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ECOLOGICAL ARGUMENTS AND FOOTPRINTS WITH AREA BASED INDICATORS OF SUSTAINABILITY

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ABSTRACT

Conventional wisdom suggests that because of technology and trade, human carrying capacity is infinitely expandable and therefore virtually irrelevant to demography and development planning. By contrast, this article argues that ecological carrying capacity remains the fundamental basis for demographic accounting. A fundamental question for ecological economics is whether remaining stocks of natural capital are adequate to sustain the anticipated load of the human economy into the next century. Since mainstream (neoclassical) models are blind to ecological structure and function, they cannot even properly address this question. The present article therefore assesses the capital stocks, physical flows, and corresponding ecosystems areas required to support the economy using "ecological footprint" analysis. This approach shows that most so-called "advanced" countries are running massive unaccounted ecological deficits with the rest of the planet. Since not all countries can be net importers of carrying capacity, the material standards of the wealthy cannot be extended sustainably to even the present world population using prevailing technology. In this light, sustainability may well depend on such measures as greater emphasis on equity in international relationships, significant adjustments to prevailing terms of trade, increasing regional self-reliance, and policies to stimulate a massive increase in the material and energy efficiency of economic activity

INTRODUCTION

According to research carrying capacity is the fundamental basis for demographic accounting. On the other hand, conventional economists and planners generally ignore or dismiss the concept when applied to human beings. Their vision of the human economy is one in which "the factors of production are infinitely substitutable for one another" and in which "using any resource more intensely guarantees an increase in output". As Daly (1986) observes, this vision assumes a world "in which carrying capacity is infinitely expandable". Clearly there is great division over the value of carrying capacity concepts in the sustainability debate.

This article sides solidly with Hardin. I start from the premise that despite our increasing technological sophistication, humankind remains in a state of "obligate dependence" on the productivity and life support services of the ecosphere. Thus, from an ecological perspective, adequate land and associated productive natural capital are fundamental to the prospects for continued civilized existence on Earth. However, at present, both the human population and average consumption are increasing while the total area of productive land and stocks of natural capital are fixed or in decline. These opposing trends demand a revival of carrying capacity analysis in sustainable development planning.

This is an ironic error shrinking carrying capacity may soon become the single most important issue confronting humanity. The reason for this becomes clearer if we define carrying capacity not as a maximum population but rather as the maximum "load" that can safely be imposed onthe environment by people. Human load is a function not only of population but also of per capita consumption and the latter is increasing even more rapidly than the former due (ironically)to expanding trade and technology.

THE ECOLOGICAL ARGUMENT

Despite our technological, economic, and cultural achievements, achieving sustainability requires that we understand human beings as ecological entities. Indeed, from a functional perspective, the relationship of humankind to the rest of the ecosphere is similar to those of millions of other species with which we share the planet. We depend for both basic needs and the production of artifacts on energy and material resources extracted from nature and all this energy/matter is eventually returned in degraded form to the ecosphere as waste. The major material difference between humans and other species is that in addition to our biological metabolism, the human enterprise is characterized by an industrial metabolism. In ecological terms, all our toys and tools are "the exosmotic equivalent of organs" and like bodily organs, require continuous flows of energy and material to and from "the environment" for their production and operation.

This approach shows that humankind, through the industrial economy, has become the dominant consumer in most of the Earth's major ecosystems. We currently "appropriate" 40% of the net product of terrestrial photosynthesis and 25-35% of coastal shelf primary production and these may be unsustainable proportions. At the same time some global waste sinks seem full to overflowing. A fundamental question for ecological economics, therefore, is whether the physical output of remaining species populations, ecosystems, and related biophysical processes and the waste assimilation capacity of the ecosphere are adequate to sustain the anticipated load of the human economy into the next century while simultaneously maintaining the general life support functions of the ecosphere.

TECHNOLOGY AND TRADE

As previously noted, conventional analysts often argue that trade and technology expand ecological carrying capacity. This is a misconception. Even in the best of circumstances, technological innovation does not increase carrying capacity per se but only the efficiency of resource use. In theory shifting to more energy and material efficient technologies should enable a defined environment to support a given population at a higher material standard or a higher population at the same material standard, thereby seeming to increase carrying capacity. However, in either case, the best we could hope for in an increasingly open global economy would be to maintain total human load constant in the vicinity of carrying capacity the latter would still ultimately be limiting. As Saunders notes this counter intuitive hypothesis has been the focus of considerable controversy. He tested it using neoclassical growth theory and found that energy efficiency gains might well increase aggregate energy consumption by making energy cheaper and by stimulating economic growth, which further "pulls up" energy use. How might this work? If a firm saves money by switching to more energy- and material efficient manufacturing processes, it will be able to raise wages, increase dividends, or lower prices,which can lead to increased net consumption by workers, shareholders, or consumers respectively. These behavioral responses to changes in prices and income are referred to as the "rebound effects" by economists. Similarly, technology-induced money savings by individuals are usually redirected to alternative forms of consumption, canceling some or all of the initial potential benefit to the environment. To the extent that such mechanisms contribute to increased aggregate material consumption and accelerated stock depletion, they indirectly reduce carrying capacity. More generally, however, technology can directly reduce carrying capacity whilecreating the illusion of increasing it! We often use technology to increase the short-term energy and material flux through exploited ecosystems. This seems to enhance systems productivity while actually permanently eroding the resource base. For example, the effectiveness of electronic fish-finding devices and high-tech catching technology has overwhelmed the reproductive capacity of fish stocks energy-subsidized intensive agriculture may be more productive than low-input practices in the short term, but it also increases the rate of soil and water depletion. The net effect is to create unsustainable dependencies on enhanced material flows while reducing long term carrying capacity.

The carrying capacity gains from trade are also illusory. While commodity trade may release a local population from carrying capacity constraints in its own home territory, this merely displaces some fraction of that population's environmental load to distant export regions. In effect, local populations import others' "surplus" carrying capacity. The resultant increase in population and resource use in import regions increases the aggregate load of humanity on the ecosphere but there is no net gain in carrying capacity since trade reduces the load-bearing capacity of the export regions.

These comments are not to be taken as arguments against technology or trade per se. Rather the point is to emphasize that conventional assumptions about both should be carefully reexamined in light of carrying capacity considerations and that certain conditions must be satisfied before either can contribute to ecological sustainability.

ECOLOGICAL FOOTPRINTS

We can now redefine human carrying capacity as the maximum rates of resource harvesting and waste generation that can be sustained indefinitely without progressively impairing the productivity and functional integrity of relevant ecosystems wherever the latter may be located. The size of the corresponding population would be a function of technological sophistication and mean per capita material standards. This definition reminds us that regardless of the state of technology, humankind depends on a variety of ecological goods and services provided by nature and that for sustainability, these must be available in increasing quantities from somewhere on the planet as population and mean per capita resource consumption increase.

A simple mental exercise serves to illustrate the ecological reality behind this approach. Imagine what would happen to any modern human settlement or urban region, as defined by its political boundaries or the area of built-up land, if it were enclosed in a glass or plastic hemisphere completely closed to material flows. Clearly the city would cease to function and its inhabitants would perish within a few days. The population and economy contained by the capsule would have been cut off from both vital resources and essential waste sinks leaving it to starve and suffocate at the same time. In other words, the ecosystems contained within our imaginary human terrarium would have insufficient carrying capacity to service the ecological load imposed by the contained population.

This mental model illustrates the simple fact is that as a result of high populationdensities, the enormous increase in per capita energy and material consumption made possible bytechnology, and universally increasing dependencies on trade, the ecological locations of human settlements no longer coincide with their geographic locations. Twentieth century cities and industrial regions are dependent for survival and growth on a vast and increasingly global hinterland of ecologically productive landscapes. It seems that in purely ecological terms, modern settlements have become the human equivalent of cattle feedlots.

CONCLUSION

Appropriated carrying capacity and ecological footprint analysis provide several informative area-based indicators of sustainability. Unfortunately, these same indicators reveal that we are presently falling distressingly short of achieving that elusive goal. Such findings do not, however, support a counsel of despair. Rather, ecological footprint analysis raises a cautionary signal, suggests a variety of concrete sustainability guidelines, and supports a broadly-based program of reforms that could redirect us in the direction we all seem to want to go. In short, to the extent that the assumptions and prescriptions of this approach are a better reflection of material reality that those of mainstream models, the present analysis is a good newsstory. The bad news is that most of the world seems committed as never before to the well-worn expansionist path.

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