THE ECOCOSM PARADOX

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Contents:

Summary:

The Ecocosm Paradox identifies critical relationships between our nonliving mineral planetary spacecraft, our human presence, the non-human living biomes that provide life support, and the environmental crisis. The paper discusses the major factors, structures, and feedback loops that constitute the Ecocosm. The Paradox suggests a tragic, species-threatening dilemma for humanity. If world human consumption continues to grow exponentially, even at a reduced growth rate, the resulting environmental destruction may precipitate a major catastrophe in Earth's life support system. Conversely, if consumption growth is stopped to save the environment, the human socio-economic system may experience a securities panic, economic depression, social instability, and world wars with modern super weapons. Although it is not certain what radical new visions and directions are needed to solve the dilemma, it is clear that the current trends can not continue much longer before they cause a

catastrophe.

1. Introduction

Exponential growth in world population, energy use, production, technology, pollution, and weapons' destructiveness has focused attention on Earth's environment and ways to insure humanity's long-term survival. This growth is resulting in serious problems such as global warming, resource exhaustion, massive species extinctions, and environmental destruction; these may eventually provoke terrorism and global war. A formula for "sustainability" is needed. Most believe the solution will come from governmental regulatory policies, automatic corrections in the world economic system, and/or the continued growth of technology. Regulatory policies, economic adjustments, and technology are not likely to solve the problems because evolutionary human instincts energize the complex, interdependent, feedback control structures in today's technological world society that produce the unsustainable growth. World human consumption growth is the primary force that drives environmental deterioration; therefore, attaining sustainability is a monumental human behavioral problem. (See *Regional Development*, *Irrigation Projects and Environment* and see *Ecological Interactions (Kaibab Plateau)*.)

The Ecocosm Paradox is the detailed hypothesis for the whole Earth system that includes closed-loop interactions between the natural mineral/living planetary environment and the technology-based global human presence (Figure 1). It considers the entire dynamic process, historical time histories for the important variables, future prospects for the Earth and humanity, and the characteristics of effective solutions and their implementation strategies that are required to resolve the growth dilemma. *Ecocosm* combines the Greek words "*oikos*" meaning "home" and "*kosmos*" meaning "universe," "form," and "order." Thus, *ecocosm* is humanity's total planetary home system; the closed-loop, unstable, long-term, living and non-living whole-Earth system. A *paradox* arises because the *ecocosm* is inadvertently producing a crisis with multiple environmental problems for which there may be no catastrophe-free solutions. If consumption growth continues, the resulting environmental destruction may precipitate a human species-threatening catastrophe in Earth's life support system. If consumption growth could be stopped to save the environment, economic, social, and military crises would arise. The interaction between nature and the human presence has reached the point where some kind of major catastrophe in the natural environment and/or the human presence appears inevitable. Humans doing seemingly normal, essential things (i.e. reproducing and consuming) are threatening the survival of *Homo sapiens*.

World human consumption is the variable that connects the natural environment and the human presence. The upper cloud in Figure 1 contains the natural environment and the Earth's available resources. In the lower cloud are the discarded waste products of human living. Consumption draws resources from the environment and turns them into waste. When people cut the trees of a forest or remove iron ore from a strip mine, they do it either directly or indirectly to make products for humans to consume. Even before consumers discard used products, the recovery process destroys environmental infrastructure and wastes resources. Product fabrication also wastes resources. Despite degradation and recycling of some waste back to usable resources, there is still a large net annual decrease in available resources at the top and a large net annual increase in the volume of pollution at the bottom, so the figure represents the net effect of human living on the environment.

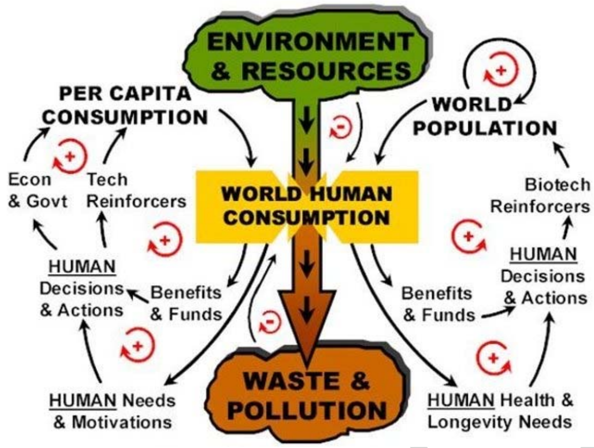

Figure 1. The Ecocosm Paradox

2. The Power of Compound Hyper-exponential Time Functions

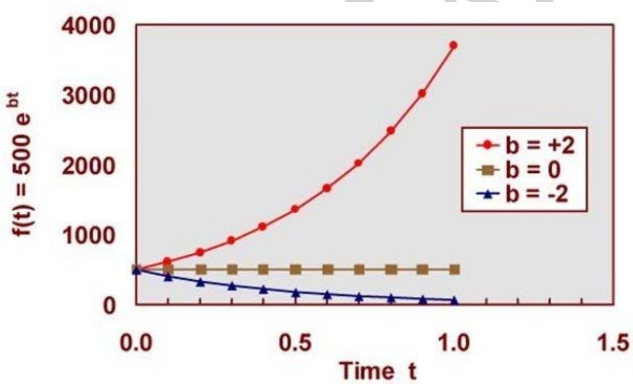

Figure 2a. Exponential time function plotted on a linear scale

The important world human variables are growing exponentially. The exponential time function is given in Equation 1, where K is a constant, e is a number 2.718…, b is a number or a function of time, and t is time.

$$f(t) = K e^{bt} \quad (1)$$

When b, the exponential growth rate coefficient, is a constant real number, the function has three possible time patterns: for b equals zero, for b less than zero, and for b greater than zero, as shown in Figure 2a. In Figure 2b, with a logarithmic vertical scale, when b is a constant, the function plots as a straight line for all three cases. Table 1 shows the relationship between b, the annual growth rate, and the time to double the function's value. This doubling time is given by (ln 2) divided by b. Very small annual percentage increases double the value in amazingly short times. A two-percent annual increase doubles the value in only 35 years.

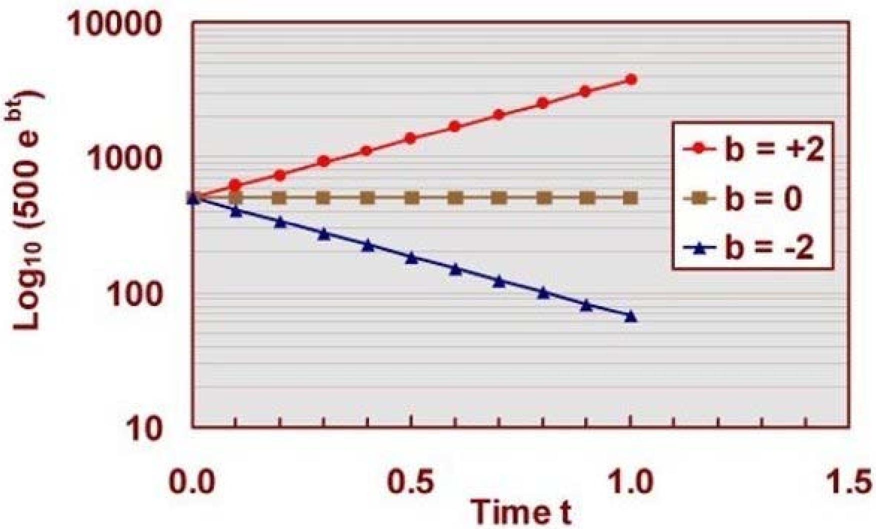

Figure 2b. Exponential time function plotted on a logarithmic scale

Growth Rate	0.1% per yr	0.5% per yr	1.0% per yr	1.5% per yr	2.0% per yr	3.0% per yr	4.5% per yr	7.5% per yr	10.0% per yr
Doubling Time	693.2 years	138.6 years	69.3 years	46.2 years	34.6 years	23.1 years	15.4 years	9.2 years	6.9 years

Table 1. Time to double the value of an exponential time function for some annual % increases

If b increases with time, the function may plot as a geometric progression even on a logarithmic scale. Such "hyper-exponential," growth is overwhelming. Not only is the variable relentlessly doubling, its doubling time is becoming progressively shorter. Hyper-exponential growth is important because, as will be shown, human population growth has been hyper-exponential over the last millenium. Compound hyper-exponential growth is even more devastating. A variable has compound hyper-exponential growth when it is the algebraic product of a hyper-exponential growth variable and an exponential growth variable. A compound hyper-exponential variable (Equation 2) has a growth rate coefficient with a growing time function a(t) part plus a constant part c.

$$f(t) = K e^{[a(t) + c]\, t} \qquad (2)$$

Most world human variables, such as consumption, are compound hyper-exponentials, since they are the product of hyper-exponential population and a per capita factor that is exponential. The rapid growth of population and per capita consumption together causes the environmental crisis.

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Biographical Sketches

Professor Willard R. Fey, born 1935, was one of the original members of the Industrial Dynamics Group that developed the System Dynamics (SD) methodology at the Massachusetts Institute of Technology (MIT). He received his academic education at MIT in electrical engineering, industrial management, systems theory, economics, psychology, and social science. While teaching at MIT, he directed the first industrial dynamics educational program, for which he received the 1966 Everett Moore Baker Award. In 1969, he brought the new field of System Dynamics to the Georgia Institute of Technology, where he has taught for 30 years. As a consultant, he has conducted SD studies of real human systems (military, higher education, criminal justice, ecological, and business) which have resulted in improved policies and procedures. He retired from teaching in 1999 to devote time to environmental research. He is currently the CEO of Ecocosm Dynamics, Ltd. (see www.EcocosmDynamics.org), a non-profit corporation that is the administrative home for this research.

Ann C. W. Lam, born 1950, received a Bachelor of Arts in Mathematical Statistics from the University of Florida and a Master of Science in Computer and Information Science from the Georgia Institute of Technology. As a software engineer and knowledge management consultant with Compaq Computer Corporation, she has designed and implemented information databases, military and financial systems, and library software. She is currently the Vice President of Ecocosm Dynamics, Ltd., and is continuing her studies in sustainable ecosystems, environmental ethics, public policy, political and social processes, and systems theory.