ecological stability

This is a brief summary of the book **Limits to Growth**, which is the first report for the Club of Rome's Project on the Predicament of Mankind. This international, interdisciplinary group construed a mathematical simulation of the world system and attempted to predict its behavior. There are many criticisms that can be made about this, based upon the fact that there is a general lack of detailed knowledge of several relationships which affect stability.

For example, the biggest problem with the MIT model derives from the fact that the model does not incorporate surprises into its structure. This criticism of the surprise-free model first raised by Herman Kahn mentions that most models are formulated using basic scientific premises, including the idea that effect always precedes cause in a basically linear form.

The linear aspect of cause and effect may be observable in simple science but when you start to consider the whole complex interrelationships occurring within society, you rarely observe a simple cause-effect relationship. In social systems cause and effect become intertwined and non-linearly related.

Also entering into cause and effect are the inevitable feedback mechanisms operating in all dynamic systems. It is these feedbacks which cause the unpredictability because of the unavoidable delays and time lags which operate within the system.

Although the model incorporates these feedbacks, it cannot, by nature of its being a predictive model based on **predetermined** factors, ever incorporate the surprise factor. Such major surprises as wars, large famines, new energy discoveries, and new technology advances cannot be incorporated.

The model is also too simple because it deals with the world as a whole instead of dividing it into 2 or possibly 3 separate sections. At the very least a 2-part model with varying inputs for underdeveloped and developed countries would increase its value tremendously.

However, this report is the most comprehensive study done to date, based upon sound ecological principles. It is therefore worthwhile to examine.

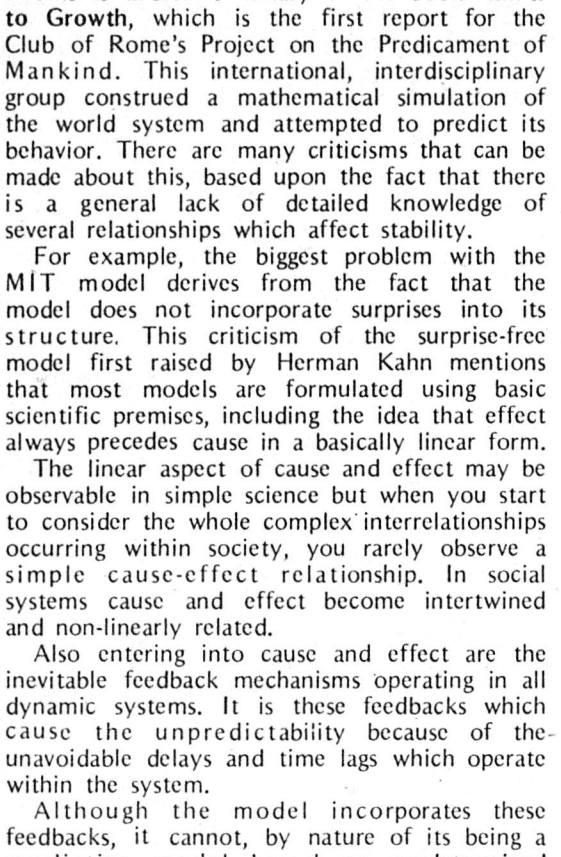

FIGURE 1 FEED BACK LOOPS OF POPULATION, CAPITAL, AGRICULTURE AND POLLUTION

Some of the interconnections between population and industrial capital operate through agricultural capital, cultivated land, and pollution. Each arrow indicates a causal relationship, which may be immediate or delayed, large or small, positive or negative, depending on the assumptions included in each model run.

In order to understand the model, it is vitally necessary to understand one of the fundamental concepts upon which the model is based, that of exponential growth, Exponential growth involves doubling; it is a process which occurs with consumption, population growth and capital growth. It is a deceptive process in that large numbers can be generated very quickly.

"There is an old Persian legend about a clever courtier who presented a beautiful chessboard to his king and requested that the king give him in return 1 grain of rice for the first square on the board, 2 grains for the second square, 4 grains for the third, and so forth. The king readily agreed and ordered rice to be brought from his stores.

"The fourth square of the chessboard required 16,384 and the twenty-first square gave the courtier more than a million grains of rice. By the fortieth square a million rice grains had to be brought from the storerooms.

"The king's entire rice supply was exhausted long before he reached the sixty-fourth square."

A French riddle for children illustrates another aspect of exponential growth – the apparent suddenness with which it approaches a fixed limit.

Suppose you own a pond on which a water lily is growing. The lily plant doubles in size each day. If the lily were allowed to grow unchecked, it would completely cover the pond in 30 days, choking off the other forms of life in the water.

For a long time the lily plant seems small, and so you decide not to worry about cutting it back until it covers half the pond.

On what day will that be? On the twenty-ninth day, of course. You have one day to save your pond.

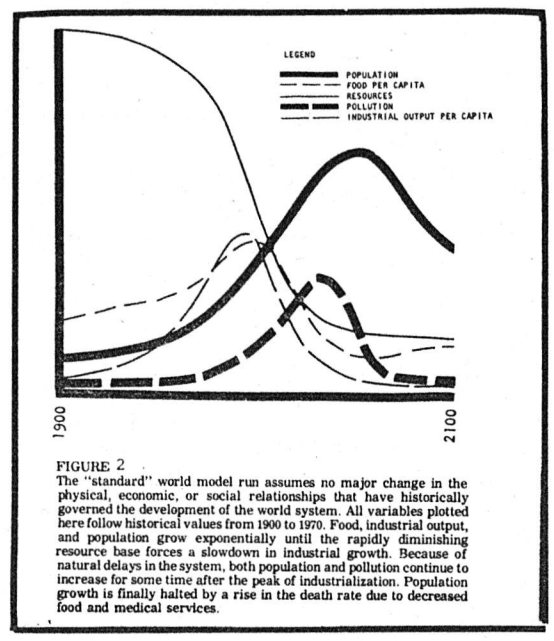

FIGURE 2

The "standard" world model run assumes no major change in the physical, economic, or social relationships that have historically governed the development of the world system. All variables plotted here follow historical values from 1900 to 1970. Food, industrial output, and population grow exponentially until the rapidly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate due to decreased food and medical services.

Perhaps the alarm manifested by many concerned people around this globe is more clear when you consider this process is also occurring with our population, our resource use, and our pollution.

Coal is a very abundant resource. We have a reserve of 2700 years at **present** rate of useage. But, (here's that exponential growth again) at 3.6% increase in energy use per year our coal will be gone in 220 years. And if the whole world (not just the developed countries) were using coal at this rate, our reserves would be depleted in 37 years.

The Club of Rome has concluded that the problem we are facing is one of extreme urgency requiring an all-out global effort to prevent disaster.

Their approach was to first construct a world model of the relationships we have with our environment and the social and economic demands we are making on these relationships. With the model they hoped to predict the general behavior of this entire system.

At the same time they would be able to study the effect of altering our demands (eg. a reduction in pollution) and hence suggest possible changes in policy and/or needed technological advances, to achieve stability.

It must be remembered that these predictions are not accurate in terms of numbers and specific values but rather are attempts to understand the system's behavior. To calculate such numbers (eg. exactly how much chromium will be left in reserves in 1997) would require complete knowledge of all world factors; something that has not yet been done. As more information is obtained the predictions will understandably become more accurate.

The world model that was constructed, includes every factor that was considered to have an effect, either direct (eg. food per capita) or indirect (eg. agricultural capital), on the world's population and life style. An illustration of how these cause and effect relationships were used in the model appears in Figure 1.

The actual model, as its purpose necessitates, is much more complicated and will be presented in detail. More information on the actual set up of the model can be found in the books **Limits to Growth** and **World Dynamics.**

When the world model was sufficiently complete to be able to predict the system's general behavior, it was programmed into a computer. The first assumption was that all present relationships and growth rates remain unchanged.

The result is shown in Figure 2. Stability was completely disrupted and the world system collapsed.

Their next step was to alter the causal relationships by assuming various technological and social advances in an attempt to attain a stable world system. Figure 3 illustrates the results of assumptions which have been briefly summarized below.

1) The birth rate is set equal to the death rate of 1975 to produce a stable population.

2) The growth of industrial capital (the amount of new money invested in industrial activities) is halted in 1990 which allows the industrial output per capita to rise to three times the present world average.

3) In 1975 technological advances enabling the recycling of non-renewable resources, a reduction in pollution, an increase in agricultural productivity and an increase in the durability of products are introduced.

4) Society accepts value changes in terms of a greater emphasis on foods and services rather than consumption of industrial products.

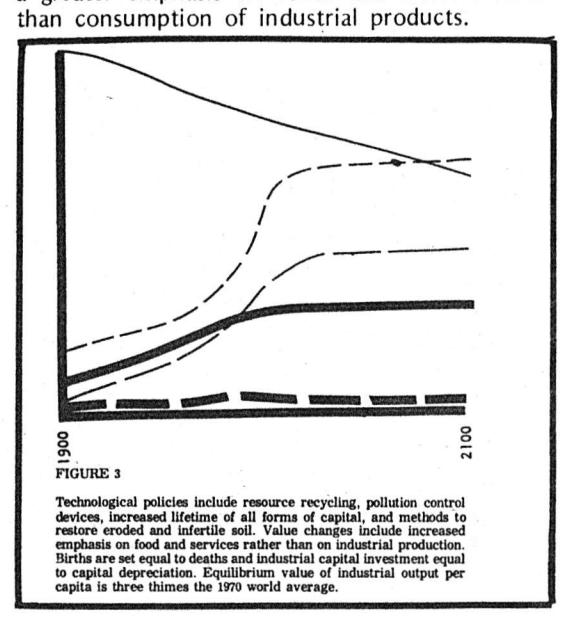

FIGURE 3

Technological policies include resource recycling, pollution control devices, increased lifetime of all forms of capital, and methods to restore eroded and infertile soil. Value changes include increased emphasis on food and services rather than on industrial production. Births are set equal to deaths and industrial capital investment equal to capital depreciation. Equilibrium value of industrial output per capita is three thimes the 1970 world average.

It should be noted that they found that the failure to introduce any of the above technological or social changes leads to environmental instability and collapse of the world system.

As an illustration, Figure 4 shows the result of not halting the growth of industrial capital. The stable situation cannot be maintained and the whole system eventually collapses.

The Club of Rome next considered the effect of delaying action until the year 2000. The result is shown in Figure 5. Stability cannot be reached because of the damage already done to our environment.

But note that the values from these Figures are not necessarily accurate numerical predictions, but rather suggest the general behavior of the systems.

There are several conclusions we can make from this study:

1) Because of an inevitable disruption of stability the world system will collapse if nothing is changed.

2) To achieve stability we must attain constant levels of population and industrial capital, minimum birth, death, investment, and depreciation rates and minimize the effects of our culture on our environment.

3) The longer we refuse to recognize the problems and do something about them, the fewer options we will have for solving them.

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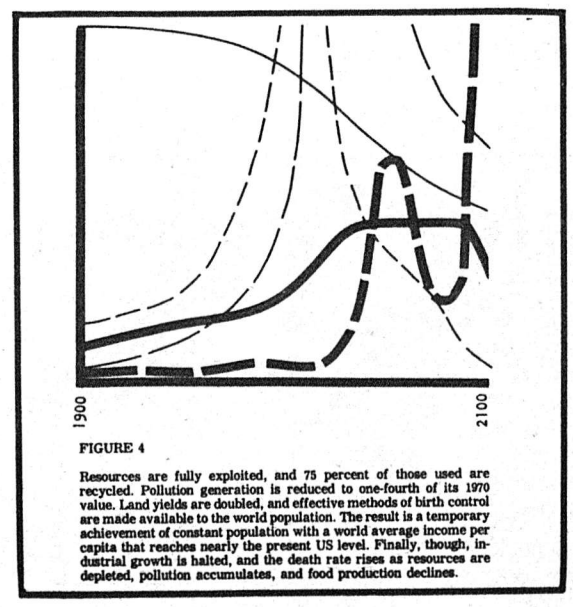

FIGURE 4

Resources are fully exploited, and 75 percent of those used are recycled. Pollution generation is reduced to one-fourth of its 1970 value. Land yields are doubled, and effective methods of birth control are made available to the world population. The result is a temporary achievement of constant population with a world average income per capita that reaches nearly the present US level. Finally, though, industrial growth is halted, and the death rate rises as resources are depleted, pollution accumulates, and food production declines.