ECO-FOOTPRINT

EPA ECOLOGICAL FOOTPRINT CALCULATORS: TECHNICAL BACKGROUND PAPER

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EPA VICTORIA

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

- ABARE – Australian Bureau of Agriculture and Resource Economics
- ABS – Australian Bureau of Statistics
- CO_2 – Carbon dioxide
- GBRS – Greenhouse Building Rating Scheme
- I-O data – Input–output data
- IT – Information technology
- SimaPro – Life cycle assessment software

1. INTRODUCTION

Ecological footprints (EFs) have most commonly been applied to cities, regions and countries, and have been calculated for the total consumption impacts of those areas, which can then be compared to the available resources in that region.

There are two recognised approaches to accounting flows, be they economic or environmental. Bottom-up approaches (sometimes referred to as process analysis) build up a system from discrete, identifiable 'unit processes', which are then assembled into an overall model of an industrial/commercial activity. Alternatively, the top-down approach examines overall exchanges between economic sectors (input–output analysis) and, by understanding the direct impacts of a single sector, indirect emissions resulting from interactions with other sectors can be estimated.

For the EPA Victoria Ecological Footprint Calculators, both process analysis data and input–output (I-O) data from the Australian Bureau of Statistics (ABS) have been used for different consumption items, depending on the specificity required in the consumption item and the availability of data. For example, consumption items such as food, computers and building are modelled using the I-O framework, while office consumables such as paper and toner cartridges are modelled from a process analysis framework, where recycled content or recycling behaviour can be taken into account.

The footprints calculated through the spreadsheets are based around consumption of items, and in terms of the household spreadsheet, total consumption by household members. Land use values in the input-output model are initially modelled around production impacts, which include local consumption and exports. When the consumption categories are calculated from the output of the I-O model they are based on local consumption of both domestic production and imported products. All imports are modelled in the I-O model as if they have the same impact as local production.

The footprints calculated by the schools and offices spreadsheets are only partial and are focused around areas of impact where the participants have some direct or indirect ability to influence consumption behaviour. This approach has implications for calculating footprints, as much of the data needs to be inferred from consumption information collected at the school or office level, which is then used to estimate overall footprints.

For the household calculator the aim is to capture the entire footprint of household occupants. The calculation is undertaken as a combination of the bottom-up (process analysis) and top-down approaches by adding up individual consumption items or, for items where process data is not available, measuring total consumption in Australia from input–output data and dividing by the population.

1.1 Structure of the footprint used

EFs have been calculated for six land use categories taken from the Living Planet Report 2002 and are described in Table 1. Fishing ground, which is included in the Living Planet Report, was excluded to simplify the footprint calculations, and on the basis that this is not one of the areas where Australia has a particularly high footprint per capita.

Areas of land represented in the footprint are initially calculated on actual hectares occupied. For display in the calculator respondents can choose to view actual hectares but, for aggregation of different land use categories, 'average' hectares are more representative of the overall impact. For comparison to other global footprints, 'global average hectares' (gha) should be used (See Section 3.7 for more detail).

Table 1: Land use categories calculated in this report

Land type	Description
Consumed land	Including buildings, roads, mining areas and so on
Cropland	Areas producing crops such as cereals, fruit and vegetables, sugar cane and so on
Pasture	Area set aside for grazing animals
Energy land	Area required to absorb carbon emitted from fuel combustion
Forest land	Land required for forests
Biodiversity land	A 12% allocation of all footprints set aside for biodiversity

2. CALCULATION OF FOOTPRINT FACTORS

2.1 Electricity footprint

Consumed land from electricity production consists of four major components, including land used for: high-tension electricity cables; power generation facilities; hydroelectric storages; and open-cut mining.

2.2 Transport footprint

Occupied land for transport is dominated by land occupied in roads, railways and, to a lesser extent, airports. This was calculated from ABS data (including lengths and estimated widths and reservations for roads), then allocated to the different uses of roads, of railway length and width and of licensed airports in Australia.

2.3 Petroleum and gas footprint

Occupied land for oil refining is calculated by taking the area of the Altona and Geelong plants and applying the following assumptions:

- Plant areas are measured from maps, while pipeline paths are taken from maps with an assumed reservation width of 10 metres.
- Production output is approximately 90% of inputs.
- Units are converted from hectares to metres squared.

The footprint for natural gas consumption is calculated using emission data from the National Greenhouse Gas Inventory.

2.4 Footprint of wood products

Hardwood forestry is assumed to have a rotation of 85 years with a sawlog harvest of 96 m^3/ha and a total pulpwood yield of 258 m^3/ha (at a green timber density of 1.2 t/m^3 and a moisture content around 33%). The footprint calculation is shown in Table 2. This hardwood is assumed to be taken from 'managed forests', which is generally native forest on long-rotation harvest. Note that there is still some logging of previously untouched native forests; however, after logging, a similar rotation system would generally be used.

Table 2: Forest footprints for hardwoods

Products	Tonnes per ha with 85-year rotation	Per year	Footprint ha.years per tonne of hardwood
Pulp logs (hardwood)	310		
Saw logs (hardwood)	115		
Harwood products total	425	5	0.2

Pine plantation data is assumed to have a rotation of approximately 40 years with a yield of wood products at 662 tonnes per hectare (at a wet density of 1 t/m^3 and a moisture content of 45%). This is in general agreement with the Greenhouse Gas Inventory's prediction of biomass increase per year with coniferous plantations, which is around 631 tonnes over 40 years.

Table 3 shows the forest footprint calculations for softwood timber.

Table 3: Forest footprints for softwoods

Products	Tonnes per ha with 40-year rotation	per year	Footprint ha.years per tonne softwood
Pine saw logs	400		
Pulp logs (pine from harvest)	28		
Thinning (pulp and saw logs)	234		
Softwood products total	662	16.5	0.06

Paper production

Data was developed for copy papers, as they are a significant contributor in the schools and office spreadsheets. Copy paper production was modelled using virgin and recycled fibres. The virgin paper was assumed to be derived from Australian hardwood, while recycled paper was produced from paper collected from office waste-paper collections. Process trees for virgin and recycled paper, showing total global footprints, are in Figure 1 and Figure 2 respectively.

Table 4 details the greenhouse footprint for the two paper types and the impact of a typical import of a kilogram of paper over 15,000 km (assumed distance from Europe). The importation is important, as many of the recycled fibre papers are from Europe.

Figure 1: Process tree for virgin paper production footprint (lower value is total footprint in gha)

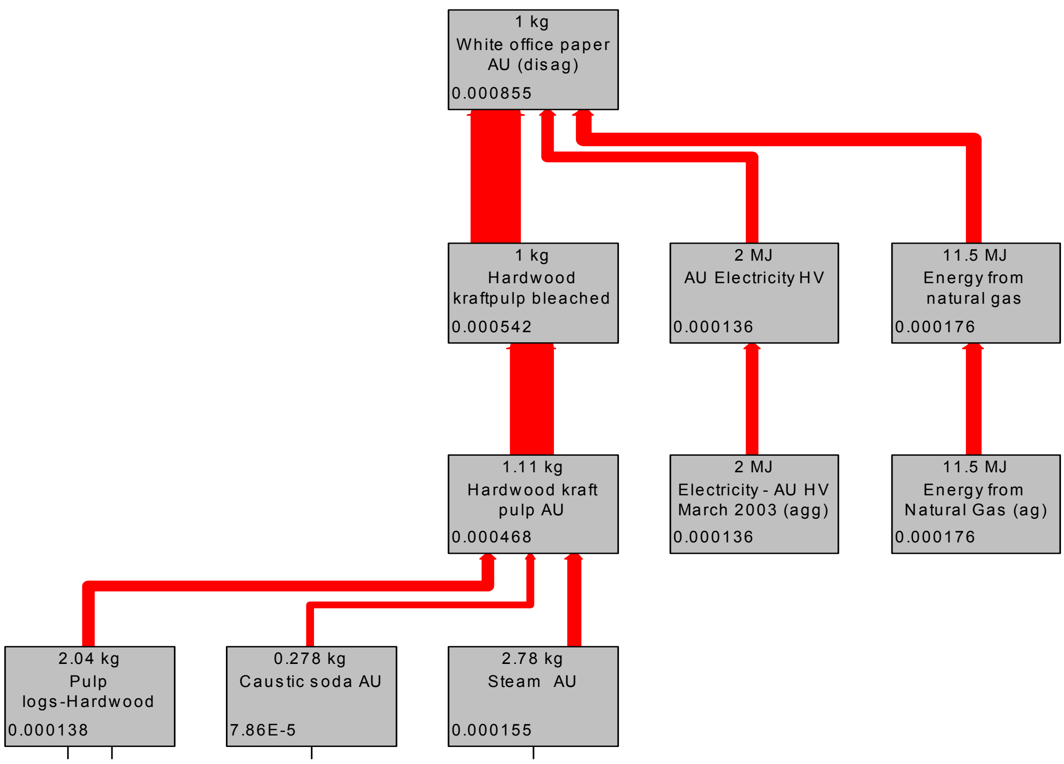


Figure 2: Process tree for recycled paper production footprint (lower value is total footprint in gha)

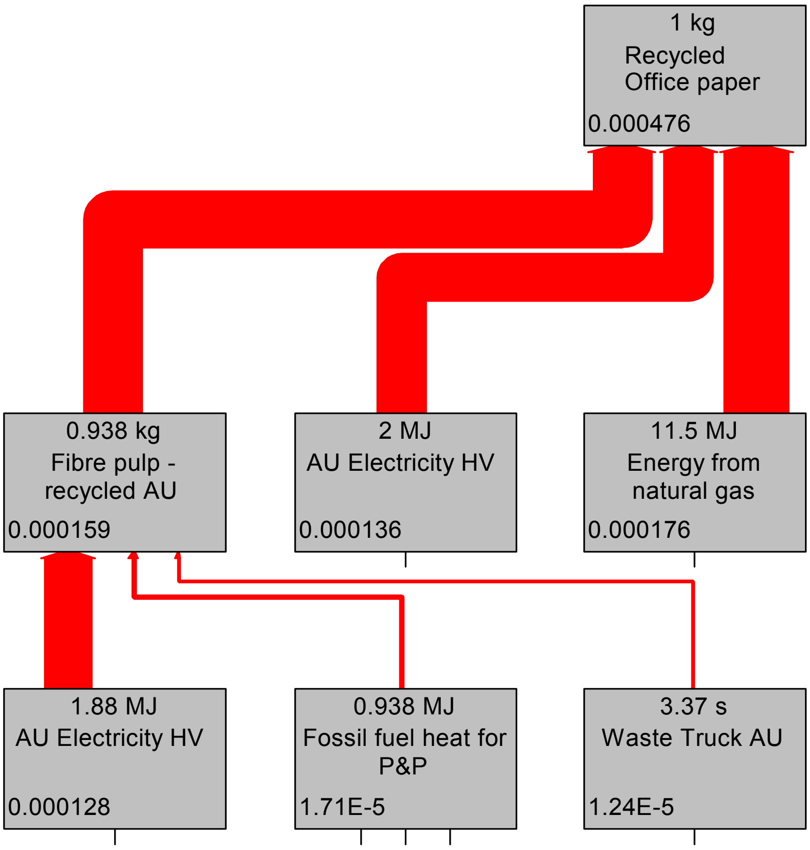


Table 4: Footprints for virgin and recycled fibre and international shipping

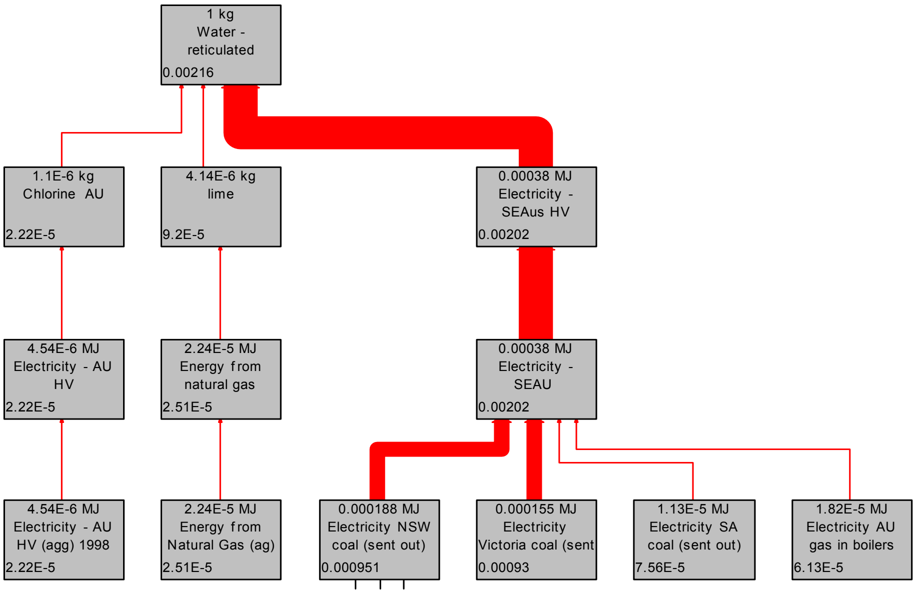
	kg CO_2/kg	Forest land m².years/kg	Built land m².years/kg
Virgin paper	2.7272942	1.53	0.0141
Recycled paper	1.7813719		0.0117
Shipping paper from Europe	0.0741548		0.0135

2.5 Water production footprint

The water footprint includes the area set aside for reservoirs and the energy consumed to supply water.

Using energy use in water supply data from Apelbaum and water chemical usage from Victorian water supply statistics, a total footprint for water supply has been calculated at around 0.002 m².years/litre (0.00216 for energy land and 2.54×10^{-6} for occupied land). Figure 3 shows the process inputs to the water supply footprint.

Figure 3: Process tree for reticulated water supply showing aggregated footprint flow (denoted by arrow width and in lower value of process box).



Note that tree impact is cumulative

2.6 Energy land footprint

All energy land calculations are based on carbon sequestration in forest areas. The National Greenhouse Gas Inventory for dense eucalypt forest assumes a total annual incremental increase in dry matter biomass of 4.81 tonnes per hectare, half of which is taken as carbon, giving 2.405 tonnes of carbon or 8.81 tonnes of CO_2 per hectare per annum. However, other forest types have lower carbon absorption values, as shown in column three of Table 5. Using this data, a weighted average carbon absorption value has been calculated to be 1.3 tonnes of carbon per hectare.

Table 5: Carbon uptake by Australian forests

Forest type	Area kha	Biomass increase factor t dm/ha/year	Biomass increase kt dm/year	Carbon fraction	Carbon uptake kt C
Rainforests	1333	1.15	1536	0.5	768
Tall dense eucalypt	3235	4.81	15546	0.5	7773
Medium dense	6705	1.9	12716	0.5	6358
Medium sparse	2029	0.35	716	0.5	358
Callitris	295	0.51	150	0.5	75
Coniferous plantation	972	7.1	6900	0.5	3450
Broadleaf plantation	503	8.65	4346	0.5	2173
Other forests	1289	0.47	606	0.5	303
Total	16,361		42,516		
Weighted average per ha		2.60		0.5	1.30

Source: Australian Greenhouse Office and National Greenhouse Gas Inventory Committee, 2002

Mathis Wackernagel, co-creator of the ecological footprint concept, uses a global average carbon absorption of 0.95 tonnes of carbon per hectare, but this figure is adjusted to average global hectares by the same productivity factor used for forest products. As the Australian productivity appears higher than average, the equivalence factor to convert from actual Australian hectares is adjusted to achieve the same gha result per tonne of CO2 as shown in Table 6.

Table 6: Calculation of carbon sequestration calculations in comparison with Wackernagel

	World average carbon absorption including roots:	Percentage carbon absorbed by oceans[d]	Total carbon offset per ha (accounting for ocean absorption)	CO_2 value of carbon offset in actual Australian hectares	Actual hectares per tonne CO_2	Equivalence factor[e]	Footprint of 1 tonne CO_2 in global hectares	Actual hectares per tonne CO_2
	[t C/ha/yr]	[-]	[t C/ha/yr]	[tCO_2/ha/yr]	ha.years/tCO_2	[gha/ha]	[tCO_2/gha/yr]	
Formulae	a	b	c=a+(a*b)	d=c*44/12c	e=1/d	f	g=d/f	h=1/g
Wackernagel	0.95a	30.8%	1.37	5.03	0.1987486	1.345	3.740878	0.267317
This report	1.30	30.8%	1.88	6.88	0.1453166	1.841b	3.737929	0.267528

Notes

a) From Wackernagel spreadsheet for Australian footprint calculations.

b) Equivalence factor adjusted to account for higher productivity of Australian forest compared to world average.

c) Ratio of mass of carbon dioxide to carbon.

d) Not all carbon released in the atmosphere has to be sequestered by forests. Wackernagel used an estimate of 30.8 percent of carbon being absorbed by ocean systems.

e) Equivalence factors are part of conversion of land areas to global averages – see discussion in section 3.7.

2.7 Input–output model calculations

Food and household products

A national economic I-O model was developed using 106-sector economic data from 1996–97. This model provides information on how individual sectors draw on inputs from all other sectors of the economy. Environmental data is developed for individual sectors and, using matrix manipulation, the total impact for each sector can be estimated. I-O tables present a comprehensive picture of the supply and use of goods and services in the economy and the incomes generated from production.

For the footprint calculations, direct land use data for the four direct land use types (pasture, cropping, forestry and built land) is calculated. From this data direct land use factors per dollar of production are calculated. For CO_2 values, data was estimated from energy data from ABARE and using the National Greenhouse Gas Inventory.

Using the I-O model based on 1996–97 economic tables provided by the Australian Bureau of Statistics, the land use data were translated to the environmental footprints listed for total domestic consumption in 1997. The basic (producers') prices (without taxes and margins) in 1997 are converted to purchase prices and corrected for inflation to 2003 dollars. The footprint for expenditure items per dollar expenditure are calculated by dividing the footprint values in 2003 purchase prices to get footprint values per dollar of current expenditure. Table 7 shows these values.

Table 7: Footprints for expenditure items per dollar expenditure.

	CO_2 (kg)/$	Pasture m^2.Years/$	Cropping Land m^2.Years/$	Forest Land m^2.Years/$	Occupied Land m^2.Years/$
Meat and meat products	0.560	142.5	8.92	1.74	0.05
Dairy products	0.589	3.62	0.36	1.53	0.04
Fruit and vegetable products	0.594	1.42	0.56	1.14	0.03
Oils and fats	0.535	11.23	2.33	0.77	0.04
Flour mill products and cereal foods	0.474	0.54	3.92	0.78	0.03
Bakery products	0.348	8.50	1.01	0.54	0.02
Confectionery	0.207	0.71	0.27	0.63	0.02
Other food products	0.447	4.73	1.49	1.02	0.03
Soft drinks, cordials and syrups	0.545	1.09	0.25	0.86	0.03
Beer and malt	0.254	0.32	1.54	0.29	0.02
Wine and spirits	0.228	0.60	0.61	1.06	0.01
Tobacco products	0.072	0.44	0.06	0.42	0.01
Textile products	0.268	6.01	0.61	0.26	0.01
Clothing	0.142	8.88	0.89	0.27	0.01
Footwear	0.124	3.97	0.35	0.18	0.01
Leather and leather products	0.297	33.50	2.63	0.56	0.02
Paper containers and products	0.480	0.32	0.03	11.76	0.01

3. CALCULATIONS FOR SPREADSHEET QUESTIONS

3.1 Building construction and site occupation

The impacts of building and maintenance are calculated using data from Treloar's embodied-energy case studies that cover residential buildings, educational buildings and commercial building and construction. As this model does not include Ecological Footprint data, the greenhouse data and other ecological footprint measures have been estimated, based on equivalent embodied-energy results from the Centre for Design, RMIT University's I-O model.

This data only covers building and construction. Allowances have been made for maintenance and renovation over the expected life of the building. Renovation over the 50-year timeframe is assumed to be roughly equal to the original construction impacts. Using this assumption, yearly maintenance is two per cent of construction. Table 8 shows these impacts with expected life spans for each of the building types.

The forestry land is highest for domestic construction, which has a higher utilisation of timber products. The footprint for pasture into building is entirely made up of the input from the sheep sector – possibly being wool input to carpet and furnishings. The built-land impacts are largely from mining operations.

Table 8: Upstream impacts of construction as derived from input-output model per unit gross floor area (GFA)

	1997 basic price per m^2	GJ	kg CO_2	Pasture land (ha)	Cropping land (ha)	Forestry land (ha)	Built land (ha)	Factor for maintenance impacts as compared with construction	Default expected life
Residential	1,820	15	1,066	0.05952	0.00605	1.32294	0.05372	1	50
Educational	2,523	16	1,202	0.06679	0.00764	0.39237	0.00592	1	30
Office	2,996	19	1,428	0.07931	0.00058	0.46594	0.04488	1	30

3.2 Green building features

A green building function is included to provide the option to vary construction material from the generic square-metre impacts. The assumptions built into the green building feature are shown in Table 9.

Table 9: Saving from green building options

	As % of concrete	As % of building	Savings from recycled aggregate /extenders as % or virgin material/ cement	Savings at 100% of usage
Concrete as % of building	16%			
Impact of aggregate	3.70%	0.61%	50%	0.30%
Cement impacts	90.80%	14.85%	50%	7.42%
Recycled materials (don't include recycled aggregate in this total)				50%
Reused materials				80%

3.3 Utilities – electricity, gas and water

Electricity is assumed to be from low-voltage average south-east Australian grid supply (NSW, Victoria, South Australia) unless green power is specified. Green power, either from a certified supplier or self-generated, is deducted from the electricity footprint and is assumed to be footprint-free.

Electricity estimator

For the household calculator a default value is provided, but users are expected to have their own energy data. For office areas and schools that do not have data on electricity, gas and water usage, estimation tools have been included.

The electricity estimator asks how many computer, printer, and copier units are used in the office or school. Using the operational hours of the office and a percentage estimation of equipment left on after hours, a total usage time is determined and multiplied by the equipment wattage (150 Wh for computers, 300 Wh for copiers, 50 Wh for printers and 80 Wh for fridges) to give kWh of electricity occupied. Similarly for the fridge the same calculation is performed, except it is assumed to run 24 hours a day, seven days a week.

Different lighting configuration options are available in the estimator. Energy use data are shown in Table 10.

Table 10: Energy use assumption for different lighting options.

Option	Energy use assumption	Data
Normal lighting	20 W/m²	GBRS states, 'Lighting power density varies in office applications from 7 W/m² in the very best installations, through 12 to 15 W/m² for average installations and upwards to 25 W/m² for older, poorly designed installations.'
Electronic ballasts	12 W/m²	
Natural lighting	15 W/m²	
Electronic ballasts with natural lighting	7 w/m²	

Note: Energy use assumption estimated from Greenhouse Building Rating Scheme data.

Heating and cooling energy use is calculated using estimates of energy use per square metre of floor area, adjusted by type of equipment and the greenhouse rating of the building (using the Australian Greenhouse Office greenhouse rating scheme). Heating is assumed to be around 35% of the energy load and cooling around 21%. These percentages were used to predict expected emissions from the building of different energy performance as shown in Table 11.

Table 11: Energy use assumption for heating and cooling

		Space heating	Space cooling	Water heating
Options	100%	35%	21%	5%
1-star building	0.0365	0.012788	0.007673	
2-star building	0.0293	0.010264	0.006159	
3-star building	0.0216	0.007572	0.004543	0.0010817
4-star building	0.0144	0.005048	0.003029	
5-star building	0.0072	0.002524	0.001514	

Note: All values based on electric appliances.

It is assumed that 25% of the total energy bill is gas heating. Hot water heating is assumed to be one-third more efficient if it was produced using gas. If solar hot water is installed, the water heating requirements for gas or electric hot water were assumed to be half.

For cooling equipment the type of equipment used is important and efficiency factors were used to convert standard energy use data in Table 12 to be more representative.

Table 12: Efficiency factors for different cooling types

Cooling Type	Efficiency factors for space cooling
Evaporative air cooling	0.5
Air conditioners	2
Centralised chillers (electric)	1.2
Centralised chillers (gas)	0.8

Gas estimator

The gas estimator uses the same estimation approach as electricity but is only included in the results for heating and hot water usage.

Water estimator

Water consumption in commercial offices and schools is estimated by adding the number of dishwasher cycles, cups hand-washed, the number of showers taken and the existence of waterless urinals in the toilets. Water usage is assumed as follows: 20 litres of water per dishwasher load, 600 ml of water per hand-washed cup, 60 litres of water per shower and 5 litres of water per toilet visit with an average of three visits per day per person.

3.4 Other consumption items

Automobile production and use

The impacts of automobile production and automobile use have been included in all spreadsheets.

Data on automobile production impacts have been derived from the I-O table for Australia. The data is based around typical prices for small, medium and large vehicles. It is recognised that the vehicle price will not be the only determinant of environmental impact. However, for the purpose of this exercise it is seen as sufficient. A ten-year life is assumed for each vehicle, so the annual footprints for vehicle product are equal to the values shown in Table 13 divided by 10.

Table 13: Estimate of car production impacts using input–output data

Car size	Purchase price estimate	Basic price estimate[1]	Primary energy MJ	CO_2 (g)	Pasture land (ha)	Cropping land (ha)	Forestry land (ha)	Built land (ha)
Small car	$15,000	$9182	6.60×10^4	5.32×10^6	0.3333	3.78×10^{-3}	3.11×10^{-3}	0.01508
Medium-size car	$25,000	$15,303	1.03×10^5	8.29×10^6	0.5197	5.90×10^{-3}	4.85×10^{-3}	0.02352
Large Car or 4WD	$40,000	$24,485	1.65×10^5	1.33×10^7	0.8319	9.44×10^{-3}	7.76×10^{-3}	0.03765

Note 1: Basic price estimate is the cost to the producer and is used to estimate impact from I-O data.
Ratio of basic price to consumer purchase price waste taken from I-O data.
Reconciliation of flows at basic prices and at purchasers' prices by product group 1996–97

The use of the automobile is calculated based on a total fuel cost entered by the users and a fuel mix specification entered in the description of vehicle in the spreadsheets. Emission factors for different fuels were taken from the National Greenhouse Gas Inventory.

Restaurants and business lunches

In the office spreadsheet, restaurant and business lunches are included in the footprint. For this category, the I-O data for accommodation, cafes and restaurant has been used. As the I-O data is from 1997 and is modelled in basic prices (suppliers' prices), it needs to be converted to purchasers' prices and in 2003 dollars. This is done using an assumption of a three percent annual increase in the consumer price index.

Stationery

For stationery use in offices and schools an estimate of the footprint was made using the I-O data. However Australia's economic data contains no sector for stationery, so an estimate was made using equal contributions (by price) between plastic products, paper containers and products and fabricated metal products.

Paper usage

For offices and schools the main paper consumption was thought to be copy papers used in printers and photocopiers. A dialogue box is provided to allow users to specify up to three paper types. For each paper type users can specify a percentage of recycled content and whether the paper was imported. Table 4 provides the relative footprints for recycled and virgin papers, along with import impacts. The data entered into the paper specification dialogue is summed to provide total mass of recycled fibre and total mass of virgin fibre, and the total proportion of all fibre imported. These values are then multiplied by the relevant footprint factors from Table 4.

Printing and publications

The consumption of printed material and the production of printed publications are dealt with using input–output data.

For consumption of paper products the printing and services-to-printing sector was used as a proxy for printed material. For publishing of materials by organisations the section 'Publishing, recorded material and publishing' sector was used. In reality there is some overlap between these two sectors, but the latter is more about value-added product and therefore has a lower impact per dollar.

Computers and IT equipment

The footprint of computers and information technology equipment is estimated from the I-O model and the expenditure of the organisation each year, rather than by defining a stock of IT equipment and trying to depreciate it in terms of the footprint. This approach was taken because of the short life of this type of equipment.

3.5 Waste management

Waste management calculations are dealt with in the school and office footprint implicitly by asking for information on the percentage of material recycled and inferring the level of recycling through analysis of the level of original consumption in the organisation.

Rather than deal with all materials, three areas are prioritised. They are paper recycling, container recycling and recycling of IT equipment.

For paper recycling it is important not to double count recycling at end of life and recycling through the purchase of recycled-content paper. To avoid this, average recycling content of papers was checked and subtracted from the recycling rate at end of life. If the recycling rate at end of life is lower than the level of recycled content, no credit was given for end-of-life recycling.

For can and bottle recycling, consumption of containers is estimated from beer and wine consumption in the office. Other drink consumption was not taken into account in the office spreadsheet, so the recycling of soft drink and fruit juice containers was not included.

For IT equipment a flat 10 per cent reduction in production impacts was credited for the recycling of IT equipment. This low figure was taken to account for the difficulty of finding an end market for reused or recycled IT equipment.

In the household spreadsheet a more complex treatment of waste management was included. It includes defining the waste stream going to landfill and its overall volume. For recycling, the mass of materials recycled, or a number of items, is then converted into weight using average-item definitions. Credits for recycling and the impacts of landfill are taken from the SimaPro process model and are based on work undertaken by the Centre for Design for EcoRecycle Victoria, shown in Table 14.

Table 14: Results from SimaPro model for waste management

	CO_2 (kg)	Forest Land (ha.years)	Consumed land (ha.years)
Food waste	0.858	x	-0.0002
Garden waste	0.107	x	-2.5×10^{-5}
Paper waste	0.905	x	-0.00021
Metal waste	0.00398	x	1.19×10^{-7}
Plastic waste	0.00398	x	x
Other waste	0.599	x	-0.00014
HDPE recycling	-0.334	x	0.000966
PET recycling	-0.744	x	-9×10^{-5}
PVC recycling	-1.6	x	0.000278
Steel can recycling	-0.736	x	-0.00054
Aluminium recycling	-15	x	3.28×10^{-5}
Glass recycling	-0.349	x	-1.2×10^{-5}
Mixed plastic recycling	0.489	-0.0001	0.000333
Paperboard recycling	-0.269	-5×10^{-5}	0.000331
ONP recycling (kerb)	-0.567	-9.2×10^{-5}	1.62×10^{-5}
LPB recycling (kerb)	0.201	-0.00016	-0.00012

3.6 Government administration

For the household spreadsheet, where the aim is to calculate the total impact of the respondent, the impacts of government administration – such as healthcare, capital works on public infrastructure and the general operation of government – needs to be included. The data from the ABS economic usage data on Government final consumption expenditure was used to estimate the total impacts of government. The footprint of government administration is shown in Table 15

Table 15: Total and per-capita footprint of government administration

	CO_2 (t)	Grazing land (ha.years)	Cropping land (ha.years)	Forest land (ha.years)	Consumed land (ha.years)
Total per year	2.57×10^{7}	3.88×10^{6}	1.69×10^{5}	6.96×10^{6}	6.04×10^{4}
Total per capita	1.43	2.15×10^{-1}	9.36×10^{-3}	3.86×10^{-1}	3.35×10^{-3}

3.7 Presentation of and normalisation of footprints

The footprints throughout the calculations in the spreadsheets are based on actual measured land areas in Australia. The resulting footprint is made up of semi-arid grazing lands, dense forests, fertile farming areas, and everything in between. If the footprint measure is to represent the utility provided by land areas, it needs to be adjusted to average land with average productivity. This is achieved by converting each land-use type with an equivalence factor. The factors provided by Wackernagel in the calculation of the Living Planet Report 2002 are shown in Table 16. The equivalence factors change the actual hectares in Australia to average hectares in Australia. It is useful for an international comparison to convert the average Australian hectares into hectares of average global productivity (global hectares). This is done using yield factors, which are the ratio of Australian average productivity and world average productivity, which are also shown in Table 16. The low values for the yield factors are a result of lower productivities in Australia compared with world averages. This has the effect of making the global hectare footprint smaller than the average Australian footprint.

Based on these different ways of measuring the footprint, all of the spreadsheet's measurement options are via a dropdown menu at the top of the worksheet.

Table 16: Equivalence factors and yield factors.

	Equivalence factor	Yield factor
	[gha/ha]	**[-]**
Primary cropland	2.174	0.94
Forest	1.346	0.20
Permanent pasture	0.473	0.24
Consumed land[a]	2.174	0.94
Energy Land	1.841	None used[b]

Notes

a) Consumed land is assumed to be on arable cropping land.

b) No equivalence value is used for energy land as the productivity difference is taken into account in the equivalence factor.

Comparison alternatives

The resultant footprint can be normalised against different benchmarks, including: World Footprint Average; Australian Footprint Average; World Bio-capacity; and Australian Bio-capacity.

The values for these are taken from the Living Planet report for 2002. The bio-capacity values are only available for cropping, grazing and forestry footprints and there is no specific land that is logically set aside for energy land or occupied land that cannot also be used for cropping, grazing or forestry. The values used are presented in Table 17 in global hectares.

Table 17: Footprint normalisations (comparison) available in the spreadsheets (gha)

	Total ecological footprint	Total energy footprint	Grazing land footprint	Cropland footprint	Forest footprint	Consumed Land	Biodiversity
World Footprint	2.5536	1.12	0.12	0.53	0.27	0.1	0.306432
Australian Footprint	8.736	4.35	0.62	1.64	0.6	0.11	1.04832
World Bio-capacity	1.9		0.27	0.53	0.86		
Australian Bio-capacity	14.61		4.94	4.38	2.3		

4 SUMMARY OF PROJECT RESULTS

The footprint calculators use a range of approaches to calculate the land-use and energy impacts. These different approaches have been chosen to obtain completeness across complex consumption categories (such as food, electrical products and buildings) while maintaining some level of specific analysis at the points which are critical to the footprint calculation (for example, use of green building features in building construction and the use of paper by offices and schools.)

There is reasonable agreement between the household calculator, which aims to account for total consumption per capita, and the results of the Wackernagel footprint calculation for Australia in the Living Planet Report 2002. The differences are to be expected, given that Wackernagel's calculation works from the top down (looking at total consumption and dividing by population) while the calculator works from the bottom up (looking at individual consumption items and allocating footprint impacts to them). They may also be due to significant errors in the selection of standard consumption data in the spreadsheet in areas such as house and block size, transport habits and so on.

Table 18: Results of household footprint calculator using average default data, compared with Wackernagel results for average Australian footprint.

Total eco-footprint	Energy land	Pasture	Cropland	Forest land	Consumed land	Biodiversity
89%	86%	136%	86%	96%	222%	89%

Note: A number less than 100% shows the calculator producing a result lower than that of Wackernagel.

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