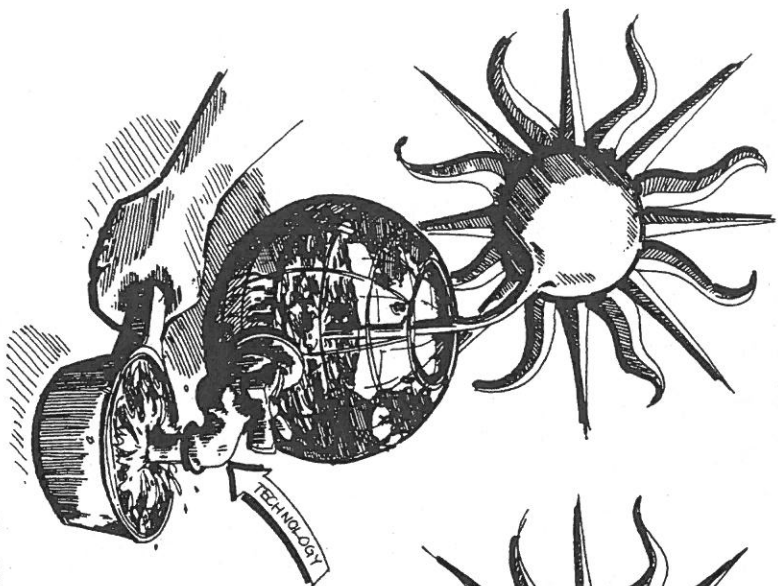


TECHNOLOGICALLY ACCELERATED
RESOURCE USE



SUSTAINABLE
RESOURCE USE

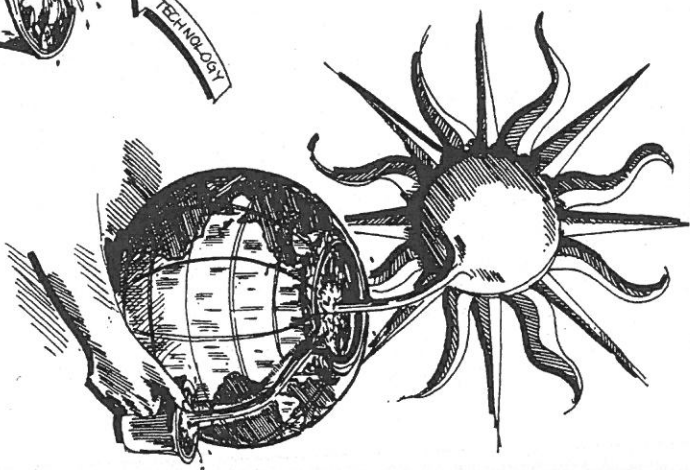


Figure 2.1: Sustainable Use: The Water Bucket Analogy.

Imagine a bucket being filled with water at a fixed rate. The water in the bucket is being a capital stock that can be drawn upon only as rapidly as the bucket is being refilled. This balanced withdrawal rate is a form of sustainable income. Similarly, nature is a "bucket" that is continuously replenished by the sun: photosynthesis produces plant matter, the basis for all biological capital and most other life, and climatic, hydrological, and other biophysical cycles are solar powered too. Sustainability implies that nature's capital should be used no more rapidly than it can be replenished (right). However, trade and technology have enabled human-kind progressively to exploit nature far beyond sustainable levels so that present consumption exceeds natural income (the "interest" on our capital). This leaves the next generation with depleted capital and less productive potential even as the population and material expectations increase (left).

acknowledging that there is.

Of course, if environmental scientists are correct (and we believe they are) the consequences of *not* acknowledging material constraints on the economy

BOX 2.2: On Natural Capital⁵

Natural capital refers to any stock of natural assets that yields a flow of valuable goods and services into the future. For example, a forest, a fish stock or an aquifer can provide a harvest or flow that is potentially sustainable year after year. The forest or fish stock is "natural capital" and the sustainable harvest is "natural income." Natural capital also provides such services as waste assimilation, erosion and flood control, and protection from ultraviolet radiation. (Thus, the ozone layer is a form of natural capital.) These life-support services are also counted as natural income. Since the flow of services from ecosystems often requires that they function as intact systems, the structure and diversity of the system may be an important component of natural capital.

Researchers typically focus on three categories of natural capital: renewable, replenishable and non-renewable. Renewable natural capital, such as living species and ecosystems, is self-producing and self-maintaining using solar energy and photosynthesis. Replenishable natural capital includes surface and ground water supplies and the stratospheric ozone layer. These stocks are non-living but are continuously restored, often through some other solar mechanism. By contrast, non-renewable forms of natural capital such as fossil fuel and minerals are analogous to inventories. Any use implies liquidating part of the stock. Since adequate stocks of self-producing and replenishable natural capital are essential for life-support (and are generally non-substitutable), we consider these categories of natural capital to be more important to sustainability than non-renewable forms.

It should be apparent from the above that Earth's "natural capital" is more than just an inventory of industrial resources; it comprises also those components of the ecosystem, and the structural relationships among them, whose organizational integrity is essential for the continuous self-production and self-regulation of the system itself. Indeed, it is this highly evolved structural and functional integration that makes the ecosystem the uniquely livable "environment" it is. In effect the ecosystem is produced, in part, by the very organisms it comprises. In addition, geoclimatic, hydrological and ecological cycles do not simply transport and distribute nutrients and energy but are among the self-regulatory, homeostatic mechanisms that stabilize conditions on Earth for all contemporary life-forms, including humankind. All these, too, are forms of natural capital.

are scarier than anything the shift to sustainability might imply. Our increasingly global consumer lifestyle — living as if there were no biophysical limits to nature — not only undermines global life-support but also threatens geopolitical stability. In this context, the good news is that today so many people today accept the sustainability challenge as the first step toward a more secure future. The bad news is that the economic and political mainstream shows little sign of recognizing biophysical constraints of any kind. Indeed, "official"

Learning from ecology: revisiting human carrying capacity

The renewed debate around the natural capital constraints on the economy demands that we revisit the ecological concept of carrying capacity.¹¹ Does it make sense to talk of the *human* carrying capacity of Earth? For purposes of game and range management, carrying capacity is usually defined as the

BOX 2.5: A Brief History of the Human Carrying Capacity Concept¹³

The oral history of concern about the relationship between people and land must go back thousands of years. Many Chinese and early Christian scholars worried about the destruction of habitat. Plato may have provided the first written account of human carrying capacity as he declared in *Laws*, Book V, that a

...suitable total for the number of citizens cannot be fixed without considering the land and the neighboring states. The land must be extensive enough to support a given number of people in modest comfort, and not a foot more is needed.

The first scholarly book on sustainable practice in the English language may be John Evelyn's *Sylva: A Discourse of Forest, Trees and the Propagation of Timber* published in 1664, two hundred years before George Perkins Marsh's study *Man and Nature* initiated the scientific debate in North America on nature's limited capacity to satisfy human demands.

Ecological accounting, the basis for carrying capacity assessments, can be traced back to at least as early as 1758. In that year, François Quesnay published his *Tableau Economique* in which the relationship between the productivity of land and wealth creation was discussed. Since then, many scholars have developed conceptual approaches and accounting procedures to analyze the relationship between people and nature.

Some of them looked at energy flows needed to support human activities. For example, in 1865 economist Stanley Jevons in *The Coal Question*, analyzed the importance of energy resources for the United Kingdom's economic performance. In the late 1800s, Serhii Podolinsky initiated the field of agricultural energetics. In the following decades, the eminent physicists Rudolf Clausius and Ludwig Boltzmann, and later Nobel Laureate Frederick Soddy, reflected upon the implications of the entropy law on economic development. Alfred Lotka introduced energy analysis to biology in the 1920s, and in the 1970s economist Nicholas Georgescu-Roegen challenged economics using thermodynamic principles.

Others have more explicitly examined the carrying capacity requirements of economies. For example, with his 1798 *Essay on the Principles of Population as It Affects the*

maximum population of a given species that can be supported indefinitely in a specified habitat without permanently impairing the productivity of that habitat. However, because of our seeming ability to increase human carrying capacity by eliminating competing species, by importing locally scarce resources, and through technology, this definition does not seem applicable to humans. Indeed, trade and technology are often cited as reasons for rejecting

Future Improvement of Society, Reverend Thomas Malthus initiated the debate on agriculture's seemingly limited ability to feed an ever larger human population. Even the Ecological Footprint has conceptual predecessors; in his above-mentioned book, Stanley Jevons observed that:

the plains of North America and Russia are our [British] corn-fields; Chicago and Odessa our granaries; Canada and the Baltic are our timber-forests; Australasia contains our sheep-farms, and in Argentina and on the western prairies of North America are our herds of oxen; Peru sends her silver, and the gold of South Africa and Australia flows to London; the Hindus and the Chinese grow tea for us, and our coffee, sugar and spice plantations are all in the Indies. Spain and France are our vineyards and the Mediterranean our fruit garden, and our cotton grounds, which for long have occupied the Southern United States, are now being extended everywhere in the warm regions of the Earth.

Forty years later, in 1902, physicist Leopold Pfaunder calculated global carrying capacity, concluding that as an upper limit, ecological production could sustain about five people per hectare of land. In North America, William Vogt (1948) and Fairfield Osborn (1953) are associated with the renewed academic interest in carrying capacity questions. Georg Borgstrom in his various publications in the 1960s and early 1970s analyzed resource consumption in terms of "ghost acreage," which referred to imported agricultural carrying capacity. One of us (Rees) developed the "regional capsule" (subsequently the Ecological Footprint) concept in the early 1970s as a teaching tool to stimulate multidisciplinary planning students to think about human carrying capacity. In 1980, William Catton added a new dimension to the human carrying capacity debate by describing the implications of overshoot — temporarily exceeding the long-term carrying capacity — and the subsequent population crash. G. Higgins and his collaborators produced a technical report in 1983 analyzing the population-supporting capacities of most developing countries for the United Nations Food and Agriculture Organization (FAO). In 1985, Ragnar Overby, then at the World Bank, proposed comparing economies by their demand on carrying capacity, and in 1986 M.A. Harwell and T.C. Hutchinson analyzed the loss of carrying capacity that would follow nuclear war. Most recently (1993) the Friends of the Earth (Netherlands) proposed the "environmental space" concept to help determine nations' fair shares of global productive/assimilative capacity.

These are only a few examples from the literature on human carrying capacity.

BOX 2.3: Strong or Weak Sustainability?

Many economists believe that "weak sustainability" is good enough. According to this view, society is sustainable provided that the aggregate stock of manufactured and natural assets is not decreasing. In other words, weak sustainability allows the substitution of equivalent human-made capital for depleted natural capital. From this perspective, the loss of the income-earning potential of a former forest is no problem if part of the proceeds of liquidation have been invested in factories of equivalent income-earning potential. By contrast, "strong sustainability" recognizes the unaccounted ecological services and life-support functions performed by many forms of natural capital and the considerable risk associated with their irreversible loss. (In addition to wood fibre, forests provide flood and erosion control, heat distribution, climate regulation, and a variety of other non-market functions and values.) Strong sustainability therefore requires that natural capital stocks be held constant independently of human-made capital. Some authors suggest that manufactured capital stocks must also be held constant for strong sustainability so there is no capital depreciation of any kind. We agree that this is to be preferred, but wish to emphasize the greater importance of maintaining adequate life-supporting natural capital. Remember too that if population and material expectations are rising, capital stocks should actually be enhanced — in other words, it is *per capita* stocks that must be increased.

The weakness of "weak sustainability" is best revealed in a study by David Pearce and Giles Atkinson. Starting from the weak sustainability assumption that natural and human-made capital are substitutable, they ranked the sustainability of 18 representative countries. They propose that "...an economy is sustainable if it saves more [in monetary terms] than the depreciation on its [human-made and natural capital...". As a result, Japan, the Netherlands and Costa Rica head the list of sustainable countries, while the poorest nations in Africa are identified as the most unsustainable. This comparison demonstrates the ecological irrelevance of "weak sustainability." It fails to recognize that much of the so-called rich countries' money savings comes from the depletion of other countries' natural capital and exploitation of global common-pool assets. For example, the apparent economic sustainability of both Japan and the Netherlands depends on large-scale imports (see Box 3.5). In effect, high material standards are maintained by a massive but unaccounted ecological deficit with the rest of the world (including some of the countries labeled "unsustainable").

BOX 2.1: Sustainability and Sustainable Development: Some Clarification⁴

The need for humanity to *live equitably within the means of nature* is the underlying message of most definitions of sustainable development beginning with the Brundtland Commission's widely accepted call to "...[meet] the needs of the present without compromising the ability of future generations to meet their own needs." However, despite the widespread acknowledgement of the ecological and social symptoms of the problem, interpretations of sustainable development and its implications are contradictory, even within the Brundtland Commission's report.

One reason for conflicting interpretations of the fundamental sustainability message is obvious — the term "sustainable development" is itself treacherously ambiguous. Many people identify more with the "sustainable" part and hear a call for ecological and social transformation, a world of environmental stability and social justice. Others identify more with "development" and interpret it to mean more sensitive growth, a reformed version of the status quo. Sharachandra Léle writes that the various interpretations of sustainable development are caused not by poor understanding, but rather by ideological differences and reluctance of many to acknowledge the implications of the underlying message. The deliberate vagueness of the concept, even as defined by Brundtland, is a reflection of power politics and political bargaining, not a manifestation of insurmountable intellectual difficulty. Michael Redcliff comments that "...unless we are prepared to interrogate our assumptions about both development and the environment and give political effect to the conclusions we reach, the reality of unsustainable development will remain...."

As suggested above, some of the confusion around "sustainable development" is rooted in general failure to distinguish between true development and mere growth. Economist Herman Daly clarifies the difference by defining "growth" as an increase in size through material accretion while referring to "development" as the realization of fuller and greater potential. In short, growth means getting bigger while development means getting better. For Daly, then, "sustainable development" is progressive social betterment without growing beyond ecological carrying capacity. Indeed, he regards "sustainable growth" as a nonsensical self-contradiction. Developing sustainability may actually require a *reduction* in aggregate economic throughput, while enabling the poor to consume more.

There are other ambiguities hidden in "sustainable development." It could refer to: a) the necessary conditions to live sustainably (a goal or state of being); b) the sociopolitical means of achieving the goal (a planning process); or, c) particular strategies to solve present problems (piecemeal solutions). Failure to clarify how the term is being used in a specific context can lead to fruitless misunderstanding. To some ears, the term "developing sustainability" is less ambiguous and is to be preferred over "sustainable development."

