documents the ecological outcome, the demand on nature resulting from human activities that occurred at a given time.

If policy makers' ultimate objective is sustainability, we need to analyse how relevant the proposed question is for addressing this goal. Does the original research question provide a better understanding of aspects of unsustainability or overshoot? If a comprehensive indication of sustainability represents the 'endpoint' desired by policy makers then, at present, any metric is merely a 'midpoint' along the journey.

In order to highlight different aspects of sustainability, variants of Ecological Footprint calculations have emerged that address slightly different research questions. One example is the Lenzen and Murray (2003) land disturbance metric. This metric measures the quality or intensity of land-use in an attempt to incorporate some measure of the ability of land to sustain a particular service in perpetuity.

The land disturbance metric altered the original Footprint research question in order to address damage, risk or intensity of land use (for which data is often limited and uncertain). The original Footprint measure only compares the availability and consumption of resources in order to investigate resource use, distribution and overuse.

In comparison, the land use metric (Hicknell et al., 1998) indicates the actual physical land area used by a population to supply the resources it requires (in hectares, and not productivity adjusted global hectares). This can be used to answer an entirely different suite of research questions such as: 'How much area is actually occupied by the economic metabolism of a given population? Where is it located? What is the distribution of land use across the world, where is ecosystem stress greatest?' (Wackernagel et al., 2002).

As it was the aim of this study to measure and compare the resources (ecological goods and services) that are produced and consumed in Victoria and Australia, the bioproductivity (global hectares, gha) metric was used in both the Ecological Footprint methods used in this report. In other words, both approaches in this study answer the same research question.

4.1.2 Limitations of the Footprint in addressing research question

It is important to acknowledge what the current methodology does not capture well:

- **Waste flows.** For many waste flows, inadequate datasets exist for Footprint calculations. For example, SO_x emissions from fossil fuel-based power plants contribute to the acidification of rainwater, which has detrimental effects on forests, fish and wildlife. However, current globally comparable data on the relationship between SO_x concentration and biocapacity are lacking. Acid rain does not yet enter into Footprint calculations, but may if better data becomes available.

- **Freshwater use.** Freshwater use is only indirectly included in the Footprint due to lack of data that links freshwater use with loss in bioproductivity. Some local Footprint assessments have included freshwater use, but national assessments do not yet do so. Freshwater shortages which do result in declining bioproductivity are reflected in biocapacity measurements.

- **Nuclear power.** Nuclear waste is intrinsically unsustainable since ecosystems have no inherent capacity to deal with them. However, not including a nuclear energy Footprint could be misinterpreted as nuclear energy having no ecological impact, and would also ignore the extent to which nuclear accidents have compromised biocapacity. Therefore, Footprint calculations count each thermal unit of nuclear energy as equal to a unit from fossil energy.

- **Aspects for which data are sparse.** Most of the underlying datasets used to calculate national Footprints and biocapacities come from the United Nations (to a large extent from the UN Food and Agriculture Organisation). These datasets do not include assessments of their data uncertainty or reliability. Accordingly, Footprint results must be interpreted with the proviso that the underlying data is assumed to be correct. When there is doubt about data values, Footprint calculations exclude impacts or use lower estimates for demand on nature, and use optimistic biocapacity accounts. This is done to avoid exaggerating ecological deficits. Results therefore\ most likely underestimate the extent of humanity's ecological overshoot.

4.2 National Ecological Footprint accounts

4.2.1 Discrepancies due to Differences in National Reference Calculation for the Footprint

The method used by Global Footprint Network and the University of Sydney to calculate national data differ. Global Footprint Network uses UN statistics, and the detailed accounting approach as described in Wackernagel et al 2005 (a methodology paper which builds on Monfreda et al (2004)). The University of Sydney's approach is described in part 1 of this report.

As a result, the absolute values for the average Australian Footprint from which both studies start differ by about 0.9 global hectares per person (7.7 gha for Global Footprint Network, 6.8 global hectares for University of Sydney). Although national accounts were aligned as closely as possible (so that real methodological differences could be revealed at the state

level) the focus of this study was not to compare detailed national Footprint accounts. Rather, the predominant emphasis was to compare the Global Footprint Network and University of Sydney methods for distributing productivity used by humans across consumption categories at the State level.

Therefore, although it is possible to more fully align national results, project time constraints did not more detailed exploration of discrepancies in the two sets of national accounts. A full reconciliation would require identification of all the possible reasons for which results differ (difference in input data, difference in calculation procedure, differences in categorization, differences in conversion factors, etc.), calculating the contribution of each, determining the extent of difference each explains, and incorporating new knowledge into more aligned national Footprint accounts. The global standardization process (which was initiated by Global Footprint Network and in which both research teams are participating) is currently underway and will ensure that national Footprint accounts are aligned in future assessments.

Below we discuss what we believe are the main sources of the discrepancy in our national Footprint accounts. The production side of the accounts was aligned as closely as possible and for most land types, the national production, imports, exports and consumption components calculated using each method are comparable (see Appendix 1). Notable differences in components are evident for imports from marine, grazing, built and fossil fuel land types and exports from cropland.

4.2.2 Discrepancies due to differences in export/import results

One reason for the diverging import and export results is a truncation error in the Global Footprint Network approach. For instance, for 'Built' imports and exports, the University of Sydney data includes built land for factories and roads that are embodied in imports and exports whereas the Global Footprint Network method does not. Similarly, CO_2 imports are probably too low for Global Footprint Network data since imports into Australia are mainly manufactured goods and a significant Ecological Footprint would be located higher upstream in these respective supply chains. It is likely, however, that Global Footprint Network embodied-energy figures would be more realistic for exports than for imports because Australian exports tend mainly to be energy-intensive goods where the embodied energy occurs on-site or in the first supply chain level. Notwithstanding the above, the domestic (primary production) total should not be and is not affected by truncation errors, since bioproductivity contributions are summed over the entire economy.

What are Truncation Errors?

Input-output analysis used by the University of Sydney automatically allocates *all* embodied energy/land to each particular commodity consumed. For example, "beef for meat for catering for business events of insurance providers selling policies" are all automatically attributed to the final consumers of insurance services. In this way the input-output approach covers an infinite number of 'supply-layers' for each commodity consumed. In comparison, the method used by Global Footprint Network requires the manual allocation of within inter-industry deliveries and is only likely to incorporate two or three upstream supply-chain layers (apart from the energy intensities taken from other researchers who calculated them using input-output approaches). Therefore, the Ecological Footprint attributed to the consumption of insurance services may only incorporate the direct Footprint of the insurance provider and not other complex higher-order supply paths.

It is likely that the University of Sydney marine imports figure is too low because some fish imports are not included in the input-output sector 'Commercial fishing', but in 'Other food products' which in its output is mainly raw sugar, and hence not recognised as processed fish. The Global Footprint Network figure is also much higher than that of the University of Sydney due to different data points used. The University of Sydney used Australian Commodity Statistics (125.3 kt imports and 59.7 kt exports; see Table 4.1) whereas Global Footprint Network used FAO statistics (491.9 kt of imports and 145.9 kt of exports). This discrepancy needs further investigation.

Fish	$m 1994-95	$m 2000-01	kt 1994-95	kt 2000-01
Imports	509.6	758.1	100.8	125.3
Exports	1088.9	1554.7	46.0	59.7
Total production	1542.0	1987.2	210.7	203.8

Table 4.1: *Production and trade statistics for fresh and processed fish (Source: ABARE 2003, Australian Commodity Statistics).*

Even the mass flow of fish imports and exports may not map Ecological Footprint contributions adequately, since the higher value of fish exports is probably backed up by real resource flows (personal communication, Barney Foran, CSIRO, 11 Oct 2004). Work is currently under way at the University of Sydney to disaggregate the input-output framework from 136 to almost 300 sectors. In this disaggregated classification, processed fish and seafood is explicitly distinguished from other food products such as raw sugar, so that misallocations can be avoided in future calculations.

CO_2 exports were higher in Global Footprint Network data than that of the University of Sydney. This may partly be due to a) Global Footprint Network CO_2 emission factors for coal being 5% higher (at 0.095 kg/MJ and 0.074 kg/MJ), and for gas 10% higher (at 0.056 kg/MJ) than ABARE figures (0.090, 0.070 and 0.051 kg/MJ, and b) exports being mainly energy-intensive goods, where the embodied energy occurs on-site or in the first supply chain level. This could mean that Global Footprint Network embodied-energy figures would be on the higher side for exports and on the lower for imports. Still, this is in contrast with an OECD study on embodied CO_2 in trade (OECD, 2003), also based on input-output analysis. Compared to this study, Global Footprint Network accounts generate typically lower figures (15 percent lower than in the OECD study). Again embodied energy figures used in this report were established based on input-output analyses and so should include more than just one supply layer.

Further discrepancies are probably due to different base years.

4.3 Allocation of Victorian Accounts to Human Activities

This section of the report combines the discussion of the third and fourth stage necessary for calculating regional Ecological Footprint accounts. In the third stage, the national resource demand is allocated to human activities. It is the comparison of the two Ecological Footprint approaches at this stage, which was of particular interest in this study. The University of Sydney distributed productivity used by humans across consumption categories analytically using input-output analysis whilst the Global Footprint Network did so manually using auxiliary data.

As data on resource consumption and trade are only available for Australia as a whole, and not specifically for Victoria, the fourth stage applies national analysis to regional Footprint calculations for Victoria. Global Footprint Network calculated Victoria's Footprint by comparing per capita consumption of Victoria and Australia in physical units, whilst the University of Sydney did so by contrasting Victorian and Australian expenditure patterns.

When consumption components are *disaggregated* into different land use and/or commodity categories, important distinctions stemming from differences in methodology become evident. The following table summarises the distributional differences between the Global Footprint Network and the University of Sydney consumption-land-use matrices for Victoria. In order to avoid discrepancies due to differences in input data, animal-based Ecological Footprints in the University of Sydney's consumption-land-use matrix were scaled up in order to match those of Global Footprint Network.[4] As a result, the remaining differences are mainly due to classifications, aggregation and accounting method (see Table 4.2 and 4.3).

	Australia USydn	Australia GFN	Victoria Usydn	Victoria GFN
Food	21%	36%	21%	37%
Housing	16%	18%	18%	19%
Mobility	9%	11%	9%	10%
Goods	16%	24%	16%	23%
Services	38%	11%	37%	11%
TOTAL	**100%**	**100%**	**100%**	**100%**

***Table 4.2**: Distribution of Percentage difference between Global Footprint Network and the University of Sydney Ecological Footprint calculations for Australia and Victoria.*

[4] Scaling was not complete – while in relative terms (i.e., difference in both method's ratio between Australian and Victorian average per capita Footprint) was about 1.5 percent, the absolute difference between the two Victorian Ecological Footprints was about 1 gha/cap, or 8.1 and 7.11 gha per capita for Global Footprint Network and the University of Sydney, respectively. For the results, Global Footprint Network's absolute numbers were taken as reference point, since they are comparable internationally (as for example in the national results published in the Living Planet Report (www.panda.org/livingplanet).

	Primary cropland (gha)	Forest AWS (gha)	Permanent pasture (gha)	Fishing (gha)	Built (gha)	CO2 land (gha)	Sum
Food	**-0.24**	*0.02*	*-0.04*	**-0.14**	*0.01*	**-0.14**	**-0.52**
.plant-based	*-0.01*	*0.02*	*0.04*	*0.00*	*0.01*	*0.01*	*0.07*
.animal-based	**-0.23**	*0.00*	**-0.08**	**-0.14**	*0.00*	**-0.15**	**-0.59**
Housing	*0.00*	**-0.21**	*0.00*	*0.00*	*0.05*	**-0.11**	**-0.26**
.new construction	*0.00*	**-0.22**	*0.00*	*0.00*	*0.00*	**-0.10**	**-0.32**
.maintenance	*0.00*	*0.00*			**0.10**	*-0.03*	*0.06*
.residential energy use	*0.00*	*0.02*	*0.00*	*0.00*	*0.01*	*0.02*	*0.05*
..electricity	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.00*	*0.02*
..natural gas	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.07*	*0.07*
..fuelwood	*0.00*	*0.02*	*0.00*	*0.00*	*0.00*	*-0.06*	*-0.05*
..fuel oil, kerosene, LPG, coal	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.01*
Mobility	*0.00*	*0.01*	*0.01*	*0.00*	*-0.07*	**-0.12**	**-0.17**
.passenger cars and trucks	*0.00*	*0.01*	*0.01*	*0.00*	*0.01*	**-0.14**	**-0.12**
.transit infrastructure	*0.00*					*0.00*	*0.00*
.motorcycles	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
.passenger air	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.08*	**0.09**
.passenger public transit	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*-0.05*	*-0.04*
Goods	*0.04*	**-0.28**	**0.22**	*0.00*	*0.01*	**-0.74**	**-0.75**
.appliance manufacturing	*0.00*	*-0.01*	*0.00*	*0.00*	*0.00*	*0.02*	*0.02*
.furniture	*0.00*	*-0.02*	*0.02*	*0.00*	*0.00*	*0.01*	*0.02*
.computers and electrical equipment	*0.00*	*-0.01*	*0.00*	*0.00*	*0.00*	*0.02*	*0.02*
.clothing and shoes	*0.01*	*0.00*	**0.13**	*0.00*	*0.00*	*0.04*	**0.19**
.cleaning products and services	*0.01*	*0.00*	*0.00*	*0.00*	*0.00*	*-0.02*	*-0.01*
.other household products	*0.00*	*0.00*	*0.03*	*0.00*	*0.00*	*0.04*	*0.07*
.paper products	*0.00*	**-0.19**	*0.00*	*0.00*	*0.00*	*-0.06*	**-0.25**
.tobacco	*-0.01*	*0.00*	*0.00*	*0.00*	*0.00*	*-0.01*	*-0.01*
.other misc. goods	*0.02*	*-0.05*	*0.03*	*0.00*	*0.02*	**-0.79**	**-0.77**
Services	**0.21**	**0.41**	**0.17**	*0.05*	*0.07*	**0.80**	**1.69**
.water and sewage	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*-0.01*	*-0.01*
.telephone and cable service	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.03*	*0.04*
.solid waste	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*-0.03*	*-0.03*
.financial and legal	*0.00*	*-0.01*	*0.01*	*0.00*	*0.00*	*0.03*	*0.04*
.medical	*0.00*	*-0.02*	*0.00*	*0.00*	*0.00*	**-0.14**	**-0.15**
.real estate and rental lodging	*0.01*	*0.03*	*0.01*	*0.00*	*0.01*	**0.10**	**0.15**
.entertainment	**0.14**	*0.01*	**0.09**	*0.03*	*0.02*	**0.24**	**0.52**
.Government	*0.05*	**0.42**	*0.05*	*0.01*	*0.04*	**0.55**	**1.11**
..non-military, non-road	*0.04*	**0.43**	*0.04*	*0.01*	*0.04*	**0.53**	**1.09**
..military	*0.00*	*-0.01*	*0.01*		*0.00*	*0.02*	*0.02*
.other misc. services	*0.00*	*-0.02*	*0.01*	*0.00*	*0.01*	*0.03*	*0.03*
Sum	*0.01*	*-0.04*	**0.37**	**-0.09**	*0.07*	**-0.31**	

***Table 4.3**: Difference between Global Footprint Network and the University of Sydney Ecological Footprint calculations for Victoria – global hectares per person. Negative figure = Global Footprint Network value > the University of Sydney value; positive figure = the University of Sydney value > Global Footprint Network value. Differences larger than 0.08 gha/person (1% of total ecological footprint) are highlighted in bold.*

Discrepancies in Ecological Footprint results obtained by Global Footprint Network and the University of Sydney have a number of origins:

4.3.1 Discrepancies due to the accounting method

On the whole there is good agreement between the findings of the two methods for most commodities. However, where discrepancies exist, an interesting trend can be observed. Differences between Global Footprint Network and the University of Sydney results are:

1. largely negative (Global Footprint Network's values larger than the University of Sydney's) for primary and land-intensive industries (agriculture);
2. less negative for primary and secondary, less land-intensive, but more energy-intensive industries (mobility, construction);
3. mixed negative and positive for secondary industries (manufacturing) and;
4. positive (the University of Sydney's values larger than Global Footprint Network's) for tertiary industries (services).

In addition to their effects on import and export data, truncation errors (discussed in the Box, above) are likely to be responsible for differences in the distribution of consumption between end use categories (economy internal distributions). Industries that are most likely to have their impacts "buried" in higher-upstream industry sectors are services. Because the University of Sydney's service items incorporate these higher-order upstream contributions, they show larger Ecological Footprints.

4.3.2 Discrepancies due to differences in input data

Global Footprint Network and the University of Sydney derived bioproductivity data for production via slightly different approaches, leading to discrepancies especially for crop land and fishing grounds (see Section 4.2). These slightly different approaches to production Footprints are due to a) different base years, b) different classifications of industry sectors, and c) difference in how sustainable yields affect estimates of "actual land use" (in Global Footprint Network accounts, only that forest portion is counted proportional to actual harvest to allowable cut). Such differences in input data mainly lead to discrepancies across land types. These discrepancies are not fundamental, and can easily be overcome by using the same input data set expressed in identical classifications.

4.3.3 Discrepancies due to differences in commodity classifications

Even though a concordance matrix was set up based on mutual agreement of both teams, mis-allocations cannot be excluded because neither team was entirely familiar with each other's classification scheme. In other words, it is a first estimation for both teams. For example, "transit infrastructure" and "house construction" is a separate item in the Global Footprint Network classification, but partly contained in "government consumption" and "gross fixed capital expenditure" in the University of Sydney framework (see Forest AWS Ecological Footprints). Also, some categories overlap, hence a transfer from one classification to the other leads to a loss of resolution. In fact, this loss of resolution may be larger than the actual difference in results.

The most significant candidate for classification errors is "other miscellaneous goods", showing a discrepancy of more than 0.7 global hectares. It appears that this group contains many more items in Global Footprint Network's classification than in the University of Sydney's.

4.3.4 Discrepancies due to aggregation

In the input-output database used by the University of Sydney, certain commodities such as fish products are combined in aggregate commodity groups, whilst the Global Footprint Network database is more detailed. Discrepancies in item 'fishing grounds' is likely to be the results of aggregation of commodities in the University of Sydney's input-output database. In other instances, for example services, the University of Sydney's database may be more detailed than that of the Global Footprint Network. Possible other candidates for discrepancies resulting from aggregation could be 'clothing' (the inability to distinguish between cotton and wool-based clothing) and paper products (the inability to distinguish between types and origins of timber used for paper).

4.4 University of Sydney and Global Footprint Network discussion

The following tables summarise the differences between the two Ecological Footprint approaches. These comments reflect the dialectic process of this methodological study, and serve as points for subsequent discussions among Footprint practitioners. By following the commentary table below, readers are able to determine for themselves the advantages and disadvantages of each approach. It is important to note that, to some extent, the value of this table is explanatory rather than purely practical because hybrid techniques would be used for detailed applications as opposed to straight input-output analysis.

4.4.1 The Ecological Footprint Research Question

University of Sydney	Global Footprint Network
Meaningfulness of the bioproductivity metric	
Any metric is only a proxy indicator for sustainability. This is particularly true for this measure. For instance, the bioproductivity is insensitive to land degradation and production method. Rather than comparing mere resource requirements, in our view, more desirable metrics would be located closer to the measurement of impact (see the land disturbance metric, Lenzen and Murray, 2001). However, the scarcity and uncertainty of adequate data for many countries would probably preclude the use of this metric in a globally standardised method. Furthermore, impact metrics do not indicate 'overshoot' and this could result in the loss of a valuable educational concept.	Footprint stands for one particular research question: how much of the regenerative capacity of the biosphere is being occupied by human activities? Sustainability is broader than these questions. The Footprint does not measure human well-being. Neither does it measure "impact." The reason is that impact has a number of dimensions: damage, risk, intensity of land use, and disturbance of ecosystems. Disturbance is a particularly tricky aspect since it is difficult to define to start with. For instance, it is not clear how it links to actual decrease in regenerative capacity.
Relevance for regional decisions	
Consider a farm or a company wishing to become more sustainable by implementing sustainable agricultural and production practices but without actually changing level of consumption and yield. The	Global Footprint Network believes local decision-makers may be concerned with both dependence on bioproductivity and adverse impacts on land. It is not an 'either or' situation. In a global economy it is a risk

University of Sydney	Global Footprint Network
farm/company would not be rewarded with a reduced Ecological Footprint, because their abatement action is aimed at *the way* they produced things, *not how much* they produce. Many opportunities for action towards sustainability considered by local business are actually about different ways of producing the same level of output/consumption. The fact that the *impacts* of such improvements would show up only years later through declined or enhanced bioproductivity/-capacity is 1) too late a "wake-up signal", and 2) doesn't motivate corporate decision-makers, because they want to see the rewards of their measures in that year's Footprint report.	not to understand the availability of resources. We believe it is useful to know the ratio between local biocapacity and consumption. It is also useful to be able to compare Footprints among nations to understand how much well-being various societies are able to generate per unit of resource input. Current accounts would capture land degradation through declining bioproductivity in future years. Businesses might be interested in these global resource issues for a number of different reasons stretching from supply chain risk to reputational issues. One example is the emerging "Footprint Neutral" campaign by UNDP and Swiss Re.

4.4.2 National Ecological Footprint Accounts

University of Sydney	Global Footprint Network
Sensitivity to agricultural production methods	
The USyd team is concerned about the Global Footprint Network method's insensitivity to agricultural production. For example, unlike in other countries, the way beef meat is produced in Australia causes substantial damage to land and biodiversity. This detail becomes lost in conversions to world-average productivity. Particularly in Australia, productivity has grown steadily, but at the cost of large tracts of agricultural land affected by salinity, soil loss, erosion, or other types of degradation. It is these adverse impacts that make headlines, and that will ultimately pose limits to production. Since these effects are long-term, eventual productivity decreases that could be recorded by the Global Footprint Network Ecological Footprint method would show up only years later. If we wait until future accounts show reduced biocapacity / productivity - it might well be too late for effective abatement action!	Global Footprint Network suggests that current accounts are capturing a number of damage caused by different agricultural production systems. These damages will show up in future accounts as reduced biocapacity. As stated above, Footprint accounts are primarily measuring current demand on and current availability of biocapacity – not how current practices might affect future bioproductivity. If agricultural production methods are truly more efficient – for instance are able to double the productivity per hectare without more input or causing ecological harm elsewhere, then our accounts would capture this by showing double the bioproductivity for this area (e.g., 3 former global hectares would then show up as 6 global hectares). Note that the Footprint is just answering one particular question. If this single metric tried to do everything, it would lose its focus and therefore its ability to answer specific questions.
Compatibility of Ecological Footprint accounts with National Accounts (such as GDP)	
The Global Footprint Network method uses various data sources. As a result, Global Footprint Network's data and Ecological Footprint categories are not aligned with traditional National Accounts. An alignment of Ecological Footprint accounts with the latter (such as in input-output-based Ecological Footprint method) would enable a) evaluation of trade-offs between the Ecological Footprint and other socio-economic indicators such as employment, surplus, income etc, and b) building on already existing UN Standards on National Accounting (SNA1993).	Correct. Yet it has been a strategic decision of Global Footprint Network to use existing UN statistics in order to put primary data gathering onus on the UN and to make results comparable across nations. Unfortunately, no single data source provides all the biophysical data required. Economic data sets along the SNA line even less. But we should certainly work towards making Global Footprint Account's calculation categories as compatible with SNA as possible.

Coverage of greenhouse gas emissions:

University of Sydney	Global Footprint Network
Emissions of non-energy CO_2, and non-CO_2 greenhouse gases are so far excluded from the Global Footprint Network analysis, but data exists that allows their inclusion for Australia and Victoria. The present scarcity of globally consistent data could preclude their inclusion in a globally standardised method.	Global Footprint Network intends to include these other greenhouse gas emissions in its accounts once it can establish that reliable global data on these emissions both exists and allows for these emissions to be accurately allocated to consumption, imports and exports. (One approach, for example, is to assign these emissions proportional to the energy embodied in trade).

4.4.3 Allocation across final demand segments: Manual vs Input-output

University of Sydney	Global Footprint Network
Supply-chain accounting and allocation across final demand segments	
The manual allocation of Ecological Footprint contributions across final consumption categories by Global Footprint Network results in truncation errors in the final footprint-consumption matrix as well as in national import and export Footprints. The magnitude of these truncation errors depends on how trade-independent the assessed entity is. While errors at the national or regional levels may not be too large, *especially councils and companies and industry sectors* are extremely interdependent with their surroundings. This means that trade is a large proportion of these entities' turnover, and truncation errors can be substantial. The allocation of production Ecological Footprints to consumption items is largely carried out by Global Footprint Network analysts. This procedure involves disparate data sources and subjective assumptions by the analysts, and therefore does not readily allow for transparent replication and QA. On the other hand, input-output tables are regularly published by national statistical bureaux all over the world.	Correct, but this error may not be that large. The advantage of the approach is that categories can be chosen according to the user's needs (i.e., analysis is not limited by official categories). By focusing on key areas and investigating the particular supply chains, more specific and accurate results might be achieved than when using IO (which assumes homogenous sectors). Still, categories used for I-O are also used in economic analyses and hence may be more interesting to policy makers. See above.
Aggregation issues	
Input-output classifications are designed for economic analyses. Therefore, aggregation is likely to occur for primary or secondary resource commodities and this categorisation may not be suitable to communicate ecological data. On the other hand, aggregation in the Global Footprint Network's method is likely to occur for service sectors that do not use much land (or other resources) directly, and are therefore not distinguished in Global Footprint Network's data sources.	Manual allocation allows users to choose their own categories. Therefore, categories can be chosen to be more ecologically relevant since they would not be limited to the resource categories defined by the I-O approach.
Timeliness and availability of data	
Input-output tables for most countries, are published in varying intervals ranging from annually to every 3-5 years. More updated tables must be extrapolated from time series of historical input-output tables (currently under way at the USyd). Input-output information is not available for many developing countries.	National Footprint and Biocapacity Accounts are available typically with a three-year delay (time from actual occurrence until UN Statistics are released). These accounts exist for every year since 1961 and are available for over 150 countries (over 97 percent of the world population).

University of Sydney	Global Footprint Network
Proportionality assumptions	
The allocation of Ecological Footprint contributions across final demand segments (final consumption, changes in inventories, government final consumption, exports) according to monetary transactions is a weakness in the USyd's input-output approach, because the assumption that land or emission requirements are proportional to value might not necessarily hold. Similarly, proportionality between land and emission requirements and mass flows, as assumed in the Global Footprint Network method, may also not necessarily hold.	Refined products could have significant differences in resources embodied per kilogram. Global Footprint Network accounts use the most complete database on embodied energy currently available, since it needs to apply these factors to all trade flows of all countries. This could potentially be replaced by data from global input-output tables that include all the countries and the necessary categories, if they were both feasible and available.

4.4.4 Comparing Victorian and National Ecological Footprint accounts

University of Sydney	Global Footprint Network
Sensitivity to consumption patterns:	
The differences in the consumption patterns between the average Australian and Victorian are minor. Since the Global Footprint Network Ecological Footprint method is predominantly sensitive to final consumption *levels*, major differences are unlikely to show up. The input-output method is able to separate population segments with regard to socio-economic-demographic aspects such as income/expenditure, household size, age, population density, house type etc, and identify driving factors that can point towards likely future trends (see Lenzen et al. 2004).	There are quite significant differences in energy amounts and energy mix, but otherwise average consumption in Victoria is similar to the national average. Typically, regional Footprint differences within a country are much less than those between socio-economic groups. The presented Footprint method can be used to compare any desired population segments if data exists showing differences in their consumption patterns.
Consistency of inclusion or exclusion of production system characteristics The Global Footprint Network approach applies conversion factors to take into account differences in yield. While varying *land* inputs (local yields) are controlled for, other industrial inputs remain a specific feature of the respective country. Considering that agricultural production efficiencies are corrected for, but not other efficiencies (such as processing efficiencies), it is a question whether this constitutes a methodological inconsistency.	Two issues: 1) Carbon intensity of purchased electricity cannot be adequately determined as long as the carbon attribute of electricity is not declared. Therefore, current allocation of carbon in electricity to end-users is relatively arbitrary. But once attributes of electricity are traded (and hence honestly declared), then allocation can be determined. 2) Somewhere supply (production/agriculture) has to be separated from demand (consumption/processing). Where to draw this line is always slightly arbitrary. This may distort international comparisons of Footprints, but not national or regional ratios between Footprint and biocapacity.

4.4.5 Other Issues

University of Sydney	Global Footprint Network
Heuristic Value	
Input-output analysis enables the use of auxiliary	The consumption-land-use matrix has the advantage of

University of Sydney	Global Footprint Network
techniques, such as production layer decomposition (breakdown by supply-chain stage) and structural path analysis (breakdown by single supply chain). These analysis techniques can help to identify maximum-leverage points for change and can reveal interdependencies and supply-chain relationships that are intuitively not very apparent Input-output-based Ecological Footprints can be assessed in a consistent global framework: Multi-Regional Input-output analysis (MRIO), where data for various nations are combined into one framework. International trade supply chains and their associated Ecological Footprints can be traced.	being pedagogically simple, based on more intuitive categories, tailored to aspects of the accounts that have more resolution. While conversion factors are ultimately still base on I-O tables, they are more sensitive to physical realities since they do not use monetary prices as proxies (see above discussion on proportionality). Therefore, it is easy to understand and explain. Access to all processes and how they were calculated means that calculations are transparent. Time trends are possible since the required data has been collected for significant longer periods of time. Because a larger data set is available globally for all nations, it is possible to assess differences between nations and global overshoot and trade balance for each resource category. In the not-so-distant future, it might become possible to do these global allocations using global input output tables,

5 Conclusions - Reconciliation of Methods

This study is the first to compare and contrast the assets and limitations of different Ecological Footprint methodologies by applying each approach to a single application – the calculation of a sub-national regional Ecological Footprint for the State of Victoria, Australia.

Comparison of the two methodologies for calculating the Ecological Footprint for Victoria involved four main steps. The first was to ensure that both methods sought to answer the same research question. The second was aligning the two methodologies' baseline national Footprint accounts for Australia as much as possible so that differences in subsequent steps could be contrasted. These National Footprint accounts were found to be largely consistent, although further efforts could help bring them into even closer agreement. Because this was not the fundamental focus of the study, it was not possible to invest further research time in this effort. Both methodologies agree that National Footprint Accounts are a good common starting ground for sub-national analyses, and they also allow international comparisons.

The third step (and the comparison of particular interest in this study) was to contrast the different approaches to allocating footprints to human activities (i.e. manual and input-output approaches). This step contributed the largest discrepancy between results from the two methods. However it was not possible to separate the magnitude of differences originating from truncation errors versus differences in categorisation. Input-output analysis is clearly a promising approach for disaggregating national data in regional applications.

In the final step, the national accounts were converted to the regional Victorian Footprint accounts. It is not possible to conclusively confirm whether physical or monetary comparisons are more effective. One reason is the situation of current energy consumption. The kind and amount of energy consumed is the biggest difference between Australia and Victoria. But the exact power-mix of energy consumed by households is not known for electricity consumed. In fact, it is not knowable since there are no contracts yet about who gets which kind of electricity (representing which carbon intensity). At this point only kWh are sold (apart from green electricity markets). Therefore, allocation of Footprints is somewhat speculative. Once electricity trade includes attributes such as carbon intensity of each kWh, the energy Footprint can be allocated more accurately.

The overall, consolidated Victorian Footprint results calculated by two different methods agreed closely (1.5 percent in relative terms, and within 12% in absolute terms when

including not fully reconciled differences in national accounts), although differences were more evident in the detailed disaggregated data (see Table 1.2).

The findings of this study indicate that no one approach may be optimal in all situations. Instead, aspects of both may have their merit and could be incorporated into 'hybrid' methods that are customised to meet the objectives of each particular application. These are discussions that the "standards committees" of Global Footprint Network and its partner organisations will be pursuing further.

Therefore, this study informs the standard setting discussion (which is currently taking place globally, hosted by Global Footprint Network) in significantly new ways. The findings highlight the importance of choosing the appropriate methodological approach that is compatible with the specific aims of an Ecological Footprint assessment and of understanding the data requirements and limitations of each approach. Addressing these will ensure that future Footprint studies produce the most robust, reliable and relevant results possible.

6 References

Ahmad, Nadim and Andrew Wyckoff, 2003, Carbon dioxide emissions embodied in international trade of goods, Working paper, OECD Paris. http://www.oecd.org/sti/working-papers

Australian Bureau of Agricultural and Resource Economics (1999). Australian energy consumption and production. ABARE Research Report 99.4, Commonwealth of Australia, Canberra, Australia.

Australian Bureau of Statistics (1997). Agriculture, Australia. ABS Catalogue No. 7113.0, Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (1999a). Australian National Accounts, Input-Output Tables, 1994-95. ABS Catalogue No. 5209.0, Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (1999b). Australian National Accounts, Input-Output Tables, 1994-95, Commodity Details. Electronic file (unpublished)

Australian Bureau of Statistics (1999c). Australian National Accounts, Input-Output Tables, Product Details, 1994-95. ABS Catalogue No. 5215.0, Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (2000a). 1998-99 Household Expenditure Survey - Detailed Expenditure Items. ABS Catalogue No. 6535.0, Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (2000b). 1998-99 Household Expenditure Survey - Detailed Expenditure Items, Confidentialised Unit Record File. Electronic file (unpublished), Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (2004a). 2002 – 03 Agricultural Commodities. ABS Catalogue No. 7121.0, Australian Bureau of Statistics, Canberra, Australia.

Australian Bureau of Statistics (2004b). Australian National Accounts, Input-Output Tables, 1998-99. ABS Catalogue No. 5209.0, Australian Bureau of Statistics, Canberra, Australia.

Bicknell, K.B., Ball R.J., Cullen R. and Bigsby H.R. (1998). New methodology for the Ecological Footprint with an application to the New Zealand economy. Ecological Economics 27(2), 149-160.

FAO - Food and Agriculture Organisation of the United Nations. 2003. *State of the World's Forests 2003*. FAO, Rome, Italy. www.fao.org/DOCREP/005/Y7581E/Y7581E00.HTM

FAO - Food and Agriculture Organisation of the United Nations. 2000b. *Global Fibre Supply Model*. FAO, Rome, Italy. www.fao.org/forestry/fop/fopw/GFSM/gfsmint-e.stm

FAO/IIASA - Food and Agriculture Organisation of the United Nations / International Institute for Applied Systems Analysis. 2000. *Global Agro-Ecological Zones (GAEZ)* CD-ROM, or www.fao.org/ag/agl/agll/gaez/index.htm

FAO/UNECE - Food and Agriculture Organisation of the United Nations / United Nations Economic Commission for Europe. 2000. *Temperate and Boreal Forest Resource Assessment 2000*. UNECE/FAO, Geneva, Switzerland.

Glanznig, A. (1995). Native vegetation clearance, habitat loss and biodiversity decline. Biodiversity Series, Paper No. 6, Department of the Environment, Sport and Territories Biodiversity Unit, Canberra, Australia.

IEA - International Energy Agency. 2003. *CO_2 Emissions from Fuel Combustion*. OECD-IEA, Paris, France. data.iea.org

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

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

Lenzen, M., Dey C. and Foran B. (2004). Energy requirements of Sydney households. Ecological Economics 49(3), 375-399.

Monfreda, C., Wackernagel, M. and Deumling, D. 2004. Establishing national natural capital accounts based on detailed Ecological Footprint and biological capacity assessments, *Land Use Policy* 21 (2004) 231–246.

National Greenhouse Gas Inventory Committee (1998). Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks. Workbooks 1.1 to 8.1, Australian Greenhouse Office, Canberra, Australia.

Ramankutty, N. and Monfreda, C. 2004. *Net Primary Productivity of World's Grasslands.* SAGE - Center for Sustainability and Global Environment, University of Wisconsin-Madison, USA (unpublished). http://www.sage.wisc.edu.

Simmons, C., K. Lewis, and J. Barrett. 2000. Two feet – two approaches: a component-based model of Ecological Footprinting. *Ecological Economics* 32(3), p 375-380.

Simpson, R., Petroeschevsky A. and Lowe I. (1998). The Ecological Footprint of Australia, with a focus on the South-East Queensland Region. Preliminary Technical Report,, School of Public Health, Griffith University, Logan Campus, QLD, Australia.

Simpson, R.W., Petroeschevsky A. and Lowe I. (2000). An Ecological Footprint analysis for Australia. Australian Journal of Environmental Management 7, 11-18.

SNA 1993 System of National Accounts, United Nations, New York.

Wackernagel, M. 1998. The Ecological Footprint of Santiago de Chile. *Local Environment* 3(1), p 7-25, February.

Wackernagel, M., White, K.S., Moran, D. 2004. Using Ecological Footprint accounts: From analysis to applications, Int. J. Environment and Sustainable Development, Vol. 3, Nos. 3/4, 2004, 293-315.

Wackernagel, Mathis, and William E. Rees. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. New Society Publishers, Gabriola Island, BC.

Wackernagel, Mathis, Niels B. Schulz, Diana Deumling, Alejandro Callejas Linares, Martin Jenkins, Valerie Kapos, Chad Monfreda, Jonathan Loh, Norman Myers, Richard Norgaard, & Jorgen Randers. 2002. Tracking the ecological overshoot of the human economy. *Proc. Natl. Acad. Sci. USA*, Vol. 99, Issue 14, 9266-9271, July 9.

Wackernagel, Mathis, Chad Monfreda, Dan Moran, Paul Wermer, Steve Goldfinger, Diana Deumling, Michael Murray, National Footprint and Biocapacity Accounts 2005: The underlying calculation method, www.footprintnetwork.org

Wood, R. (2003). The Structural Determinants for Change in Australia's Greenhouse Gas Emissions. Honours Thesis, The University of Sydney, Sydney, Australia.

World-Wide Fund for Nature International (WWF), Global Footprint Network, UNEP World Conservation Monitoring Centre. 2004. *Living Planet Report 2004*. WWF, Gland, Switzerland.

Appendix A: Disaggregation of HES data used for the USyd study

The following list provides a breakdown of disaggregated categories of Victorian HES data, by SSD/SD, family type, and income bracket.

Inner Melbourne; Couple only
Inner Melbourne; Couple with one dependent child only
Inner Melbourne; Couple with two dependent children only
Inner Melbourne; Couple with three or more dependent children
Inner Melbourne; Couple dependent and non-dependent children only
Inner Melbourne; Couple with non-dependent children only
Inner Melbourne; All other couple families
Inner Melbourne; Single parent one child families
Inner Melbourne; Single parents with more than one child
Inner Melbourne; Other one parent families and other one family households
Inner Melbourne; Multiple family households
Inner Melbourne; Lone person household
Inner Melbourne; Group household
Inner Melbourne; Quintile 1
Inner Melbourne; Quintile 2
Inner Melbourne; Quintile 3
Inner Melbourne; Quintile 4
Inner Melbourne; Quintile 5
Inner Melbourne
Western Melbourne; Couple only
Western Melbourne; Couple with one dependent child only
Western Melbourne; Couple with two dependent children only
Western Melbourne; Couple with three or more dependent children
Western Melbourne; Couple dependent and non-dependent children only
Western Melbourne; Couple with non-dependent children only
Western Melbourne; All other couple families
Western Melbourne; Single parent one child families
Western Melbourne; Single parents with more than one child
Western Melbourne; Other one parent families and other one family households
Western Melbourne; Multiple family households
Western Melbourne; Lone person household
Western Melbourne; Group household
Western Melbourne; Quintile 1
Western Melbourne; Quintile 2
Western Melbourne; Quintile 3
Western Melbourne; Quintile 4
Western Melbourne; Quintile 5
Western Melbourne
Melton-Wyndham; Couple only
Melton-Wyndham; Couple with one dependent child only
Melton-Wyndham; Couple with two dependent children only
Melton-Wyndham; Couple with three or more dependent children
Melton-Wyndham; Couple dependent and non-dependent children only
Melton-Wyndham; Couple with non-dependent children only
Melton-Wyndham; All other couple families
Melton-Wyndham; Single parent one child families

Melton-Wyndham; Single parents with more than one child
Melton-Wyndham; Other one parent families and other one family households
Melton-Wyndham; Multiple family households
Melton-Wyndham; Lone person household
Melton-Wyndham; Group household
Melton-Wyndham; Quintile 1
Melton-Wyndham; Quintile 2
Melton-Wyndham; Quintile 3
Melton-Wyndham; Quintile 4
Melton-Wyndham; Quintile 5
Melton-Wyndham
Moreland; Couple only
Moreland; Couple with one dependent child only
Moreland; Couple with two dependent children only
Moreland; Couple with three or more dependent children
Moreland; Couple dependent and non-dependent children only
Moreland; Couple with non-dependent children only
Moreland; All other couple families
Moreland; Single parent one child families
Moreland; Single parents with more than one child
Moreland; Other one parent families and other one family households
Moreland; Multiple family households
Moreland; Lone person household
Moreland; Group household
Moreland; Quintile 1
Moreland; Quintile 2
Moreland; Quintile 3
Moreland; Quintile 4
Moreland; Quintile 5
Moreland
Northern Middle Melbourne; Couple only
Northern Middle Melbourne; Couple with one dependent child only
Northern Middle Melbourne; Couple with two dependent children only
Northern Middle Melbourne; Couple with three or more dependent children
Northern Middle Melbourne; Couple dependent and non-dependent children only
Northern Middle Melbourne; Couple with non-dependent children only
Northern Middle Melbourne; All other couple families
Northern Middle Melbourne; Single parent one child families
Northern Middle Melbourne; Single parents with more than one child
Northern Middle Melbourne; Other one parent families and other one family households
Northern Middle Melbourne; Multiple family households
Northern Middle Melbourne; Lone person household
Northern Middle Melbourne; Group household
Northern Middle Melbourne; Quintile 1
Northern Middle Melbourne; Quintile 2
Northern Middle Melbourne; Quintile 3
Northern Middle Melbourne; Quintile 4
Northern Middle Melbourne; Quintile 5
Northern Middle Melbourne
Hume City; Couple only
Hume City; Couple with one dependent child only
Hume City; Couple with two dependent children only

Hume City; Couple with three or more dependent children
Hume City; Couple dependent and non-dependent children only
Hume City; Couple with non-dependent children only
Hume City; All other couple families
Hume City; Single parent one child families
Hume City; Single parents with more than one child
Hume City; Other one parent families and other one family households
Hume City; Multiple family households
Hume City; Lone person household
Hume City; Group household
Hume City; Quintile 1
Hume City; Quintile 2
Hume City; Quintile 3
Hume City; Quintile 4
Hume City; Quintile 5
Hume City
Northern Outer Melbourne; Couple only
Northern Outer Melbourne; Couple with one dependent child only
Northern Outer Melbourne; Couple with two dependent children only
Northern Outer Melbourne; Couple with three or more dependent children
Northern Outer Melbourne; Couple dependent and non-dependent children only
Northern Outer Melbourne; Couple with non-dependent children only
Northern Outer Melbourne; All other couple families
Northern Outer Melbourne; Single parent one child families
Northern Outer Melbourne; Single parents with more than one child
Northern Outer Melbourne; Other one parent families and other one family households
Northern Outer Melbourne; Multiple family households
Northern Outer Melbourne; Lone person household
Northern Outer Melbourne; Group household
Northern Outer Melbourne; Quintile 1
Northern Outer Melbourne; Quintile 2
Northern Outer Melbourne; Quintile 3
Northern Outer Melbourne; Quintile 4
Northern Outer Melbourne; Quintile 5
Northern Outer Melbourne
Boroondara; Couple only
Boroondara; Couple with one dependent child only
Boroondara; Couple with two dependent children only
Boroondara; Couple with three or more dependent children
Boroondara; Couple dependent and non-dependent children only
Boroondara; Couple with non-dependent children only
Boroondara; All other couple families
Boroondara; Single parent one child families
Boroondara; Single parents with more than one child
Boroondara; Other one parent families and other one family households
Boroondara; Multiple family households
Boroondara; Lone person household
Boroondara; Group household
Boroondara; Quintile 1
Boroondara; Quintile 2
Boroondara; Quintile 3
Boroondara; Quintile 4

Boroondara; Quintile 5
Boroondara
Eastern Middle Melbourne; Couple only
Eastern Middle Melbourne; Couple with one dependent child only
Eastern Middle Melbourne; Couple with two dependent children only
Eastern Middle Melbourne; Couple with three or more dependent children
Eastern Middle Melbourne; Couple dependent and non-dependent children only
Eastern Middle Melbourne; Couple with non-dependent children only
Eastern Middle Melbourne; All other couple families
Eastern Middle Melbourne; Single parent one child families
Eastern Middle Melbourne; Single parents with more than one child
Eastern Middle Melbourne; Other one parent families and other one family households
Eastern Middle Melbourne; Multiple family households
Eastern Middle Melbourne; Lone person household
Eastern Middle Melbourne; Group household
Eastern Middle Melbourne; Quintile 1
Eastern Middle Melbourne; Quintile 2
Eastern Middle Melbourne; Quintile 3
Eastern Middle Melbourne; Quintile 4
Eastern Middle Melbourne; Quintile 5
Eastern Middle Melbourne
Eatern Outer Melbourne; Couple only
Eatern Outer Melbourne; Couple with one dependent child only
Eatern Outer Melbourne; Couple with two dependent children only
Eatern Outer Melbourne; Couple with three or more dependent children
Eatern Outer Melbourne; Couple dependent and non-dependent children only
Eatern Outer Melbourne; Couple with non-dependent children only
Eatern Outer Melbourne; All other couple families
Eatern Outer Melbourne; Single parent one child families
Eatern Outer Melbourne; Single parents with more than one child
Eatern Outer Melbourne; Other one parent families and other one family households
Eatern Outer Melbourne; Multiple family households
Eatern Outer Melbourne; Lone person household
Eatern Outer Melbourne; Group household
Eatern Outer Melbourne; Quintile 1
Eatern Outer Melbourne; Quintile 2
Eatern Outer Melbourne; Quintile 3
Eatern Outer Melbourne; Quintile 4
Eatern Outer Melbourne; Quintile 5
Eatern Outer Melbourne
Yarra Ranges; Couple only
Yarra Ranges; Couple with one dependent child only
Yarra Ranges; Couple with two dependent children only
Yarra Ranges; Couple with three or more dependent children
Yarra Ranges; Couple dependent and non-dependent children only
Yarra Ranges; Couple with non-dependent children only
Yarra Ranges; All other couple families
Yarra Ranges; Single parent one child families
Yarra Ranges; Single parents with more than one child
Yarra Ranges; Other one parent families and other one family households
Yarra Ranges; Multiple family households
Yarra Ranges; Lone person household

Yarra Ranges; Group household
Yarra Ranges; Quintile 1
Yarra Ranges; Quintile 2
Yarra Ranges; Quintile 3
Yarra Ranges; Quintile 4
Yarra Ranges; Quintile 5
Yarra Ranges
Southern Melbourne; Couple only
Southern Melbourne; Couple with one dependent child only
Southern Melbourne; Couple with two dependent children only
Southern Melbourne; Couple with three or more dependent children
Southern Melbourne; Couple dependent and non-dependent children only
Southern Melbourne; Couple with non-dependent children only
Southern Melbourne; All other couple families
Southern Melbourne; Single parent one child families
Southern Melbourne; Single parents with more than one child
Southern Melbourne; Other one parent families and other one family households
Southern Melbourne; Multiple family households
Southern Melbourne; Lone person household
Southern Melbourne; Group household
Southern Melbourne; Quintile 1
Southern Melbourne; Quintile 2
Southern Melbourne; Quintile 3
Southern Melbourne; Quintile 4
Southern Melbourne; Quintile 5
Southern Melbourne
Greater Dandenong City; Couple only
Greater Dandenong City; Couple with one dependent child only
Greater Dandenong City; Couple with two dependent children only
Greater Dandenong City; Couple with three or more dependent children
Greater Dandenong City; Couple dependent and non-dependent children only
Greater Dandenong City; Couple with non-dependent children only
Greater Dandenong City; All other couple families
Greater Dandenong City; Single parent one child families
Greater Dandenong City; Single parents with more than one child
Greater Dandenong City; Other one parent families and other one family households
Greater Dandenong City; Multiple family households
Greater Dandenong City; Lone person household
Greater Dandenong City; Group household
Greater Dandenong City; Quintile 1
Greater Dandenong City; Quintile 2
Greater Dandenong City; Quintile 3
Greater Dandenong City; Quintile 4
Greater Dandenong City; Quintile 5
Greater Dandenong City
South East Outer Melbourne; Couple only
South East Outer Melbourne; Couple with one dependent child only
South East Outer Melbourne; Couple with two dependent children only
South East Outer Melbourne; Couple with three or more dependent children
South East Outer Melbourne; Couple dependent and non-dependent children only
South East Outer Melbourne; Couple with non-dependent children only
South East Outer Melbourne; All other couple families

South East Outer Melbourne; Single parent one child families
South East Outer Melbourne; Single parents with more than one child
South East Outer Melbourne; Other one parent families and other one family households
South East Outer Melbourne; Multiple family households
South East Outer Melbourne; Lone person household
South East Outer Melbourne; Group household
South East Outer Melbourne; Quintile 1
South East Outer Melbourne; Quintile 2
South East Outer Melbourne; Quintile 3
South East Outer Melbourne; Quintile 4
South East Outer Melbourne; Quintile 5
South East Outer Melbourne
Frankston; Couple only
Frankston; Couple with one dependent child only
Frankston; Couple with two dependent children only
Frankston; Couple with three or more dependent children
Frankston; Couple dependent and non-dependent children only
Frankston; Couple with non-dependent children only
Frankston; All other couple families
Frankston; Single parent one child families
Frankston; Single parents with more than one child
Frankston; Other one parent families and other one family households
Frankston; Multiple family households
Frankston; Lone person household
Frankston; Group household
Frankston; Quintile 1
Frankston; Quintile 2
Frankston; Quintile 3
Frankston; Quintile 4
Frankston; Quintile 5
Frankston
Mornington Peninsula; Couple only
Mornington Peninsula; Couple with one dependent child only
Mornington Peninsula; Couple with two dependent children only
Mornington Peninsula; Couple with three or more dependent children
Mornington Peninsula; Couple dependent and non-dependent children only
Mornington Peninsula; Couple with non-dependent children only
Mornington Peninsula; All other couple families
Mornington Peninsula; Single parent one child families
Mornington Peninsula; Single parents with more than one child
Mornington Peninsula; Other one parent families and other one family households
Mornington Peninsula; Multiple family households
Mornington Peninsula; Lone person household
Mornington Peninsula; Group household
Mornington Peninsula; Quintile 1
Mornington Peninsula; Quintile 2
Mornington Peninsula; Quintile 3
Mornington Peninsula; Quintile 4
Mornington Peninsula; Quintile 5
Mornington Peninsula
Melbourne; Couple only
Melbourne; Couple with one dependent child only

Melbourne; Couple with two dependent children only
Melbourne; Couple with three or more dependent children
Melbourne; Couple dependent and non-dependent children only
Melbourne; Couple with non-dependent children only
Melbourne; All other couple families
Melbourne; Single parent one child families
Melbourne; Single parents with more than one child
Melbourne; Other one parent families and other one family households
Melbourne; Multiple family households
Melbourne; Lone person household
Melbourne; Group household
Melbourne; Quintile 1
Melbourne; Quintile 2
Melbourne; Quintile 3
Melbourne; Quintile 4
Melbourne; Quintile 5
Melbourne
Barwon; Couple only
Barwon; Couple with one dependent child only
Barwon; Couple with two dependent children only
Barwon; Couple with three or more dependent children
Barwon; Couple dependent and non-dependent children only
Barwon; Couple with non-dependent children only
Barwon; All other couple families
Barwon; Single parent one child families
Barwon; Single parents with more than one child
Barwon; Other one parent families and other one family households
Barwon; Multiple family households
Barwon; Lone person household
Barwon; Group household
Barwon; Quintile 1
Barwon; Quintile 2
Barwon; Quintile 3
Barwon; Quintile 4
Barwon; Quintile 5
Barwon
Western District; Couple only
Western District; Couple with one dependent child only
Western District; Couple with two dependent children only
Western District; Couple with three or more dependent children
Western District; Couple dependent and non-dependent children only
Western District; Couple with non-dependent children only
Western District; All other couple families
Western District; Single parent one child families
Western District; Single parents with more than one child
Western District; Other one parent families and other one family households
Western District; Multiple family households
Western District; Lone person household
Western District; Group household
Western District; Quintile 1
Western District; Quintile 2
Western District; Quintile 3

Western District; Quintile 4
Western District; Quintile 5
Western District
Central Highlands; Couple only
Central Highlands; Couple with one dependent child only
Central Highlands; Couple with two dependent children only
Central Highlands; Couple with three or more dependent children
Central Highlands; Couple dependent and non-dependent children only
Central Highlands; Couple with non-dependent children only
Central Highlands; All other couple families
Central Highlands; Single parent one child families
Central Highlands; Single parents with more than one child
Central Highlands; Other one parent families and other one family households
Central Highlands; Multiple family households
Central Highlands; Lone person household
Central Highlands; Group household
Central Highlands; Quintile 1
Central Highlands; Quintile 2
Central Highlands; Quintile 3
Central Highlands; Quintile 4
Central Highlands; Quintile 5
Central Highlands
Wimmera & Mallee; Couple only
Wimmera & Mallee; Couple with one dependent child only
Wimmera & Mallee; Couple with two dependent children only
Wimmera & Mallee; Couple with three or more dependent children
Wimmera & Mallee; Couple dependent and non-dependent children only
Wimmera & Mallee; Couple with non-dependent children only
Wimmera & Mallee; All other couple families
Wimmera & Mallee; Single parent one child families
Wimmera & Mallee; Single parents with more than one child
Wimmera & Mallee; Other one parent families and other one family households
Wimmera & Mallee; Multiple family households
Wimmera & Mallee; Lone person household
Wimmera & Mallee; Group household
Wimmera & Mallee; Quintile 1
Wimmera & Mallee; Quintile 2
Wimmera & Mallee; Quintile 3
Wimmera & Mallee; Quintile 4
Wimmera & Mallee; Quintile 5
Wimmera & Mallee
Loddon; Couple only
Loddon; Couple with one dependent child only
Loddon; Couple with two dependent children only
Loddon; Couple with three or more dependent children
Loddon; Couple dependent and non-dependent children only
Loddon; Couple with non-dependent children only
Loddon; All other couple families
Loddon; Single parent one child families
Loddon; Single parents with more than one child
Loddon; Other one parent families and other one family households
Loddon; Multiple family households

Loddon; Lone person household
Loddon; Group household
Loddon; Quintile 1
Loddon; Quintile 2
Loddon; Quintile 3
Loddon; Quintile 4
Loddon; Quintile 5
Loddon
Goulburn; Couple only
Goulburn; Couple with one dependent child only
Goulburn; Couple with two dependent children only
Goulburn; Couple with three or more dependent children
Goulburn; Couple dependent and non-dependent children only
Goulburn; Couple with non-dependent children only
Goulburn; All other couple families
Goulburn; Single parent one child families
Goulburn; Single parents with more than one child
Goulburn; Other one parent families and other one family households
Goulburn; Multiple family households
Goulburn; Lone person household
Goulburn; Group household
Goulburn; Quintile 1
Goulburn; Quintile 2
Goulburn; Quintile 3
Goulburn; Quintile 4
Goulburn; Quintile 5
Goulburn
Ovens-Murray & East Gippsland; Couple only
Ovens-Murray & East Gippsland; Couple with one dependent child only
Ovens-Murray & East Gippsland; Couple with two dependent children only
Ovens-Murray & East Gippsland; Couple with three or more dependent children
Ovens-Murray & East Gippsland; Couple dependent and non-dependent children only
Ovens-Murray & East Gippsland; Couple with non-dependent children only
Ovens-Murray & East Gippsland; All other couple families
Ovens-Murray & East Gippsland; Single parent one child families
Ovens-Murray & East Gippsland; Single parents with more than one child
Ovens-Murray & East Gippsland; Other one parent families and other one family households
Ovens-Murray & East Gippsland; Multiple family households
Ovens-Murray & East Gippsland; Lone person household
Ovens-Murray & East Gippsland; Group household
Ovens-Murray & East Gippsland; Quintile 1
Ovens-Murray & East Gippsland; Quintile 2
Ovens-Murray & East Gippsland; Quintile 3
Ovens-Murray & East Gippsland; Quintile 4
Ovens-Murray & East Gippsland; Quintile 5
Ovens-Murray & East Gippsland
Gippsland; Couple only
Gippsland; Couple with one dependent child only
Gippsland; Couple with two dependent children only
Gippsland; Couple with three or more dependent children
Gippsland; Couple dependent and non-dependent children only
Gippsland; Couple with non-dependent children only

Gippsland; All other couple families
Gippsland; Single parent one child families
Gippsland; Single parents with more than one child
Gippsland; Other one parent families and other one family households
Gippsland; Multiple family households
Gippsland; Lone person household
Gippsland; Group household
Gippsland; Quintile 1
Gippsland; Quintile 2
Gippsland; Quintile 3
Gippsland; Quintile 4
Gippsland; Quintile 5
Gippsland
Victoria; Couple only
Victoria; Couple with one dependent child only
Victoria; Couple with two dependent children only
Victoria; Couple with three or more dependent children
Victoria; Couple dependent and non-dependent children only
Victoria; Couple with non-dependent children only
Victoria; All other couple families
Victoria; Single parent one child families
Victoria; Single parents with more than one child
Victoria; Other one parent families and other one family households
Victoria; Multiple family households
Victoria; Lone person household
Victoria; Group household
Victoria; Quintile 1
Victoria; Quintile 2
Victoria; Quintile 3
Victoria; Quintile 4
Victoria; Quintile 5
Victoria