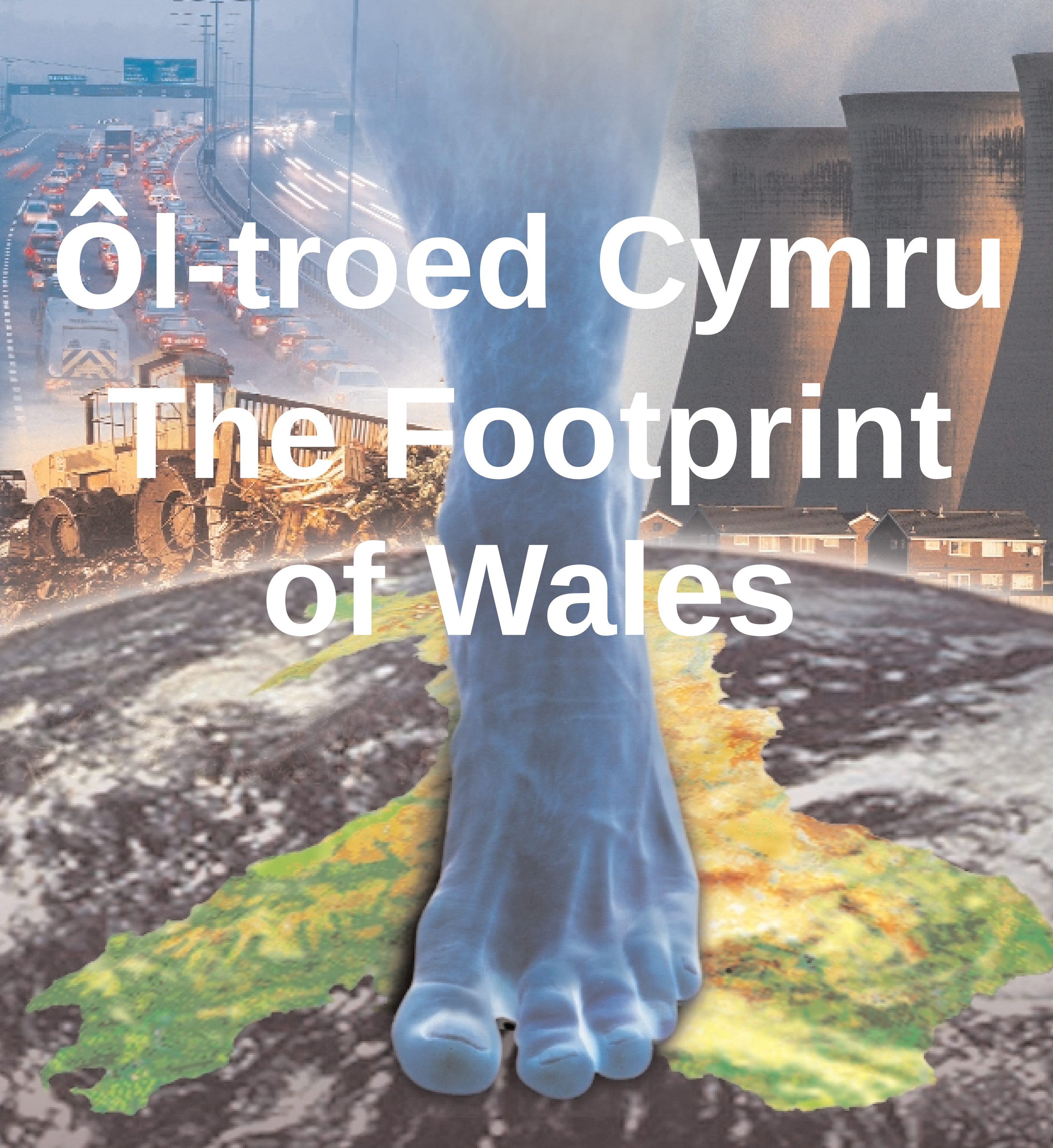

Ôl-troed Cymru
The Footprint of Wales

A Report to the Welsh Assembly Government

By WWF Cymru

Adroddiad i Lywodraeth Cynulliad Cenedlaethol Cymru

Gan WWF Cymru

Best Foot Forward

Researched and written by Best Foot Forward
April 2002

Wedi'i ymchwillio a'i ysgrifennu gan Best Foot Forward
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Executive Summary

On January 26 2000, the National Assembly of Wales launched a major consultation document; *A Sustainable Wales - Learning to Live Differently.* This sets out how it plans to meet its legal obligations on sustainable development. The document included a proposal to develop a set of headline indicators. A paper was submitted to the Assembly in January 2001 by WWF Cymru, examining the strengths and weaknesses of the proposed indicator suite, while also suggesting that the Ecological Footprint (EF) would be the ideal tool to help bridge the gap between the missing global to local elements. This was accepted in March 2001, making the Assembly the first administration in the world to use EF as an indicator of 'real progress'.

The aim of the 'All Wales Footprint as a Global Indicator' project is to undertake a preliminary calculation of the Ecological Footprint of Wales for the year 2000 with a view to understanding the benefits of, and barriers to, undertaking more detailed time-series analyses in future years.

The value of this work is therefore four-fold:

- To provide an initial benchmark EF figure for Wales to permit an early sustainability assessment
- Identification of 'big hitters' in terms of environmental impact
- To identify where there are data-gaps in the available Wales-specific data which would hinder future detailed analyses
- To present several outline consumption scenarios - to illustrate how the use of the Ecological Footprint might be developed

As part of this short study, a partial resource flow analysis was also undertaken to estimate material flows through the Welsh economy. This analysis, as well as enabling the EF analysis, also produced interesting results of its own. Total accounted material consumption was 8,468,481 tonnes or around 2.9 tonnes per resident (excluding agricultural wastes, water and fuel). Carbon dioxide emissions arising from electricity, gas and heating oil consumption were also estimated at 14,648,040 tonnes or 5 tonnes per resident. Both figures include domestic, commercial and industrial consumption.

Gaps were identified in existing sources that prevented the exclusive use of Wales-specific data. There were omissions in the areas of trade statistics, transport and energy.

Ecological Footprint results are presented for Wales as a whole and for the average Welsh resident. They have been calculated in such a way as to allocate, as far as possible, material and energy use to personal consumption. The total EF of Wales was found to be 15,468,887 area units, which equates to 5.25 area units per capita. This compares favourably to the UK per capita EF of 6.00 area units but far exceeds the average sustainable 'earthshare' of 1.9 area units. Thus if everyone on the planet consumed as much as the Welsh then we would need around 1¾ additional earths to sustainably support global resource demands.

The Welsh per capita EF is then compared to the available biocapacity (the bioproductive capacity of Wales). The total biocapacity of Wales is 6,729,313 area units or 2.29 area units per capita. Assuming only minimal space is set aside for other species, then an area about 2½ times bigger than Wales would be needed to sustainably support current Welsh lifestyles.

In the final section of the report, a limited set of 10-year scenarios are developed to illustrate the potential effects on the Ecological Footprint of current National Assembly policies and proposals[1]. Areas covered are:

- electricity consumption and generation;
- rail and road modes of transport; and
- waste materials production and management options.

Given certain basic assumptions, as described, improvements are demonstrated for electricity and waste only. All scenarios show, particularly transport, how background changes in demand could easily undermine the potential beneficial effects of existing, or anticipated, policy targets.

The importance of aligning the Wales footprint work with current European developments in the use of the EF as a sustainability indicator is briefly addressed.

In conclusion, the duty to promote sustainable development is undoubtedly a challenging one as the analyses presented in this report demonstrate. It is hoped that this first calculation and exploration of Wales' Ecological Footprint proves a helpful first step, and a continuing companion, on the road to a more sustainable Wales.

[1] The targets relating to the recycling and composting of waste materials, at the time of writing, have not been formerly adopted.

Contents

Sustainable Development in Wales

The UK Government was one of 178 Governments that adopted a declaration at the Earth Summit in Rio de Janeiro in 1992, committing themselves to making development sustainable.

The UK Government's strategy for achieving sustainable development is set out in *A better quality of life*[2]. This document emphasises four key goals:

- social progress which recognises the needs of everyone
- effective protection of the environment
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth

The stated aim of the National Assembly for Wales (NAW) is to "add value to work done at the UK level on sustainability, building on the UK Strategy, reflecting the needs of Wales as necessary"[3].

Unlike the UK as a whole, the Assembly has a legal duty to consider sustainability. Section 121 of the Government of Wales Act 1998 requires the Assembly to set out how it proposes to promote sustainable development. The Scheme has to be derived through consultation, kept under review and reguarly updated[4].

The challenge and potential benefits of delivering sustainable development in Wales has been acknowledged in Westminster. When the 1998 Act was being debated in the UK Houses of Parliament, Welsh MP Cynog Dafis had this to say about the proposed new duty:

"We have a serious opportunity to put Wales at the forefront of that transition to sustainable development, just as Wales was at the forefront of the transition to industrialism 200 years ago, when our resources of energy were a crucial consideration. The Assembly therefore has every reason to adopt sustainable development as a central theme for Wales." [5]

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[2] http://www.environment.detr.gov.uk/sustainable/quality/life/foreword.htm

[3] http://www.wales.gov.uk/themessustainabledev

[4] Government of Wales Act 1998 http://www.legislation.hmso.gov.uk/acts/acts1998

[5] The UK Parliament's discussion of this duty is recorded in Hansard 25th February 1998 http://www.publications.parliament.uk

On 26 January 2000 the National Assembly launched its major consultation document *A Sustainable Wales - Learning to Live Differently* that sets out how it's going to meet its legal obligations on sustainable development[6]. These include a proposal to develop a set of headline indicators.

The ecological footprint was formally adopted as one of the headline (and only global) indicator for the National Assembly's overarching Sustainable Development Scheme 'Learning to Live Differently' on March 1st 2001[7].

[6] http://www.wales.gov.uk//content/consultation/consultext_e.htm

[7] This is referred to in an The Official Record of the National Assembly 1st March 2001 http://www.wales.gov.uk

Aim of the All Wales Footprint Project

Commissioned by WWF-Cymru, in collaboration with the National Assembly for Wales, the aim of the 'All Wales Footprint as a Global Indicator' project is to undertake the first ever calculation of the Ecological Footprint of Wales. The specific study methodology and outputs are outlined in the project brief:

1. undertake secondary data research using official data sources
2. utilise these to calculate the Ecological Footprint of Wales
3. prepare a report on the findings

Outputs include:

1. Data collection and review - to include information on data gaps
2. A component-based analysis of Wales - to include both resource 'demand' (the Ecological Footprint) and regional 'supply' (the biocapacity)
3. A report setting out four basic scenarios for Wales' future to be developed in collaboration with Cardiff University or 'other partners identified by WWF Cymru'[8].

This project was completed by staff at Best Foot Forward within the 29½ person-days allotted and to budget. It satisfies all the outputs above.

[8] The scenario data was in the end supplied by WWF Cymru directly with no involvement from Cardiff University, the anticipated partners.

Profile of Wales

Wales is one of the three countries of Great Britain. Wales is bounded by the Irish Sea to the west and the Bristol Channel in the south. Wales is landlocked on the eastern side by the English counties of Cheshire, Shropshire, Herefordshire and Gloucestershire.

The land area of Wales extends to almost twenty one thousand square kilometres; four-fifths of which is committed to agriculture (80% of which, under the agricultural land classification is Grade 4 or 5), while woodland covers another eighth. There are many reservoirs and around 24,000 kilometres of river (including first and second order streams and unclassified rivers) and 1,300 kilometres of coastline.

Three National Parks and five areas of outstanding natural beauty cover almost a quarter of the country. There are 1,008 sites of special scientific interest, over 100 nature reserves, and six environmentally sensitive areas.

Since July 1999, The National Assembly for Wales (NAW) has had the power and responsibility to develop and implement policy and make vital decisions in a range of areas such as, agriculture, economic development, the environment, local government, industry and tourism.

Wales has a resident population of 2,946,200 (mid-year 2000 estimate, Office for National Statistics 2001), which is projected to rise to nearly 3 million by 2011 (Government Actuary's Department 2001).

A population profile is given in Table 1.

Table 1: 1999 Age, Ethnicity and Population Growth for Wales and UK

	0 - 4 (%)	5 - 15 (%)	16 - 19(%)	20 - 24 (%)	25 - 44 (%)	45 - 59 (%)	60 - 64 (%)	65 - 79 (%)	80 and over (%)	Ethnic minorities (%)	Total change 1991-99 (%)
Wales	5.8	14.5	5.2	5.6	27.4	19.1	5.1	13.0	4.3	2	1.6
UK	6.1	14.3	5.0	5.9	29.9	18.4	4.8	11.7	3.9	7*	2.9

* - Great Britain only. Source: Office for National Statistics, Regional Trends 36 2001

The Welsh GDP is the third lowest among the 13 UK regions at £10,449 compared with a UK figure of £13,213 (Office for National Statistics 2001). Average gross household incomes are also below the National average at £12, 655 compared to £14,684 per head per year (Office for National Statistics 2001).

Industry is concentrated in the area known as Industrial South Wales, which has strong economic ties with the English West Midlands. Businesses are concentrated in two sectors; agriculture (livestock farming) and tourism. The proportion of businesses in each sector is compared with UK-wide distribution in Table 2.

Agriculture, however, employs relatively few people (2% of Welsh jobs) compared with the manufacturing industry (22%), distribution, hotels and catering, repairs (22%) and education, health and social services (22%). The other significant sectors of employment are financial and business services (11%) and public administration and defence (7%) (Office for National Statistics 1999).

Table 2: Distribution of businesses by sector in Wales and the UK as a whole, 2000

	Agri-culture, hunting, forestry and fishing (%)	Mining & quarrying, energy, water supply & manufact-uring (%)	Construct-ion (%)	Distri-bution, hotels & catering repairs (%)	Trans-port & commun-ications (%)	Financial intermed-iation, real estate, renting & business activities (%)	Education & health (%)	Public admini-stration & other service (%)
Wales	16.8	7.0	9.2	30.2	4.2	16.0	7.5	9.2
UK	7.2	8.1	8.7	28.9	4.3	26.0	6.9	9.9

Source: Office for National Statistics, Regional Trends 36 2001

Wales has 1.2 million households - dwellings of type set out in Table 3. 71% of properties are owner occupied, which is slightly higher than the UK national figure of 67% (Office for National Statistics 1999).

Table 3: Type of dwelling for Wales and the UK, 1999/2000

	Detached house (%)	Semi-detached (%)	Terraced house (%)	Purpose-built flat (%)	Other (%)
Wales	28	33	32	6	1
UK	23	32	28	12	5

Source: Office for National Statistics, Regional Trends 36 2001

Resource Consumption

This section reviews and summarises the available data on the energy and materials consumption of Wales. Such an analysis is a necessary pre-cursor to undertaking Ecological Footprint calculations.

Data Availability

The limited time available for this project have meant that the authors have had to rely on the analysis of existing data sources. The methodology used follows that described in the *Island State* report (Best Foot Forward and Imperial College 2000)[9], which considered the resource consumption of the Isle of Wight, but, unlike that study, it has not been possible to undertake any primary data collection.

A wide range of secondary sources have been sifted to identify Wales-specific data. Where such local data has not been available, estimates of Welsh consumption have been made by proxying UK sources using UK or per capita averages.

The use of proxy data does tend to mask regional differences in consumption and this should be born in mind when considering the figures presented here. Proxy consumption data presented in this report are highlighted in the tables below with an asterisk (*). In future analyses it is hoped that the use of proxy data can be reduced either by undertaking more primary research or by drawing on new official data sources from the NAW.

The number of tourists can significantly effect such calculations and it has therefore been necessary to consider the tourist population when estimating per capita consumption. This avoids inflating the actual consumption of residents. However, having looked at tourism data for Wales[10] it was found that UK and overseas visitor bed-nights equated to just under 120,000 permanent residents' equivalents (out of a population of 2.9m). Assuming tourist consumption to be the same as the resident population, then it is necessary to reduce the per capita consumption of residents by around 4%. To counter this it has not been possible to account for the impact of Welsh residents when on vacation (except for their travel). It is therefore proposed that the impact of tourism ('distribution, hotels, catering, repairs') is ignored. This is consistent with the approach taken by the Living Planet Report 2000, which considers only consumption within National boundaries.

For the analyses presenter here data for the year 2000 is used where possible. Where earlier data is used this is indicated.

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[9] Available for free download from www.bestfootforward.com

[10] A Tourism Strategy for Wales 2000, Welsh Tourist Board.

Resource data is presented below, by category:

- Direct Energy
- Materials & Waste
- Passenger Transport
- Freight Transport
- Water & Sewage

Direct Energy

It is notoriously difficult to obtain energy data, particularly electricity data, due to de-regulation of the market. Whereas electricity companies previously distributed to one region they now sell more widely, making it difficult to secure local consumption data. Commercial confidentiality has also become more of an issue.

The available energy data is listed in Table 4 along with details of any breakdown. Total energy consumption is estimated to be 54,447 GWh per annum. No detail was available on the independent supply and uptake of renewable energy but this is thought to be limited to small-scale biomass and wind generation. Renewable electricity supplied through the national grid is included in the main figure given for electricity. Similarly, the use of oil for energy generation (outside of that for domestic use and for grid electricity generation) has not been accounted.

Table 4: Welsh energy consumption data broken down by category

	GWh
Electricity *of which*	**16,837**
Domestic*	4,883
Commercial*	2,947
Industrial*	4,883
Other*	4,125
Gas *of which*	**36,029**
Domestic*	11,890
Commercial*	2,342
Industrial*	6,485
Other*	15,312
Heating Oil – domestic*	**1,577**
TOTAL	**54,447**

Sources: DUKES 2001, Transco 2000, DTI pers. comm. 2001. * Wales-specific gas and electric totals have been used but UK proportions are used to estimate domestic, commercial and industrial breakdowns.

As elsewhere in the UK, Wales' energy supply is primarily fossil fuel-based. The carbon emissions arising from the energy consumption given in Table 4, have been calculated using CarbonCalc™, a software package produced by Best Foot Forward, which uses standard Government conversion factors to estimate pollution (DETR 1999).

Carbon emissions for direct energy use are estimated at 3,994,920 tonnes per annum. This is equivalent to 14.6Mt tonnes of carbon dioxide. See Table 5 for a breakdown by source. Note that other sources of emissions, such as transportation, are not included. Official UK government statistics estimated Wales' total carbon dioxide emissions to be 36.7Mt[11] in 1998.

Table 5: Carbon and carbon dioxide emissions by energy source.

	GWh	Carbon (tonnes)	Carbon dioxide (tonnes)
Electricity	16,837	2,020,440	7,408,280
Gas	36,029	1,866,957	6,845,510
Heating Oil – domestic*	1,577	107,523	394,250
Total	**54,447**	**3,994,920**	**14,648,040**

Sources: CarbonCalc™, DETR 1999

Materials & Waste

Materials and waste are grouped together as they are essentially two sides of the same coin. Waste is merely the product of some process or activity that is perceived to have little value.

Material flows, in the form of raw materials and manufactured products, can be easily tracked at a national level by using trade statistics but no such comprehensive data set yet exists for Wales. The exception is food data that is collected regionally by the Office for National Statistics (ONS). Consumption of foodstuffs is dealt with in a separate section.

Consumption at a local level can, at best, be estimated by either 'back-casting ' from local waste statistics or profiling from local consumer spending. Both approaches have their advantages. In this study the author's have chosen the former approach. It should be noted that estimating material consumption from

[11] http://www.aeat.co.uk/netcen/airqual/statbase/

waste ignores those materials that are retained within the economy. Evidence suggests that the vast majority of retained materials are used for construction (roads, housing and so on).

Table 6 presents waste data for Wales categorised by origin; municipal, industrial and commercial. Where further breakdowns by material are available these are shown.

Table 6: Waste data for Wales.

	Tonnes
Municipal *of which*	**1,616,774**
Recycled *of which*	84,103
Paper & card	32,909
Glass	15,317
Compost	12,244
Scrap metals/white goods (assume steel)	13,520
Textiles	2,693
Cans	958
Plastics	387
Other Mixed	6,075
Commercial *of which*	**1,141,000**
Inert/ construction & demolition	9,000
Paper & card	106,000
Food	18,000
General commercial	853,000
General & biodegradeable	80,000
Metals & scrap equipment	22,000
Contaminated general	33,000
Minerals wastes & residues	1,000
Chemicals & other	19,000
Industrial *of which*	**4,989,000**
Inert/construction & demolition	129,000
Paper & card	150,000
Food	105,000
General industrial	572,000
General & biodegradeable	370,000
Metals & scrap equipment	393,000
Contaminated general	198,000
Minerals wastes & residues	2,654,000
Chemicals & other	418,000
Commercial Waste accounted as Municipal Waste	**-209,000**
Total	**7,538,000**

Sources: Environment Agency 2000, DEFRA 2001. Data rounded to nearest 1000 tonnes.

Food

The UK National Food Survey records consumption of food within Wales. Most food waste finds its way into the sewage system but it should be borne in mind that some unused solids (scraps, peelings, leftovers and so on) do find their way into the municipal, commercial or industrial waste streams as indicated above (c.123,000 tonnes of food waste has been identified in these waste streams plus a considerable tonnage of unknown waste classified as biodegradeable) and this needs to be discounted to avoid double-counting total consumption.

A breakdown of food items is shown in Table 7.

Table 7: Food consumption within Wales

	Tonnes
Milk and cream	311,006
Cheese	13,592
Meat and meat products	153,793
Fish	22,298
Eggs	19,500
Oils/Fats	27,948
Sugar and preserves	23,978
Vegetables - fresh potatoes	114,696
Vegetables - fresh green	33,599
Vegetables - other fresh	64,450
Vegetables – processed	90,871
Fruit – fresh	88,427
Fruit – processed	40,472
Bread (White)	112,558
Cereals	98,660
Tea	3,971
Coffee	2,138
Other Beverage	458
Soft drinks	229,239
Alcoholic drinks	64,297
Confectionery	10,233
Miscellaneous	57,577
Total	**1,583,759**

Source: MAFF 2000

Passenger Transport

The total length of the Welsh road network is about 34,500 kilometres. Most roads are minor highways with main roads (motorways, trunk and principal roads) accounting for just 13% of the total length. This can be contrasted with the 1,700 kilometres of rail track (National Assembly for Wales 1999, 2000).

Cardiff International Airport had 65,680 aircraft movements and 1.5 million passengers during the year 2000 (National Air Traffic Services, 2001).

Passenger travel data for Wales is incomplete. Whilst good data is available on resident travel by car and bus, information on other modes of transport (sea, air and train) is patchy. Data for these latter modes has therefore been estimated from UK-wide sources.

Table 8. Estimated distance travelled by different modes of transport in Wales

	Passenger Travel (000's vehicle km/yr)
Travel by car	20,737,749
Travel by bus	239,000
	Passenger travel (000's passenger km/yr)
Travel by train*	1,928,696
Travel by air*	360,332
Travel by ferry*	29,616

Sources: SRA Bulletin 2001, DETR Bulletin of Public Transport Statistics: Great Britain 2000, National Assembly for Wales 2001.

Freight Transport

Goods are carried mainly by road. In 2000, almost 57.5 million tonnes were moved within Wales, a further 59 million tonnes were moved between Wales and the rest of Great Britain, and there were almost 1 million tonnes in overseas trade (National Assembly for Wales 2001). Over 60 million tonnes of goods moved through Welsh sea ports, over half through the oil port of Milford Haven (National Assembly for Wales 2000).

Despite these figures, it is difficult to attribute freight transport to a particular region as many goods produced in an area are exported and many items are freighted through an area to another destination. As well as tonnage data, travel distance is also required to undertake environmental assessments.

Imports to, and exports from Wales by road are given in Table 9. For non-road transport modes Wales' data is generated by proxied UK data and shown in Table 10.

Table 9: Road Freight - import and export tonnages by road

	000's tonne-kilometres
Exports (from Wales)	594,000
Imports (to Wales)	265,700
Total (net movement of goods)	-328,300[1]

[1] Note that the minus figure represents a greater flow of materials out of Wales, than into Wales.

Source: National Assembly for Wales, DTLR 2001

Table 10: Freight transportation by mode (in thousands of tonne kilometres per annum).

	000's Tonne-kilometres
Road freight*	7,762,928
Rail freight*	908,233
Sea freight*	2,616,107
Air freight*	274,543
Total	**11,561,812**

Source: Transport Statistics: Great Britain 2000, DETR

Water & Sewage

The Environment Agency Wales (2001) concludes that *'although Wales is often considered to have abundant water resources, there are some areas where improvements to the water environment are necessary. We believe this may require the recovery of some 13 Ml/d* [Megalitres per day] *from existing licensed abstractions'* and *'continued availability of reliable public water supply is essential. We recommend the enhancement of public water supply by up to 7 Ml/d above present levels by minor resource development and infrastructure improvement to move water from areas of surplus to areas of need.'*

Rainfall in Wales is higher than in the English regions. An average of 1,310mm per year is deposited, though this ranges from less than 700mm per annum in the Welsh Borders to more than 4,000mm in Snowdonia (Environment Agency Wales 2001).

The Welsh public water supply is provided primarily by Dwr Cymru (a water service company) and Dee Valley (a water supply company). Leakage accounts for around one-third of supply (29%).

Table 11: Domestic and commercial water consumption (April 1999 - Mar 2000)

	000 litres/year
Domestic	**188,334,120**
Industry *of which*	**102,355,500**
Agriculture	10,235,550
Food and drink	9,416,706
Oil, chemical, coal & mineral extraction	11,463,816
Metal manufacture	8,188,440
Engineering	4,913,064
Other production and construction	11,054,394
Wholesale and retail distribution	5,731,908
Catering & tourism	12,692,082
Public administration and defence	5,322,486
Education	5,731,908
Health	5,322,486
Other service sectors & transport	12,282,660
Leakage	**118,732,380**
Total	**409,422,000**

Source: Environment Agency Wales 2001

Summary Resource Flows

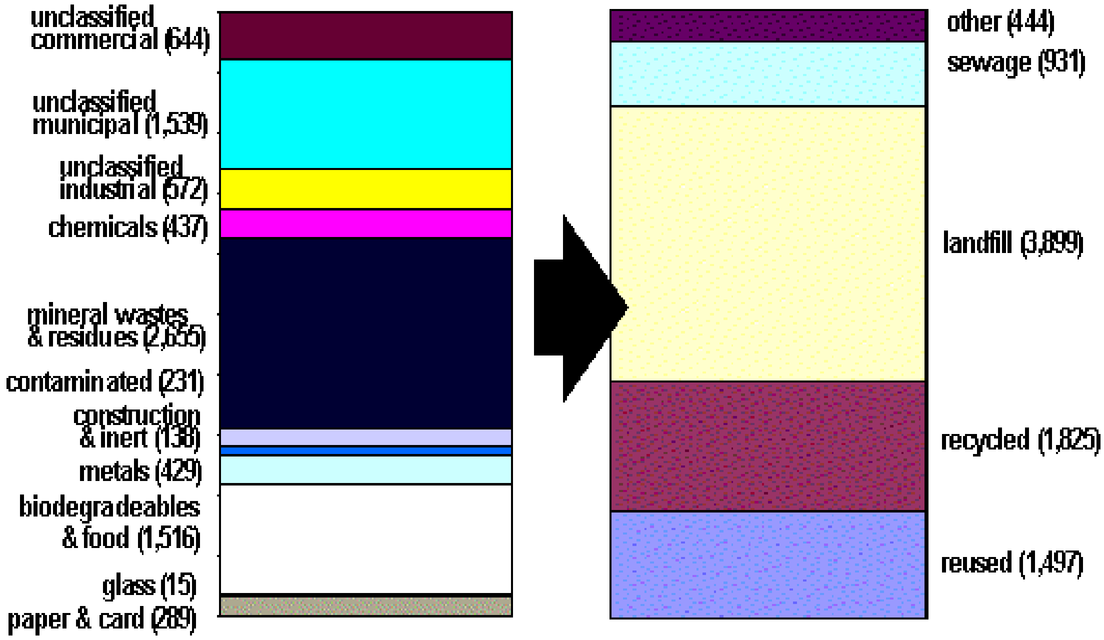
Material consumption for the year 2000 has been estimated by aggregating the available waste data by material type (where known). To this has been added the available food data.

Some key points should be noted:

- Due to a lack of materials consumption data, no attempt has been made to calculate the capital stock; those materials (typically construction materials) retained within the economy (as roads, housing or other infrastructure).
- Foodstuffs not finding their way into the recorded waste streams as food waste, compost or biodegradeables are assumed to have been consumed and turned into the products of digestion (energy and sewage) with no loss of mass.
- Water consumption has been excluded. Household and commercial water is either lost as leakage or put into the sewerage system. Water which is used for agricultural and industrial purposes typically finds its way more directly to the rivers or watercourse.
- Fossil fuels have been accounted separately from other materials. Estimates of carbon dioxide emissions (for direct energy use only) are given in Table 5.
- Agricultural wastes are excluded due to insufficient data regarding the management of these materials. These are accounted by the Environment Agency Wales, with the vast majority comprised of animal matter, which is processed mainly on-farm.

Total accounted material consumption is 8,468,481 tonnes or around 2.9 tonnes per resident. Of course, this is not all direct personal consumption. Some relates to industrial and commercial outputs.

Figure 1: Waste production and management routes for Wales. All figures are in 000's tonnes.



Note: there is an unexplained discrepancy of 128,000 tonnes (1.5%) between production and management.

Data Gaps

A key aim of this short study was to identify where secondary data was unavailable or unsuited for generating natural resources accounts. It is hoped in this way to shape the data that will be collected in the future by the National Assembly.

Such data gaps have generally been 'plugged' in the material flow and Ecological Footprint Analysis presented here by using UK data proxied for the Welsh population. Clearly, this affects the sensitivity of the results and makes the distinctiveness of Welsh consumption patterns more difficult to identify. Having said this, much existing Welsh-specific data was collected and collated from a range of sources. The conclusion, though, is that more work is needed to provide National data if future natural resource accounts for Wales are to be considered reliable and sensitive to year-on-year trends.

Described below are the main data problems encountered during the current study.

Trade Statistics

The National Assembly does not collect and collate separate trade statistics.

This has had implications for the calculation of the Ecological Footprint of Wales. Firstly, the absence of trade data has limited the range of footprint analysis techniques that can be used and, secondly, it has resulted in difficulties tracking the flow of materials through the Welsh economy.

On the first point, it was not possible to undertake a 'compound' Ecological Footprint Analysis consistent with the calculations that appear in WWF's Living Planet Report (Loh *et al*. 2000). This is not felt to have unduly affected the comparability or accuracy of the results (see 'The Component Approach', p.22).

The absence of materials data did, however, present more of a challenge. Fortunately, trade statistics are not the sole source of Welsh net consumption data. Many UK government/Welsh National Assembly, Environment Agency and private company sources report direct consumption of resources such as energy consumption, transport use, waste production and food consumption for example. These sources enabled the study to obtain net consumption data for the consumption items analysed. However, actual data relating to production, imports and exports remains the ideal source for manufactured and retail products. The lack of this data led to assumptions being made which altered the study boundary (see 'Study Boundaries', p.25).

Electricity

A total consumption figure for electricity was determined through the Digest of United Kingdom Energy Statistics (DTI 2001) which reports electricity distributed by public supplier (p.132) to various UK regions, including 'South Wales' and 'Merseyside and North Wales'. To obtain specific data, it has been assumed that North Wales accounts for 25% of this second region (DTI 2001).

No further data was available to breakdown total consumption into different user groups. Therefore, UK electricity consumption patterns have been directly applied to Wales. For example, 29% (DTI 2001) of UK electricity is consumed by the domestic sector and this has been assumed to apply to Wales also.

Transport

For this analysis, transport in general was found to be the component most lacking in Wales-specific data.

Passenger Transport

Existing data sources for passenger transport related only to car, taxi and bus modes. Initial data relating to cars and taxis only reported journeys on major roads in Wales. Data for other passenger transport modes (rail, air and ferry) were not available.

To overcome these data gaps, UK and more general Welsh data were used to estimate consumption. Data reporting vehicle-kilometres on minor roads was assumed to comprise the same proportion of car and taxi usage as on major roads. The estimate for minor roads represented 39% of the total vehicle-kilometres. Overall, Welsh passenger travel by car was found to be slightly higher than the UK average.

To estimate rail and air passenger travel, data for Welsh travel by ‘other’ modes was consulted. UK data was consulted to gain a proportion of the total ‘other’ modes that corresponded to rail and air travel. These percentages (71% for rail and 1% for air) were then applied to the total passenger-kilometres travelled by ‘other’ modes.

No specific data was available for passenger ferry travel and therefore UK data was used as a proxy. This data related only to passenger-kilometres undertaken within the UK.

Freight transport

Similarly to passenger transport, freight transport data relating to Wales was only recorded for road. To gain estimates for rail, air and sea freight, UK data was again used as a proxy.

Ecological Footprint Analysis

What is Footprint Analysis?

Co-originated in the early 90's by Professor William Rees and Dr. Mathis Wackernagel, Ecological Footprint Analysis[12] has rapidly taken hold and is now in common use in many countries at national and local levels; for example, Mexico, the United States, Canada, Holland, Denmark, Sweden, Norway, Italy, Spain and Australia. The Ecological Footprint of a region or community can be said to be the bioproductive area (land and sea) that would be required to sustainably maintain current consumption, using prevailing technology.

Imagine a glass dome over Wales - what area would this dome have to cover to ensure that the Welsh population could maintain their current lifestyles using only the bioproductive space within the dome?

For the purposes of the Ecological Footprint calculation, land and sea area is divided into four basic types; bioproductive land, bioproductive sea, energy land (forested land and sea area required for the absorption of carbon emissions) and built land (buildings, roads etc.). A fifth type refers to the area of land and water that would need to be set-aside to preserve biodiversity (see Figure 2).

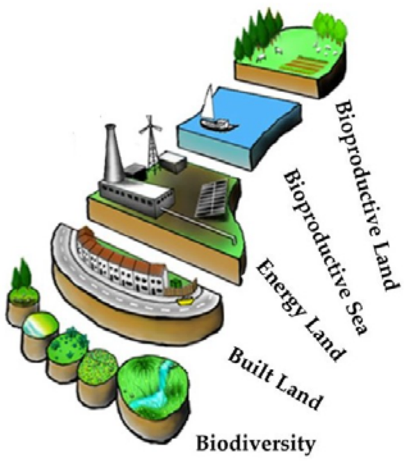


Figure 2: Land types used for Ecological Footprint Analysis

Example 1: A cooked meal of fish and rice would require bioproductive land for the rice, bioproductive sea for the fish, and forested 'energy' land to re-absorb the carbon emitted during the processing and cooking.

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[12] Those wishing to understand more about the Ecological Footprint, its benefits, strengths and weaknesses, are referred to two background papers supplied as Annex 1. Those wishing to go beyond the outline given in these summary papers are recommended to read '*Sharing Nature's Interest'* by Chambers, Simmons and Wackernagel (www.ecologicalfootprint.com)

Example 2: Driving a car requires built land for roads, parking, and so on, as well as a large amount of forested 'energy' land to re-absorb the carbon emissions from petrol use. In addition, energy and materials are used for construction and maintenance.

Once a total Ecological Footprint for a region is calculated, this figure can be used in certain ways. For example, by comparing the use of bioproductive area by an 'average' Welsh resident with the available average ‘earthshare’, one can estimate ecological sustainability. The earthshare is calculated by dividing the total amount of productive land on the planet by the population. Loh *et al*. (2000) estimate the average 'earthshare' to be about 1.9 hectares[13]. This earthshare can be considered as the maximum, equitable Footprint allowance, without depriving either future generations or those now living.

An annual Footprint of Nations study, now published as part of the *Living Planet Report* (Loh *et al*. 2000), provides a national context for considering regional Ecological Footprints (see also Wackernagel *et al.* 2000 and Lewan & Simmons 2001). The latest 1996 data gives an EF for the United Kingdom of 6.3 hectares per person[14] compared with a bioproductive capacity of just 1.8 hectares – a deficit of almost 4.5 hectares. Of the 152 Nations studied, only seventeen had similar, or larger, Ecological Footprints than the UK (Figure 3).

Globally, the average Ecological Footprint was 2.85 hectares in 1996 – as opposed to an available capacity of 2.18 hectares (excluding biodiversity considerations) - suggesting that humanity is using more natural resources than can be sustained in the long term.

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[13] The actual figures given by Loh *et al* (2000) are 2.18 hectares for an average earthshare, which reduces to 1.92 hectares when 12% provision for biodiversity protection is considered. Figures are rounded in this report.

[14] Comparing the Welsh average per capita Ecological Footprint to the average earthshare, addresses the question: Is the average Welsh resident living ecologically sustainably? Comparing the figure with the UK average answers the question: How is Wales performing ecologically compared to the UK as a whole?

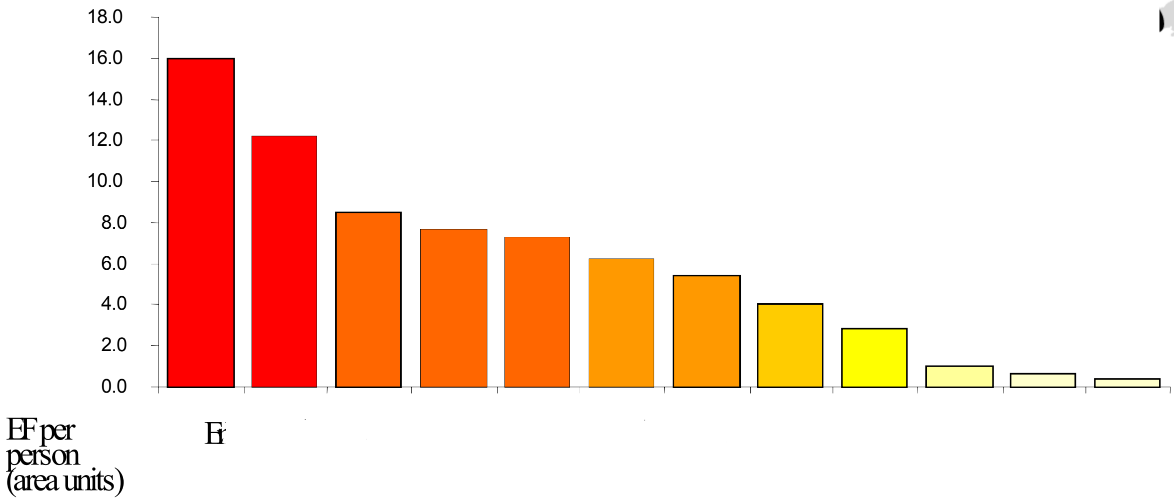

Figure 3: Comparison of the Ecological Footprints of various countries (1996 data)

The EcoIndex™ Methodology

The Component Approach

The EcoIndex™ Methodology, developed by Best Foot Forward (see Chambers, Simmons & Wackernagel 2000), uses a 'component' (or 'bottom-up') approach to perform Ecological Footprint Analysis. Though different data sources are necessarily used, the calculation method is wholly compatible with, the 'compound' (or 'top-down') approach taken by Wackernagel *et al.* in the Footprint of Nations studies (1997, 1999, 2000), which use international trade statistics as a starting point.

In the EcoIndex™ Methodology, wherever possible, full life cycle impact data are used to derive Ecological Footprint conversion factors for key activities (the 'components'). For example, to calculate the Ecological Footprint of a car passenger travelling one kilometre, fuel use, materials and energy for manufacture and maintenance of the vehicle, and the share of UK roadspace appropriated by the car are accounted for (Table 12). This conversion factor is then applied to the number of passenger-kilometres travelled.

Table 12: An example analysis for the Footprint of UK car travel (per passenger-km)

COMPONENT	Inputs	CO_2 Emissions	Built-Upon Land	FOOTPRINT
Petrol	0.094 Litres	0.22 Kg		0.000031[ii] area unit-yrs
Maintenance & Manufacture	0.0423 Litres equivalent	0.10 Kg		0.000014[iii] area unit-yrs
Road Space	258,175 Ha		[a] 817,043 area units (1)	
Car Road Share	[b] 86%			
Car Kms	[c] 362,400,000,000			
Average Occupancy	[d]1.6 persons			
Calculation			*(a+b)/c/d*	*i+ii+iii*
FOOTPRINT			0.0000012[i] area unit-yrs	**0.000046** area unit-yrs/pass-km

(1): This figure is the hectares of 'global average' land equivalent to the actual UK area built on by roads. Sources: DETR 2000, Wackernagel & Rees 1996, BRF 2000, DETR 1999c.

A similar approach is used to derive a range of Ecological Footprint component values, representing the main categories of impact, before summing them to calculate a total Ecological Footprint for Wales. The key components we have used in this study are:

- Material consumption (including waste)
- Food consumption
- Energy use
- Passenger transport
- Freight transport
- Water use
- Built (degraded) land

Each of these key components is made up of smaller sub-categories. For example, Energy is made up of electricity, gas and domestic heating oil. Each of these sub-categories is broken down further. For example, electricity and gas have both been further broken down to represent domestic, commercial and industrial consumption. This approach utilises, and builds upon, the data supplied by the resource flow analysis presented earlier.

Using this component approach enables the calculation of Ecological Footprints at any level – for a product, organisation, activity or region.

Box 1: Take only pictures - leave only footprints

It is important to note that Ecological Footprint Analysis is a ‘snapshot’ methodology. It tells us how much bioproductive area would be required based on a specific data set - it does not attempt to predict future or past impacts (although as shown later in this report it is possible to develop scenarios based on set assumptions).

It is likely that, due to technology changes and variations in material flows into the economy, the Ecological Footprint will change over time.

In the period during which data is recorded some of the input flow of materials will stay in the economy, as stock, and some will flow out as waste. In both cases these materials are considered to have been ‘consumed’.

Exports, on the other hand, of agricultural products for example, are discounted. Where data is available, the analysis is therefore based on net consumption, which is calculated by adding production to imports and then subtracting exports.

The Double Counting Demon

In this component approach it is important that consumption is not double counted. For example, the Ecological Footprints of materials inclusive of freight transport are given to show the true ‘cost’ of consumption. Freight transport as a separate component is also given in its own right to show the relative impacts of transporting goods. Similarly, the Ecological Footprint of water consumption includes the energy used to treat and supply the water, although this energy is also included in the energy component. In both these situations, the same impact is included in different categories, and therefore when all the Ecological Footprint components are added, an adjustment is made to eliminate these double counted impacts.

Study Boundaries

Any study of resource consumption face boundary issues; what to include and what to exclude.

One approach is to include all consumption that takes places within certain geographical bounds . This is known as the Geographical Principle. The other common approach is to consider only the consumption attributable to those living within a geographic area (the Responsibility Principle). This latter approach is favoured by WWF in their Living Planet Report (Loh *et al* 2000) and is therefore the approach adopted in this report.

As far as possible, data permitting, this report has therefore sought to account only from the consumption attributable to the Welsh population.

A further discussion of the Geographical and Responsibility Principle can be found in Lewan and Simmons (2001).

Box 2: The Secret Life of Everyday Things

All the data used in this analysis to estimate the material consumption of Wales comes from the Environment Agency's Strategic Waste Management Assessment for Wales (2000) (for commercial and industrial waste) and the UK government's municipal waste survey (DEFRA 2001) (for household and municipal waste). These sources collate together the type of materials in the waste stream (classified as inert, paper and card, metals and general waste for example), and how these materials are 'managed' (such as landfilling, incineration or recycling).

In this study waste data has been used to estimate materials consumption. This approach under-estimates consumption as materials retained within the economy are not accounted. However, without detailed input/output trading accounts – as are available for the UK as a whole – estimating stock retained within the economy is not possible within the scope of this project. A previous material flow analysis for the Isle of Wight suggested that most of the retained stock is construction materials which have a relatively low environmental impact (for example, aggregates).

When accounting for the Ecological Footprint of materials in the waste stream the complete life cycle of the material is considered as far as possible; extraction, processing, transportation and so on. Much of the environmental impact of an economy is 'captured' by looking in detail at the waste stream.

Where materials are reused, recycled, or incinerated – rather than landfilled - the environmental benefits are accounted accordingly by deducting the embodied energy savings. These savings vary according to the material life cycle. Though these can be substantial for certain materials, reductions in material throughput generate larger savings in all case.

A worked example for recycled and virgin paper can be found in 'Sharing Nature's Interest' (Chambers, Simmons and Wackernagel 2000) pages 93 to 94.

[15] Strictly, this boundary change means the results of this study are not comparable to the results of the *Living Planet Report* 2000. However, if it is assumed that imports are equal to exports, the per capita Ecological Footprint of Wales becomes 6.37 area units. By using the same EcoIndex™ Methodology, a comparable per capita Ecological Footprint for the UK has been estimated at 6.75 area units.

The All Wales Ecological Footprint

Tables 13a to 13g and Figure 4 summarise the Ecological Footprint of Wales, drawing on the data presented above. Figures relate to annual consumption.

Table 13a: The Ecological Footprint of Wales – energy component

	FOOTPRINT (*area units*)
Energy	
Electricity – domestic*	472,603
Electricity – commercial*	285,192
Electricity – industrial*	472,603
Electricity – other*	399,268
Gas – domestic*	535,214
Gas – commercial*	105,421
Gas – industrial*	291,935
Gas – other*	689,291
Heating Oil – domestic*	90,310

Table 13b: The Ecological Footprint of Wales – personal transport component

Passenger Travel	FOOTPRINT (*area units*)
Travel by car	1,521,478
Travel by bus	55,838
Travel by train*	74,530
Travel by air*	3,830
Travel by ferry*	1,840

Table 13c: The Ecological Footprint of Wales – freight transport component

Freight Transport	FOOTPRINT (*area units*)
Road freight – import	31,568
Road freight – export	57,581
Rail freight*	15,454
Sea freight*	19,918
Air freight*	100,119

Table 13d: The Ecological Footprint of Wales – food component

Agricultural Produce	FOOTPRINT (*area units*)
Milk and cream	728,905
Cheese	136,865
Meat and meat products	2,344,601
Fish	112,769
Eggs	125,985
Oils/Fats	404,370
Sugar and preserves	10,358
Vegetables – fresh	89,922
Vegetables – processed	51,888
Fruit – fresh	67,608
Fruit – processed	33,686
Bread (White)	346,272
Cereals	331,905
Tea & Coffee	21,713
Other Beverage	3,069
Soft drinks	69,634
Alcoholic drinks	126,681
Confectionery	125,614
Miscellaneous	121,590

Table 13e: The Ecological Footprint of Wales – built land component

	FOOTPRINT (*area units*)
Built (degraded) land	217,652

Table 13f: The Ecological Footprint of Wales - waste component

Diverted Materials	FOOTPRINT (*area units*)
Paper Recycled	285,499
Glass Recycled	13,191
Plastics Recycled	1,246
Aluminium Recycled	407
Steel Recycled	4,298
Inert Reused/Recycled	0
Other Mixed Recycled	18,516
Composted Materials	44,243
Incineration Materials	113,824
Materials Disposed to Landfill	FOOTPRINT (*area units*)
Household	4,407,376
Commercial	1,946,261
Inert	216

Table 13g: The Ecological Footprint of Wales – water component

Water	FOOTPRINT (*area units*)
Water – domestic	15,477
Waster – commercial	4,643
Water – Leakage	9,758

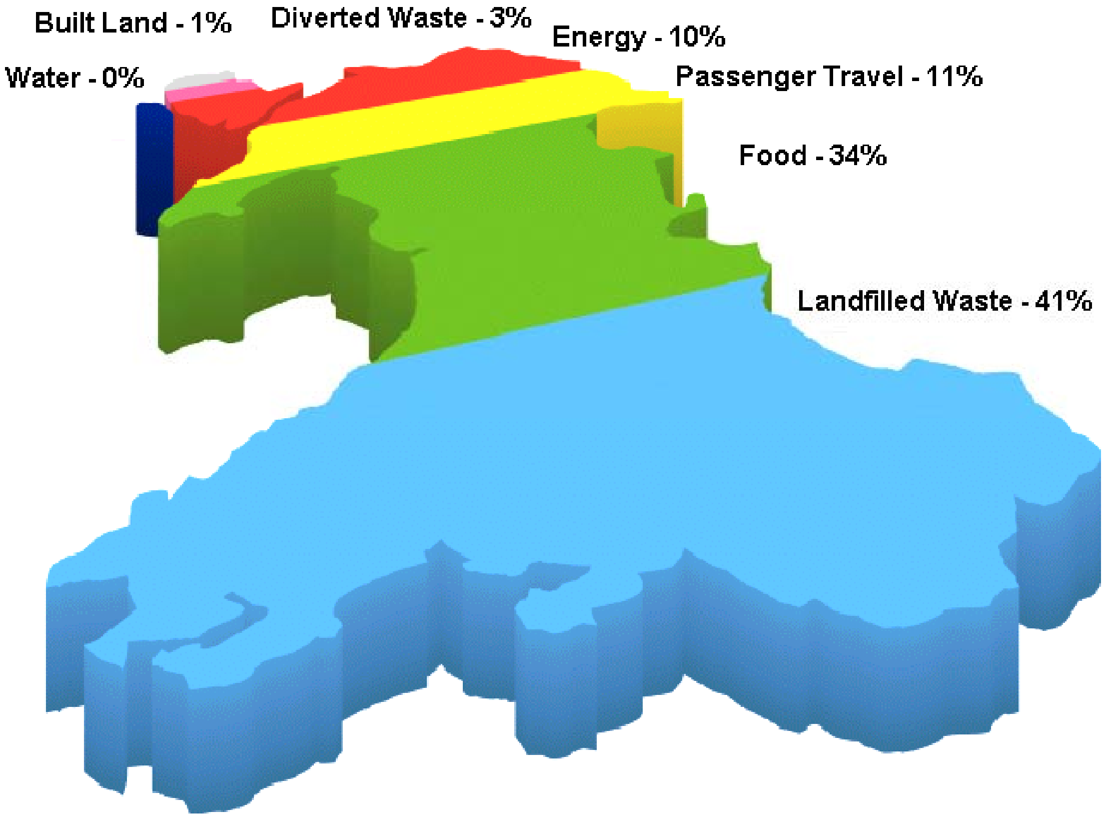

Figure 4: Component breakdown of the Ecological Footprint of Wales

Table 14 shows the Ecological Footprint for Wales as a whole, and on a per capita basis, after adjustments for double counting. A comparative Ecological Footprint for the UK is also shown. A land type breakdown (Table 15) and summary component breakdown by percentage (Figure 4) are also given for both the Wales and the UK per capita Ecological Footprints.

Table 14: Total and per capita results after adjusting for double-counting

	FOOTPRINT (area units)
Total EF of Wales (area-units)	**15,468,887**
Total EF of UK (area-units)	357,708,025
Per capita EF – Wales (area-units)	**5.25**
Per capita EF – UK (area-units)	6.00

Table 15: Per Capita Ecological Footprints (area units) for Wales and UK by land types

Arable	Pasture	Forest	Energy	Built	Sea	TOTAL	
1.59	0.38	0.70	3.14	0.15	0.04	6.00	UK
1.67	0.40	0.61	2.44	0.09	0.04	5.25	Wales

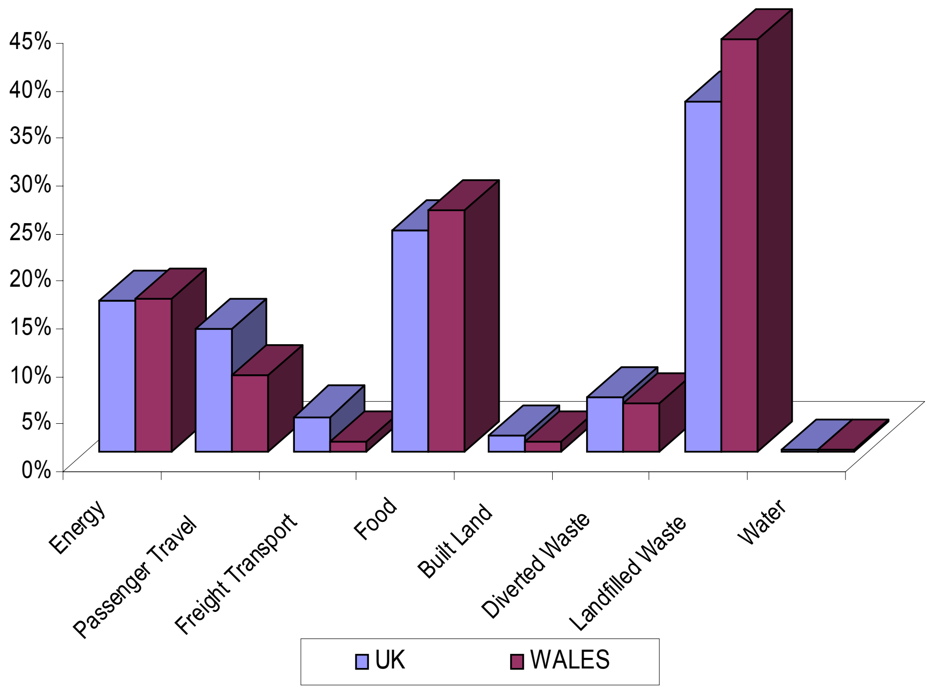

Figure 5: Summary component breakdown of the per capita EF for Wales and the UK

The Biocapacity of Wales

The actual geographical size of the Wales is 2,077,800 hectares. The biocapacity of Wales derives from the bioproductivity of this land and the surrounding sea. This bioproductivity can be expressed in 'area units[16]' to be comparable with the Ecological Footprint. To enable this, a number of 'factors' are applied to the actual Welsh land cover to convert hectares into 'area units'.

Firstly, yield factors are applied to translate local bioproductivity into 'global average' bioproductivity. For this study, UK yield factors have had to be applied as a proxy. As the UK as a whole is more bioproductive than the world in average, this increases its biocapacity.

Secondly, 'equivalence' factors, developed by Wackernagel *et al.* (in Loh *et al*. 2000), are applied to convert different land (and sea) types into 'global average' land (and sea). For example, 'global average' arable land is over 3 times more biologically productive than 'global average' land. Therefore, the second stage is to convert 'global average' arable, pasture, forest and built land into 'global average' land.

Sea

To account for bioproductive sea, this report uses the area within the UK's Economic Exclusive Zone (up to 200 nautical miles offshore). If this is allocated using the Welsh population as a proxy, then the amount of sea theoretically ‘available’ to Wales is 2,948,770 area units.

Biodiversity Land

An additional land category is biodiversity land. This represents the area required to be set aside for the preservation of non-human species. There are many different estimates of how much this should be – ranging from 12% to 75% of the Earth's surface for example[17].

At least 23% of Wales is currently designated as having varying conservation importance, which it can be argued is essential to protect biodiversity. However, for consistency with other analyses this report uses the conservative estimate of 12% of the adjusted land supply (as suggested by the Brundtland Report (1986) to determine the bioproductive area available to service human consumption.

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16 Area units are the preferred unit to express Ecological Footprints. They were first introduced in the *Living Planet Report* 2000, in which 'one area unit' is described as being equivalent to one hectare of biologically productive space with world average productivity (Wackernagel *et al*. in Loh *et al*. 2000).

17 The World Commission on Environment and Development (The 'Brundtland Report') in 1986 stated that 12% of the Earth's surface should be set-aside for biodiversity. In 1970, the ecologist Eugene Odum proposed that this figure should be 40%. Further estimates from Reed Noss and Allen Cooperrider (1994) state that this figure should be a minimum of 25% with a potential maximum of 75%.

Wales' Biocapacity

The total biocapacity of Wales is 6,729,313 area units or 2.29 area units per capita. Setting aside a modest 12% for biodiversity conservation leaves a biocapacity of 2.02 area units per head of population.

Thus, even with a minimal allowance for biodiversity, an area about 2½ times the size of Wales would be needed to sustainably support current Welsh lifestyles.

Ecological Sustainability

This section of the report assesses the ecological sustainability of Wales comparing consumption with global capacity.

To facilitate Ecological Footprint comparisons between regions and nations this report uses 'area units'. These present the Ecological Footprints in a common unit, independent of the actual bioproductivity of the area appropriated and therefore where this area is located on the planet. The use of 'area units' enables questions such as 'How does the 'average' Welsh resident compare to other 'average' residents in different regions and countries?'; and 'Is the 'average' Welsh resident living in an ecologically sustainable manner?'

Global Ecological Sustainability

Perhaps the most illuminating question is:

'If everyone lived like the population of Wales, how many planets would we need to sustain current lifestyles?'

This study is able to measure ecological sustainability by comparing the 'average' Welsh resident's Ecological Footprint, with the biocapacity available locally and globally, per person - the average earthshare.

The average earthshare is derived by dividing the planet's bioproductive areas by the global population. In 1996 (the latest year for which all data is available for the calculation) the average earthshare was estimated to be 2.18 hectares (Wackernagel et al. in Loh et al. 2000), which becomes 1.92 hectares when 12% is set aside for biodiversity conservation.

Table 16: The Ecological Footprint (demand) shown against the Biocapacity (supply)

Average earthshare	Biocapacity of Wales	Current Ecological Footprint
1.92	2.02	5.25

This assessment indicates that the 'average' Welsh resident is using about 2¾ times (275%) the average earthshare. This is slightly less than the UK 'average' resident who uses over 3 times (313%) the earthshare.

To look at this finding in another way, if everyone on the planet consumed the same as the average Welsh resident, we would need around 1¾ additional Earths to support global demand.

Possible Footprints of the Future: Scenario planning

A powerful feature of the Ecological Footprint is the ability to develop scenarios based on predicted or estimated consumption patterns.

The scenarios presented can be considered as 'snap shots' of a range of possible futures based on certain underlying assumption about resource use and technology decisions.

The year 2010 has been chosen as a future reference data as this provides both a convenient 10-year time frame for comparative purposes and is a date that recurs in several existing strategic targets.

The components selected for the scenarios are:

- Electricity consumption and generation;
- Passenger car and rail travel;
- Road and Rail freight use;
- Recycled and Composted materials; and
- Landfilled materials.

Stuart Bond at WWF Wales undertook data research for the 2010 scenario targets.

Electricity consumption and generation

Target: *10% of electricity to be generated by renewables by 2010*

This scenario requires alterations to both the consumption of electricity in Wales and how this electricity is generated. Consumption has been estimated using the UK energy demand growth estimate of 0.5% per annum (DTI 1998). No account of the potential influences of energy conservation measures has been taken.

Electricity generation in Wales currently consists of:

- Gas: 50%
- coal: 25%
- nuclear: 22%
- renewables: 3%

Wales is currently a net exporter of electricity and it has been assumed that this remains the case (NAW 2001). The target above relates to the renewable electricity supply only. The Wylfa nuclear power station on Anglesey is currently the only nuclear power station in Wales and this is due to close in 2004. It has been assumed that no nuclear stations will replace Wylfa. Trends in the UK and Wales are similar relating to the reduction in coal generation and increases in gas. Gas is, and is assumed to remain, the main fuel for electricity generation. New plants are 'relatively cheap to build and (have) an energy conversion efficiency of 60% whilst conventional coal fired stations operate at around 37%' (NAW 2001).

Therefore, Welsh electricity generation in 2010 is assumed to consist of:

- Gas: 73%
- Coal: 17%
- Nuclear: 0%
- Renewables: 10%

Table 17 represents the results of this scenario.

Table 17: The electricity consumption and generation scenario

	2000	2010	% difference
Consumption			
Electricity consumption (GWh)	16,837	17,698	5%
Ecological Footprint			
Electricity (area units)	1,629,666	1,569,484	-4%

It can be seen from Table 17 that even though the demand for energy is assumed to rise by 5% the change in generation methods will reduce the Ecological Footprint of Wales' electricity supply by 4%.

Passenger and freight transport

Targets: *25% of commuter transport by public transport and bicycle*
Increase freight carried by rail

This scenario assumes a modal switch away from both passenger car travel and the transport of freight by road. Estimates are based upon the UK Government's 'Transport 2010: the 10 year plan' (DETR 2000c). These estimates show that overall use of freight transport is expected to rise, but with a move towards rail and away from road transport. The growth estimates for passenger transport are given in Table 18. Freight transport growth estimates for rail are 80%, whilst road freight has been assumed to grow by 17% (the 'all areas' traffic growth assumption).

Table 18: Estimated growth and modal shift for car and rail passenger transport

	Passenger Rail Demand Growth	**Car Traffic Growth in England**
Baseline	23%	21%
Plan	***51%***	***17%***
Illustrative constant motoring costs scenario	83%	12%

Source DETR 2000c

Table 19 presents the results of this scenario. The percentage growths for both passenger modes have been modified. The growth in car travel has been reduced by a 2% rise in cycling. Passenger rail travel grows by an overall 44%, which is made up by a 39% rise in non-commuter travel (DETR 2000c) plus the 5% rise in commuter travel target.

Table 19: The passenger and freight transport scenario

	2000	2010	% difference
PASSENGER TRANSPORT:			
Consumption			
Car travel (000s vehicle-km)	20,737,749	23,848,412	15%
Rail travel (000s passenger-km)	2,459,051	3,541,033	44%
Ecological Footprint			
Car & Rail (area units)	1,596,008	1,857,023	16%
FREIGHT TRANSPORT:			
Consumption			
Road Freight (000s tonne-km)	265,700	310,869	17%
Rail Freight (000s tonne-km)	911,078	1,639,941	80%
Ecological Footprint			
Road & Rail (area units)	38,931	55,316	42%

The results in Table 19 show that the estimated modal shifts away from car travel and road freight are insufficient to counter the predicted increases in the demand for personal travel and freight transportation. For both passenger and freight transport the Ecological Footprint is predicted to increase by 16% and 42% respectively.

Materials management scenarios

Targets: *40% of municipal waste materials to be managed via recycling or composting with a minimum of 15% by either recycling or composting.*

Municipal waste materials to be reduced to the 1995 level of 1.5 million tonnes.

Two scenarios are presented to indicate the potential implications of two materials management options. To clarify matters, only household waste is accounted in these scenarios. Scenario 1 assumes that the recycling and composting target is achieved, but production of household waste materials continues to grow at the current rate of 3% per annum. To achieve the desired recycling and composting targets whilst waste continues to grow presents a challenging 'moving target' in terms of meeting diverted materials tonnages. The scale of recycling and composting increases required is shown in Table 20 along with the predicted decreases in landfill waste tonnages

Table 20: Recycling and composting in 2010 if household waste materials production continues to grow (Waste Scenario 1)

	2000	2010	% diff
Consumption			
Diverted Materials:			
Paper (tonnes)	32,909	246,583	649%
Glass (tonnes)	15,317	88,245	476%
Plastics (tonnes)	387	3,483	800%
Aluminium (tonnes)	235	2,118	800%
Steel (tonnes)	723	6,508	800%
Steel (scrap) (tonnes)	32,664	72,072	121%
Other Mixed (tonnes)	8,768	54,105	517%
Compost (tonnes)	12,244	283,869	2219%
Landfilled Materials:			
Household (tonnes)	1,320,133	1,135,477	-14%
Ecological Footprint			
Diverted Materials (area units)	130,107	1,544,225	1087%
Landfilled Materials (area units)	4,407,376	2,389,932	-46%
Total Materials (area units)	4,537,482	3,934,157	-13%

The results in Table 20 show that although the footprint of the diverted materials increases substantially (due to its increased volume) it is offset by the decrease in the footprint of landfilled materials whose volume decreases. Overall this results in a modest net saving of 13% of the diverted and landfilled materials EF.

Waste Scenario 2 also implements the recycling and composting targets, but additionally assumes that production of municipal waste materials reduces to 1995 levels of 1.5 million tonnes. A total of 1.5 million tonnes of municipal waste, based on 2000 percentages, is equal to 1,306,462 (1.3 million) tonnes. The results of this scenario are shown in Table 21.

The focus in this scenario, although still requiring some dramatic changes in recycling and especially composting, is upon a reduction in the materials sent to landfill. To achieve the 1995 levels target, materials sent to landfill will have to be reduced by 41% by 2010. As shown in Table 21, if this equally ambitious target can be met, the net savings to the diverted and landfilled materials EF is 40%.

Table 21: Recycling and composting in 2010 if household waste materials production reduces to 1995 levels (Waste Scenario 2)

	2000	2010	% diff
Consumption			
Diverted Materials:			
Paper (tonnes)	32,909	170,229	417%
Glass (tonnes)	15,317	60,920	298%
Plastics (tonnes)	387	2,405	521%
Aluminium (tonnes)	235	1,462	521%
Steel (tonnes)	723	4,493	521%
Steel (scrap) (tonnes)	32,664	49,755	52%
Other Mixed (tonnes)	8,768	37,351	326%
Compost (tonnes)	12,244	195,969	1501%
Landfilled Materials:			
Household (tonnes)	1,320,133	783,877	-41%
Ecological Footprint			
Diverted Materials (area units)	130,107	1,066,057	719%
Landfilled Materials (area units)	4,407,376	1,649,891	-63%
Total Materials (area units)	4,537,482	2,715,948	-40%

Into the future?

Due to the time constraints placed on this project, the individual scenarios presented in this report are clearly limited in their scope but provide a flavour of how the use of Ecological Footprint Analysis might be utilised further to assist in the development, and monitoring, of sustainability strategies for Wales. Work currently underway to develop the Ecological Footprint as a sustainability indicator for regions across

Europe provides useful pointers as to how the use of the Ecological Footprint could be further developed for Wales (Lewan and Simmons 2001). One aim of this work is to develop a software tool which allows policy-makers to interact with the component parts of the footprint to dynamically assess possible scenarios.

The 10-year analyses undertaken here for electricity, transport and waste illustrate both the opportunities for reducing Wales' Ecological Footprint and the significance of changes in demand (and in the case of electricity generation the technology used) over the same period. This is particularly apparent in the personal and freight transport scenarios where predicted increases in the demand for travel outweighs any benefits to be gained from the planned changes in transport mode.

Of course, there is nothing inevitable about the scenarios presented here. As stated, they are merely models of consumption based on assumptions about future demands and technologies. Improvements in vehicle fuel efficiency or increased car-sharing, to give just two examples, would limit the impacts of car use and could thus change the balance in the personal transport scenario.

It is hoped that the initial scenarios offered here, based on existing policy targets, will form the basis of a more comprehensive vision of what a sustainable Wales will look like.

The duty to promote sustainable development is undoubtedly a challenging one. It is hoped that this first calculation and exploration of Wales' Ecological Footprint proves a helpful first step, and a continuing companion, on the road to a more sustainable Wales.

References

Best Foot Forward & Imperial College, 2000. *Island State: An Ecological Footprint Analysis of the Isle of Wight*. Funded by Biffaward and supported by Isle of Wight Council. Pub. Best Foot Forward.

Chambers, N., Simmons, C. & Wackernagel, M., 2000. *Sharing Nature's Interest: Ecological footprints as an indicator of sustainability*. Earthscan: London.

Department of Environment, Food & Rural Affairs, 2001. *Municipal Waste Survey, 1999-2000.*

Department of Environment, Food & Rural Affairs (MAFF), 2000. *National Food Survey*.

Department of the Environment, Transport & the Regions, 1999. *Environmental Reporting: guidelines for company reporting on greenhouse gas emissions*. Prepared in consultation with the Scottish Office and Welsh Office.

Department of the Environment, Transport & the Regions, 2000a. *Transport Statistics: Great Britain.*

Department of the Environment, Transport & the Regions, 2000b. *A Bulletin of Public Transport Statistics: Great Britain.*

Department of the Environment, Transport & the Regions, 2000c. *Transport 2010: The 10 year plan*

Department of Trade & Industry, 2000. *Digest of United Kingdom Energy Statistics*.

Department of Transport & Local Regions, 2001. *Strategic Rail Authority Bulletin*: *Rail statistics: Quarter 1 2000/2001*

Environment Agency, 2000. *Strategic Waste Management Assessment: Wales.*

Environment Agency Wales, 2001. *Water Resources for the Future: A strategy for Wales.*

Lewan, L. and Simmons, C. 2001 "The use of Ecological Footprint and Biocapacity Analyses as Sustainability Indicators for Sub-national Geographical Areas: A Recommended Way Forward" http://www.prosus.uio.no/english/sus_dev/tools/oslows/2.htm

National Air Traffic Services, 2001. Cardiff Airport Statistics, www.nats.co.uk/services/cardiff.html

National Assembly for Wales, 1999. *A Statistical Focus on Wales*. Government Statistical Service.

National Assembly for Wales, 2000. *Digest of Welsh Local Area Statistics*. Statistical Directorate.

Office for National Statistics, 2001. *Regional Trends No. 36*. Government Statistical Service

Transco, 2000. *Gas Consumption Data*.

Wackernagel, M.; Callejas, A.; Deumling, D.; Schulz, N.; Sanchez, M. & Falfan, I., 2000. Ecological Footprint in J. Loh (ed.), *Living Planet Report 2000*. WWF International, Switzerland.

Welsh Tourist Board, 2000. *Achieving our Potential: A tourism strategy for Wales*.

Annex 1: Ecological Footprint Analysis

This Annex contains two short background papers:

- More about Ecological Footprint Analysis
- Critiques of Ecological Footprint Analysis

Paper 1: More about Ecological Footprint Analysis

What is an Ecological Footprint?

Footprinting essentially accounts the use of the planet's renewable resources (its 'interest' rather than its 'capital'). Non-renewable resources are accounted for only by their impact on, or use of, renewable, bioproductive capacity.

The footprint deals only with demands placed on the environment. It does not attempt to include the social or economic dimensions of sustainability.

The footprint is a 'snapshot' estimate of biocapacity demand and supply usually based on data from a single year. Both available biocapacity and the eco-efficiency of the economy can change over time which is why it is not possible to forecast or 'backcast' footprints from current data although it is possible to make assumptions about future consumption and thus create informative, but speculative, scenarios.

The use of bioproductive area as an aggregate unit makes it a powerful and resonant means of measuring and communicating environmental impact and sustainability. In this sense it is comparable to many economic indicators such as the Retail Prices Index (RPI) and GDP.

The Bathroom Scales and Footprints

The footprint has been compared to measuring ones own weight. You can find out how heavy you are, and the difference from your ideal weight, but the process of measuring does not tell you how to lose weight. However, you can speculate that if you do certain exercises and eliminate certain calorific foods from your diet you will shed a certain number of kilos.

An Additive Model

The basic Ecological Footprint is an additive model. It sums several mutually exclusive uses of bioproductive area; arable, forest (for both wood products and carbon sequestration), pasture, degraded or built land, and sea space.   Exceptions to the additive model have been made for footprinting certain types of pollution and water catchment where spatial uses overlap.

A key issue in the calculation of Ecological Footprints and biocapacities is the method used to aggregate areas of different quality facilitating international comparisons. Areas of generally different productivity (arable, pasture, forest, sea) are 'normalised' by multiplying them by equivalence factors relating to their bioproductivity. The equivalent areas are then expressed as standardised hectares of world average productivity (more recently referred to merely as 'area units').

Use of fossil fuel-derived energy is typically accounted for in terms of its carbon dioxide emissions although it is also possible to assess Ecological Footprints of energy use in terms of the land area required to sustainably derive biofuel alternatives. The former results in a more conservative estimate of the impact of fossil fuel use and have thus been the more common method.

Biocapacity

For calculation of national/regional biocapacity, local yield factors are introduced. These factors show how much higher or lower the yield per local ha is compared to the yield per area unit. There is always the possibility of converting ha of unit area into ha of national/regional average productive space for both supply and demand. Thus it is possible to answer two questions; *How many planets would it take to if everyone consumed as much as the average resident of Region X* and *How many Region X's would it take to satisfy the current demands of that Region*. This calculation was performed for the Isle of Wight (Chambers et al 2000). Using local yield values it was shown that two additional Islands would be needed to sustainable support consumption. Using global yield factors it was shown that, if everyone lived like the average Islander, 1½ extra planets would be required. The approach of using local yields is also favoured by a number of the studies reviewed in this report.

Some biocapacity must be set aside for non-human use. The necessary amount of pristine habitat is not known but, as a general rule in footprint calculations, not more than 88% of the existing biocapacity is considered 'available' for human use. The LPR 2000 accounts for biodiversity as a percentage of the footprint (demand). Previously biodiversity area has been subtracted from the available regional supply.

Paper 2: Critiques of the Ecological Footprint

Critical Studies

Several critiques of the Ecological Footprint exist (notably VROM-Council 1999, Van Kooten and Bulte 2000, van den Bergh and Verbruggen 1999, Pearce 2000). These reviews contain a mix of positive and negative comments relating to the application of the methodology as well as suggestions for improving its structure and use.

It is important to address these briefly both to understand the limitations of the methodology, its strength and weaknesses, and to assist in assessing the various applications of the methodology within the EU.

Answering the Critics

Here we paraphrase 10 key points listed by Van Kooten and Bulte (2000) and use these as a framework for comment. Their comprehensive critique is arguably the harshest of those listed above and was used by Pearce as the basis for his submission to the EU Commission DGXI. One of the co-founders of the Ecological Footprint concept, Dr. Mathis Wackernagel, has also had the opportunity to address the points raised in a corresponding submission to the EU Commission (Wackernagel 2000) and here we draw on his comments augmenting these with our own thoughts and experiences. The reader is also referred to Chapter 6 of 'Sharing Nature's Interest' (Chambers, Simmons and Wackernagel 2000) which addressed these and additional points.

1. Footprint accounts are incomplete

Ecological Footprint Analysis does not claim to account for all human impacts on the environment. Instead it prefers to offer a conservative underestimate whilst acknowledging that other impacts exist. Most obviously, the accounts focus on resource consumption, with the exception of water, and underestimate the impacts of waste products.

However, several footprint studies have addressed both of these shortfalls. Chambers et al. (2000) demonstrate two methods of incorporating water consumption into footprint accounts. The same publication presents a study that includes footprint estimates for several pollutants.

Other studies have tackled the complex task of accounting for pollutants other than carbon dioxide, for example, Folke et al. 1997, Wackernagel et al. 1997 though they remain excluded from National footprint calculations. The main hurdle to further integration of pollution accounting would seem to be a lack of reliable research data on the way in which pollutants interact and affect bioproductivity. Further discussion on this issue is contained within a paper by Holmberg, Lundqvist, Robért and Wackernagel (1999).

There is also some confusion amongst critics of the method as to what the footprint is intended to account. The footprint typically accounts only those resources which are part of the biosphere's cycles. It is implicitly assumed that the use of heavy metals and hazardous chemical (those which are persistent, bio-accumulative or toxic) should either be eliminated or must be handled in totally closed loops which do not involve release into the natural environment. Studies have shown that the impact on bioproductive capacity of, for example, heavy metals are massive and usually swamp other effects of consumption. The natural assimilation rate of Copper, for example, is 42mg per square metre per year. The footprint of a kilogram of copper would therefore be 2.38 ha-years. The footprint of a kilogram of PCB's is an impressive 2,000 ha-years (Krotscheck and Narodoslawsky 1996).

2. Applying Carrying Capacity concepts to human populations is flawed. Evidence has shown that (a) humans, unlike other animals, can and do increase the carrying capacity of their environment to meet their needs and (b) certain regions and communities seem to be living beyond their local carrying capacity now with few ill effects.

Criticism (a) is based on a misunderstanding of how footprinting accounts for changes in biocapacity. As the footprint is a 'snap shot' measure, reflecting the supply and demand at the time of the analysis, future effects (such as increases or decrease in biocapacity) would only become apparent in subsequent analyses.

Criticism (b) ignores the fact that populations can exceed local carrying capacity either temporarily, by running down natural capital, or more permanently, by importing or appropriating capacity from elsewhere. Take the example of a fishing community dependent on a local lake for their food. They can over-fish the lake, temporarily increasing supply, by catching smaller and smaller fish. This will impact on the ability of the fish population to sustain itself leading to decline in stocks. This is of course what has happened on a wider scale in European waters where arguments have raged over the gauge of fishing nets which will allow the immature females to escape. Another option for the fishing community is to simply import produce from elsewhere, either fish or another protein substitute, thus appropriating carrying capacity form elsewhere.

3. The very process of aggregating land types to calculate a footprint assumes substitution - yet this is not possible.

This is a complex point raised in different forms by various commentators. Basically, this comment is based on a misunderstanding about the nature of the footprint as a measure of impact based on current biocapacity calculations. Aggregating information into a single indicator need NOT imply that the elements being measured are interchangeable in any real sense. For example, MTOEs (Million Tonnes of Oil Equivalent) is a common unit used for aggregating the energy content of different fuel types to derive a overall indication of energy consumption. Aggregating in this way does not imply that the fuels are in any way interchangeable - natural gas cannot substitute for diesel, for example.

4. Carrying capacity is irrelevant since resource yields can be increased in the case of renewable resources, and depletion profiles can be extended by technology in the case of non-renewable resources.

Indeed, carrying capacity can be altered: both eroded as in the case of desertification, and enhanced as in the case of careful management schemes. That's why Ecological Footprints are always compared to the biocapacity of a given year (as mentioned earlier). In fact, as footprint accounts point out, technological efficiency is one possible strategy to reduce humanity's draw on nature (as long as the efficiency gains are not outpaced by an increase in consumption).

5. Carrying capacity calculations have limited relevance when trade is possible since the scarce resource can be imported in exchange for another asset in which the exporting nation has a comparative advantage.

Footprint accounts do not argue against trade. They point out that not all countries can be net-importers of ecological capacity if global overshoot is to be avoided. Footprint accounts make ecological trade imbalance visible and show to what extent nations depend on net imports of ecological services. Further, Pearce's interpretation that shifting to imports from high-yield areas will reduce a country's overall footprint is incorrect. From a global perspective, this is a zero-sum game at best. And in fact, in our accounts, a shift to imports from higher-yield areas does not reduce the importer's footprint.

6. Certain economies that are highly urbanized (Netherlands, Singapore, Hong Kong) can never be sustainable since they can never meet their ecological demands from their own land.

Of course, urbanised economies are more likely, by definition, to need to import resources to meet their needs. This does not mean they can never achieve sustainability, it just means that they will have a more dispersed footprint which will have a certain transportation 'overhead'.

7. Footprinting is a survivability concept not a sustainability concept. Survivability is about maximizing the time available on Earth for human species, independently of the quality of that existence.

Certainly footprint estimates are a *minimum* requirement for sustainability. In other words, living within global carrying capacity is necessary but not sufficient for sustainability. It may be desirable to increase the footprint to allow for a higher quality of existence.

8. Calculating the fossil fuel footprints in terms of area needed to absorb the corresponding CO_2 is inadequate according to some critics.

The area included for CO2 sequestration represents the degree by which the planet would need to be larger in order to cope with anthropogenic CO_2 output. Finding other ways to combat atmospheric CO_2 accumulation would open dramatic possibilities for reducing humanity's footprint. Calculations for various forms of renewable energy are included in Chambers et al. (2000).

Another method of calculating the fossil fuel footprint is to assess the biological area necessary to produce a substitute. This would lead to even larger footprints.

9. There are substantial uncertainties about how to calculate the land areas required to offset waste flows.

The science of accounting for various pollutants is in its early stages and by omitting these footprint studies underestimates environmental impact. Examples of studies where the footprints of wastes have been included are referred to earlier.

10. Footprint accounts make no distinction between land uses that are sustainable and those that are not.

This is correct. But as mentioned previously changes in productivity due to unsustainable land use do appear in future estimates of biocapacity. If activities in one year lead to an increase in desertification, for example, then the bioproductive supply will decrease in subsequent years.