Technological Progress and Biodiversity Conservation: a Dollar Spent, a Dollar Burned

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Introduction

Biodiversity at all levels is important to the composition, structure, and functioning of ecosystems, and it provides many of the ecological services underpinning the human economy. Therefore, challenges to biodiversity conservation have become a major topic of academic and public debate. I have argued theoretically (Czech 2000) and empirically (Czech et al. 2000) that economic growth is the primary challenge to biodiversity conservation and ultimately to human economic sustainability. However, technological progress is proffered as a reconciler of economic growth and biodiversity conservation (Lomborg 2001).

Here, I present a theoretically and empirically derived opinion on the prospect of reconciling economic growth and biodiversity conservation via technological progress. I describe the nature and sources of technological progress and hypothesize that technological progress does not occur except via economic growth at preexisting levels of technology. If this hypothesis is correct, then technological progress will not reconcile economic growth with biodiversity conservation, and a steady-state economy will be required for biodiversity conservation and a sustainable society. I also posit that a steady-state economy does not entail technological stagnation but does entail de-institutionalization of technological progress.

Economic Growth and Biodiversity Conservation

Two of the major challenges to biodiversity conservation are human population growth and, in the developed nations, increasing per capita consumption. The synthesis of these two trends is economic growth, an increase in the production and consumption of goods and services. The economic growth occurring within a nation's borders is typically guaged by gross domestic product (GDP). For the world, we may refer to the size of the human economy as gross global product (GGP).

Pursuant to the ecological principle of competitive exclusion, resource consumption by any species increases only at the expense of other species. The scope of competitive exclusion is determined by the breadth of the species' niche. Due to the tremendous breadth of the human niche, the scale of the human economy (GGP) expands at the competitive exclusion of nonhuman species in the aggregate. Growth in GGP occurs via the reallocation of natural capital (water, forests, minerals, etc.) from the "economy of nature"—used here to refer to nonhuman species in the aggregate—to the human economy. This relationship is consistent with the few studies that have analyzed species endangerment explicitly in terms of economic scale and sectors (Czech et al. 2000; Naidoo & Adamowicz 2001). It suggests that national and international goals of economic growth and biodiversity conservation are conflicting. However, policymakers throughout the world have denied that this conflict exists, claiming instead that economic growth and biodiversity conservation may be reconciled via technological progress.

In the vernacular, technological progress refers to invention and innovation. In economic terms, however, not all inventions and innovations result in technological progress. In economics, technological progress occurs when more is produced with a given amount of resource input; it is synonymous with rising productive efficiency. It would seem that technological progress in its strict economic sense would indeed offer a way out of the conflict between economic growth and biodiversity conservation.

Yet the list of causes of species endangerment is a virtual who's who of the human economy. The various

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economic sectors have a "trophic structure" as in the economy of nature, with its producers (plants), consumers (herbivores, omnivores, and carnivores), and service providers (e.g., detritivores). In the human economy, agriculture and extraction form the productive base, supporting manufacturing sectors from heavy to light, all of which are aided by banking, insurance, and other services. Technological progress has long characterized the dynamics of this trophic structure. Some of the technology has been sector-specific (e.g., crop-harvesting implements), whereas some has been employed in all sectors (e.g., computer technology). With all this technological progress, why does biodiversity continue to decline? To answer this question, it is necessary to investigate the nature and sources of technological progress.

Nature and Sources of Technological Progress

There are two basic types of technological progress: extractive and end-use (Wils 1998). The purpose of extractive technology is extraction of natural capital, as in, for example, mechanical engineering, which allows for mining at deeper depths. Extractive technological progress is clearly not conducive to biodiversity conservation because, if employed, it results in the reallocation of more natural capital from the economy of nature to the human economy. End-use technological progress, on the other hand, increases productive efficiency without necessitating a reallocation of natural capital from the economy of nature to the human economy. An example is the development of more fuel-efficient engines. This type of technological progress is central to the concept of "natural capitalism." Theoretically, if end-use technological progress were the sole source of economic growth, it could reconcile economic growth with biodiversity conservation.

However, the income saved via end-use efficiency may simply be spent on more end uses. For example, money saved on fuel costs as a result of fuel-efficiency technology may then be used to purchase more fuel or other goods and services, all of which represent one of the sectors of the human economy and all of which entail the reallocation of natural capital consistent with the principles of trophic theory. One may argue that the income saved did not have to be spent on additional goods and services and that therefore technological progress offered a reconciliation of economic growth and biodiversity conservation that was rejected by the consumer. To the contrary, if the income saved was not spent on additional goods and services, then technological progress may have occurred, but economic growth (an increase in the production and consumption of goods and services) did not.

Another explanation for the failure of technological progress to reconcile economic growth with biodiversity conservation involves the sources of technological progress. Technological progress has been one of the defining traits of the genus *Homo* for 2 million years. Indeed, the sapience ascribed to the remaining hominid has been meted out largely via inventions and innovations, increasing productive efficiency all along. Unlike prehistoric human societies, however, in which virtually all technological progress resulted from individual tinkering, technological progress is now a highly institutionalized process. It is rare today to hear of an invention or discovery of anyone outside of academia, industry, or government, the three of which interact and cooperate to a large degree. Today's technological progress is provided primarily by professional scientists and engineers, and it must be paid for. Programs designed to produce technological progress are generally referred to as "research and development" (R&D).

Because of the relationship of R&D to economic growth, it has been accounted for almost as carefully as the latter. Industry performed about 75.4% ($199.2 billion) of R&D in the United States in 2000 (Payson & Jankowski 2000). Industry also provided about $3.4 billion to universities and nonprofit organizations for R&D in 2000. Only the federal government is a significant additional source of R&D funds; industry and the federal government provided about 95.2% of R&D funding in 2000.

Industry R&D is a function of corporate profits, which prior to technological progress derive primarily from economies of scale, frequently realized via monopolization. Like technological progress, economies of scale offer increased efficiency. Unlike technological progress, however, economies of scale operate precisely via increased consumption. In other words, increased production and consumption must ensue for technological progress via corporate R&D to transpire. Without increasing scale, corporate profits dry up pursuant to competition and principles of general equilibrium.

Federal R&D is dependent almost entirely on corporate and income taxes, with other tax revenues being earmarked for other purposes. Corporate taxes reduce corporate profits, so there is a trade-off between federal R&D and industry R&D. As for income, none of it is unrelated to production. The fundamental identity of national income accounting provides that total income = total expenditure = total production. Therefore, all current income and income-based R&D represents production and consumption of goods and services at current levels of technology (i.e., the production and consumption already operating at the competitive exclusion of nonhuman species). In other words, technological progress does not reconcile the conflict between economic growth and biodiversity conservation because it arises only in tandem with the conflict.

Policy Implications

My argument stops just short of claiming that technological progress cannot reconcile the conflict between economic growth and biodiversity conservation. That would be a theoretical issue well worth considering. My objective is more practical, however, and my argument addresses the issue of whether technological progress does reconcile the conflict between economic growth and biodiversity conservation under current circumstances. In the case of U.S. political economy and its institutional arrangements, at least, it clearly does not.

The implications of this argument may be interpreted as radical, yet they are conservative in a profound way because they call for fiscal conservatism and concomitant conservation of natural capital. Perhaps the major macroeconomic implication is that a steady-state economy with stable population and per capita consumption (i.e., stable GDP) is required for biodiversity conservation and economic sustainability. Pursuant to the steady state, technological progress (at least for purposes of economic growth) would be largely de-institutionalized so that it would not require the reallocation of natural capital from the economy of nature to the human economy. Americans would replace much of their faith in technological progress with the pursuit of other forms of cultural progress.

As Herman Daly recently argued before the World Bank, frugality induces efficiency, but efficiency does not induce frugality; it simply makes frugality less necessary (Herman Daly, 30 April 2002, "Sustainable Development: Definitions, Principles, Policies," World Bank, Washington, D.C.). If biodiversity, ecological integrity, and economic sustainability are good things, then frugality, thrift, and conservation are virtues. In this context, efficiency is just a tool for lessening the ecological impacts of production and consumption and, like most tools, can be used or abused. Efficiency is no substitute for frugality, and economic growth is no substitute for a steady-state economy.

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