PEOPLE AND THE PLACES THAT SUPPORT THEM

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We are used to asking the question: 'How many people can a given area of land support at a particular standard of living?' The question is, however, difficult to answer; this is especially so now that the growth of the global economy means that people may draw on many places to support them, above and beyond the territory which they inhabit. The concept of the ecological footprint allows us to turn the question around and ask: 'How much land do a given number of people draw on to support themselves at a particular level?' Current research shows that Australians and other citizens of developed countries draw on a great deal. If the concept of a 'fair share' of the Earth's resources is used, inhabitants of the industrialised nations consume far more than they should and there is not enough land to support even half the world's current population at this level.

Human carrying capacity has received much attention in recent years but quantification can be difficult in the case of regions which are involved in the global economy.[1] The issue can be examined from a different perspective by the calculation of ecological footprints and this approach has received some international attention. The purpose of this article is to bring footprinting to a wider audience and give some indication of the light it can throw on the debate about population and environment. In other words — people are supported by places, but where are these places and do we have enough of them? The calculation of footprints is one way of examining this issue, and figures to date indicate that the planet does not have sufficient productive area to support the present six billion people in the manner to which industrialised nations are accustomed. Footprinting can also examine the implications of a transition from fossil to renewable energy, and indicates that this transition could increase even further the demands wealthy economies make on natural ecological processes.

CARRYING CAPACITY

The air, water, food and fibre on which humans depend are produced and maintained by natural ecological processes, even when human input may be considerable, as in the case of cropping. Human dependence on the environment is only too obvious in the case of subsistence peasants or hunter-gatherers, since people relying on local resources suffer greatly when those resources fail, and human numbers are perforce kept within the capacity of the local area to support them. In contrast, modern city dwellers use huge amounts of fossil fuels to produce and transport all their needs and a local crop failure may go almost unnoticed. The ability of the wealthy to exploit the resources of the entire planet offers the illusion of independence from ecological limitations and they may regard 'the environment' as a distant place inhabited by cute and cuddlies, a place to which they should be kind, but on which they do not depend

The ecological ability of land to support humans can be expressed as carrying capacity — the number of people that can be supported by a particular area of land assuming particular consumption patterns and technology. Quantification is relatively simple in the case, for example, of an isolated community living in a valley in the New Guinea highlands. The community lives entirely off the produce of its gardens and surrounding jungle and observation can indicate the number of people that can be supported, with that lifestyle and economy, by that particular area.

More difficult is the case of places that are part of the global economy. What, for example, is the carrying capacity of Manhattan Island? Rain falling there becomes polluted urban runoff and soil is buried under steel and concrete so the island's ability to support life is virtually zero. Millions of people work and live there because of a huge network of production, processing, packaging and transport that brings the produce of the planet to the occupants of the island. Thus it may not be helpful to examine the carrying capacity of Manhattan or of other modern city areas, as in all of them development has destroyed resources other than built infrastructure.

For the assessment of carrying capacity most places fall between an isolated valley and Manhattan. At a recent population conference[2] the question of the carrying capacity of an area of south east Queensland was raised. Since Queenslanders are not wholly dependent on local products the question needs to be cast in terms of a specific resource—for example coastal marine ecosystems. If it is essential to preserve clean beaches, estuaries, sea grass beds, reefs and fisheries then development, and therefore carrying capacity, of the coastal and riverine catchment would be greatly restricted. If, however, the productivity and aesthetic attractions of the local seas are to be sacrificed on the assumption that Queenslanders will purchase fish from elsewhere and holiday at other coastlines, then the carrying capacity of the region with respect to this particular resource is virtually unlimited. Queensland would then resemble Manhattan to the degree that it is accepted that fish and coastal holidays must be sought elsewhere as development has destroyed that particular local resource. Other resources or constraints may then impose restrictions — for example the availability of fresh water or the ability and willingness of the rest of the world to provide a highly developed area with its ecological needs.[3]

THE CALCULATION OF ECOLOGICAL FOOTPRINTS

Because the global economy creates difficulties in the calculation of local carrying capacities, over the last decade the question has sometimes been posed differently. Attempts have been made to measure the area of land of average productivity which is currently needed to support an individual at a specified standard of living *in terms which are independent of where the land or the individual may be situated.* National statistics provide information about the average per capita consumption of products such as wood, grain, fish, minerals and energy. Each product which is being used is translated into the land area needed to produce it and this becomes the per capita 'footprint' for this component of national consumption. The resources may come from, and thus the footprint may fall on, either a local area or distant lands. Thus this technique, described by Doug Cocks as 'illuminating',[4] can be used to assess the consumption of people who are part of the global economy as well as those in isolated subsistence communities.

Five years after the Earth Summit held in Rio de Janiero in 1992, a 'Rio+5 Forum' study was commissioned by The Earth Council of Costa Rica. The study[5] compares the national statistics of 52 nations, comprising 80 per cent of the world's population, and calculates footprints for various resources for each nation. For the purposes of this article just ten footprints of four contrasting countries will be considered—the USA, the Netherlands, Australia and Bangladesh. This is sufficient to illustrate the way footprinting can be used to examine the relationship between humans and their environment. In Table 1 all areas have been translated into average worldwide productivity. This avoids problems which would arise if areas with fertile, well watered fields were compared with areas of arid, infertile rangeland. All figures in Tables 1 come from a single source,[6] and all are based on the Rio+5 study mentioned above.

Table 1 illustrates the much greater area of land needed to support people in wealthy nations than those in poor nations. These figures, it should be remembered, are footprints, not statements of the amount of land of this type available in each nation. (The Netherlands, for example is a major importer of the products of arable, pasture and forest land, and therefore much of the footprint of her inhabitants falls outside her boundaries. In contrast, the USA and Australia export such products and these form part of the footprint of the importing, not the exporting, nation.) However, revealing though these figures are, they do not allow for six factors—waste disposal, sustainability, water catchment, wildlife preservation, climate change and above all energy usage. These factors would, if incorporated into the figures, increase the size of the footprints of Table 1 or require additional footprints.

Waste disposal can have considerable impact on large areas and should be afforded a footprint category of its own, particularly since most waste is released into air, soil and water in the hope that the environment will purify it. To the knowledge of the writer little has been done on this except for the sequestration of carbon dioxide.

The sustainability of many agricultural practices around the world is under question since they result in loss of topsoil or depletion of ground water. Much American agriculture is highly productive because of irrigation from ground water sources that are being used at a rate far higher than they can be replenished.[7] Australia may find in a few decades that her agricultural production is falling due to environmental factors.[8] The Netherlands' intensive animal production causes pollution of both air and water.[9] (If the production per hectare of wealthy countries falls because the methods now current prove unsustainable then maintaining the current standard of living would require a larger footprint (whether produce is sourced at home or abroad). The Bangladeshi footprint is already so small that a further reduction of either area or yield would have devastating effect on the population — as indeed occurs during natural disasters.

Table 1: Ecological footprints, hectares per capita (ha/cap) at worldwide productivity

	USA	Netherlands	Australia	Bangladesh
Pasture land	1.84	1.42	3.55*	0.08
Forest land	1.38	0.56	0.81	0.19
Built up land	0.39	0.04	0.39	0.01
Total of the above	4.03	2.57	5.44	0.39

* Australia's pasture footprint is surprisingly high. For an account of the methodology used in calculating footprints see M. Wackernagel, L. Onisto, P. Bello, A. Linares, I. Falfen, J. Garcia, A. Guerrero, M. Guerrero, 'National natural capital acocunting with the ecological footprinting concept', *Ecological Economics*, vol. 29, 1999, pp. 275-390.

In most parts of the world water catchment is provided by forest or farmland and a separate footprint for water catchment is not required (though it may be that specific restrictions are placed on landowners in a catchment to prevent pollution of water and siltation of dams). Thus Table 1 includes no water catchment footprint. In the case of Australia many cities do have an area set aside specifically to provide an unpolluted catchment and a separate catchment footprint could be helpful.

Wildlife preservation is widely regarded as a public good and there is a danger that footprinting can cause us to regard the planet as an elaborate feedlot for humans. If the survival of other species is to be considered then areas for their habitat will affect footprint calculations or the conclusions drawn from those calculations. For example, if it were decided that 20 per cent of Australian forests should be harvested only every 200 years in order to provide habitat, this would reduce forest yield per hectare and therefore necessitate a larger forest footprint in order to maintain production.

Climate change due to human production of greenhouse gases has attracted considerable public interest in recent years. Certain land use practices can absorb such gases, particularly carbon dioxide, and this has lead to the study of the area required to absorb the greenhouse gas production of different lifestyles and communities. These 'carbon sinks' can be expressed as footprints and could be added to those of Table 1.

ENERGY USE

Energy use is crucial to the maintenance of wealthy lifestyles and economies. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has graphed the size of the Australian economy against energy use over this century and found the two have grown in exact proportion.[10] Other commentators have described modern agriculture as being a means of converting petroleum into food. People in the USA, the Netherlands and Australia live better than people in Bangladesh because the latter, for complex historical reasons, do not have access to the energy that would lift their standard of living. Fossil fuel usage in the four countries under consideration, expressed as an average flow of kilowatts per capita, is USA 9.93, Netherlands 6.85, Australia 6.93 and Bangladesh 0.09.[11] The importance of energy supplies in maintaining a satisfactory standard of living is hard to overstate. For example, in parts of Bangladesh water supplies are polluted due to overcrowded catchments yet many people do not have sufficient fuel to boil water to make it safe to drink.[12]

Fossil fuel consumption will not continue indefinitely. Either climate change will become such an imperative that nations will be forced to modify consumption or the planet will run out of deposits—it is believed that oil production, for example, will begin to decline early this century.[13] Oil is an extraordinarily important part of our energy supply because it is readily transportable and can fuel mobile machines such as the tractors, harvesters and transport vehicles that make modern life possible. Known substitutes are either more expensive, less available or more polluting, and they may require large areas of land to produce. In other words per capita footprints for oil substitutes may be large, as indicated in Table 2.

It is comforting to consider the large deposits of coal enjoyed by Australia[14] and it is widely believed that we have a sufficient supply for several centuries at present rates of consumption. However consumption rates will rise due to a number of factors: population increase; economic growth; the production of synthetic oil from coal; the use of energy from coal to mine more coal (as oil supplies dwindle); and the later exploitation of poorer deposits yielding less energy relative to the energy needed for production. Not to be forgotten, too, are the two billion people whose present lives are largely untouched by modern technology. Were they to share the comfort afforded by fossil fuel our apparently large reserves would shrink rapidly. There seems little doubt that the above problems will arise well within the lifetimes of those alive today[15] and it is therefore important to consider the footprints of alternative energy production.

RENEWABLE ENERGY

The implications of reliance on renewable energy are considerable, Modern economies cannot return to the use of the horse and cart — it has been calculated[16] that in 1900, before the widespread use of motorised transport, one quarter of agricultural production in the USA was devoted to growing transport energy -- oats and hay. Since 1900 the population of the US has trebled and the economy multiplied many times so a return to the energy supply of one century ago would not suffice, and other forms of renewables are under examination. Table 2 shows the areas that would be required if each source of renewable energy were alone to supply the energy flows listed.

The figures in Table 2 could be modified by interpretation. For example, though wind turbines need to be widely spaced and therefore require much land, the area between them can be farmed so in some circumstances the footprint for the exclusive use of the turbines could be smaller by a factor of ten. On the other hand the area for the provision of hydroelectric power includes only the area of the reservoir, ignoring impact downstream and restrictions on land use above the dam, so this footprint could be too small by a similar factor. The areas required to harvest energy from biomass are alarmingly large, since these areas provide possible substitutes for oil and utilising extensive areas of fertile land for fuel production would inevitably impact on either bio-diversity, other forms of agricultural production, or both. As indicated below, the productive capacity of the planet is already fully stretched by human demands. There are indeed widespread concerns about the availability and affordability of various forms of alternative energy[17] but these are beyond the scope of this article.

EQUITY AMONG NATIONS

In any discussion of differing international standards of living the question of equity arises. Some nations clearly live better than others and the traditional solution is to encourage 'development' in poorer nations with the expectation that standards of living will rise, since that has been the experience this century among nations now wealthy.

Table 2: Hypothetical renewable energy footprints in ha/cap at worldwide productivity

	USA	Netherlands	Australia	Bangladesh
Windpower, after storage and retrieval	17.6	12.1	12.3	0.16
Photovoltaic, after storage and retrieval	0.8	0.5	0.5	0.01
Methanol via short rotation woody crops	7.3	5.0	5.1	0.07
Ethanol from sugarcane, Louisiana	4.5	3.1	3.2	0.04
Hydroelectric	2.5	1.7	1.8	0.02

Source: Based on A. Ferguson, *Energy Footprints,* Optimum Population Trust 2000 (in preparation)

Unfortunately the high standard of living has been achieved by using fossil fuel to appropriate more than a fair share of the produce of the planet. If all the ecologically productive land (excluding icecaps, deserts and other non-productive areas) were divided equally among the present six billion humans we would each enjoy the benefit of approximately 1.5 hectares. That is our 'fair earth share'[18] and even the limited footprints of Table 1 show that the USA, the Netherlands and Australia now utilise far more than 1.5 hectares. Footprints for other industrialised nations, not listed in this article, are similarly large. Bangladesh, by contrast, would benefit by an increase in footprint size to the 'fair earth share', as would other 'undeveloped' nations, but while the footprints of wealthy nations remain so large the planet cannot provide larger footprints for poorer nations.

It can be argued that footprinting suffers from the hazards of all international statistical comparisons, that those who collect figures in each nation do not all make the same assumptions or accept the same definitions, and no doubt figures will be modified as they attract wider attention.[19] However sufficient work has already been done to suggest that it is unlikely that future research will present a markedly different overall picture, and the limited number of footprints in Table 1 show that wealthy nations use far more than their fair share of planetary produce. For the wealthy quarter of humanity to reduce its footprint to 1.5 ha would require such a drop in standard of living that it will not happen voluntarily. Some theorists believe that it is possible for current standards of living to be maintained while dropping resource use by a factor of five or ten, but others regard this as a pious hope, and it is certainly not a firm prediction.[20] Indeed the entry on world carrying capacity in a forthcoming encyclopaedia of human ecology[21] suggests that even if wealthy nations reduced their resource consumption considerably the planet would still be able to offer a reasonable standard of living (that of an average citizen in one of the poorer industrialised nations) to possibly fewer than 3 billion persons.

CONCLUSION

Footprinting is a method by which the resource requirements of different life-styles and economies are translated into the land area needed to produce them. Poor people are supported by places that are largely within walking distance of their homes. Wealthy people are supported by many places thanks to cheap, plentiful energy. Footprinting figures compiled to date indicate that there are not enough ecologically productive places to support the current global population at an acceptable standard of living without extraordinary changes in the functioning of wealthy economies. The situation is complicated by current dependence on fossil fuels, particularly oil, supplies of which may dwindle far sooner than is generally expected. If energy must be sourced from renewable alternatives it appears that the maintenance of wealthy lifestyles would require even more of the earth's productive capacity.

References

1 This difficulty is noted, for example, in D. Cocks, *People Policy: Australia's Population Choices,* University of NSW Press, Sydney, 1996, p. 98.

2 Australian Population Association Biennial Conference, University of Queensland, October 1998, as reported in *Newsletter* Australians for an Ecologically Sustainable Population, SEQ Branch, Queensland, December 1998

[3] Australian literature on the relationship between humans and their environment is extensive. Reviews of this literature include: T. Norton, S. Dovers, H. Nix, D. Elias, *An Overview of Research on the Links between Human Population and the Environment,* Bureau of Immigration and Population Research (BIPR), Canberra 1994, and R. Harding, 'the debate on population and the environment: Australia in the global context' in *Journal of the Australian Population Association*, vol. 12, no. 2, 1995, pp. 165-195

[4] Cocks, op. cit. p. 101

[5] Mathis Wackernagel assembled a team to examine the huge amount of data regarding production and trade that is necessary to calculate national ecological footprints. The resultant study and accompanying disk are available from ICLEI, City Hall, East Tower, 8th Floor, 100 Queen St., West Toronto, ON, M5H 2N2, Canada, and the title of the study is: M. Wackernagel, L. Onisto, A. Linares, I. Falfan, J. Garcia, A. Guerrero, M. Guerrerl, *Ecological Footprints of Nations: How Much Nature Do They Use? How Much Nature Do They Have?* Centre for Sustainability Studies, Universidad Anahuac de Xalapa, Mexico, 1997.

[6] A. Ferguson, *The Carrying Capacity and Ecological Footprint of Nations,* Spreadsheet, Optimum Population Trust, Taf Alaw, Llanfallteg, Dyfed, and European Pherology Organisations Confederation, Leystad, Netherlands, Third edition, 1998

[7] D. Pimentel and M. Pimentel, *Food, Energy and Society,* University Press of Colorado, 1996, p. 157

[8] Organisation for Economic Cooperation and Development (OECD), *Environmental Performance Reviews: Australia,* OECD, Paris, 1998, p. 77

[10] B. Foran, F. Poldy, D. Crane, S. Phipp, M. Slessor, *Riding the Long Wave: The OzEcco embodied energy model of Australia: its population, lifestyle, organisation and technology options*, Energy Research and Development Corporation, Canberra, 1997, Chapter III, p. 8

[11] Ferguson, op. cit.

[12] P. Chatterjee, 'Water of life or death', *Development and Cooperation,* no. 2, 1999, Deutsche Siftung fur internationale Entwicklung, Berlin, p. 28

[13] B. Fleay, *The Decline of the Age of Oil: Petrol Politics: Australia's Road Ahead* Pluto Press, Sydney, 1995

[14] Confidence in Australia's coal supplies, though widespread, has never been universal. See, for example, D. Evans and S. Bradford 'Constraints to Growth: the Latrobe Valley' in R. Birrell, D. Hill, J. Stanley (Eds), *Quarry Australia? Social and Environmental Perspectives on Managing the Nation's Resources,* OUP, Melbourne, 1982, pp. 129-146.

[15] For further discussion on the utilisation of fossil fuel reserves see J. Gever et al., *Beyond Oil: the Threat to Food and Fuel in the Coming Decades,* University Press of Colorado, 1986; and W. Youngquist, *Geodestinies,* National Book Company, Portland, Oregon, 1997.

[16] C. Ponting, *A Green History of the World,* Penguin Books, 1993, p. 274

[17] See, for example, G. Gartside 'Can we grow our own fuel' in Birrell et. al. (Eds), op. cit. pp. 183-196, and F. Trainer, 'Can renewable energy sources sustain affluent society?' *Energy Policy,* vol. 23, no. 12, 1995, pp. 1009-1026.

[18] M. Wackernagel and W. Rees, *Our Ecological Footprint: Reducing Human Impact on the Earth,* New Society Publishers, Canada, 1996, p. 54

[19] Critics of the Wackernagel study (see note 5) have suggested that footprints for individual cities or bioregions would be more useful than those for nations. However statistics are generally not available for trade in and out of, for example, the island of Manhattan or the area of South East Queensland, and figures for resource consumption for such areas must be estimated. (See, for example, I. Lowe, Chair, State of the Environment Advisory Council, *Australia: State of the Environment: 1996,* CSIRO Publishing, Melbourne, 1996, where, on p. 3-34, it is noted that 'no comprehensive input and output data are available for most Australian settlements'.)

[20] See, for example, G. Gardner, P. Sampat, J. Peterson, *Mind Over Matter: Recasting the Role of Materials in Our Lives,* Worldwatch Paper 144, Worldwatch Institute, Washington, 1998, and D. Cocks, *Future Makers, Future Takers: Life in Australia 2050*, University of New South Wales Press, Sydney, 1999.

[21] A. Ferguson, 'World carrying capacity', in K. E. F. Watt (Ed.), *Encyclopedia of Human Ecology,* Academic Press Inc., San Diego, CA, 2000 (in press)