The Environmental Impacts of Consumption at a Subnational Level

The Ecological Footprint of Cardiff

Andrea Collins, Andrew Flynn, Thomas Wiedmann, and John Barrett

Keywords

decision support
environmental indicator
consumption
resource use
sustainability
Wales

Summary

This article analyzes the environmental effects of resource consumption at a subnational level (by Cardiff, the capital city of Wales), using the Ecological Footprint as a measure of impact assessment. The article begins by providing a short critique of the Footprint methodology and the limitations of methods traditionally used to calculate national Footprint accounts. We then describe the Footprint methodology developed by the Stockholm Environment Institute to overcome some of these problems and used as the basis of the Reducing Wales' Ecological Footprint project, of which the Cardiff study has been a part. The main portion of this article focuses on presenting and discussing the Footprint results for Cardiff. The Ecological Footprint of household consumption in Cardiff will be presented using the international Classification of Individual Consumption According to Purpose (COICOP). Based on the results, we found that the areas of consumption that are a priority for Cardiff in terms of reducing resource use are food and drink, passenger transport (car and aviation), domestic fuel consumption, waste, and tourism. We also discuss how these findings have been presented to the Cardiff Council. We report on the initial reactions of policy officers to the Footprint results and how the Council plans to use them to influence policy decisions relating to sustainability. Finally, in the Conclusions section, we briefly explain the value of applying the Ecological Footprint at a subnational level and its value as an evidence-based tool for sustainability decision making.

Address correspondence to:
Andrea Collins
ESRC BRASS Research Centre
Cardiff University
Cardiff CF10 3AT
United Kingdom
<collinsa@cardiff.ac.uk>
<www.brass.cf.ac.uk>

Volume 10, Number 3

Introduction

Ecological Footprint analysis was initially pioneered in the early 1990s (see Wackernagel and Rees 1996). Following its early conceptual development, Ecological Footprinting has gained interest amongst academics and practitioners internationally (e.g., Environment Waikato 2003; EPA Victoria 2003; James and Desai 2003; WSP Environmental and Natural Strategies 2003a and 2003b; NAfW 2004; NRG4SD 2004; Aall and Norland 2005). The starting point for the Ecological Footprint concept is that there is a limited amount of bioproductive land on the planet to provide for all human resource demands. Sustainable development requires that we live within the carrying capacity of the earth, allowing our economies to develop while still ensuring that human needs are met.

The Ecological Footprint is an aggregated indicator of demand on nature and is measured using a standardized area unit termed a "global hectare" (gha), which is usually expressed on a per capita basis (gha/cap).[1] The Ecological Footprint is derived for a defined population for one year by estimating the area of land required to support their resource consumption—for example, the demands of that population in terms of their food, travel, and energy use. This demand on nature can be compared with the Earth's available biocapacity, which translates into an average of 1.8 gha/cap in 2001 (WWF 2004). Humanity is currently using 2.2 gha/cap, which indicates a situation of "overshoot" where nature's capital is being spent faster than it is being regenerated (WWF 2004). Overshoot may permanently reduce the Earth's ecological capacity.

Although the Ecological Footprint relates to the consumption activities of a defined population, it has many potential applications.[2] For example, the Footprint has been applied to organizations, cities, regions, and individuals. Currently no complete catalog of studies undertaken in the United Kingdom is available; but based on interviews with key Footprint consultants in the United Kingdom it is estimated that between 60 and 70 Footprint studies were undertaken between 1999 and 2004. Local and regional governments, as well as devolved governments, have shown a strong interest in the Footprint, with the Welsh Assembly Government having formally adopted the Ecological Footprint as one of its headline indicators for sustainability (NAfW 2004). This article analyzes the environmental impacts of resource consumption at a subnational level. The unit of analysis is Cardiff, the capital city of Wales. Cardiff provides an interesting case study because it is currently caught up in Welsh-wide debates on the value of the Footprint, and as a city that has been subject to recent rapid growth, it has shown considerable interest in issues surrounding resource consumption.

Although the Ecological Footprint is being widely used and applied in the United Kingdom and elsewhere, the concept has faced a number of criticisms. Among the main points, critics have argued that the Footprint does not accurately reflect the impact of human consumption (see Van den Bergh and Verbruggen 1999; Lenzen and Murray 2001; Ferng 2002); it does not allocate responsibilities for impact correctly (see Herendeen 2000; McGregor et al. 2004); and it does not provide decision makers with a useful tool for policy making, as there is limited understanding of how different consumer activities relate to impact (see Van den Bergh and Verbruggen 1999; Ayres 2000; Van Kooten and Bulte 1999; Moffatt 2000; Ferng 2002). A more recent critique of the Ecological Footprint concept can be found in an article by McDonald and Patterson (2004, 52–54) and a more general debate can be found in work by Ferguson (2001) and by Van Vuuren and Smeets (2001).

In the following sections we address some of these issues. The focus of this article is the value of the Ecological Footprint for decision makers. Here, however, it is worth noting that at its most informative level, the Footprint method provides valuable insights into natural resource use and an estimate of the land area required to support a specified level of consumption. As the Ecological Footprint aggregates the impacts of different consumption activities into a single measure, it also offers policy makers the ability to clearly identify and compare the environmental impact of different activities such as transport, waste production, and energy use. More promising still, the Footprint provides the potential for policy makers to prioritize their actions in a more informed and integrated

manner. Policy makers can thus potentially measure the effectiveness of policies for pursuing sustainable development. One reason that the Ecological Footprint may be helpful to policy makers is its communicative power. The Footprint personalizes sustainability by assessing the impact of consumption from a consumer perspective (i.e., it takes into account the impact of residents within a defined boundary rather than the industries in a particular locality). It can therefore be a useful tool by which to communicate to people and to help them appreciate the link between their local (consumption) activities and global environmental impacts.

The Decision to Measure Cardiff's Ecological Footprint

As part of the Reducing Wales' Ecological Footprint project (see Barrett et al. 2005), an Ecological Footprint study was undertaken of Cardiff, the capital city of Wales (see Collins et al. 2005). Between January 2003 and January 2005, a partnership including the BRASS Research Centre at Cardiff University,[3] Cardiff Council, and Stockholm Environment Institute (SEI), and the World Wildlife Fund Cymru undertook a collaborative project to measure Cardiff's Ecological Footprint. Cardiff Council had specific reasons for wanting to undertake a Footprint study. First, the Council's local sustainability strategy and community strategy endorsed the Footprint and the Council wanted to mainstream the project and its outcomes into existing policy. Second, policy officers wanted a clearer picture of the scale of the environmental challenge that the city faces if it is to become more sustainable. The Footprint study would provide an initial benchmark for the city, and future Footprinting exercises could then be used to track the Council's performance. Third, the Footprint would provide the Council with a resonant tool and metaphor from which to promote awareness of sustainable consumption and lifestyles. Finally, data developed within the project and the overall Footprint results would provide policy officers with additional evidence from which to inform debate and policy development within the Council. More specifically, the team of sustainability officers within the Council hoped that the Footprint study could answer the following questions: What is Cardiff's Ecological Footprint per capita? What is the Footprint made up of? What are the most significant areas of resource use within the city? Is the Council prioritizing the right areas to reduce the city's Footprint? Are the Council's current policies sufficient to move the city towards more sustainable consumption? How can the data derived from the Footprint study be used to inform policy, manage resources more sustainably, and raise awareness of sustainable lifestyles?

To provide credible answers to these questions, two types of methodological innovation were required. First, the processes of data collection and analysis needed to be as transparent as possible and engage with key council officers to ensure as far as possible that they regarded the Footprint results as legitimate. (This process is explained fully in a report by Collins et al. 2005.) Second, the calculation of the Ecological Footprint needed to be sensitive to local circumstances. This point is discussed below.

Traditionally, national Ecological Footprints (the "national footprint accounts") have been calculated based on a country's domestic production and its imports and exports of primary materials and secondary products,[4] together with an estimate of the embodied energy of secondary products (Monfreda et al. 2004). But this method does not assign the resource flows accurately to final consumption categories, because it omits all mutual interrelationships between product sectors and excludes the environmental effects of tertiary products (e.g., services). To address these issues, researchers based at SEI have developed a methodology that allows intermediate resource flows to be assigned to final consumption, thereby adding significant strength to the Ecological Footprint calculation (see Barrett et al. 2005; Wiedmann et al. 2006).

The method developed by SEI takes the existing National Footprint Account provided by the Global Footprint Network (GFN 2004) as a starting point. The total Footprint of the United Kingdom is then disaggregated by economic sector and reallocated to final demand using input-output analysis based on economic supply and use tables. The breakdown of final demand categories includes detailed household consumption activities according to the international Classification

of Individual Consumption According to Purpose (COICOP) classification system and a detailed breakdown of capital investment. With this method it is possible to calculate Footprints for subnational geographical areas (e.g., Cardiff) or socioeconomic groups, while ensuring full comparability of results with the National Footprint Account data. The method can be applied to every country for which a National Footprint Account exists and for which appropriate economic and environmental accounts are available. A detailed description of this method is published in work by Wiedmann and colleagues (2006) and addresses issues including the accounting of capital investment and the embedded impacts throughout all consumption categories, as well as limitations and assumptions inherent in the method.

The methodological approach to Footprinting that we have described above is also designed to capture resource use and environmental impacts that residents generate via their direct consumption, and has a number of distinct advantages for policy makers. First, the method uses standardized, official, and annual statistics; this increases its robustness and reliability as an indicator. It also encourages the development of comparative (national and international) studies that can promote methodological innovation because of their comparability. Second, using localized and detailed household expenditure data, Footprints can be generated at regional and local levels. The method has been successfully used to calculate the Footprint of the United Kingdom, Wales, and Cardiff (see Barrett et al. 2005; Collins et al. 2005). Finally, by allocating the Footprint to final demand categories, the method emphasizes consumer responsibilities, which in turn are valuable in developing policy scenarios.

The calculation of Cardiff's Ecological Footprint is based on household expenditure on goods and services (using the COICOP categories) by socio-economic breakdown using the A Classification Of Residential Neighbourhoods (ACORN) groupings for the subnational area. In the United Kingdom, COICOP data are available from the UK Office for National Statistics (ONS 2003). COICOP divides household expenditure into twelve categories, for example, "food and nonalcoholic beverages," "transport," and "health." Each of these top-level categories can be further subdivided. ACORN profile data are available from CACI (a UK marketing data company) for 1.7 million postcode areas in the United Kingdom, within which there are 55 neighborhood categories referred to as ACORN "types."[5] The data range from ACORN group 1 (wealthy achievers, suburban areas), type 1 (wealthy suburbs, large detached houses) to ACORN group 17 (people in multiethnic, low-income areas), type 54 (multiethnic, high unemployment, overcrowding). Type 55 is "unclassified."

Multiplying the total populations of different socioeconomic groups in Cardiff (i.e., ACORN types) by their typical expenditure for each COICOP category results in a total final expenditure of households in Cardiff. This consumption pattern is typical for Cardiff residents and can hence be used to calculate a characteristic Ecological Footprint of an average Cardiff resident using the total Footprint multipliers derived from national input-output analysis.

Figure 1 illustrates the methodology on which the Cardiff Footprint calculations were based. The "top-down" approach depicts the stages that are used to model local consumption by using localized and detailed household expenditure data and input-output multipliers. In the "bottom-up" approach, locally specific data—if available—can be used to replace the top-down modeled data. For a more detailed description of the methodology see the work by Barrett and colleagues (2005) and Wiedmann and colleagues (2006).

Ecological Footprint of Cardiff, the Capital City of Wales

Cardiff is a major European city and in 2001, the year that the Footprint was calculated, the city had 307,300 residents, 10% of the total population of Wales (2.9 million) (ONS 2001). As the capital city of Wales, Cardiff is also the center for economic growth in the Southeast Wales subregion but also increasingly in Wales as a whole. Over the last decade Cardiff has enjoyed significant growth, including the development of retail, housing, and leisure in its suburbs and the redevelopment of its Bay area. The city has a thriving retail sector and is one of the most consistently successful retail locations in the United

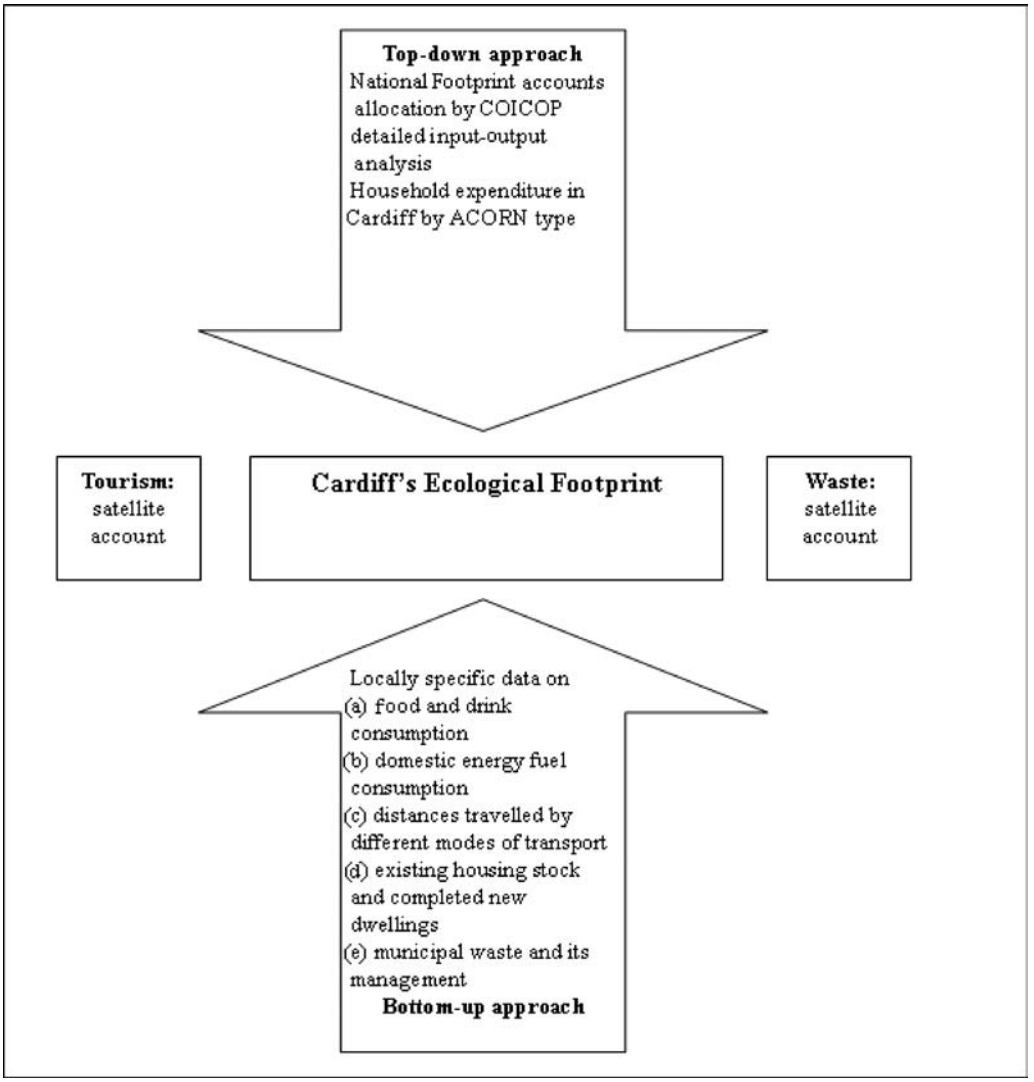

Figure 1 Outline of method used to calculate the Ecological Footprint of Cardiff as a local authority area in the United Kingdom in the year 2001 (adapted from Barrett et al. 2005). COICOP = the international Classification of Individual Consumption According to Purpose; ACORN = A Classification Of Residential Neighbourhoods.

Kingdom. Cardiff has also become an increasingly prosperous city, with total employment increasing from 149,000 in 1991 to 173,200 in 2001 (Cardiff County Council 2002a). Following the decline of the city's heavy industry in the later part of the 20th century, the public, service, and finance sectors now dominate Cardiff's economy, with just 10.3% of the total workforce being employed in manufacturing. Major events such as the 1999 Rugby World Cup, FA Cup Final, Worthington Cup, and Wales Rally GB (formerly Network Q Rally) have raised the profile of the city internationally, with over 10.6 million tourists visiting Cardiff in 2001 (Cardiff County Council 2002b).

The overall Ecological Footprint for Cardiff was 1.72 million gha in 2001—the year for which the most recent household expenditure data were available at a subnational level. Cardiff's Footprint is equivalent to 82% of the total area of

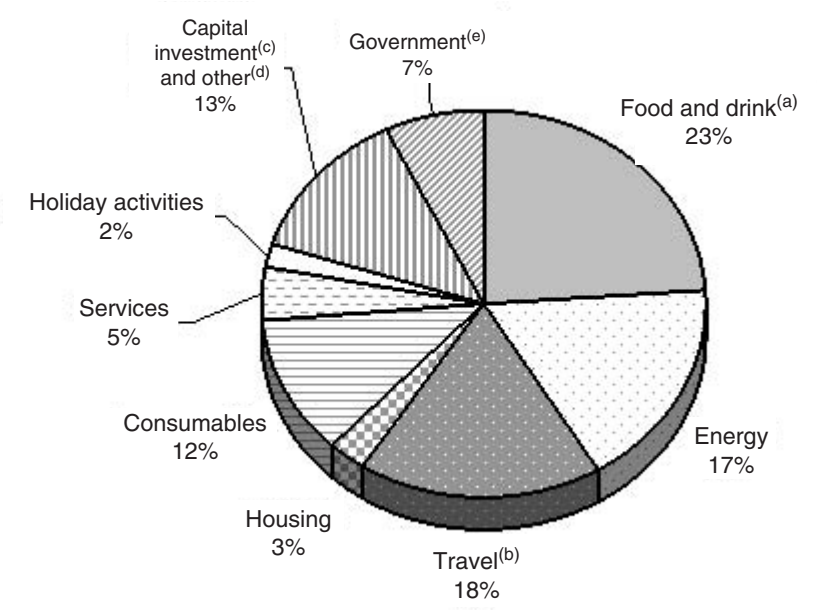

Figure 2 Major components of Cardiff's Ecological Footprint: (a) includes catering services; (b) includes transport services and air travel; (c) capital investment or gross fixed capital formation (GFCF) relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment, dwellings, and other buildings and structures; (d) includes nonprofit institutions serving households, valuables, changes in inventories, and overseas tourists in the United Kingdom; (e) includes central and local government. The Footprint calculations assume shared responsibility for resource use by government, that is, equal values for the United Kingdom, Wales, or Cardiff. "Holiday Activities" refers to vacationing activities.

Wales (2.1 million hectares). On a per capita basis, the Ecological Footprint of an average Cardiff resident is 5.59 global hectares, and is greater than the Footprint of an average UK or Welsh resident (5.35 gha/cap and 5.25 gha/cap respectively). The magnitude of these figures shows that the level of consumption by Cardiff residents is currently inequitable, as they are using resources more than three times the average "earthshare" of 1.8 gha/cap. In terms of equity, Cardiff's residents would need to reduce their ecological demand by 68% to reach the average earthshare.

In figure 2 and table 1, we show respectively how the relative sizes of the different components in the Footprint and its total size are inextricably linked to the lifestyles of Cardiff residents. Figure 2 illustrates that almost one-fourth of the Cardiff Footprint is made up of the consumption of *food and drink*, and that together with three other components—*travel*, *energy*, and *consumables*—this contributes 70% of the total Footprint. That four factors can so dominate the Cardiff Footprint is indicative of how contemporary patterns of consumption have major implications for resource use.

From an ecological perspective, figure 2 poses major challenges to the long-term sustainability of the Cardiff lifestyle. The results suggest that fundamental changes need to be made to consumption practices if the size of the Footprint is to be reduced. Is it possible, for instance, to shrink the relative size of the food and drink component? To simply replace energy-inefficient products in the kitchen with more efficient ones is, at best, likely to slow the rate of growth in the food Footprint. Decoupling consumption and resource use will, on the Footprint results, require a more fundamental change to social practices, for example, in relation to the type, preparation, and use of foods by manufacturers and in the home.

Table 1 Ecological Footprint (EF) for Cardiff, Wales, and the United Kingdom in 2001, broken down by COICOP category for household consumption (all numbers in global hectares per capita, gha/cap)[a]

COICOP number	*Consumption category*	*EF of Cardiff gha/cap*	*EF of Wales gha/cap*	*EF of United Kingdom gha/cap*
	Household consumption			
	Food and drink			
01.1	Food	0.759	0.748	0.771
01.2	Nonalcoholic beverages	0.050	0.048	0.050
02.1	Alcoholic beverages	0.090	0.083	0.078
11.1	Catering services	0.431	0.411	0.439
	Subtotal food and drink	**1.33**	**1.29**	**1.34**
	Energy			
	Domestic fuel consumption	0.57	0.512	0.546
04.5	Electricity and gas distribution	0.42	0.405	0.358
	Subtotal energy	**0.99**	**0.92**	**0.90**
	Travel			
	Private transport (fuel)	0.285	0.276	0.287
07.1	Purchase of vehicles	0.125	0.109	0.116
07.2	Operation of personal transport equipment	0.150	0.130	0.103
07.3	Transport services	0.091	0.066	0.092
	Aviation	0.336	0.198	0.124
	Subtotal travel	**0.99**	**0.78**	**0.72**
	Infrastructure (housing)			
04.1	Actual rentals for housing	0.032	0.034	0.033
04.2	Imputed rentals for housing	0.072	0.076	0.075
04.3	Maintenance and repair of the dwelling	0.054	0.057	0.067
	Subtotal infrastructure	**0.16**	**0.17**	**0.18**
	Consumables and durables			
	Consumables			
02.2	Tobacco	0.024	0.024	0.024
09.5	Newspapers, books, and stationery	0.027	0.026	0.029
12.1	Personal care	0.024	0.023	0.028
	Durables			
03.1	Clothing	0.023	0.022	0.029
03.2	Footwear	0.011	0.010	0.012
05.1	Furniture, furnishings, carpets, and other floor coverings	0.049	0.049	0.057
05.2	Household textiles	0.012	0.013	0.013
05.3	Household appliances	0.091	0.095	0.115
05.4	Glassware, tableware, and household utensils	0.007	0.007	0.011
05.5	Tools and equipment for house and garden	0.019	0.019	0.017
05.6	Goods and services for routine household maintenance	0.008	0.008	0.009
06.1	Medical products, appliances, and equipment	0.008	0.008	0.010

Table 1 Continued

COICOP number	*Consumption category*	*EF of Cardiff gha/cap*	*EF of Wales gha/cap*	*EF of United Kingdom gha/cap*
08.2	Telephone and telefax equipment	0.0002	0.0002	0.0005
09.1	Audiovisual, photo, and information processing equipment	0.076	0.072	0.069
09.2	Other major durables for recreation and culture	0.010	0.012	0.020
09.3	Other recreational items and equipment	0.200	0.200	0.187
12.3	Personal effects n.e.c.[b]	0.083	0.080	0.123
	Subtotal consumables and durables	**0.67**	**0.67**	**0.75**
	Services			
04.4	Water supply and miscellaneous dwelling services	0.024	0.021	0.018
06.2	Outpatient services	0.003	0.002	0.006
06.3	Hospital services	0.004	0.004	0.004
08.1	Postal services	0.001	0.001	0.002
08.3	Telephone and telefax services	0.019	0.018	0.023
09.4	Recreational and cultural services	0.042	0.042	0.043
10.0	Education	0.017	0.013	0.026
11.2	Accommodation services	0.055	0.053	0.071
12.4	Social protection	0.017	0.017	0.025
12.5	Insurance	0.038	0.037	0.046
12.6	Financial services n.e.c.	0.019	0.018	0.033
12.7	Other services n.e.c.	0.017	0.017	0.022
	Subtotal services	**0.26**	**0.24**	**0.32**
	Holiday activities[c]			
	Residents' holidays abroad	0.103	0.101	0.122
	Nonhousehold consumption			
	Capital investment[d]			
	Gross fixed capital formation	0.744	0.744	0.744
	Government[e]			
	Central government	0.241	0.241	0.241
	Local government	0.167	0.167	0.167
	Subtotal government	**0.41**	**0.41**	**0.41**
	Credits for recycling	−0.030	−0.027	−0.108
	Other[f]	−0.031	−0.031	−0.031
	Total Ecological Footprint (gha/cap)	**5.59**	**5.25**	**5.35**

[a] For more detailed results see Barrett and colleagues (2005) and Collins and colleagues (2005). One hectare (ha) = 10^4 square meters (m^2, SI) ≈ 2.47 acres.
[b] N.e.c. = Not elsewhere classified.
[c] "Holiday activities" refers to vacationing activities.
[d] Capital investment or gross fixed capital formation (GFCF) relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment, and dwellings and other buildings and structures.
[e] The Footprint calculations have assumed shared responsibility; therefore the Footprint per capita is the same for the United Kingdom, Wales, and Cardiff.
[f] *Other* includes nonprofit institutions serving households, valuables, changes in inventories, and overseas tourists in the United Kingdom; overseas tourists result in an overall Negative Footprint in Cardiff, Wales, and the UK for this category. This is because these impacts are included in the Footprint of the visitors' country of origin.

Because consumption is embedded deep within current social practices and institutional structures, the Footprint results provide a challenge to the way in which Cardiff residents live their lives. Indications of the scale of resource use and how different components make up the Footprint result are contained in table 1. The results are classified by COICOP final demand categories to aid comparison with other work on resource use. What both table 1 and figure 2 also suggest, however, is that it is not simply that residents must change their behavior if the Footprint is to be minimized. Rather, the structures of provision of goods and services need to be radically reshaped to reduce the scale of resource use and thus the size of the Footprint.

The results in table 1 show that food and drink consumption is the largest single category, with a Footprint of 1.33 gha/cap, and is responsible for almost one-fourth of Cardiff's total Ecological Footprint. Cardiff's per capita Footprint figure for food and drink is larger than that for Wales and similar to that for the United Kingdom (see table 1). The reason that this figure is so large relates to the scale, type, and pattern of food and drink consumption. Consumption at home accounted for 68% of the Footprint figure for food and drink. For instance, much of the food will be grown or raised in an energy-intensive manner and then manufactured or processed, which in turn requires substantial amounts of energy. A further reason that the food and drink Footprint figure is so high is that residents are also consuming large amounts of food and drink outside the home. *Catering services* accounted for almost one-third of the Footprint figure for food and drink. This includes food that is intensively produced and prepared and then eaten in restaurants, fast food outlets, and canteens. These activities cumulatively can involve relatively large amounts of energy and land use and result in a high Footprint score.

Travel and *energy* consumption each have a Footprint of 0.99 gha/cap and are each responsible for nearly one-fifth of Cardiff's total Footprint. Cardiff's per capita Footprint figure for transport is significantly larger than those for Wales and the United Kingdom, 0.78 and 0.72 gha/cap, respectively. The size of Cardiff's passenger transport Footprint is surprising, as it has a relatively compact city center containing key retail and civic amenities. Good surface rail and bus networks also exist. Undermining these positive features, though, has been the development of dispersed neighborhoods and of retail and leisure amenities on the fringe of the city, which tend not to be well-linked to public transport, and so encourage increased car travel. The Footprint results show that Cardiff residents place a heavy reliance on private modes of travel. Travel by private transport includes fuel, the purchase of vehicles, and the operation of vehicles, and together these are responsible for 57% of the total travel Footprint. Fuel alone accounted for almost 30% of the total transport Footprint figure. In comparison, public *transport services* accounted for only 9.2% of the transport Footprint figure. Another significant factor contributing to the size of Cardiff's transport Footprint is its residents' air travel. *Aviation* does have a large ecological impact and is responsible for 34% of the residents' travel Footprint (0.34 gha/cap). This number is much higher than those for Wales and the United Kingdom (see table 1). The close proximity of two international airports (Cardiff and Bristol) that both operate budget airlines means that Cardiff residents are taking advantage of air travel. This increase in holidays (vacationing) abroad is reflected not only in the *aviation* Footprint result but also in the Footprint for Cardiff *residents' holidays abroad* (0.103 gha/cap), though the figure excludes the impact of travel to the holiday destination. As the city's affluence continues to grow, it is likely that the Cardiff Footprint will increase in these specific areas.

Cardiff's domestic fuel consumption accounted for 58% of the Footprint for domestic energy use (0.57 gha/cap). The other 42% is due to the consumption of electricity and the distribution of natural gas (0.42 gha/cap). Both figures are higher than the respective numbers for Wales and the United Kingdom. Cardiff's increase in young and affluent professionals and the rise in the development of single-occupancy and executive-type dwellings may provide a possible explanation as to why Cardiff has a relatively large Footprint for domestic fuel consumption. These residents tend to have high levels of disposable income and are more likely to purchase and use household electrical items

and to heat/air condition their homes all year round.

Residents' consumption of consumables and durables has an ecological impact of 0.64 gha/cap, equivalent to more than one-fifth of the residents' total Footprint. This Footprint figure is the same as for Wales but lower than that of the United Kingdom. On closer examination, though, the results also provide indications of the environmental impacts associated with the increasingly affluent lifestyles of those who live in Cardiff. Residents' consumption of *other recreational items and equipment* is the largest single subcategory and is responsible for more than one-third of Cardiff's Footprint for consumables and durables. This COICOP subcategory includes equipment and items for sports, games, hobbies, camping, outdoor recreation, gardening, and also pet products and veterinary services. This Footprint figure may be a reflection of the increasing number of households in Cardiff with high levels of disposable incomes, which may be more likely to purchase high-cost items and equipment for recreation and outdoor activities.

Audiovisual equipment, *household appliances*, and *personal effects n.e.c.*, when combined, are responsible for more than a fourth of the consumables and durables Footprint. The COICOP category "audio, visual equipment" includes photographic, media, and information processing equipment and its repair. *Household appliances* includes all major and small household appliances (e.g., refrigerators, freezers, microwaves, ovens, washing machines, toasters, teakettles) and their repair. *Personal effects n.e.c.* includes jewelry, watches, and personal items such as suitcases, handbags, and wallets. Again, this figure may be a reflection of the increasing number of households with high levels of disposable income, which will purchase and use more of these items per household and replace them on a more frequent basis.

Finally, of the *other* consumption categories, gross fixed capital formation (capital investment) has the largest Ecological Footprint, with an impact of 0.74 gha/capita. Gross fixed capital formation relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment, dwellings, and other buildings and structures. The Footprint figure for Cardiff is the same as for Wales and the United Kingdom, as it is assumed within the Ecological Footprint model that residents have equal responsibility for such shared investments. Although on the grounds of equity it may make sense to apportion investments in physical infrastructure among all citizens, in terms of consumption practices it does appear anomalous when applied to a capital city like Cardiff. By European standards Cardiff is a small city, but because it is a capital city, it will be overendowed with the infrastructure of a capital—everything from administrative buildings to cultural assets such as museums and galleries. This will inevitably skew the consumption opportunities, and thus practices, of the city's residents.

Waste Satellite Account

The Ecological Footprint for waste is not included in the "standardized" Footprint calculations but instead is treated as a satellite account. The reason for this is that the impacts of household consumption can only be counted once, either as inputs, when products are bought or consumed, or as outputs, when these products are discarded. Because the Footprint methodology used here considers the environmental impacts of consumables, double counting would occur if the impact of waste from these consumables were included in the final result. Nevertheless, both in terms of their value for policy makers and for communicating to citizens the environmental impact of resource use, it is very important to calculate this satellite account.

The Footprint figure for waste only provides a partial picture of the impact of waste, because it refers only to household waste, and excludes other waste such as construction, demolition, and commercial waste. Cardiff's waste has a Footprint result of 0.81 gha/cap, 17% larger than that for Wales and the United Kingdom. *Credits for recycling* produces a negative Footprint of -0.03 gha/cap as recycled materials reenter the economy (see table 1). These results show that Cardiff residents are wasteful and that as of 2001 only a low level of recycling was taking place. Table 1 provides some indication as to sources and composition of residents' household waste: *food* consumed at home and in *catering services*, *newspapers, books and stationery*, *personal care*

Table 2 Ecological Footprint results for Cardiff tourists

Component areas	*Ecological Footprint [gha/tourist]*
Catering and accommodation services	4.90
Other services	0.31
Clothing	0.16
Other products	2.50
Transport services (United Kingdom only)	0.63
Total (excluding travel to the United Kingdom)	**8.50**
Transport (to the United Kingdom)	0.17
Total (including travel to the United Kingdom)	**8.67**

Note: gha/tourist = "global hectares" per tourist; 1 ha = 2.47 acres.

items, *clothing*, *footwear*, *furniture*, *furnishings*, *carpets and other floor coverings*, and *household textiles*.

Tourism also takes the form of a satellite account and can be calculated using two different methods: top-down and bottom-up. The top-down approach uses modeled expenditure data; the bottom-up approach uses locally specific data. The top-down approach enables the Ecological Footprint to be calculated using expenditure data for overseas tourists in the United Kingdom. These data include all tourist activities with monetary transactions and can be found under "Non-residential household expenditure in United Kingdom" in the COICOP breakdown of final household consumption (Mahanjan 2003). We aggregate the data into five main categories of tourist expenditure: catering and accommodation services, clothing, other products, transport services (United Kingdom), and other services. In the top-down approach for Cardiff, two key assumptions are that overseas and domestic tourists in Cardiff have the same expenditure, and therefore the same consumption pattern. Based on these expenditure data, the Ecological Footprint of Cardiff's tourists was calculated as 280,000 gha in total or 8.5 gha per tourist (see table 2).

Although the top-down approach is useful in providing an indication of tourists' impact during their stay in Cardiff, it does not account for "overseas" tourist travel to the United Kingdom. This was calculated using the bottom-up approach, as Cardiff-specific data on overseas tourist travel to the United Kingdom were available from a 2001 Cardiff Visitors Survey. Using the bottom-up approach, visitors' air travel to the United Kingdom created an additional Footprint of 5,536 global hectares. This is equivalent to 0.17 gha per tourist. For the purposes of reporting the Ecological Footprint, this figure is expressed as an average per tourist, as the impact of air travel has been shared between Cardiff's overseas and domestic visitors. When added to the total top-down Footprint figure, the Ecological Footprint for all Cardiff tourists is 286,000 global hectares, or 8.67 gha/tourist. This suggests that the impact of a Cardiff tourist's consumption activities is considerably higher than that of a Cardiff resident (5.59 gha/cap), and is equivalent to 17% of the total Footprint for Cardiff residents in the same year (1.7 million global hectares). Table 2 shows the overall Footprint figure for tourists, combining both approaches, and the breakdown by activity. Tourist consumption of catering and accommodation services and other products have the largest ecological impact and together account for 85% of the overall tourist Footprint. Tourist total travel was responsible for almost 10% of the tourist Footprint figure.

Tourism is an important part of Cardiff's development strategy. The city offers a number of tourist products relating to culture, sport, and leisure. These results draw attention to the environmental pressures that are attributable to Cardiff's promoting itself as a tourist destination.

In the presentation of the Ecological Footprint results for Cardiff, a set of priorities has emerged. The "big hitters" ecologically for Cardiff's residents are consumption of food and drink; passenger transport, particularly in relation to air and car travel; domestic fuel consumption; and waste. Tourism is also a priority area, as tourists have a large impact in areas where Cardiff's Footprint is

already under considerable pressure, namely food, transport, and waste. For these activities and others as well, this study shows that development trends in the city are exacerbating the problem of a large Footprint.

Responses to Cardiff's Ecological Footprint Results

From an academic and policy perspective it is important to be able to assess the rigor of the Footprint as a tool and how it may work alongside or compete with other organizational decision-making tools to assess environmental or sustainability impacts. For example, environmental or sustainability appraisal tools require professionals to make judgments about the impacts of a policy, program, or plan, on the environment. By way of contrast, the Ecological Footprint has the potential to provide environmental data in a user-friendly form so that decision makers could, if they wished, claim to make more "objective" or "informed" judgments.

During the Cardiff Footprint study, the Council was kept informed of progress made on data collection and given the opportunity to ask questions as to how the Footprint findings would relate to policy. The approach used to collect data for the Cardiff project has been significantly different from that which has been used to construct Ecological Footprints for local and regional governments elsewhere in the United Kingdom, as it has involved a continuous process of checking the quality of data used in the Footprint calculations. This has required researchers at Cardiff University to work closely with officers when interpreting local data and considering its appropriateness and use in the Footprint calculation. Although this aspect of the Cardiff study has been extremely resource-intensive and required a great deal of investment by the three partners involved, it has assisted in ensuring that the Footprint calculation is as accurate as possible and has raised the credibility of the whole process within the Council.

Considerable effort was also devoted to developing with Council staff the outlines of policy scenario options. The work remains at a preliminary stage but does illustrate the potential of the Footprint to provide policy-relevant environmental information. The scenario results were presented and discussed in a series of workshops conducted during the summer of 2004. The aim of the workshops was threefold. First, to present preliminary Footprint results and check the appropriateness of any assumptions made in the calculations. Second, to encourage policy officers to think differently as to how they could address issues relating to sustainability in their area of work. Third, to see how different policy areas interrelate—for example, food, energy, and waste and consider whether current targets are ineffective or failing to address the most significant issues. The workshops also had the potential to help formulate targets based on the best available evidence in areas where Council policy is poor—for example, climate change, energy and food, and what direction policy needs to take to achieve a reduction in the Cardiff Ecological Footprint.

The study has provided policy officers for the first time with evidence on the ecological impact of residents' consumption and the environmental implications of various policies and policy options. In some policy areas, especially where there are already existing models and worldviews, professionals have reacted with, at best, caution to the findings. In other policy areas different responses can be envisaged. Where professional groups have been weak or under threat, the Footprint results could be more enthusiastically embraced and used to bolster positions within the Council.

The Ecological Footprint results will enable the Council to think in a more integrated way as it shows that at present the activities of one part of the organization are putting costs on to another. For example, promoting Cardiff as an events city is positive from an economic perspective but by following resource use, the Footprint study has clearly shown that the Council will have to pay for the collection and disposal of waste. These costs did not appear to have been taken into account in event planning or tourism promotion. The Footprint results have also highlighted issues surrounding planning decisions being made on proposed developments and whether long-term ecological costs were being considered. Take for example, the development of flats on Brownfield sites and whether residents would have access to

public transport or have adequate facilities for recycling waste. Within the Council, staff and elected members have also recognized the value of the Footprint as an aid to decision making on sustainability issues and have gone so far as to make suggestions for further areas of research including commuting, schools, and food procurement.

Conclusions

In presenting an overview of the Footprint results for Cardiff, this article has identified a number of key themes. An agenda or set of priorities is beginning to emerge within the City Council. The biggest ecological impacts are from consumption of food and drink, passenger transport, energy use, and production of municipal waste. The relative significance of these items and their Footprint figure is in large part a reflection of two factors. One is the lifestyle of the city's residents. For instance, the food and drink that residents consume and how they are consumed contribute to a large Ecological Footprint. Similarly, Cardiff's residents take advantage of the opportunities for air travel and this also contributes to a large Ecological Footprint.

But lifestyles and the consumption decisions that go with them are rooted in social practices. Consumption "choices" are mediated through production. As Dale Southerton and his colleagues have argued:

> processes of consuming are configured by many aspects of production which have a structuring effect on what goods and services are provisioned, how those goods and services shape the consumption of related products, and how objects are used. (Southerton et al. 2004, 7)

Any policy prescriptions, therefore, cannot simply focus on trying to modify consumers' behavior. Moreover, although the Footprint highlights inequities in consumption between the developed and less-developed world, it should be remembered that the results reported here are based on an average Cardiff resident and that there will be very large variations in the opportunities for and experiences of consumption by residents across the city.

A further structural point to be borne in mind is that the Footprint of the city is exacerbated by the way in which it is organized and has developed. Although Cardiff appears to be compact because of the design of its city center, large neighborhoods have developed on the urban fringes, and "outside of town" retail and leisure facilities encourage car use. The development of the city in this way is typical of a number of other cities in the United Kingdom, and throughout Europe and North America. As Cardiff continues to grow and develop, it will face difficulties in maintaining its Ecological Footprint at the 2001 level (5.59 gha/cap). Reducing residents' levels of consumption and therefore Footprint toward a more equitable level will prove to be even more of a challenge.

The novelty of the Footprint methodology used in the Cardiff study is that comparable Ecological Footprints can be calculated on a subnational level and for different socioeconomic groups. Previously it has not been possible to compare the Ecological Footprints of a city, a region, or a devolved country and a nation (e.g., Cardiff, Wales, and the United Kingdom). The use of economic input-output analysis, the detail of disaggregation by consumption category, and the expanded use of household expenditure data all extend the potential for applications of the Ecological Footprint concept and help to inform scenarios, policies, and strategies on sustainable consumption.

For Cardiff, the results from this study have demonstrated that the Ecological Footprint is a useful tool by which the Council and other organizations can consider the longer-term and global impacts of the city's growth and development. The Footprint allows the identification of areas of priority for policy and can help officers and local politicians to contribute to more informed debates about a vision of a sustainable Cardiff. Even so, interest in the Footprint results is variable, in part depending upon calculations of whether particular interests will be furthered or stifled by promoting the Footprint. For example, in novel policy areas for the Council, such as food or climate change, some officers have been keen to utilize the results of the Footprint and champion it as a tool as a way of bolstering their position and the credibility of the Footprint within the

organization. Meanwhile, other officers have felt that the Footprint results may challenge long-held policy objectives or favored policy-evaluation tools and have sought to dismiss or discredit the findings. The debates that the Footprint process has provoked have subjected the methodology to considerable scrutiny.

As officers within the Council have become more confident in the robustness of the Ecological Footprint as a tool and the legitimacy of its data, they have been keen to engage in evaluations of different policy options. Here the Footprint provides an innovative perspective on environmental pressures and is able to communicate them to officers in a readily understandable form. On its own, though, the Ecological Footprint will not change decisions within the Council (or any other organization). Economic factors continue to dominate and the interpretation of the Footprint results or the development of alternative developmental perspectives based on the Footprint currently remains within the shadow of a pro-growth agenda.

Acknowledgments

We would like to thank Biffaward for their financial assistance, WWF Cymru and Cardiff County Council for their support, and two anonymous referees for their comments.

Notes

1. One hectare (ha) = 10^4 square meters (m^2, SI) ≈ 2.47 acres.
2. *Editor's note:* For more on the uses of ecological footprint in industrial ecology, see work by Van der Voet (2000), York and colleagues (2005), and Frey and colleagues (2006).
3. BRASS is the Research Centre for Business Relationships Accountability, Sustainability and Society which was established by the Economic and Social Research Council (ESRC) in October 2001. See <http://www.brass.cf.ac.uk>.
4. Primary materials are those that are unprocessed and can be used directly with minimal alteration or processed into a secondary product. Examples include raw fruit, vegetables, and forage for livestock. Secondary products are goods derived from primary products. Examples include meat and milk.
5. ACORN profiles by postcode can be viewed on the Internet at <www.upmystreet.com>.

References

Aall, C. and I. T. Norland. 2005. The use of the ecological footprint in local politics and administration: Results and implications from Norway. *Local Environment* 10(2): 159–172.

Ayres, R. U. 2000. Commentary on the utility of the Ecological Footprint concept. *Ecological Economics* 32(3): 347–349.

Barrett, J., R. Birch, N. Cherrett, and T. Wiedmann. 2005. *Reducing Wales' ecological footprint—Main report*. Cardiff, UK: World Wildlife Fund WWF Cymru (Wales). <www.walesfootprint.org>. Accessed 20 February 2006.

Cardiff County Council. 2002a. *Economic development plan 2003–2004*. Cardiff, UK: Cardiff Council.

Cardiff County Council. 2002b. *City and county of Cardiff STEAM report 2001*. Numeric Executive Summary (reissued April 2002). Cardiff, UK: Cardiff Council.

Collins, A., A. Flynn, and A. Netherwood. 2005. *Reducing Cardiff's' ecological footprint—Main report*. BRASS, Cardiff University. Cardiff, UK: WWF Cymru. <www.walesfootprint.org>. Accessed 20 February 2006.

Environment Waikato. 2003. *Regional ecological footprint*. Waikato Regional Council, Hamilton East, New Zealand. <www.mfe.govt.nz/publications/ser/eco-footprint-sep03/eco-footprint-chapter6.pdf>. Accessed 20 February 2006.

EPA Victoria. 2003. *EPA Victoria and eco-footprint*. Environment Protection Authority, Victoria, Australia. <www.epa.vic.gov.au/eco-footprint>. Accessed 20 February 2006.

Ferguson, A. R. B. 2001. Comments on eco-footprinting. *Ecological Economics* 37(1): 1–2.

Ferng, J. J. 2002. Toward a scenario analysis framework for energy footprints. *Ecological Economics* 40(1): 53–69.

Frey, S., D. J. Harrison, and E. H. Billett. 2006. Ecological footprint analysis applied to mobile phones. *Journal of Industrial Ecology* 10(1–2): 199–216.

GFN (Global Footprint Network). 2004. *National Footprint and Biocapacity Accounts*. Oakland, CA: GFN. <www.footprintnetwork.org/gfn_sub.php?content=nrb>. Accessed 20 February 2006.

Herendeen, R. A. 2000. Ecological footprint is a vivid indicator of indirect effects. *Ecological Economics* 32(3): 357–358.

James, N. and P. Desai. 2003. *One planet living in the Thames Gateway*—A WWF-UK

One Million Sustainable Homes Campaign Report; BioRegional Development Group, Surrey, UK, June 2003. <www.wwf.org.uk/filelibrary/pdf/thamesgateway.pdf>. Accessed 20 February 2006.

Lenzen, M. and S. A. Murray. 2001. A modified Ecological Footprint method and its application to Australia. *Ecological Economics* 37(12): 229–255.

Mahanjan, S., ed. 2003. *United Kingdom input-output analyses*, 2003 edition. London: ONS. <www.statistics.gov.uk/inputoutput>. Accessed 20 February 2006.

McDonald, G. W. and M. G. Patterson. 2004. Ecological footprints and interdependencies of New Zealand regions. *Ecological Economics* 50(1–2): 49–67.

McGregor, P. G., J. K. Swales, and K. R. Turner. 2004. The impact of Scottish consumption on the local environment: An alternative to the Ecological Footprint? Fraser of Allander Institute, University of Strathclyde. Quarterly Economic Commentary. *Economic Perspectives* 29(1): 29–34.

Moffatt, I. 2000. Ecological Footprints and sustainable development. *Ecological Economics* 32(3): 359–362.

Monfreda, C., M. Wackernagel, and D. Deumling. 2004. Establishing national natural capital accounts based on detailed Ecological Footprint and biological capacity assessments. *Land Use Policy* 21(3): 231–246.

NAfW (National Assembly for Wales). 2004. *Sustainable development indicators for Wales 2004*. NafW, Statistical Bulletin 18/2004. <www.wales.gov.uk/keypubstatisticsforwalesheadline/content/sustainable/2004/hdw20040323-e.htm>. Accessed 20 February, 2006.

NRG4SD (Network of Regional Governments for Sustainable Development). 2004. *International seminar on sustainable development indicators—Bases for developing common indicators at a regional level*. NRG4SD, ENCORE, Basque Government; Carlton Hotel, Bilbao, Basque Country, November 9–10, 2004. <www.nrg4sd.net/ENG/Events/Other/BilbaoNov2004.htm>. Accessed 20 February 2006.

ONS (Office for National Statistics). 2001. *Census 2001: The most comprehensive survey of the population*. London: ONS. <www.statistics.gov.uk/census2001/>. Accessed 20 February 2006.

ONS. 2003. *Detailed household expenditure by UK countries and government office Regions 2001-02*; revised September 2003. London: ONS.

Southerton, D., B. Van Vliet, and H. Chappels. 2004. Introduction: Consumption, infrastructure and environmental sustainability. In *Sustainable consumption: The implications of changing infrastructures of provision*, edited by D. Southerton, H. Chappells, and B. Van Vliet. Cheltenham, UK: Edward Elgar.

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

Van der Voet, E. 2000. Book review: *Our ecological footprint* by Mathis Wackernagel and William Rees. *Journal of Industrial Ecology* 3(2–3): 185–186.

Van Kooten, G. C. and E. H. Bulte. 1999. *The Ecological Footprint: Useful science or politics?* Working Paper 1999–2005, University of Alberta, Alberta, Canada. <http://www.biology.ualberta.ca/sfm>. Accessed 20 January 2005.

Van Vuuren, D. P. and E. M. W. Smeets. 2001. Ecological footprints: Reply to A.R.B. Ferguson. *Ecological Economics* 37(1): 2–3.

Wackernagel, M. and W. E. Rees. 1996. *Our ecological footprint. Reducing human impact on the Earth*. Gabriola Island, BC: New Society Publishers.

Wiedmann, T., J. Minx, J. Barrett, and M. Wackernagel. 2006. Allocating ecological footprints to household consumption activities by using input-output analysis. *Ecological Economics* 56(1): 28–48.

WSP Environmental and Natural Strategies. 2003a. *Towards a sustainable London—Reducing the capital's ecological footprint*. Phase 1 Report: Determining London's Ecological Footprint and Priority Impact Areas for Action. Oakland, CA: WSP Environmental Ltd, London and Natural Strategies LLC. <www.londonremade.com/lr_footprinting.asp>. Accessed 20 February 2006.

WSP Environmental and Natural Strategies, 2003b. *Towards a sustainable London—Reducing the capital's ecological footprint*. Phase 2 Report: Proposals to Reduce London's Ecological Footprint. Oakland, CA: WSP Environmental Ltd, London and Natural Strategies LLC. <www.londonremade.com/publications_research.asp>. Accessed 20 February 2006.

WWF (World-Wide Fund for Nature International). 2004. *Living planet report 2004*. WWF, Global Footprint Network, UNEP World Conservation Monitoring Centre. Gland, Switzerland: WWF. <www.panda.org/livingplanet>. Accessed 20 February 2006.

York, R., E. A. Rosa, and T. Dietz. 2005. The Ecological Footprint intensity of national economies. *Journal of Industrial Ecology* 8(4): 139–154.

About the Authors

Andrea Collins is a research associate at the ESRC Centre for Business Relationships, Accountability, Sustainability and Society (BRASS) at Cardiff University. **Andrew Flynn** is a senior lecturer in Cardiff University's Department of City and Regional Planning, in the United Kingdom. **Thomas Wiedmann** and **John Barrett** are research associates at the Stockholm Environment Institute, based at the University of York in the United Kingdom.