OUR ECOLOGICAL FOOTPRINT

REDUCING HUMAN IMPACT ON THE EARTH

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Illustrated by Phil Testemale

NEW SOCIETY PUBLISHERS

Preface

Some years ago, I read of a species of tiny woodland wasp that lives on mushrooms. It seems that when a wandering female wasp chances upon the right kind of mushroom in the forest, she deposits her eggs within it. Almost immediately, the eggs hatch and the tiny grubs begin literally to eat themselves out of house and home. The little maggots grow rapidly, but soon something very odd happens. The eggs in the larvaes' own ovaries hatch while still inside their immature mothers. This second generation of parthenogenic grubs quickly consumes its parents from within, then breaks out of the empty shells to continue feeding on the mushroom. This seemingly gruesome process may repeat itself for another generation. It doesn't take long before the entire mushroom is over-filled by squirming maggots and fouled by their bodily wastes. The exploding population of juvenile wasps consumes virtually its entire habitat which is the signal for the largest and most mature of the larvae to pupate. The few individuals that manage to emerge as mature adults then abandon their mouldering birthplace, flying off to begin the whole process over again.

We wrote this book in the belief that the bizarre life-cycle of the mushroom wasps may offer a lesson to humankind. The tiny wasps' weird reproductive strategy has apparently evolved under extreme competitive pressure. Good mushrooms — like good planets — are hard to find. Natural selection therefore favored those individual wasps and reproductive traits that were most successful in appropriating the available supply of essential resources (the mushroom) before the competition had arrived or became established.

No doubt human beings also have a competitive side and both natural and sociocultural selection have historically favored those individuals and cultures that have been most successful in commandeering resources and exploiting the bounty of nature. There is also plenty of archeological and historic evidence that, like the over-crowded mushroom, many whole cultures have collapsed from the weight of their own success. Human societies as temporally and spatially far-flung as the Mesopotamians, Mayans, and Easter Islanders likely came to ruin by expanding beyond the capacity of their environments to sustain them. Like the forest wasps, they depleted their local habitats. Humanity as a whole survived, however, because there were always other figurative "mushrooms" elsewhere on Earth capable of supporting people.

Today, of course, humankind has become a global culture, one increasingly driven by a philosophy of competitive expansionism, one which is subduing and consuming the Earth. The problem is that, unlike the wasp, even the fattest and richest among us have no means to abandon the withered hulk of our

habitat once consumed and there is no evidence yet of other Earth-like "mushrooms" in our galactic forest.

The good news is that — also unlike the wasp — humans are gifted by the potential for self-awareness and intelligent choice, and *knowing our circumstances is an invitation to change.*

The first step toward reducing our ecological impact is to recognize that the "environmental crisis" is less an environmental and technical problem than it is a behavioral and social one. It can therefore be resolved only with the help of behavioral and social solutions. On a finite planet, at human carrying capacity, a society driven mainly by selfish individualism has all the potential for sustainability of a collection of angry scorpions in a bottle. Certainly human beings are competitive organisms but they are also cooperative social beings. Indeed, it is no small irony (but one that seems to have escaped many policy advisors today) that some of the most economically and competitively successful societies have been the most internally cooperative — those with the greatest stocks of cultural and social capital.

Our primary objective with this book is to make the case that we humans have no choice but to reduce our "Ecological Footprint." We hope that it also conveys our essential confidence in the resourcefulness of the human spirit. People have great untapped potential to meet this greatest of challenges to our collective security. As William Catton stated in his 1980 classic, *Overshoot*: "If, having overshot carrying capacity, we cannot avoid crash, perhaps with ecological understanding of its real causes we can remain human in circumstances that could otherwise tempt us to turn beastly." Indeed, we believe that confronting together the reality of ecological overshoot will force us to discover and exercise those special qualities that distinguish humans from other sentient species, to become truly human. In this sense, global ecological change may well represent our last great opportunity to prove that there really *is* intelligent life on Earth.

William Rees
Gabriola Island
Summer 1995

Introduction

Humans are facing an unprecedented challenge: there is wide agreement that the Earth's ecosystems cannot sustain current levels of economic activity and material consumption, let alone increased levels. At the same time, economic activity on the globe as measured by Gross World Product is growing at four percent a year, which corresponds to a doubling time of about 18 years.[1] One factor driving this expansion is the growth of the world's population: in 1950, there were 2.5 billion people, while today there are 5.8 billion. There may well be 10 billion people on Earth before the middle of the next century. Even more ecologically significant is the rise in *per capita* energy and material consumption which, in the last 40 years, has soared faster than the human population. An irresistible economy seems to be on a collision course with an immovable ecosphere.

Why Worry About Sustainability?

The conventional approach to development has been highly successful at expanding economic activity and economic growth remains at the forefront of most nations' political agendas. The long-term goal is to integrate local and national economies into one global economy with unrestricted trade and capital flows. This will greatly boost industrial production and likely further increase resource consumption. However, the weaknesses in the conventional model are more and more apparent. For example, increasing economic production has neither levelled income differences, made the "haves" noticeably happier, nor satisfied the basic needs of the world's poorest one billion people. While 20 percent of the world's population enjoys unprecedented material well-being, at least another 20 percent remain in conditions of absolute poverty. In fact, the top 20 percent of income earners take home over 60 times more than the poorest 20 percent, and this gap has doubled over the last 30 years.[2] Conventional economic development has been challenged for this glaring social inequity since its inception with the Bretton Woods agreements after the Second World War.

Today, in the face of ecological constraints, the criticism is even more severe. Current rates of resource harvesting and waste generation deplete nature faster than it can regenerate. Stanford University biologist Peter Vitousek and his

colleagues calculated in 1986 that human activities were by then already "appropriating," directly or indirectly, 40 percent of the products of terrestrial photosynthesis — in effect, humanity was channelling through its economy 40 percent of nature's land-based biological production — and more recent work suggests that human exploitation of the continental shelves is approaching similar levels. If the human use of other natural functions of nature is included, such as waste absorption by the land and water, and the protection from harmful ultraviolet radiation (by the stratospheric ozone layer), it is not hard to imagine that human activities may be using the world beyond long-term capacity.

The accelerating resource consumption that has supported the rapid economic growth and the rising material standards of industrialized countries in recent decades has, at the same time, degraded the forests, soil, water, air and biological diversity of the planet. As the world becomes ecologically overloaded, conventional economic development actually becomes self-destructive and impoverishing. Many scholars believe that continuing on this historical path might even put our very survival at risk. Certainly, there is little to indicate that current sustainability initiatives will be effective at reversing global ecological deterioration. Indeed, pressure on both ecological integrity and social health is mounting. More effective sustainability initiatives are required, including tools to stimulate a wider public involvement, evaluate strategies and monitor progress.

Why Worry? As the world becomes ecologically overloaded, conventional economic development becomes self-destructive and impoverishing — and puts human survival at risk (after Horst Haitzinger).

What We Hope to Achieve

This book describes a planning tool that can help to translate sustainability concerns into public action: we call it "Ecological Footprint" analysis. The Ecological Footprint concept is simple, yet potentially comprehensive: it accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows. This technique is both analytical and educational. It not only assesses the sustainability of current human activities, but is also effective in building public awareness and assisting decision-making. The Ecological Footprint is not about "how bad things are." It is about humanity's continuing dependence on nature and what we can do to secure Earth's capacity to support a humane existence for all in the future. Understanding our ecological constraints will make our sustainability strategies more effective and livable. Ecological Footprint analysis should help us to choose wisely, which we think is preferable to having nature impose a choice of its own.

Thus, to the extent that Ecological Footprint analysis reflects biophysical reality it is *good news* for a better and more secure future. The *bad news* is the conventional dream that the human enterprise can be expanded forever on a finite planet. This expansionist vision might sound attractive, but it is bound to fail in its current form. This failure would be very painful. It would hurt the poor first, the rich a little later, and all the way along destroy many of our fellow species.

The Ecological Footprint approach acknowledges that humanity is facing difficult challenges, makes them apparent, and directs action toward sustainable living. Admittedly, acknowledging the darker side of the human condition is sometimes painful — avoidance is sweet temptation. However, this book takes the position that denial today leads to greater pain tomorrow. We believe that the first step toward a more sustainable world is to accept ecological reality and the socioeconomic challenges it implies. Any "business as usual" strategy that perpetuates today's destructive lifestyles would be a disservice to our children.

A Matter of Perspective

To develop a way of living that is fulfilling *and* sustainable within nature, we need to rethink our relationships with each other and with the rest of nature. This book tries to stimulate such thinking. There are, of course, many books with a similar purpose but we hope this one is a little different.

To begin with, most writers on the subject — even the good ones — treat the "environment" as something *out there*, separate and detached from people and their works. This is, in fact, a fair reflection of our prevailing cultural ethic. Judging from our actions and our language, modern humans generally tend to see society as more or less independent of nature. Thus, when economic activity causes unexpected damage to some environmental value, we call it a "negative externality," emphasizing the environment's place on the periphery of modern consciousness. Little wonder that conventional approaches to development treat the environment as a kind of backdrop to human affairs! The environment may be aesthetically pleasing, but it is expendable if economic push comes to shove. The loss of environmental value is still seen as an unfortunate but mostly necessary "trade-off" against economic growth. The well-worn old saw "you can't stop progress" catches the prevailing ethic pretty well.

This book starts from a different premise. We argue that the human enterprise cannot be separated from the natural world even in our minds because there is no such separation in nature. In terms of energy and material flows, there is simply no *"out there"* — the human economy is a fully dependent sub-system of the ecosphere. This means that we should study humanity's role in nature in much the same way we would study that of any other large consumer organism. The fact is that through the economic production-consumption-pollution cycle, humankind has become a major — and often the dominant — species in virtually every significant ecosystem on the planet.

The premise that *human society is a subsystem of the ecosphere,* that human beings are embedded in nature, is so simple that it is generally overlooked or dismissed as too obvious to be relevant. However, taking this "obvious" insight seriously leads to some profound conclusions. The policy implications of this ecological reality run much deeper than pressing for improved pollution control and better environmental protection, both of which maintain the myth of separation. If humans are part of nature's fabric, the "environment" is no mere scenic backdrop but becomes the play itself. The ecosphere is where we live, humanity is dependent on nature, not the reverse. Sustainability requires that our emphasis shift from "managing resources" to managing *ourselves*, that we learn to live as part of nature. Economics at last becomes human ecology.

This book shows that we can develop more sustainable lifestyles. We propose tools and frameworks for understanding the challenges, evaluating strategies and monitoring progress, and provide examples of how these

The Ecological Footprint is a measure of the "load" imposed by a given population on nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population.

strategies work. Achieving sustainability will require much thought and sweat, but changing the world can also be pretty exciting.

We have tried to appeal to a diverse audience, and hope to offer something to every level of interest. Chapter one describes and illustrates the Ecological Footprint concept. Chapter two links it to the sustainability debate. The next chapter explains the procedure for Footprint calculations and discusses 17 applications. Finally, we conclude the book with a discussion of sustainability strategies and a summary of what we have learned.

Notes

1. The Gross World Product rose from $3.8 trillion in 1950 to $19.3 trillion in 1993 (measured in 1987 US dollars). Worldwatch Institute, *Vital Signs 1994* (NY: W. W.

Norton, 1994).
2. United Nations Development Program (UNDP), *Human Development Report* (NY: Oxford University Press, 1992, 1994).

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ECOLOGICAL FOOTPRINTS FOR BEGINNERS

Many of us live in cities where we easily forget that nature works in closed loops. We go to the store to buy food with money from the bank machine and, later, get rid of the waste either by depositing it in the back alley or flushing it down the toilet. Big city life breaks natural material cycles and provides little sense of our intimate connection with nature.

Obvious but Profound: We Depend on Nature

Despite this estrangement, we are not just *connected* to nature — we *are* nature. As we eat, drink and breath, we constantly exchange energy and matter with our environment. The human body is continuously wearing out and rebuilding itself — in fact, we replace almost all the molecules in our bodies about once a year. The atoms of which we are made have already been part of many other living beings. Particles of us once roamed about in a dinosaur, and some of us may well carry an atom of Caesar or Cleopatra.

Nature provides us with a steady supply of the basic requirements for life. We need energy for heat and mobility, wood for housing and paper products, and nutritious food and clean water for healthy living. Through photosynthesis green plants convert sunlight, carbon dioxide (CO_2), nutrients and water into chemical energy (such as fruit and vegetables), and all the food chains that support animal life — including our own — are based on this plant material. Nature also absorbs our wastes and provides life-support services such as climate stability and protection from ultraviolet radiation. Finally, the sheer exuberance and beauty of nature is a source of joy and spiritual inspiration. Figure 1.1 shows how very tightly human life is interwoven with nature, a connection we often forget or ignore. Since most of us spend our lives in cities and consume goods imported from all over the world, we tend to experience nature merely as a collection of commodities or a place for recreation, rather than the very source of our lives and well-being.

If we are to live sustainably, we must ensure that we use the essential products and processes of nature no more quickly than they can be renewed, and that we discharge wastes no more quickly than they can be absorbed. Even

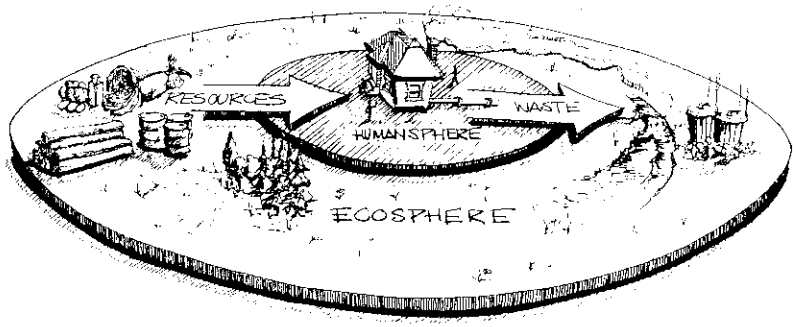


Figure 1.1: We are part of nature. Nature supplies material requirements for life, absorbs our wastes, and provides life-support services such as climate stabilization, all of which make Earth hospitable for people.

today, however, accelerating deforestation and soil erosion, fisheries collapse and species extinction, the accumulation of greenhouse gases and ozone depletion all tell us our current demands on nature are compromising humanity's future well-being. In spite of these trends, society operates as if nature were an expendable part of our economy. For example, agriculture, forestry and fisheries are considered to be mere extractive sectors of the economy, and since such primary activities contribute relatively little to the Gross National Product (GNP) of most industrialized countries, they are not considered to be particularly important. This perspective forgets that nature's products are indispensable to human well-being, however "insignificant" their dollar contribution to the country's GNP might be. Similarly, some people reduce the economy-ecology connection to pollution that directly threatens the health of people (e.g., urban air pollution). No doubt, this is an important problem but the emphasis on human health betrays a narrow ecological understanding. The economy's growing demands on nature endanger the planet's ability to support life on a much more fundamental level. Over-harvesting and waste generation not only reduce future productivity, but can lead to ecosystems collapse. So far, this phenomenon has been confined to the local or regional level (desertification in the African Sahel and the loss of North Atlantic groundfish stocks being recent examples). However, increasing evidence of global change is clear warning that human activity may now be undermining global life-support systems. The prospect of significant climate change, with its potential threat to food production and the safety of coastal settlements, should *in itself* be sufficient to force society to adopt a less cavalier attitude toward "the environment" that sustains us (to say nothing of 30 million other species).

What *is* an Ecological Footprint?

Ecological footprint analysis is an accounting tool that enables us to estimate the resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area. Typical questions we can ask with this tool include: how dependent is our study population on resource imports from "elsewhere" and on the waste assimilation capacity of the global commons?, and will nature's productivity be adequate to satisfy the rising material expectations of a growing human population into the next century? William Rees has been teaching the basic concept to planning students for 20 years and it has been developed further since 1990 by Mathis Wackernagel and other students working with Bill on UBC's Healthy and Sustainable Communities Task Force.

To introduce the thinking behind Ecological Footprint analysis, let's explore how our society perceives that pinnacle of human achievement, "the city." Ask for a definition, and most people will talk about a concentrated population or an area dominated by buildings, streets and other human-made artifacts (this is the architect's "built environment"); some will refer to the city as a political entity with a defined boundary containing the area over which the municipal government has jurisdiction; still others may see the city mainly as a concentration of cultural, social and educational facilities that would simply not be possible in a smaller settlement; and, finally, the economically-minded see the city as a node of intense exchange among individuals and firms and as the engine of production and economic growth.

No question, cities are among the most spectacular achievements of human civilization. In every country cities serve as the social, cultural, communications and commercial centers of national life. But something fundamental is missing from the popular perception of the city, something that has so long been taken for granted it has simply slipped from consciousness.

We can get at this missing element by performing a mental experiment based on two simple questions designed to force our thinking beyond conventional limits. First, imagine what would happen to any modern city or urban region — Vancouver, Philadelphia or London — as defined by its political boundaries, the area of built-up land, or the concentration of socioeconomic activities, if it were enclosed in a glass or plastic hemisphere that let in light but prevented material things of any kind from entering or leaving — like the "Biosphere II" project in Arizona (Figure 1.2). The health and integrity of the entire human system so contained would depend entirely on whatever was initially trapped within the hemisphere. It is obvious to most people that such a city would cease to function and its inhabitants would perish within a few days. The population and the economy contained by the capsule would have been cut off from vital resources and essential waste sinks, leaving it both to starve and to suffocate

at the same time! In other words, the ecosystems contained within our imaginary human terrarium would have insufficient "carrying capacity" to support the ecological load imposed by the contained human population. This mental model of a glass hemisphere reminds us rather abruptly of humankind's continuing ecological vulnerability.

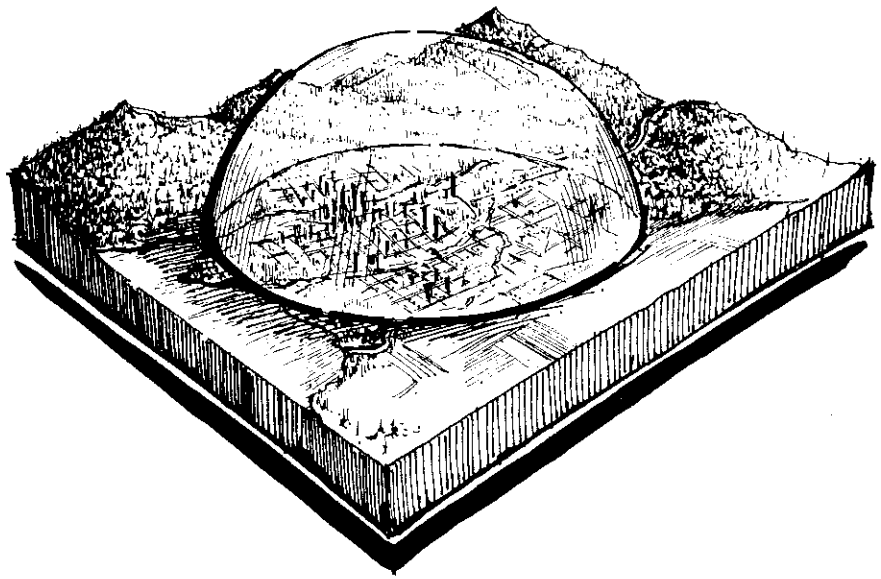


Figure 1.2: Living in a Terrarium.
How big would the glass hemisphere need to be so that the city under it could sustain itself exclusively on the ecosystems contained?

The second question pushes us to contemplate this hidden reality in more concrete terms. Let's assume that our experimental city is surrounded by a diverse landscape in which cropland and pasture, forests and watersheds — all the different ecologically productive land-types — are represented in proportion to their actual abundance on the Earth, and that adequate fossil energy is available to support current levels of consumption using prevailing technology. Let's also assume our imaginary glass enclosure is elastically expandable. The question now becomes: how large would the hemisphere have to become before the city at its center could sustain itself indefinitely and exclusively on the land and water ecosystems and the energy resources contained within the capsule? In other words, what is the total area of terrestrial ecosystem types needed continuously to support all the social and economic activities carried out by the people of our city as they go about their daily activities? Keep in

mind that land with its ecosystems is needed to produce resources, to assimilate wastes, and to perform various invisible life-support functions. Keep in mind too, that for simplicity's sake, the question as posed does not include the ecologically productive land area needed to support other species independent of any service they may provide to humans.

For any set of specified circumstances — the present example assumes current population, prevailing material standards, existing technologies, etc. — it should be possible to produce a reasonable estimate of the land/water area required by the city concerned to sustain itself. By definition, the total ecosystem area that is essential to the continued existence of the city is its *de facto* Ecological Footprint on the Earth. It should be obvious that the Ecological Footprint of a city will be proportional to both population and *per capita* material consumption. Our estimates show for modern industrial cities the area involved is orders of magnitude larger than the area physically occupied by the city. Clearly, too, the Ecological Footprint includes all land required by the defined population wherever on Earth that land is located. Modern cities and whole countries survive on ecological goods and services appropriated from natural flows or acquired through commercial trade from all over the world. The Ecological Footprint therefore also represents the corresponding population's total "appropriated carrying capacity."

By revealing how much land is required to support any specified lifestyle indefinitely, the Ecological Footprint concept demonstrates the continuing material dependence of human beings on nature. For example, Table 3.3 (pages 82-83) shows the Ecological Footprint of an average Canadian, i.e., the amount of land required from nature to support a typical individual's present consumption. This adds up to almost 4.3 hectares, or a 207 metre square. This is roughly comparable to the area of three city blocks. The column on the left shows various consumption categories and the headings across the top show corresponding land-use categories.

"Energy" land as used in the Table means the area of carbon sink land required to absorb the carbon dioxide released by *per capita* fossil fuel consumption (coal, oil and natural gas) assuming atmospheric stability as a goal. Alternatively, this entry could be calculated according to the area of cropland necessary to produce a contemporary biological fuel such as ethanol to substitute for fossil fuel. This alternative produces even higher energy land requirements. "Degraded Land" means land that is no longer available for nature's production because it has been paved over or used for buildings. Examples of the resources in "Services" are the fuel needed to heat hospitals, or the paper and electricity used to produce a bank statement.

To use Table 3.3 to find out how much agricultural land is required to produce food for the average Canadian, for example, you would read across the "Food" row to the "Crop" and "Pasture" columns. The table shows that,

on average, 0.95 hectares of garden, cropland and pasture is needed for a typical Canadian. Note that none of the entries in the table is a fixed, necessary, or recommended land area. They are simply our estimates of the 1990s ecological demands of typical Canadians. The Ecological Footprints of individuals and whole economies will vary depending on income, prices, personal and prevailing social values as they affect consumer behavior, and technological sophistication — e.g., the energy and material content of goods and services.

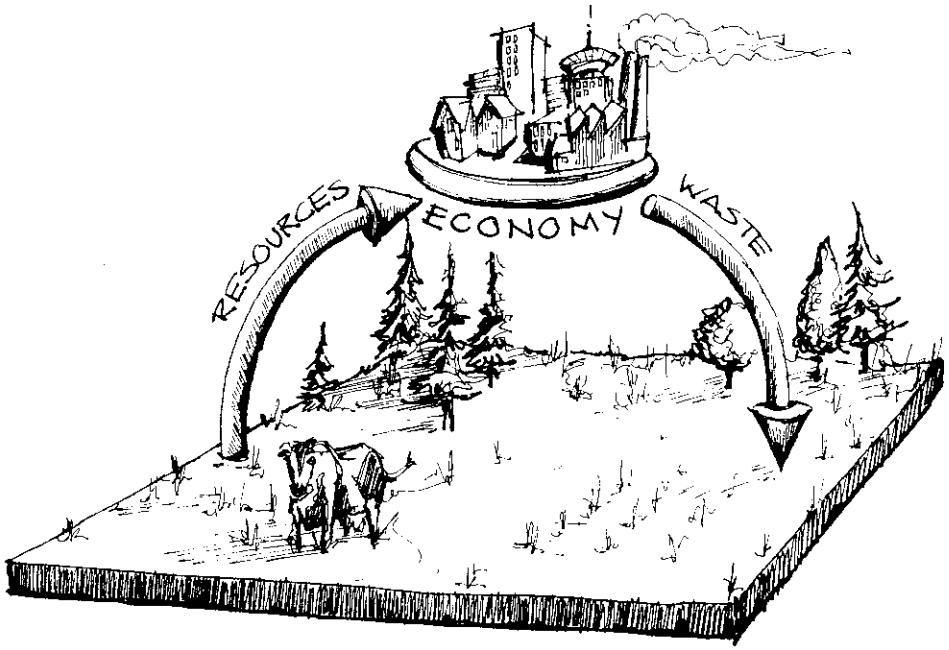


Figure 1.3: What is an Ecological Footprint?
Think of an economy as having an "industrial metabolism." In this respect it is similar to a cow in its pasture. The economy needs to "eat" resources, and eventually, all this intake becomes waste and has to leave the organism — the economy — again. So the question becomes: how big a pasture is necessary to support that economy — to produce all its feed and absorb all its waste? Alternatively, how much land would be necessary to support a defined economy sustainably at its current material standard of living?

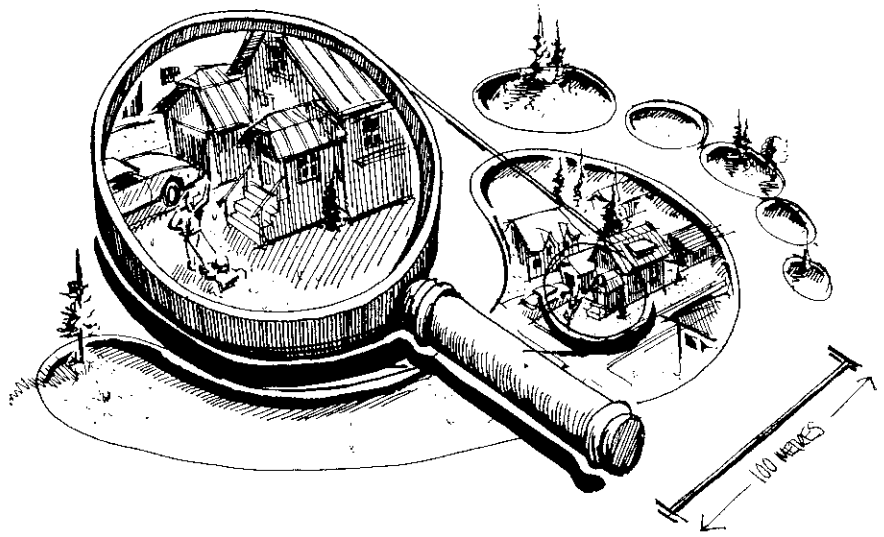


Figure 1.4: Your Footprint. The average North American Footprint measures 4 to 5 hectares or is comparable to three-plus city blocks.

So What? — The Global Context

Our economy caters to growing demands that compete for dwindling supplies of life's basics. The Ecological Footprint of any population can be used to measure its current consumption and projected requirements against available ecological supply and point out likely shortfalls. In this way, it can assist society in assessing the choices we need to make about our demands on nature. To put this into perspective, the ecologically productive land "available" to each person on Earth has decreased steadily over the last century (Figure 1.5). Today, there are only 1.5 hectares of such land for each person, including wilderness areas that probably shouldn't be used for any other purpose. In contrast, the land area "appropriated" by residents of richer countries has steadily increased. The present Ecological Footprint of a typical North American (4–5 ha) represents three times his/her fair share of the Earth's bounty. Indeed, if everyone on Earth lived like the average Canadian or American, we would need at least three such planets to live sustainably (Figure 1.6). Of course, if the world population continues to grow as anticipated, there will be 10 billion people by 2040, for each of whom there will be less than 0.9 hectares of ecologically productive land, assuming there is no further soil degradation.

Such numbers become particularly telling when used to compare selected geographic regions with the land they actually "consume." For example, in Chapter 3 we estimate the Ecological Footprint for the Lower Fraser Valley, east of Vancouver to Hope, B.C. This valley bottom has 1.8 million inhabitants for a population density of 4.5 people per hectare. In short, the area is far smaller than needed to supply the ecological resources used by its population. If the average person in this basin needs the output of 4.3 hectares (Table 3.3), then

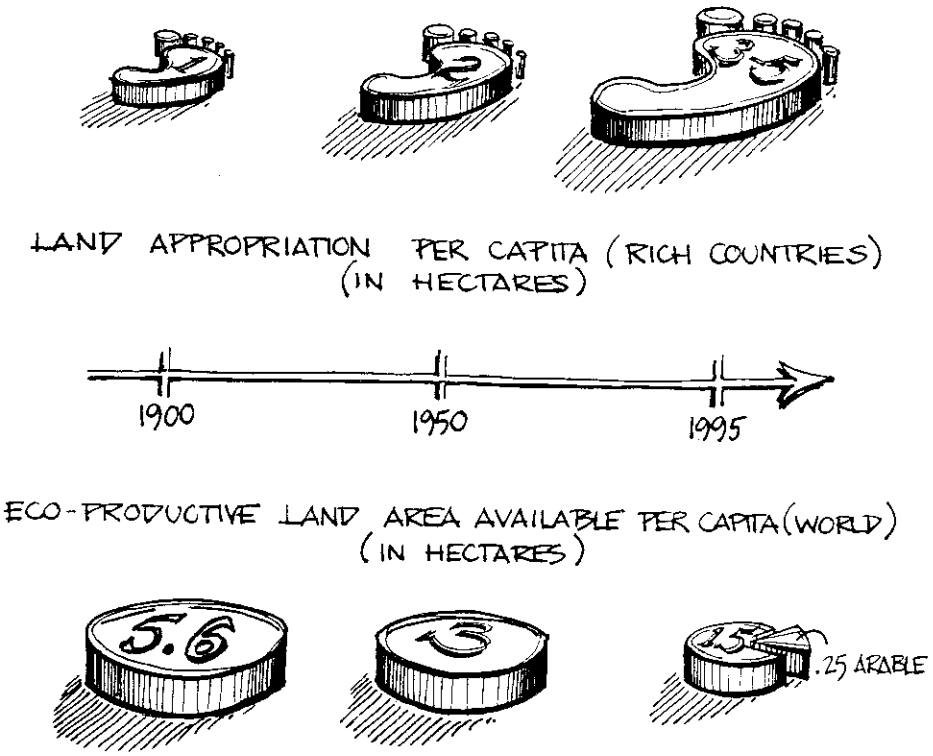


Figure 1.5: Our Ecological Footprints Keep Growing While Our per capita "Earthshares" Continue to Shrink. Since the beginning of this century, the available ecologically productive land has decreased from over five hectares to less than 1.5 hectares per person in 1995. At the same time, the average North American's Footprint has grown to over 4 hectares. These opposing trends are in fundamental conflict: the ecological demands of average citizens in rich countries exceed *per capita* supply by a factor of three. This means that the Earth could not support even today's population of 5.8 billion sustainably at North American material standards.

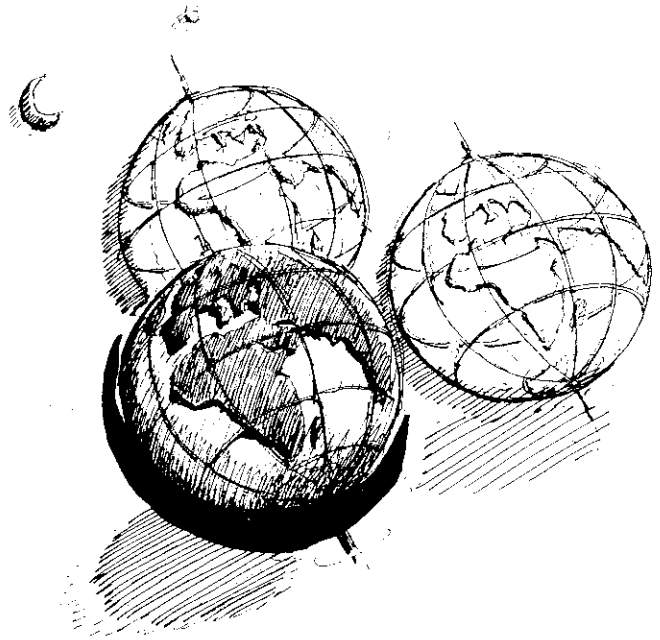


Figure 1.6: Wanted: Two (Phantom) Planets. If everybody lived like today's North Americans, it would take at least two additional planet Earths to produce the resources, absorb the wastes, and otherwise maintain life-support. Unfortunately, good planets are hard to find...

the Lower Fraser Valley depends on an area 19 times larger than that contained within its boundaries for food, forestry products, carbon dioxide assimilation and energy (Figure 3.5). Similarly, Holland has a population of 15 million people, or 4.4 people per hectare, and although Dutch people consume less than North Americans on average, they still require about 15 times the available land within their own country for food, forest products and energy use (Figure 3.8, Box 3.4). In other words, the ecosystems that actually support typical industrial regions lie invisibly far beyond their political or geographic boundaries.

A world upon which everyone imposed an over-sized Ecological Footprint would not be sustainable — the Ecological Footprint of humanity as a whole must be smaller than the ecologically productive portion of the planet's surface. This means that if every region or country were to emulate the economic

example of the Lower Fraser Basin or the Netherlands, using existing technology, we would all be at risk from global ecological collapse.

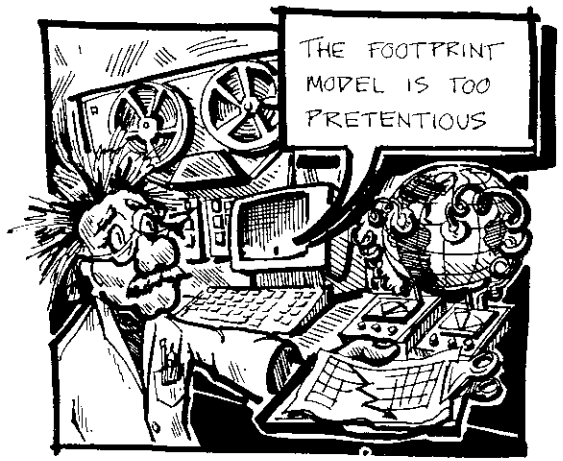
The notion that the current lifestyle of industrialized countries cannot be extended safely to everyone on Earth will be disturbing to some. However, simply ignoring this possibility by blindly perpetuating conventional approaches to economic development invites both eco-catastrophe and subsequent geopolitical chaos. To recognize that not everybody can live like people do in industrialized countries today is not to argue that the poor should remain poor. It is to say that there must be adjustments all round and that, if our ecological analyses are correct, continuing on the current development path will actually hit the less fortunate hardest. Blind belief in the expansionists' cornucopian dream does not make it come true — rather it side-tracks us from learning to live within the means of nature and ultimately becomes ecologically and socially destructive.

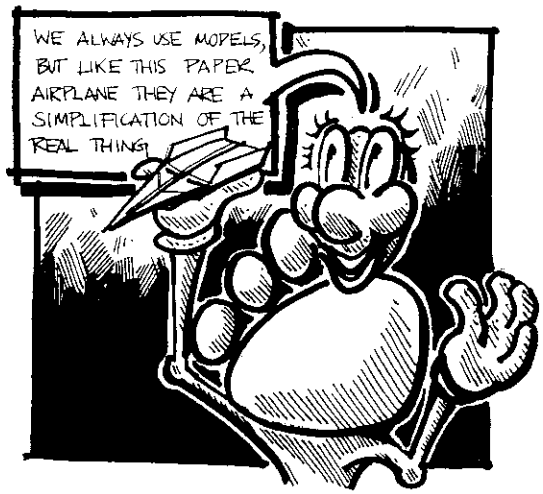
Dr. Footnote Explains

Various critics have raised well-reasoned objection to aspects of the Ecological Footprint concept. In this section, sustainability counsellor Dr. Footnote addresses some of the issues they have raised.

THE POWER OF SCIENCE:

Analytical Scientist: The Ecological Footprint is much too pretentious. For example, in spite of years of detailed and systematic research, we still do not know exactly how single organisms work (be they bacteria or blue whales), and we know even less about how they interact. We scientists work with models, but they are crude simplifications — and we can never prove them right. The best we can do is prove them wrong. As good scientists we must acknowledge our enormous ignorance of nature. We need to be humble. So, how can you claim that the complex interactions between people and nature can be reduced to a matter of hectares?





Dr. Footnote: You're right. The Ecological Footprint doesn't tell the whole story. However, while many people strive toward the absolute truth, a more relevant question is whether the knowledge we use is compatible with the phenomena that we observe. Know-ledge needs

to be appropriate to the task. For example, Newton's mechanical laws were good enough to fly us to the moon, in spite of their shortcomings in light of Einsteinian relativity. Not knowing something with certainty should not deter us from taking action or counter-action. Let's avoid paralysis by analysis, but rather err on the safe side. We must advocate precaution where potential danger looms — even if we do not know the exact nature of the hazard.

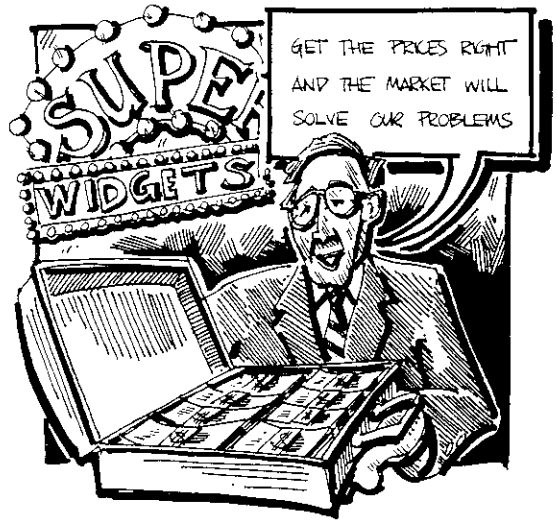
The Ecological Footprint model may be simple — like any ecological model, it does not represent all possible inter-actions. However, it estimates the minimum land area necessary to provide the basic energy and material flows required by the economy. We don't look at pollution beyond carbon dioxide. If anything, therefore, our current Ecological Footprint calculations underestimate humanity's draw on nature.

Even so, our calculations show that people have overshot global carrying capacity and that some people contribute significantly more to that overshoot than others. It is questionable, of course, whether humanity's Ecological Footprint should even approach the size of the Earth. Only a smaller Footprint provides any ecological resilience in the face of global change. In any case, today's ecological overshoot can only be temporary, and comes at a high cost to the future.

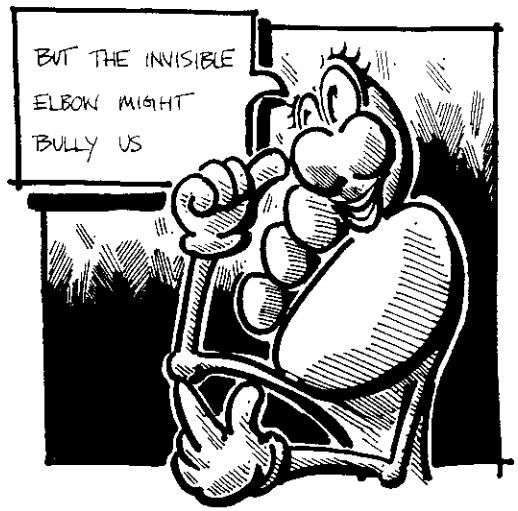
In short, we may not know exactly how nature works, but by using fundamental laws and known relationships we can calculate useful (under)estimates of human demands. They may not be precise enough for managing nature, but they do provide challenging guidelines for managing ourselves in an ecologically and socially more responsible way.

THE WISDOM OF THE MARKETPLACE:

Business person:
The trends are clear. Global income is rising faster than human population. Illiteracy is declining. Agri-cultural production has increased because it responds to growing demand. Life on the planet is better than ever. If we have environmental problems it is only because property rights are poorly defined or prices do not reflect the true costs. Once we get the prices right, the "Invisible Hand" will take care of those problems. Prices are the most effective way to tell people what to do and what not to do and government interference should be kept to a minimum. Society's needs will then be met as people pursue their own individual interests.



Dr. Footnote: You're right, to a point. When nature's goods and services are underpriced they become overused and abused, and the "Invisible Hand" that is supposed to automatically balance the market becomes the destabilizing "Invisible Elbow." Thus, adjusting prices through depletion taxes and pollution charges, for example, can be effective in reducing activities that are ecologically destructive. However, the Invisible Hand may often depend on the Ecological Footprint to work its magic. Ecological Footprint analysis may help us to assess the true social costs of growth because it makes visible many impacts to which traditional monetary analysis is usually blind. But let's be realistic, the "free market" will not solve all our problems. Not everything of value can (or should) be privatized and not all nature's services can even be quantified, let alone priced.



(What's the market price of a stable and predictable climate? How much ozone layer is enough?) The fact is that many decisions about people, resources and the ecosphere will continue to rely on partial scientific information and political judgment. Even such economic incentives as resource depletion taxes and tradable pollution rights require government intervention in the economy.

By the way, there is nothing inconsistent between your global economic trends and Ecological Footprint analysis. Higher incomes mean greater access to resources and bigger Ecological Footprints for the privileged minority. However, superabundance today does not guarantee even adequacy tomorrow. Much of our present "income" is derived from the liquidation of natural capital. Our Footprints are expanding even as the land upon which we stand shrinks beneath us.

THE DOCTRINE OF FREE TRADE:

Pilot: It seems to me that the Ecological Footprint questions the value of trade. I don't want to live in the Middle Ages! Trade is beneficial to everyone. For example, in North America, we cannot grow coffee and bananas, while coffee and banana exporters may not be able to build computers or grow wheat. Also, it is more economically efficient if we produce the products where it is ecologically most efficient. For example, is it not stupid to grow winter tomatoes in heated greenhouses in Canada rather than import them from California or Mexico?

Dr. Footnote: Ecological Footprint analysis is not against trade per se. However, it examines trade through an ecological lens and reveals its environmental consequences. When economists talk about trade balances they refer only to money flows, not ecological flows. The fact is that some areas constantly give up ecological productivity, while others continuously draw on it. For example, Hong Kong, Switzerland and Japan, which have positive dollar trade balances, provide little ecological productivity to the world, while importing a great deal from other places to maintain their high levels of consumption. Unfortunately, not everybody can be a net importer of ecological goods and services. On the global scale, for every importer there must be an exporter. This means that even though most developing nations are trying to follow the development of places like Japan, Hong Kong or Switzerland, it is physically impossible for all of them to succeed.

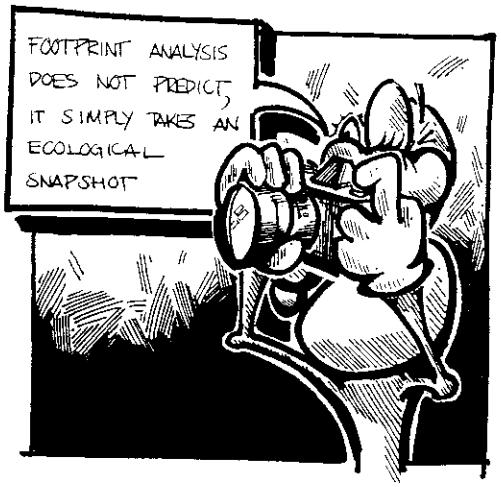
Expanding world trade leads to increased global resource flows, which stimulates total economic production and accelerates the depletion of the planet's natural assets — and there are other problems. People who live on ecological goods imported from afar (and on "common-pool" ecological functions such as climate control, which are shared by everyone) are spatially and psychologically disconnected from the resources that sustain them. They lose any direct incentive to conserve their own local resources and have no hand in the management of the distant sources of supply. In fact, they may remain blissfully unaware of both the ecological and social effects of prevailing terms of trade. Modern intensive production methods not only accelerate the depletion and

contamination of field and forest, but the economic benefits of the increased productivity are inequitably distributed, particularly in low-income countries. Those who need the income may actually be displaced from the land to make way for export crops while the profits flow mainly to the already well-off. In short, in a world where the global economy is already pressing ecological limits and poverty still stalks a billion people, we don't need "free trade," but terms of trade that encourage the rehabilitation of natural capital and direct the benefits of export activities to those who need them most.

THE UNCERTAIN FUTURE:

Fortune Teller: Ecological Footprint analysts claim to see the future. But predictions and extrapolations are always way off. The only thing we know about the future is that it is likely to be different from what we think it will be. Even I have difficulty seeing into the future with my crystal ball...

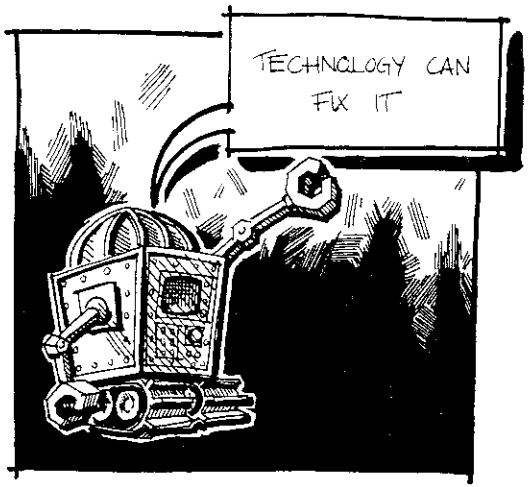
Dr. Footnote: Ecological Footprint analysis is not a predictive tool. It is an "ecological camera" that takes a snapshot of our current demands on nature. Extrapolation to the anticipated human population and resource flows in 2040 does suggest there are serious biophysical barriers on our current development path, but the numbers do not predict how things will turn out. Rather, they measure the "sustainability" gap that society must somehow close to ensure a stable future. In short, Ecological Footprint analysis can show how much we have to reduce our consumption, improve our technology, or change our behavior



to achieve sustainability. It can also reveal with graphic clarity the chronic material inequity that persists between affluent and low-income countries today. Most important, Ecological Footprint analysis suggests some of the ways society can begin the shift toward sustainability and which of these measures provide the greatest leverage. To reiterate, this tool is not a telescope into the future, but a way to visualize the consequences of current trends and to assess alternative "what if" scenarios on the road to sustainability.

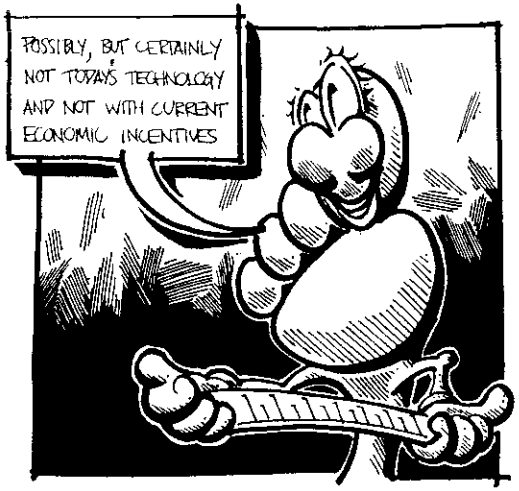
THE TECHNOLOGICAL FIX:

Robot: For hundreds of years people have worried that we would run out of land or resources. But no: the technological revolution has increased the abundance and lowered the prices of goods and services. Thanks to technology, a single farmer produces more than 200 farmers did 200 years ago. Thanks to



technology, millions of people in North America live more comfortably, are healthier, feel more secure and eat better than even kings and queens could dream of a few hundred years ago.

Who could have anticipated the computer revolution? Who can anticipate the future benefits of genetic engineering? For the last two hundred years, technology has successfully met the challenges of growth. Once people are faced with a problem, they will come up with a solution. Our greatest resource is the human mind, and the potential for innovation is unlimited. Just think about recent advances in medicine, transportation and communications. Why shouldn't we be able to fix any problem in the future?

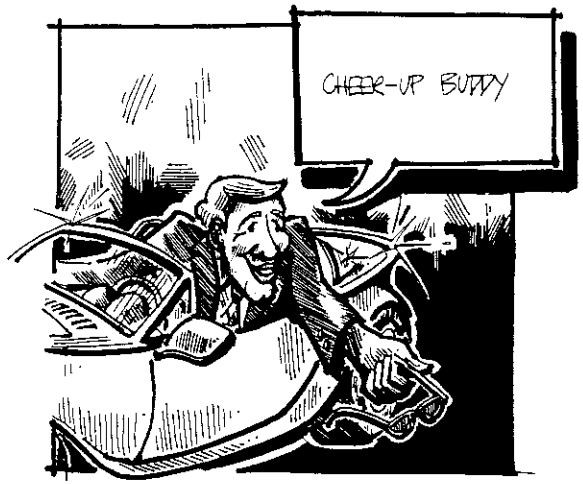


Dr. Footnote: Ecological Footprint analysis does not question the importance of technological innovation. In fact, technology will play a major role in making society more sustainable. If we really want to build a global economy five to 10 times the size of today's (as suggested by the Brundtland report), then we need technology that makes us five to 10 times more resource-efficient. Some analysts already refer to this as the "factor-10" economy (see chapter 4).

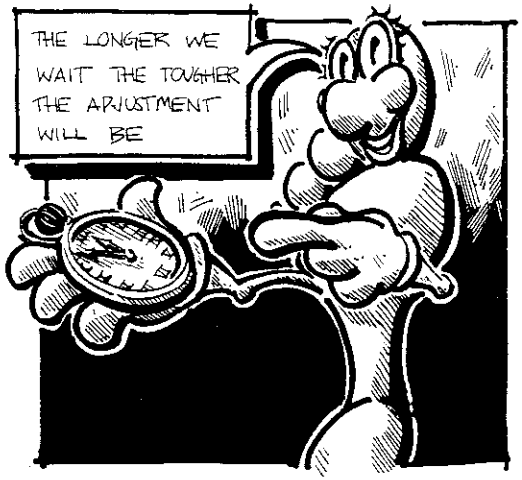
Clearly, improved technologies are essential. Even simple things like solar water heaters or better insulation in our houses can reduce our Footprint without compromising our material standards of living. However, keep in mind that many technological innovations have not reduced our use of resources, but only substituted capital — resources and machines — for labor. For example, while modern agriculture produces more output per farmer than traditional agriculture, it requires much more energy, materials and water per unit of crop produced (as the tomato example shows in Chapter 3). Also, in present circumstances, gains in technological efficiency often encourage increased consumption — more efficient cars are more economical and are consequently used more frequently by more people. Indeed, in spite of efficiency gains, most industrial countries' total energy consumption has increased in recent years. In this context, the Ecological Footprint can be an important measuring rod of progress toward sustainability. Can new technology increase or reduce society's demand on nature? It depends; if new technology is to reduce our Ecological Footprint, it must be accompanied by policy measures to ensure that efficiency gains are not redirected to alternative forms of consumption.

THE MANTRA OF OPTIMISM:

Optimist: Ecological Footprint analysis is depressing. It paints a bleak picture of the future. People like you seem to have an affinity for apocalyptic visions. Such visions have existed all through human history, but they have never come true. Why do you not look on the bright side of life? Stop to smell the roses — let's have a good time!



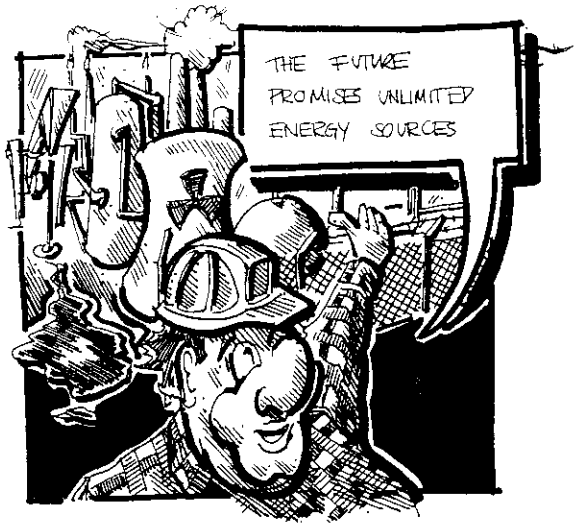
Dr. Footnote: Acknowledging that nature has a finite capacity is not pessimistic, just realistic. It makes room for wise decisions. To ignore these basic constraints would jeopardize future well-being. Ecological Footprint analysis starts from the premise that humanity must live within global



carrying capacity. It also maintains that if we choose wisely it might even be possible to increase our quality of life. Our concern is that the way we now live on the planet is self-destructive. The Footprint is a tool that facilitates learning about ecological constraints and developing a sustainable lifestyle. The earlier humanity starts to act upon the new challenges, the easier it will be.

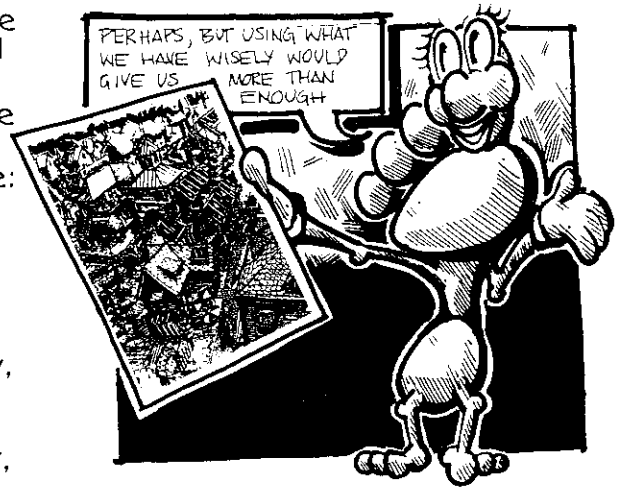
THE GROWTH OF LIMITS:

Energy Producer: Energy is the driving force of the human enterprise. If we have enough energy, we can do anything we like: clean up the environment, irrigate deserts, build fast transport-ation networks, power highly productive greenhouses — you name it! Today's ecological scarcity is only temporary. It won't be long before we develop



unlimited energy sources. Fusion energy is promising and we have hardly tapped into the potential for conventional fission power. And, imagine the potential if we could use all the tidal wave or solar energy that goes to waste today!

Dr. Footnote: Some people do hope that humanity will be able to harness unlimited energy supplies. In fact, we already are endowed with a huge energy source: the sun beams 175,000 terawatts to our planet, compared to just 10 terawatts of commercial energy, mainly fossil fuel, used by the human economy. However, imagine the impact of an unlimited energy supply, if not used wisely or with restraint. We've run down much of the planet with just 10 terawatts! Unlimited cheap energy could simply expand human activities further, depleting other natural capital stocks until we run into some new — and probably more severe — limiting factor. It may not be energy resources, but the waste assimilation capacity of our planet, that becomes most limiting. For example, while we used to be concerned about running out of fossil fuel, scientists now realize that CO_2 sinks are even scarcer (they're already filled to overflowing).



Of course, used with due caution, technology can help to overcome ecological scarcity. Indeed, moving toward a solar economy may be the most promising strategy for reducing our Ecological Footprint. Solar energy, with all its necessary equipment, will be more expensive, and we will use it more wisely. However, with a solar economy we should be able to secure a higher future quality of life.

Planning for a Sustainable Future

The Ecological Footprint is a tool to help us plan for sustainability. It not only addresses such global concerns as ecological deterioration and material inequity, it also links these concerns to individual and institutional decision-making. Further refinement is necessary to develop the tool's full potential for planning practitioners' everyday decisions. However, it has already been applied in over 20 different situations, including those presented as examples in this book. In these applications, which range from environmental outdoor education for children to policy and project assessments for municipalities, Ecological Footprint analysis is already helping to frame sustainability issues and solutions in Canada and several other countries.

Ecological deterioration and social injustice can be reversed — there are

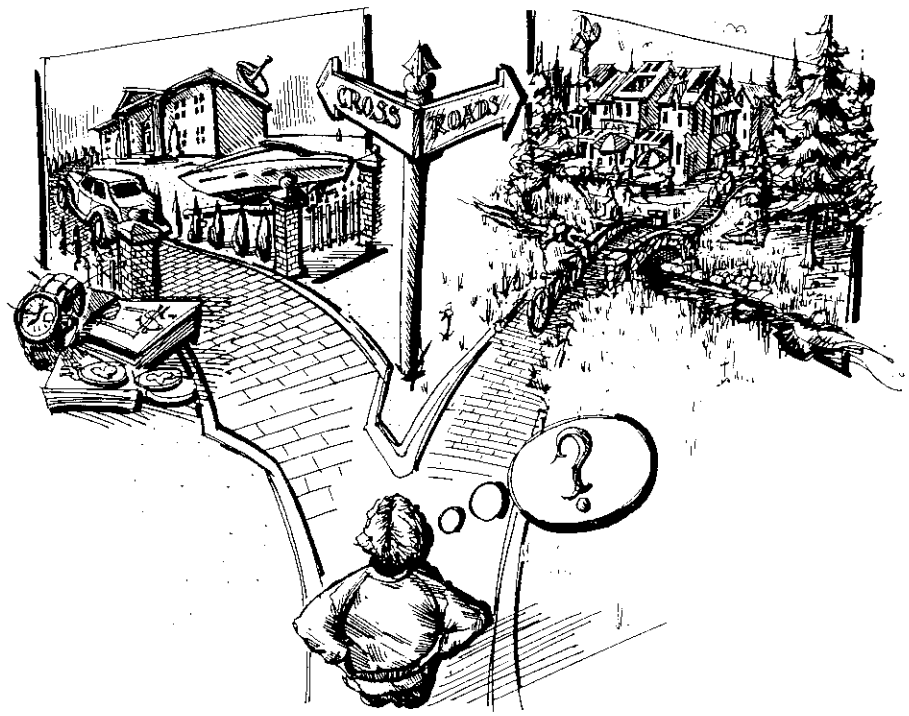


Figure 1.7: Paths We Can Choose.
What kind of future would you like and how can we get there?

thousands of conceptual tools and inspiring ideas about how to plan for a safer and more secure world. The Ecological Footprint is one of these tools. It helps us to understand both our present situation and the implications of policy choices.

Ecological Footprint analysis helps to put things in the larger perspective. To return to a previous image, we interpreted the Footprint of a city as the total area that would have to be enclosed with the city under a glass capsule to sustain the consumption patterns of the people in that city. Even without actual data, this mental image illustrates an important reality: as a result of high population densities, the rapid rise in *per capita* energy and material consumption, and the growing dependence on trade (all of which are facilitated by technology), *the ecological locations of human settlements no longer coincide with their geographic locations.* Modern cities and industrial regions are dependent for survival and growth on a vast and increasingly global hinterland of ecologically productive landscapes.

There is a small irony here — many science fiction writers have also evoked the image of a domed city, but in science fiction the device is usually needed to isolate and protect the human habitat from a hostile external environment. By contrast, our capsule experiment emphasizes that, without free access to the "environment," it is the isolated human habitat that becomes hostile to human life!

Thinking about such an encapsulated city forces us to consider not only all the ways in which we remain dependent on nature, but also on all the ways we can reduce humankind's negative impact on the systems that sustain us. For example, assume for a moment that *your* city or community is confined within a human terrarium as described above. That is, the hemisphere containing your city is just adequate to sustain the present population at prevailing material standards. Now ask yourself what the planning process and land-use bylaws might look like in the urban capsule. What sort of decision-making process would there be and who would be involved? What "trade-offs" and development costs that we currently ignore suddenly become very important? What criteria might be used to decide between private interests and the common good? To make this really interesting and more concrete, compare the desired planning process and legal regime with those currently in use in your community. Why are they different? Do these differences really make sense when we consider that the ecosphere is nothing but one big capsule containing the entire human family? The following chapters take off from here to explain how the Ecological Footprint concept contributes to building a sustainable society.