Planning with Ecological Footprints: a sympathetic critique of theory and practice

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ABSTRACT The concept of the Ecological Footprint has become a popular and increasingly used approach in environmental policy and planning, for western cities in particular. The concept is useful not least as a metaphor that effectively communicates the message that environmental impacts extend beyond the built area of cities. However, the use of Ecological Footprint analysis as a measuring tool is problematic, particularly when it is used as a tool for comparisons between jurisdictions. This paper sets out the benefits of the concept, indicates its history and use, and offers a sympathetic critique of both the theory and practice of Ecological Footprints. We believe this is necessary so that policy makers thinking of adopting this approach are aware of its strengths and limitations, and avoid using the concept in a manner that may be misleading.

KEYWORDS cities / Ecological Footprint / hinterlands / planning / sustainability

I. INTRODUCTION

In line with the management consultancy mantra that to manage something effectively you need to be able to measure it, the metrics of sustainability have become increasingly important in the policy world, as governments, NGOs and others attempt to identify whether their strategies and policies are indeed beginning to have an impact. This "metric turn" has bolstered support for existing measurement techniques such as environmental audits, environmental impact assessments, strategic environmental assessments and state of the environment reporting, while unleashing a range of new techniques for quantifying environmental impacts. These approaches range from sustainability appraisal to more radical ideas such as Ecological Footprints. Both new and older techniques for measuring sustainability jostle for policy saliency, each with its own intellectual rationales, supporters and detractors, and in most cases, people whose income or professional standing in some part derive from their adoption and, equally important, local adaptation. The key players in the new metrics industry include those in consultancies of various kinds, universities, NGOs and government departments. We do not mean to impute base motives to any of those involved, since most are keenly committed to developing approaches that help shift behaviour patterns in ways intended to bring about environmental improvements.

We do, however, want to argue that there is more at stake here than who measures sustainability best; underlying the competition for how to

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measure sustainability is an ideological debate about what it is that needs to be measured, why and how. In terms of environmental problems, for instance, there are always underlying political and scientific biases in choosing which "problem" merits most research money attention in different contexts. The choice of problem for policy attention then, is from the start almost always subject to various selectivities, often underpinned by an uneven science base.(1) Directly following on from this type of analysis, it is always important to look carefully at the inclusions and exclusions of each sustainability tool, if we are to begin to unravel why some find more favour than others with, for instance, either the big institutional players or local green groups. For instance, the amount of attention paid to social and economic aspects of sustainable development can be indicative of a whole series of underlying political values – where "green" supporters in particular may favour approaches that are stronger in their treatment of environmental issues than, for instance, social issues.

The concept of Ecological Footprints as a way of ascertaining sustainability was developed by Bill Rees and his students, particularly Mathis Wackernagel, at the University of British Columbia in Vancouver, Canada.(2) The approach is set within a rich theoretical critique of sustainability. Recent approaches to sustainable development have focused on the argument that economic growth is necessary for poverty alleviation and to maintain lifestyles. This concern with economic growth provides a stark contrast to earlier debates on the environmental limits to growth, where unbridled economic growth was seen as part of the problem rather than part of the solution. Not surprisingly in this context, debates over the "precise" or "true" meaning of sustainable development have spawned a whole academic, policy and consultancy apparatus seeking to engage with, develop and critique the concept in an almost infinite variety of ways. Most analyses of sustainability, whether radical or mainstream, recognize that major concentrations of human consumption generate impacts well beyond a nation or a city's formal boundaries and, in the process, highlight the uneven geographical and social spread of environmental burdens and risks. However, until the pioneering work around Ecological Footprints, very few policy, lobby group or academic analyses successfully moved beyond highlighting these external impacts as an issue that needed to be addressed. What Ecological Footprint analysis managed to do was put forward a way of both measuring and vividly demonstrating how ecological impacts extend far beyond the built area of cities, highlighting that "*. . . the ecosystems that actually support typical industrial regions lie invisibly far beyond their political or geographical boundaries*".(3)

This paper builds upon previous work on the strengths and weaknesses of this approach, but tries to set it within the wider context of moves to measure sustainability.(4) Our approach is broadly sympathetic, since we believe that it is essential to raise our understanding of externalized environmental burdens if we are to address the nature, scope and extent of the impacts of human behaviour. We highlight a series of concerns about the assumptions and coverage of the model itself, before moving on to link these to concerns about how the model is used to promote sustainable development. Despite its flaws, Ecological Footprint analysis has been more successful than other approaches in this regard. A limited number of papers are openly critical of the Ecological Footprint

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1. Haughton, Graham (forthcoming), "In pursuit of the sustainable city", in Marcotullio, Peter and Gordon McGranahan (editors), *Scaling the Urban Environmental Challenge: From the Local to the Global and Back Again*, Earthscan, London.

2. Rees, William (Bill) (1997), "Is 'sustainable city' an oxymoron?", *Local Environment* Vol 2, No 3, pages 303–310; also Wackernagel, Mathis and William (Bill) Rees (1996), *Our Ecological Footprint: Reducing Human Impact on the Earth*, New Society Publishers, Gabriola Island, Canada.

3. See reference 2, Wackernagel and Rees (1996), page 15.

4. McManus, Phil (2005), *Vortex Cities to Sustainable Cities: Australia's Urban Challenge*, UNSW Press, Sydney; also see reference 1.

approach,[5] and while their criticisms may have some validity, this current paper should not be closely associated with this body of sceptical Ecological Footprint literature. Rather, we note that the Ecological Footprint approach pioneered by Bill Rees and Mathis Wackernagel has been improved mainly by application[6] and by sympathetic critiques,[7] and that the refinements to the methodology have then been used by organizations responsible for environmental reporting and management. In this vein, the current paper summarizes the theory of Ecological Footprints, identifies similar approaches, identifies the strengths of Ecological Footprints, and then discusses weaknesses in the theory and in the implementation of the concept.

II. ECOLOGICAL FOOTPRINTS – A SUMMARY

The concept of the Ecological Footprint is a metaphor for ecological impact, regardless of where that impact occurs. The Ecological Footprint measures the impact of consumption and subsequent waste discharge (including consumption of food, housing, transportation, consumer goods and services) by converting impact variables into the single unit of land. This includes land appropriated by fossil energy use, the built environment, gardens, crop land, pasture, managed forest and land of limited availability, including untouched forests and non-productive areas such as deserts and icecaps. It has been applied at various scales, but it appears to be especially popular at the national, urban and personal scales, although recently, it has been acknowledged that the approach perhaps works best at the national level, and that particularly for comparative purposes more work needs to be done to improve its application at the urban level.[8]

In the case of a city, the approach can be used to calculate the equivalent amount of land consumed in order for a city to function. This equivalent amount of land is influenced by changes in both population and per capita material consumption. As Bill Rees noted, "*. . . cities as presently conceived are incomplete ecosystems, typically occupying less than 1 per cent of the ecosystem area upon which they draw*."[9]

One goal of Ecological Footprints is to document "overshoot", which refers to the excess global demand over global supply of nature's resources for human use.[10] Importantly, the founders of the Ecological Footprint approach recognize that the goal is satisfying human needs. Wackernagel claims that "*. . . the enormous social and economic inequities that exist within countries, and even more blatantly worldwide, are not only inhumane, but also threaten everybody's security*."[11] He advocates that "*. . . a true sustainability package must devise more courageous strategies to promote equity, rather than just promising more production*."[12] In summary, healthy fulfilling lives for the world's citizens can only be achieved within ecological limits if there is a process of redistribution from the wealthy to the poor.

III. SIMILAR APPROACHES

Ecological footprint analysis is similar to a number of other concepts in its metaphoric character, its assumptions, its accounting methodology and its outcomes. For instance, Moffatt refers to the "sustenance space of

5. Levett, Roger (1998), "Footprinting: a great step forward, but tread carefully – a response to Mathis Wackernagel", in *Local Environment* No 3, pages 67–74; also van Kooten, G Cornelius and Erwin Bulte (2000a), "The Ecological Footprint: useful science or politics?", *Ecological Economics* Vol 32, No 3, pages 385–389; van Kooten, G Cornelius and Erwin Bulte (2000b), *The Economics of Nature: Managing Biological Assets*, Blackwell, Malden, Massachusetts; and Ayres, Robert (2000), "Commentary on the utility of the Ecological Footprint concept", *Ecological Economics* Vol 32, No 3, pages 347–349.

6. Wackernagel, Mathis, Chad Monfreda, Niels Schulz, Karl-Heinz Urb, Helmut Haberl and Fridolin Krausmann (2004), "Calculating national and global Ecological Footprint time series: resolving conceptual challenges", *Land Use Policy* Vol 21, pages 271–278.

7. See Lenzen, Manfred and Shauna Murray (2001), "A modified Ecological Footprint method and its application to Australia", *Ecological Economics* Vol 37, No 2, pages 229–255, which led to a change in methodology for the *New South Wales State of the Environment Report* in 2003.

8. See, for example, the article by Wackernagel et al. (2006) in this issue of *Environment and Urbanization*.

9. See reference 2, Rees (1997), page 308.

10. See reference 6.

11. Wackernagel, Mathis (2001), *Advancing Sustainable Resource Management: Using Ecological Footprint Analysis for Problem Formulation, Policy Development and Communication*, Redefining Progress, Oakland, page 4.

12. See reference 11, page 4.

cities", a concept that can be found in a 1917 study by Mark Jefferson of England's urban geography.[13] Jefferson does not use this actual term in his article, but the concept of English industrial cities depending upon imports from other parts of the planet is central to his analysis. This analysis is akin to later observations by Mahatma Gandhi that London needs half the world to keep it operating, and George Orwell that "*. . . in order that England may live in comparative comfort, a hundred million Indians must live on the verge of starvation – an evil state of affairs, but you acquiesce in it every time you step in a taxi or eat a plate of strawberries and cream.*"[14]

Another similar approach involves the idea of "ghost acres", developed by the Swedish academic Georg Borgstrom in 1965.[15] The focus of Borgstrom's work was adequate nutrition for a growing population. He was critical of the traditional measures used to calculate food, i.e. either monetary value or weight, because both concepts are "*. . . less suited for a realistic appraisal of the feeding capacity and overall food balance of a country*."[16] To investigate this issue, Borgstrom calculated the "land equivalent" in acres that would be required to supply a country with food. He introduced the concept of "ghost acres", which was the "*. . . computed, non-visible acreage which a country would require as a supplement to its present visible agricultural acreage in the form of tilled land in order to be able to feed itself.*"[17] The ghost acres were comprised of "fish acreage" and "trade acreage". The concept was used in India in the 1980s, and extended by Jim MacNeill and colleagues in the lead-up to UNCED in Rio de Janeiro in 1992. The metaphor of ghost acres for food production was extended to include other consumption concerns, and repackaged as "shadow ecologies".[18]

More recently, as acknowledged by Wackernagel and Rees, William Catton discussed the idea of "phantom land".[19] This ecological concept refers to how we currently use the ecological productivity of ecosystems that no longer exist. Nature cannot, for example, replace fossil fuels such as coal and oil at the rate at which we are diminishing this stock of non-renewable resources.

A somewhat similar concept is the "ecological rucksack", which differs mainly in that it uses the weight of materials rather than land as the measurement. This was developed at the Wuppertal Institute in 1993.[20] This is part of a wider set of ideas associated with "environmental space", an approach that has attracted considerable interest and funding from the European Commission. In this approach, a global ceiling is set for the use of natural resources and resulting outflows (pollution), involving attempts to calculate carrying capacity, and with strong attention to equity principles in terms of deciding how to allocate "environmental space" rights among nations. For different resources, different assumptions are brought into play. For instance, those for energy reflect the recommendations of the IPCC on climate change, requiring a global 50 per cent reduction in fossil fuel energy use, which is translated into suggestions for a targeted reduction for Europe of 85–90 per cent. In terms of agriculture and forestry, the approach assumes that balanced trade across nations is fine, but argues that Europe with its fertile soils is in an unethical and unsustainable position when it is in a position of continuing net trade deficit. Work by Friends of the Earth UK goes further, arguing that as Europe possesses on balance more fertile and productive land than the global average, on equity grounds it should be a net exporter of agricultural produce.[21] Proponents of the environmental space concept also

13. Moffatt, Ian (1999), "Edinburgh: a sustainable city?", *The International Journal of Sustainable Development and World Ecology* Vol 6, pages 135–148; also Jefferson, Mark (1917), "The distribution of British cities and the Empire", *Geographical Review* Vol 4, pages 387–394.

14. Orwell, George (1989, originally 1937), *The Road to Wigan Pier*, Penguin, London, page 148; also Robins, Nick, editor, (1995), *Citizen Action to Lighten Britain's Ecological Footprints: A Report by Nick Robins from the International Institute for Environment and Development to the UK Department of the Environment*, IIED, London.

15. See reference 14, Robins (1995); also Borgstrom, Georg (1965), *The Hungry Planet: The Modern World at the Edge of Famine*, Macmillan, New York.

16. Borgstrom, Georg (1972), *The Hungry Planet: The Modern World at the Edge of Famine* (2nd revised edition), Macmillan, New York, page 75.

17. See reference 16, Borgstrom, page 75.

18. MacNeill, Jim, Pieter Winsemius and Taizo Yakushiji (1991), *Beyond Interdependence: The Meshing of the World's Economy and The Earth's Ecology*, Oxford University Press, New York; also see reference 14, Robins (1995).

19. Catton, William Jr. (1980), *Overshoot: The Ecological Basis of Revolutionary Change*, University of Illinois Press, Urbana.

20. See reference 14, Robins (1995); also The Takeda Foundation (2002), "The Takeda Award 2001", last updated 4 May 2002, accessed 22 March 2004 at <http:www.takeda-foundation.jp/en/award/takeda/2001/fact/03_l.html>.

21. McLaren, Duncan (1996), "Sustainable Europe and

use it as a lobbying device, mainly by pointing to what they argue is the over-consumption in some areas, when judged against their "fair" share of natural resource available globally.

Robins has identified a number of other similar accounting approaches, including food miles and environmental debt.[22] These approaches, and the ones discussed above, are similar in that they aggregate environmental impacts in order to derive a single figure of impact. For example, the Ecological Footprint of the Lower Fraser Valley (including Vancouver) is said to be 19 times the size of the region;[23] or the United Kingdom, which was using 16.6 ghost acres compared with 13.7 acres per capita to feed its population.[24] The choice of a single number for communication purposes is seductive, partly because it is effective. The aggregation approach is also used by Alan AtKisson and, more recently, by Kent Portney in his assessment of the implementation of sustainability initiatives in selected cities in the USA. The advantages and disadvantages of this crucial methodological decision are discussed in more detail below.[25]

Given the numerous other theoretical approaches to measuring sustainability, or more accurately to measuring unsustainability, why is the Ecological Footprint approach so popular in environmental policy circles and in environmental planning? We believe that the answer can be found partly in the strengths and weaknesses of the theory as explained below, but a major reason, which we hesitate to identify as a strength, is the discourse slippage between impacts and footprints. The book *Our Ecological Footprint*[26] built upon the global discourse of the United Nations (with book titles such as *Our Common Future*,[27] containing chapter titles such as Our Threatened Future), and was accompanied by fun images of footprints, phantom planets and so on. In short, it was an example of excellent communication. The slippage occurs when Ecological Footprint and ecological impact are seen as synonymous, with footprints being the more colourful and interesting image. As we establish below, these terms are not synonymous, and that is important for planners who are attempting to identify, reduce and ameliorate ecological impacts.

IV. STRENGTHS OF THE CONCEPT

The origins of the Ecological Footprint concept in the School of Community and Regional Planning at the University of British Columbia mean that, unlike earlier approaches that were based on nutrition or weight, the Ecological Footprint contains elements that are more likely to appeal directly to planners. These include the focus on cities and the use of land as a unit of comparison. These factors, in addition to the effective communication of the concept, may partly explain its growing popularity, among planners in particular. Portney, for instance, argues that the Ecological Footprint represents "*. . . perhaps the single most important analogy to suggest that sustainability at the local level is relevant, even in industrialized nations*".[28]

The major strength of the Ecological Footprint as a way of measuring the sustainability of cities is that it enables us to think about the flows of materials into and out of the city. These flows of resources and wastes all form part of the "linear metabolism" of cities, involving a process that,

environmental space", downloaded in May 2005 from www.foe.co.uk/resource/articles/sustain_europe_env_space.html.; also Spangenberg, J (n.d.), "How the environmental space for Europe was calculated", downloaded in May 2005 from www.foeeurope.or/sustainability/europe.

22. See reference 14, Robins (1995).

23. See reference 2, Wackernagel and Rees (1996.)

24. See reference 14, Robins (1995); also see reference 15, Borgstrom (1965).

25. AtKisson, Alan (1999), *Believing Cassandra: An Optimist looks at a Pessimist's World*, Scribe Publications, Melbourne; also Portney, Kent (2003), *Taking Sustainable Cities Seriously: Economic Development, the Environment, and the Quality of Life in American Cities*, The MIT Press, Cambridge, Massachusetts.

26. See reference 2, Wackernagel and Rees (1996).

27. World Commission on Environment and Development (1987), *Our Common Future*, Oxford University Press, Oxford.

28. See reference 25, Portney (2003), page 18.

typically, serves to desensitize consumers to awareness and concern about where their resources come from and wastes disappear to and, in the process, contributing to habits which are unsustainable.[29] The idea of thinking beyond the city is not new in urban planning, as evidenced by the "city within a region" concept of Lewis Mumford, the rise of regional planning and the concepts of a system of cities.[30] What is unusual, particularly in urban planning, is the idea that ecological and political–economic linkages with what Wackernagel and Rees called the "distant elsewhere" should actually matter to urban planners.[31] As David Satterthwaite noted, "*. . . to progress towards the achievement of sustainable development goals, the environmental performance of cities has to improve not only within their boundaries, but also in terms of reducing the transfer of environmental costs to other people, other ecosystems or into the future.*"[32]

There are a variety of ways in which Ecological Footprints can be seen as a positive development in policy analysis.[33] As we have already noted, it is an excellent way of promoting policy debate and is a useful education tool. In addition, Holden argues that its strengths include an incorporation of the lifecycle principle and its focus on consumption, given that "*. . . consumption patterns and volumes must be a central part of sustainable development.*"[34] Aggregation and synthesis into a single measure are identified by Holden as strengths, in contrast to van den Bergh and Verbruggen, who are critical of the aggregation aspect of Ecological Footprint analysis and instead favour decomposition approaches to measuring sustainability.[35] The approach also shares with the environmental space concept an underlying premise that we need to address equity in how environmental impacts are measured and assessed, albeit that this is really only addressed in terms of a broad concern with geographical equity and a lack of sensitivity to social equity issues (see below).

We readily accept the importance of these strengths and the major contribution of the approach to developing a better understanding of sustainability as a more than local, more than global set of concerns. What Ecological Footprints help to do is raise our general awareness that sustainable development requires attention to the interplay of the local and the global, not least when it comes to looking at the uneven geographical distribution of environmental burdens and risks that arise from human behaviour. At a broad level then, the metaphor appears sound. The growing body of local studies that adopted this approach are individually and collectively helpful in raising awareness of the underlying issues which face society in terms of moving towards more sustainable behaviour patterns. Where we depart from the supporters of Ecological Footprint is that while we see the benefits of aggregation in terms of communication, for a variety of reasons we are reluctant to endorse this central aspect of the accounting methodology of the Ecological Footprint approach. This reluctance stems from the problems of aggregation when undertaken within one city at a particular point in time (see below for details), and the use of the numerical outputs to compare cities that are very different. As we demonstrate below, this can produce an inaccurate understanding of a city's environmental impact. Indeed, in a worse case scenario, a favourable comparison with another city could be used to justify inaction on important ecological issues, even though this is completely the reverse of what the originators of the concept intended.

29. Girardet, Herbert (1992), *Cities: New Directions for Sustainable Urban Living*, Gaia Books, London.

30. Mumford, Lewis (1961), *The City in History: Its Origins, Its Transformations and Its Prospects*, Secker and Warburg, London; also Hall, Peter (1975), *Urban and Regional Planning*, David and Charles, Newton Abbott.

31. See reference 2, Wackernagel and Rees (1996).

32. Satterthwaite, David (1997), "Sustainable cities or cities that contribute to sustainable development?", *Urban Studies* Vol 34, No 10, pages 1667–1691.

33. Holden, Erling (2004), "Ecological Footprints and sustainable urban form", *Journal of Housing and the Built Environment* Vol 19, No 1, pages 91–109.

34. See reference 33, page 99.

35. See reference 33; also van den Bergh, Jeroen and Harmen Verbruggen (1999), "Spatial sustainability, trade and indicators: an evaluation of the 'Ecological Footprint'", *Ecological Economics* Vol 29, No 1, pages 61–72.

V. CHALLENGES IN THE THEORY

As we have already indicated, there is a growing debate about some of the assumptions and applications of the technique including, for example, concerns that carrying capacity should not be applied to humans, as they have the capacity to use technology to change limits, and that footprint accounts are incomplete, notably in relation to water and waste streams, and so forth. Some of these are accepted as limitations by the proponents of the techniques, others strongly countered as involving a misreading of the technique.(36) Here, we want to focus on a number of more abstract concerns about the way in which the techniques is conceived, used and policy conclusions drawn, while maintaining our position that the concept is very useful for identifying sustainability issues and extending the area for consideration by policy makers and urban planners who are promoting sustainable cities. In this paper, we present ten theoretical concerns about Ecological Footprints, before discussing issues about the representation of the theory.

First, is it desirable to convert everything into a single unit called money (as in the case of an economy) or land (as is the case in Ecological Footprint analysis)? Once complex values such as labour costs, environmental costs, status premiums, shortages in supply relative to demand, and so on, are converted into a single unit of currency, then how are changes in these factors reflected in the unit of value? In the case of money, increased quantity becomes the goal. In the case of Ecological Footprints the implicit if not the explicit goal becomes simplified to the question of how best to reduce the size of the footprint. This is problematic in that reducing the size of the Ecological Footprint does not necessarily equate to reducing external environmental impacts, not least since there are ways that appear to reduce the size of an Ecological Footprint that do nothing at all to reduce the total environmental impacts of consumption. For example, Portney noted that a city could pursue a policy of annexation of surrounding agricultural land, and therefore appear to have a reduced Ecological Footprint without reducing consumption.(37) Some critics have also argued that aggregation implies that substitution is possible across the various components, although those favouring the approach reply that this is a misreading of the argument, and substitution is not actually implied.(38) A related concern is the implicit assumption in the approach that it is the quantity of consumption that is always and everywhere a problem, something that is simply not true – what we consume may be at least as important as how much we consume, so we need to differentiate quite carefully between how different types of consumption behaviour create different types of environmental impacts. Reducing all types of impact to a land measure is not helpful in this sense.

Our second concern is with the lack of attention to differences in the productive and absorptive capacities of the "hinterland" areas. Unlike environmental space, which explicitly seeks to take into account local environmental conditions, Ecological Footprint analysis only differentiates at the global level between "productive" and "non-productive" land, while using only crude functional categories of abstract types of land use (agriculture, forestry, etc), with nothing to say about differences in local environmental, economic and social conditions. It is thus important to stress that the Ecological Footprint is not really the same thing as

36. See Annex 1, Paper 2 in Lewan, L and C Simmons (2001), "The uses of Ecological Footprint and biocapacity analyses as sustainability indicators for sub-national geographical areas: a recommended way forward", Final Report, European Common Indicators project. EUROCITIES, Abiente Italia. (accessible at www.bestfoot forward.com/downloads/ECIP %20Final%20Report%20with% 20Annexes.pdf); also Jones, Peter, Daphne Comfort and David Hillier (2005), "Ecological Footprints over Europe", *Town and Country Planning* Vol 74, No 9, September, pages 271–273.

37. See reference 25, Portney (2003).

38. See reference 36, Lewan and Simmons (2001), Annex 1, page 4.

environmental impact, since it crudely categorizes land into a limited number of land types, in the process underplaying differences in ecosystem value – biodiversity, species scarcity, habitat and landscape uniqueness, and so on. Indeed, it is perfectly conceivable that it may be ecologically and culturally desirable to increase a city's Ecological Footprint for its transport function by, for example, building a new road or railway around, rather than through, the last remaining habitat of a rare and endangered species of amphibian. Each time a vehicle travels the extra distance required by this route deviation, the Ecological Footprint is increased. In other words, a smaller footprint does not necessarily mean less impact qualitatively, if the impact is in a high-value ecological area.[39]

Third, as noted by Yencken and Wilkinson[40] and others, water needs to be considered much more centrally than it is, since it is not always included in the Ecological Footprint approach for the calculations of "land" impacted. This is very important in a dry country such as Australia. Borgstrom's[41] "ghost acres" included the marine environment in food production, which is crucial in assessing environmental impact given the state of the world's major fisheries and the sites of consumption of the fish. This point is particularly important when considering the ecological productivity of developing countries where fishing is essential for human survival. It was also noted in *Europe 2005: The Ecological Footprint* that "*. . . water is addressed only indirectly in Ecological Footprint accounts. Overuse of freshwater affects present and future plant growth . . .*".[42]

Fourth, Ecological Footprint analysis rightly extends the focus beyond the city to look at environmental impacts, but it fails to acknowledge sufficiently the environmental impacts occurring within a city. This is true in terms of the uneven distribution of both environmental burdens and environmental risks across cities, for instance access to clean water, proximity to contaminated water, and vulnerability to flooding and subsidence from water table depletion.[43] Geographically, environmental burdens inevitably fall unevenly, given variability in local conditions, but almost invariably the areas with poorest quality environmental conditions are those with the highest proportions of the socially excluded, whether in rich cities or poor ones. Concerns about the uneven social and geographical impacts of, for instance, hazardous waste facilities have given rise to the environmental justice movement in the US and elsewhere.[44] Thus the issue of inequitable environmental burdens needs to be charted much more closely than through crude assumptions that all environmental problems are displaced externally. This relates to two of our other concerns, namely that Ecological Footprint analysis does not offer any analytical insight about precisely where and on which types of people and habitats burdens fall outside the city.

Our fifth concern[45] is that flows of "benefits" are not considered in the Ecological Footprint methodology. These flows might include the technological advances and communications that improve the quality of life for people living outside of the city, new ideas for sustainable farming, building design, more energy efficient cars and tractors, and so forth. A more difficult concept to incorporate into the Ecological Footprint methodology, but one that in the name of balance should be considered, concerns the land-related benefits of urban living, for instance, in reducing rural land take for housing and factories. More than this, the very concentration of population and services in cities reduces the

39. Contrast this with the example of Ecological Footprints of bridges in Wackernagel and Rees (1996), pages 109–111 (see reference 2), although they do acknowledge the need to examine hidden indirect effects too.

40. Yencken, D and D Wilkinson (2000), *Resetting the Compass: Australia's Journey Towards Sustainability*, CSIRO Publishing, Melbourne.

41. See reference 15, Borgstrom (1965).

42. WWF, Global Footprint Network, NC–IUCN (2005), Europe 2005: *The Ecological Footprint*, WWF European Policy Office, Brussels, page 14.

43. See reference 32.

44. Bullard, Robert D (1994) *Dumping in Dixie: Race, Class and Environmental Quality*, Westview Press, Boulder, Colorado.

45. This has previously been identified by Portney (2003) (see reference 25); also see reference 1.

amount of travel undertaken compared to their rural counterparts who need to travel further distances to get to schools, clinics, shops and so on. Cities can also be home to considerable biodiversity and stupendous cultural landscapes – beautiful buildings, monuments, open spaces, parks, etc. In other words, the benefits of cities are not adequately demonstrated within the Ecological Footprint framework because it focuses on quantifying the transference of carrying capacity from one location to another.

Sixth, differences between areas in their carrying capacity are not adequately addressed, with no attempt to examine or disaggregate in any meaningful way the differing assimilative capacities and productive capacities of either cities, their hinterlands or the "distant elsewhere" that cities often draw upon for their perpetuation. Undoubtedly, many cities could improve their sustainability and reduce the size of their Ecological Footprint by restricting the imports of food from other parts of the planet and, instead, concentrating on regional produce. However, the flaw in this thinking is to ignore the differences between cities in their productive capacity and that of their hinterlands. Some cities may be surrounded by relatively infertile soils, others may have unreliable rainfall, and so on. In some instances, it may be appropriate to import food from further away in order to use water for drinking, or to allow for some urban expansion on former agricultural land so as to protect forests or wetlands from urbanization.

Seventh, the problem of aggregation means that many assumptions have to be made about ecological impact. While this methodology may deliver a crude numerical ratio of the size of a city relative to the land equivalence for its resource inputs and waste outputs, it does not easily translate into an approach that can be applied to shape policy interventions. The potential of Ecological Footprints to be used for policy development has been one of the most contentious debates in the Ecological Footprint literature.[46] While Wackernagel clearly outlines the policy potential of Ecological Footprints at the national scale, the translation problem is partly about jurisdictional responsibility and tracking international flows of natural resources.[47] Assuming a willingness on the part of policy formulators to reduce the ecological impacts of human activities, and it is worth noting that not all policy makers are even prepared to take this step, then Ecological Footprints can only be used for limited policy development by local governments, for example. It is possible to develop far-reaching policies using this approach, but the implementation of these policies will be inadequate.

Given that we are both geographers, our eighth concern is perhaps predictable: the problem of boundary definition for comparing Ecological Footprint "scores". It is easy to achieve a smaller Ecological Footprint where the boundary around a city is drawn wide enough to include agricultural land (this explains some of the huge discrepancies in footprints between Sydney and South East Queensland (SEQ), for example). Intriguingly, Portney[48] discusses annexation as a strategy for reducing the Ecological Footprint of a city, which might work in terms of reducing the Ecological Footprint "score", but would achieve precisely nothing in terms of actual environmental impact. As we have seen, there have been a number of studies of different cities around the world using broadly similar methodologies, so it becomes possible to compare the results and arrive at some logical but erroneous conclusions. For example, if London's footprint is said to be 120 times the size of its urban area,[49] and the

46. See reference 5, van Kooten and Bulte (2000a); also see reference 5, van Kooten and Bulte (2000b), page 264; and see reference 6.

47. See reference 11.

48. See reference 25, Portney (2003).

49. See reference 14, Robins (1995).

Lower Fraser Valley's Ecological Footprint is 19 times its size, does this mean that the Lower Fraser Valley is six times more sustainable than London? No. Rather, it suggests that areas with a high population and without agricultural land within their borders will inevitably generate a higher Ecological Footprint unless there is a huge discrepancy in the material consumption between the two areas.

Our ninth concern is the assumption that land is used only for single functions, or that land uses only meet one particular ecological service. Neither assumption is tenable.[50] One implication of ignoring the multiple use possibilities of land is to bias the Ecological Footprint upwards. A more serious problem could occur if the multiple uses of land were not recognized in a planning context, and inappropriate designation or development followed. For example, if land were being used for housing, could it also be used for wildlife corridors, water harvesting and so on? This raises questions about policies of housing density – increased urban consolidation may reduce the Ecological Footprint of a city compared to "sprawl", but if the low-density city was supporting wildlife, biodiversity, food production and water harvesting, how will these important functions be maintained? It is possible, but only if there is recognition of the multiple uses of a single category of "land". In terms of the multifunctionality of land, it is worth noting that the major component of most Ecological Footprint for cities is "energy land". For instance, in the case of the Lower Fraser Valley, the total footprint was calculated to be 77,000 square kilometres, of which 42,000 square kilometres were energy land.[51] The reason for such a large footprint is the assumption that the land area needed to assimilate the emissions of burning fossil fuels is forest, but this forest cannot be used for other purposes such as the provision of construction materials nor is its recreational or water catchment value recognized. There is potentially a degree of double-counting here, although recent variants of the model have attempted to acknowledge this concern.

Our tenth, and perhaps most important, concern is that the potential for trade to improve social welfare is not adequately addressed in the Ecological Footprint methodology. This is because the methodology is designed as a surrogate snapshot of environmental impacts rather than a policy for equity. Let us be clear – Wackernagel and Rees[52] are very explicit in their concern about equity issues, not least where they highlight the concept of "fair earth shares." It is clearly recognized that the rich should consume less resources so that the very poor can raise their consumption to an adequate level. They develop from this concern to argue that "*. . . international terms of trade should therefore be re-examined to ensure that they are equitable, socially constructive and confined to true ecological surpluses*."[53] More recently, Wackernagel and colleagues have addressed the accusation of an anti-trade bias in the Ecological Footprint analysis, notably suggesting that "*. . . the unequal distribution of biological capacity suggests that normative concerns about equitable access to this capacity must admit extensive trade among nations*."[54]

While there is this clear acknowledgement that, in principle, international trade may be both necessary and valuable, the technique has not been refined in ways that allow these concerns to be incorporated into the methodology. As such, the blunt metrics of Ecological Footprints remain open to the accusation that, implicitly at least, they are sending the signal to policy makers and the public that international trade is

50. See reference 35, van den Bergh and Verbruggen (1999).

51. See reference 2, Wackernagel and Rees (1996).

52. See reference 2, Wackernagel and Rees (1996).

53. See reference 2, Wackernagel and Rees (1996), page 133.

54. See reference 6, pages 276–277.

inherently problematic, insufficiently problematizing those occasions where trade may exert deleterious social and ecological impacts on the distant elsewhere, those where it might bring some benefits, and the more common situation of a complex balance sheet of gains and losses. We would want to emphasize, for instance, that ecologically there is a clear logic in producing certain types of goods where this can be done most efficiently – for example, tropical foods may involve many "food miles" if sent thousands of miles away, but this may provide local jobs in the donor areas and be preferable to using high energy inputs (e.g. in greenhouses) to produce similar goods in the "receiving" city. We are not saying that all types of such trade are necessarily always good, but simply wish to highlight that there is a balancing act that needs to be considered. Fair trade rather than "no trade" relations are almost always the ideal way forward, where those buying goods pay for the true costs of production.

These ten elements of our critique are not equal in importance, nor are they unique to the Ecological Footprint model. It is important, however, to understand these limitations in the theory before engaging in a brief discussion about some of the challenges in the representation of Ecological Footprint analysis.

VI. CHALLENGES IN PRACTICE: THE ECOLOGICAL FOOTPRINT IN ACTION

The Ecological Footprint has been used in many cities, including Vancouver, London and Hong Kong.[55] Work in the UK in the last five years, for example, has argued that London has an Ecological Footprint of 5.8 global hectares per person, 10 per cent above the national average; the southwest region has an Ecological Footprint of 5.56 global hectares per person, while a third study provides similar estimates for Aberdeen (5.87 global hectares per person), Dundee (5.51), Edinburgh (5.60), Glasgow (5.37) and Inverness (5.47).[56] In Wales, the Welsh Assembly has been given a statutory duty to pursue sustainable development and, as part of that, it has adopted Ecological Footprints as a key indicator to assess its progress. Ecological Footprint projects are being carried out both at the national level and for Cardiff and Gwynedd.[57] What we can begin to see here is how, from an initial base as an academic technique, Ecological Footprint analysis has very quickly spawned a small commercial and academic industry of consultancy organizations that offer to provide reports for municipalities and regions. The usual approach is to provide a report that sets out a detailed methodology, highlights caveats and refines the technique in some way, and then sets out as clearly as possible in a variety of ways the apparent extent of the Ecological Footprint, alongside options for reducing the size of the footprint. This is usually announced with a media splash and political backing for specific types of environmental policy, typically aimed at reducing energy consumption or moving from carbon-based fuel sources. It is a technical tool then, which becomes transformed into a political tool used to pursue particular local agendas. In essence, the Ecological Footprint is a very effective way for officials and politicians to convince the public of their environmental policies, by appealing to the apparent common sense and fair play aspects of reducing the negative impacts of a city on areas beyond its boundaries.

55. See reference 2, Wackernagel and Rees (1996); also Girardet, Herbert (1999), "Big foot, small world", *The New Internationalist* Vol 313, pages 16–17; and Friends of the Earth (Hong Kong) (2002), " 'Agenda 2047' – A community dialogue", *One Earth* Vol 49, pages 17–25.

56. See reference 36, Jones, Comfort and Hillier (2005), Summary.

57. See Barrett, John, Nia Cherret and Rachel Birch (2004), "Exploring the application of the Ecological Footprint to sustainable consumption policy", Paper presented at a workshop in Leeds and accessible at http://www.env.leeds.ac.uk/%7Ehubacek/leeds04/5.3 Leeds%20SC%20Conference%20-%20John%20Barrett%20paper.pdf; also Sustainable Scotland Network/WWF (2003), "Proceedings of quarterly meeting 'Ecological Footprinting'", article by Stuart Bond and accessible at www.wwf.org.uk/filelibrary/pdf/ecofootscotland.pdf, pages 4–7.

The Ecological Footprint has been widely used for some years now in Europe, allowing the collective experience to be brought together and assessed, notably the workshop report by Lewan and Simmons.[58] This report provides a detailed overview of the methodological refinements undertaken by those using the technique, and a series of recommendations for moving towards a common approach once more. It also includes some fascinating appendices, most notably a response to the critics of the technique (Annex 1, Paper 2) and a very useful summary of some of the main applications of the technique in Europe (Annex 2). Looking at the combined experiences of Finland, Italy, the Netherlands, Norway, Spain, Sweden and the UK, we can begin to pick out some interesting themes, notably the wide range of interested partners who have supported this kind of work, including central government and municipal departments, some industrial sponsors, community groups and educational establishments. There have been universal problems in finding appropriate disaggregated data to feed into the model, requiring a wide range of different compromises and assumptions in order to make progress. To get a feel for some of this work, a technique has been developed for use in Stavangar, Norway, that involves attempts to calculate footprints at the level of the city, the household and the individual, all with an emphasis on reducing the amount of data collection. The Ecological Footprint approach has also been used in Norway to guide housing design and location, and to identify those settlement patterns that were likely to have larger or smaller Ecological Footprints after allowing for factors such as socioeconomic considerations.[59]

58. See reference 36, Lewan and Simmons (2001).

59. See reference 33.

In the Netherlands, eight towns have been involved in a major project that has successfully been used in public campaigns and education, including the use of computer discs to calculate personal footprints. The data collection proved intensive and problematic, leading to the conclusion that it was easier to calculate footprints at the national and personal levels rather than at the level of the individual town and city. Moreover, it is reported that the differences between towns were small, so the results may not justify the expense involved in producing estimates at this level.[60]

60. See reference 36, Lewan and Simmons (2001).

As we have already seen, in the UK, there have been a number of governments and local authorities that have commissioned studies of their Ecological Footprints, many of them involving the specialist consultants Best Foot Forward, who have developed an approach which uses *". . . proprietary EcoIndexTM software . . . [which] builds components 'bottom-up' using lifecycle data, rather than relying on national trade data."*[61] We cite this simply to give a feel for the increasing technical sophistication that different organizations are developing in order to sell their particular approach to footprinting. Interestingly, in this context, the Ecological Footprint study for Angus in Scotland, also undertaken by Best Foot Forward, claims it is Scotland's first community-based study, in the process describing most previous studies as largely desk-based.[62] Thus the "expert" emphasis is shifted here from massaging numbers on computers with ever-increasing sophistication, to experts helping communities produce and input information, another kind of expert input.

61. See reference 36, Lewan and Simmons (2001), Annex 1, page 18.

62. See www.bestfootforward.com/downloads/Case%20Study%201-%20Angus.PDF, accessed December 21 2005.

In Australia, the NSW Environmental Protection Authority (EPA) has used this technique to calculate the footprint of Sydney.[63] It has also been used to calculate the footprint of Canberra and of South East

63. Environment Protection Authority, New South Wales (EPA NSW) (1997), *New South Wales State of the Environment Report*, EPA NSW, Sydney.

Queensland (SEQ),[64] as well as the footprint of major institutions such as the University of Newcastle.[65] The calculations invariably indicate that the Ecological Footprint of a country, city or university is much larger than the land area that it occupies. This is then used as a catalyst to promote actions to reduce the footprint as part of a move towards sustainability.

Although largely taken up by Western countries, it has been used elsewhere,[66] most notably in Santiago de Chile,[67] where major difficulties were found in accessing suitable disaggregated data, requiring some fairly large leaps of faith in translating data to the local level. One of the main findings of this work was the large disparity that might exist between the poor and the rich in their Ecological Footprints, with the lowest-income 10 per cent of society estimated to have an Ecological Footprint of 0.4 hectares each, compared to 12 hectares for those whose income was in the top 10 per cent.

VII. CHALLENGES IN THE REPRESENTATION

Many of the challenges we are most concerned about here lie more with the way the Ecological Footprint technique has been applied than with the original idea, not least where using, selling or popularizing the approach seems to ignore or forget some of the key points being made by the original authors. Indeed, even some supporters of Ecological Footprints argue that many of the misconceptions surrounding the technique derive from it being "oversold" as a comprehensive indicator.[68] But there are other aspects to the misrepresentations that the technique has been subject to. For instance, given that the footprint of a city occurs "*. . . wherever on Earth that land is located*",[69] it was disappointing to see the city and its immediate hinterland being used to represent Sydney's Ecological Footprint.[70] This is an inaccurate representation and gives the impression that the "region" of a city can be equated with its hinterland, rather than an important idea of Ecological Footprint analysis, which is that cities consume parts of the planet far away from the city.

A similar approach was undertaken in Toronto, Canada, where the footprint of Toronto in 1996, the Greater Toronto Area in 1996 and the projected footprint of the Greater Toronto Area in 2015 were superimposed on a map of parts of North America that focused on the east coast–Great Lakes region.[71] This representation has a number of implications. First, growing cities become portrayed as a "threat" to their neighbours in new, insidious and potentially politically volatile ways. Second, the projection to 2015, while useful as an advocacy tool, is not a "snapshot" of the demands of humans on nature as they currently exist. It flies against the claims by Wackernagel and Rees, and later by Wackernagel and colleagues, that "*. . . Ecological Footprints are not normative but merely document demands on nature*."[72]

In the case of Scotland, the production of a national Ecological Footprint study is used to tell people that if the whole world was to live like the average Scot, then we would need two extra planets to supply them – a vivid and compelling image. The Scottish footprint study is also used to argue that "*. . . for the first time we can now measure exactly how sustainable Scotland really is and see the scale of the challenge*."[73] Different future scenarios are produced for the footprint to see how it

64. See reference 40, Yencken and Wilkinson (2000).

65. Flint, K (1999), *Institutional Ecological Footprint Analysis: A Case Study of the University of Newcastle*, unpublished honours thesis, University of Newcastle, Australia.

66. See, for example, the article on South Africa by Mark Swilling in this issue of *Environment and Urbanization*.

67. Wackernagel, M (1998), "The Ecological Footprint of Santiago de Chile", *Local Environment* Vol 3, No 1, pages 7–25.

68. See reference 57, Barrett, Cherret and Birch (2004), page 246.

69. See reference 2, Wackernagel and Rees (1996), emphasis in the original, page 52.

70. See reference 63.

71. Onisto, Lawrence, Eric Kraus and Mathis Wackernagel (1997, revised 1998), "How BIG is Toronto's Ecological Footprint? Using the concept of appropriate carrying capacity for measuring sustainability", The Centre for Sustainable Studies and the City of Toronto, Toronto.

72. See reference 2, Wackernagel and Rees (1996); also see reference 6, page 276.

73. Dr Richard Nixon, WWF Scotland. Quote contained on www.scotlands-footprint.com/launch.htm, accessed May 2005.

might be reduced by different initiatives, leading to the conclusion that even if all the current waste management targets were met, the country's footprint would go up. Switching 40 per cent of electricity from brown grid to renewable sources would reduce the footprint by 10 per cent. What we begin to see is that the tool is much more than an educational one, it is also a lobbying one, and in the process there is an elision between the rather rough science of the project and the rhetorically convenient claims of exact measures from which it is possible somehow to derive detailed policy prescriptions.

VIII. CONCLUSION

The concept of the Ecological Footprint as a way of measuring (un)sustainability and as a catalyst for positive changes has become increasingly popular in environmental policy and environmental planning work. This is not without justification, because the concept has been important in encouraging urban planners and environmental managers to look beyond the traditional scales of planning and environmental management to consider the regional and international environmental impacts of a city's activities. Inevitably, given the use of land as a unit of comparison, the approach has a particular appeal to planners, but it has been used by many other disciplines involved in environmental management.

We have argued here that useful though the concept is, it is not without some important flaws in theory, application and representation. Indeed, it may not even be the best measure of its type, lacking the sensitivity to place and scale of, for instance, the environmental space concept. What it does have though is major visual and commonsense appeal, making it a useful tool for raising awareness of issues. But this too is part of the reason why we need to be careful in how the approach is used and abused. It provides a limited view of what it is to be sustainable, one that underemphasizes the social justice and economic progress aspects of sustainable development in the actual methodology. It is liable therefore to cooptation in pursuit of sometimes fairly narrow ideological or sectoral policy objectives. Perversely, it may in the process narrow our understanding of sustainable development, even as it seeks to raise the general awareness of environmental issues. We are concerned too about the ways in which, without due care, the approach in effect decontextualizes place and the diversity and wonderment of nature, by suggesting that the problems, even if not solutions, are essentially reducible to a common metric. In practice, problems that have their origins in practices that work out across scales, from the neighbourhood to the global, require a more profound and explicit way of dealing with place than the Ecological Footprint allows. Although the tool is intended to be used sensitively by those developing it for different places, this caveat is not enough to overcome our concerns about the tendency inherent in a universalizing tool to reduce issues to over-simplistic readings of problems, and from this, their solutions.

In essence, what we hope to have provided here is a sympathetic critique of the approach, together with some cautionary words about a technique that is, in many arenas, in danger of becoming almost beyond criticism. Our findings, particularly concerning the weaknesses of the

concept, should be considered carefully by those who wish to commission Ecological Footprint studies in the search for clear policy recommendations. We would argue that policy recommendations may address the concerns raised by Ecological Footprints, but that this type of analysis cannot of itself provide ready policy solutions and, moreover, if poorly interpreted it can lead to poor policy pointers.