Minimizing Ecological Footprints

An urban "ecological footprint" is simply the total amount of the earth's surface needed to support a given city's level of consumption and absorb its waste products. The developers of this concept, William Rees and Mathis Wackernagel, compare a city to a large animal grazing in a meadow and pose the ecological footprint as a question: "How large a pasture is necessary to support that city indefinitely—to produce all its 'feed' and to assimilate all its wastes sustainably?" (Wackernagel and Rees 1995). In other words, the ecological footprint is a geographical measure of an urban population's demand on natural capital.

The surface area that makes up a footprint is a sum of all land required to supply resources and absorb wastes, wherever that land may be on earth. For example, residents of a Chinese city may require provincial land for a reservoir to supply water and for forests to absorb the carbon dioxide that they produce. They may rely on coal mines in other provinces for their heating and industrial energy. Their footprint can also extend beyond their borders, perhaps to North American grain fields to supply feed for

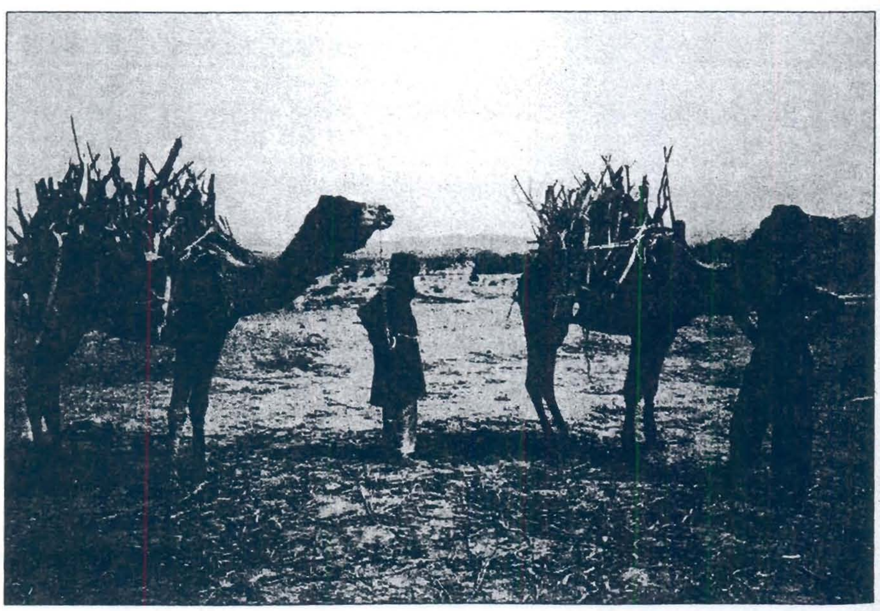

Figure 4-1 Rural effect of urban footprints: Fuelwood supply in Baluchistan, Pakistan.

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the livestock that they consume or to coastal fisheries in Thailand for some of their seafood consumption. The sum of all this land and surface water directly related to resource consumption and waste absorption becomes the city's ecological footprint. Information regarding the footprint generated by Vancouver, British Columbia, appears in Box 4-1.

Two key concepts underlie ecological footprint analysis. The first is that sustainable development is primarily about whether we use natural capital in a sustainable manner. The developers of the footprint approach prefer a definition known as *strong sustainability:* "Each generation should inherit an adequate per capita stock of natural capital assets no less than the stock of such assets inherited by the previous generation" (Costanza and Daly 1992). Second, they believe in intragenerational global equity, or the "fair earthshare" as they call it. There are an estimated 8.9 billion hectares of ecologically productive land on earth; if this is allocated to the 1995 population of 5.8 billion, then each person's fair earthshare is 1.5 hectares. The implication is that global equity will be served to the extent that individuals alter their consumption and waste habits so that each person's footprint approaches the global average.

BOX

Calculations indicate that the average Canadian requires at least 4.3 hectares of land to support present consumption levels, including 2.3 hectares for assimilation of carbon dioxide. The 1991 population of Vancouver was 472,000 and the city covered an area of 11,400 hectares. The average Canadian also requires 0.7 hectares of marine surface area to meet demand for seafood. Thus, Vancouver's total footprint is:

472,000 x (4.3 hectares + 0.7 hectares)
= 2.36 million hectares

Another way of looking at the footprint is that Vancouver requires more than 200 times its geographic size to support its level of consumption and waste generation. This ratio becomes less dramatic if one considers the Lower Fraser Basin, the watershed that encompasses Vancouver. The basin has a population of 1.78 million, a land area of 555,000 hectares, and an ecological footprint (including marine surface area) of 8.9 million hectares, or 16 times the basin's physical area.

Box 4-1 Vancouver's ecological footprint.
SOURCE: Rees 1997.

The major conclusions that can be drawn from footprint analysis are:

- *Urban "self-sufficiency" is impossible.* A city cannot live off of its physical area. Its residents would be impoverished, starve, or suffocate on their own wastes if they tried to do so.
- *Geographical location does not equal ecological location.* Because no city lives within its geographical means, a city's ecological reach will always be larger than (and will not coincide with) its administrative boundaries.

- *The wealthy have bigger footprints within a city.* In Santiago, Chile, the ecological footprint of the highest income quintile was estimated to be 16 times greater than that of the lowest quintile (Wackernagel 1998).
- *Globalization can increase urban vulnerability.* Footprint analysis demonstrates that cities are dependent on distant sources for food, water, energy, and other resources. This raises a city's vulnerability to global climate change, trade restraints, competition, and price fluctuations.
- *Urban form and technology choice have important environmental impacts.* Increased urban density (high-rise apartments instead of single-family homes) reduces the footprint components associated with housing type and urban transportation by 40 percent (Walker 1995).
- *Cities create ecological benefits, as well as costs.* Cities incorporate economies of scale that reduce the cost per capita of providing services and infrastructure as well as collecting and recycling or treating wastes. Higher population density reduces per capita demand for residential land.

The strengths of the footprint method lie in its measurability. The approach allows one to quantify a particular definition of sustainable development. Once a city's footprint has been measured, it can be compared with those of similar cities to identify differences and their causes. A city's footprint can also be regularly drawn and compared over time to determine whether it is growing on a per capita basis (becoming less sustainable) or shrinking (becoming more sustainable). The components of the footprint can also be examined to determine which are most significant. Policymakers can then focus on

BOX

One option for reducing a city's ecological footprint is to shift from fossil fuels to renewable sources of energy. However, increased reliance on renewables will also increase the footprint of these energy sources if consumption continues at current levels.

Photovoltaics. **The average energy in sunlight in the United States is about 177 watts per square meter. A photovoltaic cell 2 meters on each side would be required to power a single 100-watt light bulb at current levels of conversion efficiency. A huge land surface area would thus be required to meet even a fraction of American energy demand.**

Wood energy. **A moderately well-insulated U.S. house needs about five cords of deadwood for heating in an average winter. In the hardwood forests of the northeastern United States, an acre produces one cord of deadwood on a sustainable basis. So, each house requires about five acres of forest to meet heating needs on a renewable basis. Scaling up to a city level, a 30-story apartment building would need something on the order of 600 acres of forest to meet its heating needs.**

Box 4-2 Urban energy footprints.

SOURCE: Trefil 1994, 107.

reducing those activities, factors, and technologies that are the major contributors to the footprint. See Box 4-2.

First definition of urban sustainability: *Cities with relatively lower or decreasing ecological footprints per capita are more sustainable.*

The ecological footprint method is hobbled by a number of limitations. It assesses only the natural capital dimension of sustainability, and does not deal directly with economic and social development. Thus, a city's footprint may be small or getting smaller, but its population might also be getting impoverished, less healthy, and less literate. Next, the footprint approach is a snapshot of a situation and does not recognize ecological, technological, and price changes. It is also descriptive: The approach gives us a total surface area—an area used per capita and the ratio of urban area to total ecological use area—but it does not tell us what to do. Finally, the approach has some methodological weaknesses. Only one type of land use for waste products is typically calculated as part of the footprint (land area required as a CO_2 sink) so the calculation probably underestimates reality. Also, the magnitude of the ratio of city size to ecological use area can be misleading. The Vancouver ratio of 1 to 200 (Box 4-1) is cause for concern; casting a wider net by using the Lower Fraser Basin yields a perhaps less worrisome ratio of 1 to 16.

Sustaining the Production of Wealth

Traditional measures of urban development have focused on assessing and comparing flows of produced assets. *Produced assets* are the goods and services created by a geographical unit, such as a city, usually over the course of a year. By this measure, cities with higher per capita incomes were classified as more developed. This measurable but simplistic indicator of development has been criticized for several reasons:

- *Counting "goods" and "bads" equally.* Both positive goods and services as well as negative ones (e.g., cleaning up a polluted river, responding to crime, or repairing people and vehicles after car crashes) are counted and contribute to income growth.