Limits to Growth Revisited: A Review Essay

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"If this book doesn't blow everybody's mind who can read without moving his lips, then the earth is kaput." Thus blurbed Robert C. Townsend, former president and CEO of Avis Rent A Car, when *Limits to Growth* appeared in 1972 (Meadows et al. 1972). Despite the fact that I could perform the taxing reading trick described in Townsend's tortured syntax, my mind remained unblown. My most immediate reaction after opening that slim paperback was a twofold surprise. First, why so much fuss about a book that infuriatingly mixed so many truisms (exponential growth of material consumption is supportable for only a limited period of time: I do not think that even the most ardent techno-optimist ever believed that he can own enough television sets to equal the mass of the Earth) with so many arbitrary assumptions (such as a "lifetime multiplier from pollution" that cuts global life expectancy by a fixed number of years).

And I wondered why so much fuss when just about everything in the book was old news: the original modeling exercise had already been published the previous year, and this upgrade added nothing of notable value. While many (most?) people were smitten by the novelty and the daring of it all (modeling the world's fate in a few hundred lines of software!) and excited, as humans always are, by the prospect of civilization's demise (nay, one scientifically foretold by a computer!), what I saw in the first place was a reheated meal, with a bit of spicing and plenty of celebrity-style marketing through a campaign by The Club of Rome that supported this "remarkably ambitious undertaking" (their own self-appraisal) probing the Predicament of Mankind (their capital letters).

Let me digress, giving the reader first a much more egregious (and vastly more lucrative) example of this repackaging phenomenon that has become so widespread in the world of ideas. Microsoft, the world's largest software company, became a global monopolist thanks to products that were actually reheated twice. Microsoft's DOS, which became the monopoly software on all IBM PCs and their numerous clones, was nothing but a prettied-up version of QDOS (Quick and Dirty DOS) that Tim Paterson of Seattle's

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Computer Products wrote in about two months in 1980 (an enhanced version came out in April 1981). In 1998 Paterson admitted that he was not the program's inventor because that "implies a certain level of creativity that wasn't really the case" (Conner 1998). Quite: he bought the CP/M manual before he started to write QDOS: Gary Kildall wrote that pioneering software (Control Program for Microcomputers) in 1973 with his students at the Navy's Postgraduate School in Monterey, California in order to read and write files from the newly developed 8″ floppy disk.

What was true about DOS was also true about Microsoft Windows 1.0 that followed Apple's windows that were, in turn, derived from Xerox's Palo Alto Research Center Star computer. And Microsoft's first Internet Explorer was nothing but Spyglass Mosaic (developed at Urbana-Champaign concurrently with Netscape) with some changes. But Microsoft marketed these derivative products as if they were revolutionary inventions. And so it was with The Limits to Growth: it was just a slightly modified version of Jay W. Forrester's model that linked five key global variables: population, natural resources, capital investment, capital-investment-in-agriculture fraction, and pollution (Forrester 1971). Forrester devised this dynamic model of world interactions very quickly in the early part of July of 1970 after he attended The Club of Rome meeting in Bern in June 1970, where it was agreed that the Massachusetts Institute of Technology's System Dynamics modeling approach should be the principal method adopted for the organization's project on the future of mankind.

The hastily drafted model was reviewed at another Club of Rome meeting in July, where the decision was made to delve more deeply into several of the model's subsystems. But when Forrester's World Dynamics, a 136-page hardback that included all 120 lines of the model's equations and control commands in an appendix, was published in 1971 it did not make any big waves. Those familiar with Forrester's work could see its unmistakable origins in his earlier volumes on Principles of Systems (Forrester 1968) and Urban Dynamics (Forrester 1969) that, in turn, had their origin in his Industrial Dynamics (Forrester 1961). In broader terms, the approach reflected some of the intellectual concerns, and was made possible by some of the emerging technical capacities, of the late 1960s. At that time it became fashionable to assay quantifications of complex systems, and proponents of this approach ranged from Ludwig von Bertalanffy and numerous adherents of general system studies (von Bertalanffy 1969) to consulting modelers at the Rand Corporation in Santa Monica.

Concurrently, new software languages made computerized modeling much easier. BASIC (Beginners All-Purpose Symbolic Instruction Code), the first nonforbidding programming language, was released by John Kemeny and Thomas Kurtz of Dartmouth College in 1964, and Forrester's model was written in DYNAMO, a new language that was tailor-made for this kind of integrative and feedback simulation and that was developed by Alexander L. Pugh III at MIT in the early 1960s (Pugh 1961) and later upgraded in several versions. At the MIT July 1970 meeting, Volkswagen Foundation offered to fund additional modeling work and Dennis Meadows, Forrester's student (and a professor in MIT's System Dynamics group at the Sloan School of Management), became the leader of small team whose principal collaborators included his wife Donella, Jorgen Randers, and William W. Behrens III.

And so Forrester's hasty, brief computer program was expanded, given a more environmental slant—and then the marketing took over. Before the final report was published in 1972 (as The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind) its findings were presented during the summer of 1971 at two well-publicized international meetings, in Moscow and Rio de Janeiro. Principal changes to Forrester's model included subdivision of two main-level variables (population into three age categories; capital into service, industrial, and agricultural segments) and addition of a new subsystem-level variable, arable land. The natural resources subsystem remained unchanged (except for renaming the level variable "nonrenewable resources"), and the pollution subsystem was also left intact, its level responding as before to two specified commands (pollution generation rate and pollution absorption rate).

The final report's basic concern about whether we "may not overshoot the carrying capacity of this planet" and the need to consider "the chilling alternatives such an overshoot implies for ourselves, our children, and our grandchildren" suited perfectly the tenor of the time. Undoubtedly, the report's appearance was perfectly timed as the ground for its acceptance was prepared by the culmination of new-found environmental concerns (the first Earth Day took place in 1970, the UN's first Conference on the Human Environment two years later) and as some of its conclusions seemed to be turning into realities shortly after its publication (OPEC-driven crude oil price increases, beginning in 1973, appeared to confirm one of the report's key tenets, namely that as the world is running out of key natural resources their prices will soar, bringing ever closer the inevitable collapse of modern civilization).

Environmentalists found the report a welcome addition to their moral appeals: although it was produced at one of the high seats of technocracy and endorsed by an international group of industrialists and sages, it carried the same message as did the marching activists. Moreover, these conclusions were built on computer simulations, adding a quantitative endorsement to the qualitative plaint of the movement, and one that combined the prestige of science with a mystique of a black-box approach. At that time computer modeling was still a relatively rare and arcane art that needed rooms full of machines: Intel's first puny microprocessor (and hence a chance to build powerful PCs) became available only in November 1971, after the report's completion. And, of course, mass media, forever hungry for new bad news, were attracted by the computer-generated curves showing a pollution-induced population collapse that was to take place sometime before the middle of the twenty-first century. There was, of course, immediate criticism too—offered by scientists as well as economists (Maddox 1972; Kaysen 1972; Solow 1973)—and afterward came the counterattack by the devotees of unlimited growth (Simon 1981; Simon and Kahn 1984).

Three decades later arguments about the nature, desirability, and consequences of economic growth, sometime incisive but often just evasive, continue, now largely under the rubric of the politically oh-so-correct concept of sustainability. (Factually, there is not the slightest chance of sustainability unless we cease burning nearly 10 billion tones of fossil carbon every year.)

My substantive reaction to the 1972 report (beyond the surprise at the degree of adulation given to that short and simplistic computer program) was informed not only by my interest in interactions among population, environment, and energy but also by my fluency in DYNAMO and hence my appreciation of the model's inherent limitations once I deconstructed it line by line. First, the level of integration seemed to me ill-advised and utterly misleading rather than bold and revealing. What kind of insight can one get by sweeping all forms of environmental degradation into a single level variable called "pollution" and feeding it through a predetermined "pollution generation" rate and bleeding it through a "pollution absorption" rate? The answer should be obvious to any competent environmental scientist.

A single example illustrates the uselessness of that approach. Sulfur dioxide emitted from a large coal-fired power plant may be airborne just a few minutes before it is oxidized to sulfate and rained out on a crop field that can actually benefit from added sulfur (an important plant micronutrient). Or it can remain aloft for a day or more, be transported some 1,000 km downwind, and when precipitated it can lower the pH of an already acid lake or it can add to the tropospheric haze that cools parts of the Northern hemisphere. Obviously, not even a single pollutant can be treated in a ridiculously simplistic single-rate generation-absorption manner, but the Limits to Growth model swept everything from long-lived radionuclides to DDT, from particulate matter to organic wastes from a sugar factory, from lead to benzene into one box, fed and bled by two grand in-and-out rates—and as if that would not be meaningless enough, it did so in a globally averaged manner!

Nor was the model's treatment of population dynamics any more confidence-inspiring. I will use an example that also introduces my second major category of concerns about Limits to Growth modeling: an indefensibly arbitrary choice of quantitative assumptions. DYNAMO uses table functions in order to predetermine particular links between variables. For example, DRPMT (death rate-from-pollution-multiplier-table) specified, for the entire planet, that a dimensionless DRPM (death-rate-from-pollution multiplier) will go from 2 to 6 as another dimensionless number, POLR (pollution ratio) rises from 20 to 45 (remember, POLR is determined by global inflows and outflows of every pollutant, no matter how short- or long-lived, no matter how innocuous or health-threatening, no matter whether locally insignificant or globally worrisome). But one does not have to be an expert in environmental chemistry, toxicology, or demography to know that despite some very large (even order-of-magnitude) increases of various pollutant levels during the course of the twentieth century, we have seen universal and stunningly large declines in mortality. One must therefore wonder where the exponentially rising numbers in DRPMT came from.

The 30-year update of The Limits to Growth is a bough stemming from the original trunk, so it makes no sense to replay yet again a point-by-point critique. Pollution still keeps boosting, contrary to available evidence, global mortality. Declining arable land still keeps lowering food production, while in the real world there is, globally, an obscene surplus of food as epidemics of obesity affect more and more countries. And, once again, the report has been treated with plenty of uncritical awe: "The authors of this book are the Paul Reveres of our time" blurbs Betsy Taylor of the Center for a New American Dream on its back cover.

But there are also notable differences. The new book is more substantial both in its length (338 standard-size pages vs. 205 pages of smaller format) and its contents. There are, as always in system dynamics books, numerous graphs that chart feedback loops and too many arbitrarily constructed scenarios of the world as it will *not* look in 2100. But many discussions of the charted links are informative descriptions, there is a section dealing with an illustrated example of "back from beyond the limits" (an early identification and rapid resolution of stratospheric ozone decay caused by CFCs), and two lengthy closing chapters (7 and 8) describe transitions to a sustainable global system and tools available for this daunting endeavor.

Still, the book's key message is even darker than that of its progenitor: "[W]e are much more pessimistic about the global future than we were in 1972" (p. xvi). And the authors marshal many expected numbers and trends to support this upgraded gloom. These proofs range from rising atmospheric concentrations of carbon dioxide, methane, and nitrous oxide through the losses of farmland to the key deviation-amplifying threat that rules the authors' thinking about the world's population: more people means more poverty which means more people. To make sure we get that last message, they give us a charming circular graph on page 45. Readers of this journal will, I am sure, have a bit more nuanced understanding of that link than is offered by the authors' three-arrow circle with a plus sign in its center. And the text simply bristles with "overshoot." Unlike The Limits to Growth, this book has an index—and overshoot gets no fewer than 30 of its lines. The authors see the sign of this terrifying process wherever they look, from the destruction of fisheries to rising oil prices. Overshoot, they say (using the system dynamics lingo), results from delays in feedbacks. If only the real world were that simple: we repeatedly choose to act, both as individuals and as polities, in ways whose undesirable consequences are perfectly clear to us before we do so—but....

How to deal with this computerized system dynamics view of the world broadcast yet again three decades later? Not by disputing this or that dubious statement, and certainly not by pointing out truck-size holes in various scenarios of the global future. As with all such modeling exercises, I cannot take any of these numerous long-range scenarios seriously. I have shown in great detail (using a key variable: energy supply) how all such attempts are destined to fail (Smil 2003). But you would not have to read, and be convinced by, any proofs and arguments of mine: just try to forecast the world of 2005 with the understanding we had in 1905 and see how ridiculous any such effort would look. Even more impressively, you can get pretty much the same result by contrasting 1955 with 2005. Unpersuaded? Then let me digress just once more, with a single timely example.

In 1955 it was just six years after the Communist victory in China's protracted civil war and three years before the beginning of the worst (Mao-made) famine in history, which killed some 30 million people. At that time China, under a regime unrecognized by the United States, was an impoverished, subsistence agrarian economy, glad to receive a few crumbs of wasteful Stalinist industrialization, and its annual per capita GDP was less than 4 percent of the US mean. Yet by 2005 China, still very much controlled by the same Communist party, had become a new workshop for the world, an indispensable supplier of goods ranging from pliers to laptops (no Wal-Mart, that paragon of American capitalism, without Communist China); and the fate of America's wobbly currency depended to a large degree on China's willingness to continue record purchases of US Treasury bills. If you are certain that you could have anticipated all of this in 1955 (or for that matter in September 1976 right after Mao's death, or even in summer 1989 after the Tiananmen killings), then you are holding the wrong job.

There is a great deal of inertia in long-range technical and social developments, and this fact allows us to look ahead with a great deal of understanding (Smil 2005). But, Francis Fukuyama's prophesyings aside, history has not ended and it always advances through lurching discontinuities, most of them utterly unpredictable and hence unprogrammable. And for those historical saltations whose coming can be nebulously discerned, we are bound to miss the critical dimensions of timing and intensity. Like all other grand empires, the Evil one was sure to collapse, but who would have, even in 1985, timed it for 1991? Like other fundamentalist fanatics, militant Muslims have never admired modernity but who would have, in 1991, forecast 9/11 of 2001? And yet these discontinuities rarely compound in a single direction: world history does not move up or down. Neither is it made of oscillations of ascent and collapse, hope and despair. The world always unravels as it is built anew; a polity may collapse but the underlying civilization may live on. Human ingenuity and adaptability always offer a frustrating mixture of advances and failures.

Both the original report and its 30-year update are thus profoundly ahistorical. We simply cannot specify a distant, desirable global optimum (whatever its name: limits to growth, sustainable economy, reduced ecological footprint) and lay down technical and economic specifications tending, globally, toward that goal. Human societies are too human for such grand designs: they create miraculous advances even while tolerating incomprehensible failures. When seen in this perspective, the book's real goal becomes clear: it is, much more so than was its progenitor, simply a modern sermon. The authors admit as much (p. xvii): "The message is that if we persist in our pedagogic effort, the world's people will increasingly choose the right way ahead, out of love and respect for their planetary companions...."

But for preaching thus there is no need for all those computerized exercises, for all those risibly detailed specifications of this or that variable's progress during the coming century in yet another alternative scenario, no need for making dubious linkages between dynamic and poorly understood aggregative and globe-spanning functions, no need for all those printout curves that rear up before overshooting and falling down. The message is simple, stated in a few sentences on page xv: "To reach sustainability, humanity must increase the consumption level of the world's poor.... There must be greater respect, caring, and sharing...."

Righteous choices, succoring the poor, sharing.... For all of this in a majestic translation you might as well reread (or you are in for an even greater treat if you have never read it) the sixth chapter of the King James version of Luke's Gospel. As the Romans would have it, *nihil novum sub sole*.

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↑ MIRO ŠVOLÍK *Noha rýchlejšia ako hlava,* 1993