[Reviews and critiques]

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(Reviews and Critiques)

Mr. Forrester's Terrible Computer

By David C. Anderson

Jay W. Forrester is a computer engineer and a professor of management at the Massachusetts Institute of Technology who likes to play disturbing games with graphs.

One of his graphs, for example, shows several lines labeled variously "pollution," "capital investment," "population" and "natural resources." Each is the reflection of a mathematical formula—population, for example, is determined by the balance of the birth rate and the death rate. The lines are plotted against decades of time.

By 1970 the graph shows that pollution, capital investment and population have been rising moderately; quality of life (the index of a number of quantative factors) is declining; so are natural resources. Examination of the past behavior of the lines and the formulas they reflect reveals that they influence each other in certain obvious ways—decline in quality of life is linked to rise of population and pollution, for example.

The Mind's Limitations

Now if Mr. Forrester feeds his formulas into a computer, it will print out the movement of the lines on the graph as they might continue into the future, based on their inherent relationship and current behavior. Such prophesy by technology amounts to sophisticated guessing, of course, but Mr. Forrester claims it has some advantages over the human mind.

The human mind he explains, is best at observing "the pressures, fears, goals, habits, prejudices, delays, resistance to change, dedication, good will, greed and other human characteristics that control the individual facets of our social system." It takes a human mind in other words, to express the human facets in mathematical terms.

"But when the pieces of the system have been assembled"—all the formulas written—"the mind is nearly useless for anticipating the dynamic behavior that the system implies. Here the computer is ideal. It will trace the interactions of any specified set of relationships without doubt or error."

And indeed, if the formulas for 1970 were to hold good for the indefinite future, the computer reveals, population, capital investment and pollution will peak out in the first half of the next century, in the years between 2030 and 2040. Then they slope downward, while natural resources and quality of life begin to flatten out at low and uncomfortable-looking levels.

Well, all of that is predictable enough, however depressing; Mr. Forrester's games grow more interesting when he tries to make his graphs account for ways man is trying to improve his standing with the environment.

For example, he can alter the formula for natural resources to make the decline less steep; he assumes, in effect, that technological advance or exploration opens up new sources of needed energy and materials, a likely enough assumption.

Is the depressing downturn in quality of life and investment put off? Hardly. Population and investment rise about as before, but in that same 2030 to 2040 time span the pollution curve suddenly rockets upward; the population curve turns nearly vertically downward, investment falls off and quality of life suffers a deep, ominous slide. The lines depict a fearsome trauma for the whole world. In a period of about two decades, nearly 85% of the human race disappears.

Well then, how about birth control? Reducing the birth rate input to the formula which yields the population line results in slower population growth, to be sure, but the drain on natural resources still prevails as a powerful depressing factor, hardly unchanged from the first graph. And if birth rate is reduced along with a slower drain on natural resources the cataclysm still results as the years advance beyond 2030.

Pollution rises steeply; population falls just as steeply as in the previous graph; but since it didn't get so high in the first place, fewer people—only about 75% of humanity—die off. Quality of life, which rose briefly during the period of low birth rate, falls even more sharply than before.

Pollution control? Again, it does little to mitigate the effects of the resource drain, and if lower resource use is assumed, the horrible decades of pollution catastrophe are only postponed to the 2070s and 80s, Mr. Forrester's computer contends. (Pollution control permits heavy population growth and capital investment, which then generate overwhelming pollution.)

Similar results occur if food production is increased. If investment capital generation is increased, on the other hand, the pollution-population holocaust comes earlier, in the 2020s.

Mr. Forrester has published all of this under the title "World Dynamics" (Wright-Allen Press, 142 pages, $9.75) and there is, of course, much reason for skepticism about it. Many of his formulas are simply educated guesses with no precise basis in research. Reducing human facets of life to mathematical formulas, however obvious, still oversimplifies them in some degree. And consideration of them as a dynamic whole, even with a computer's rigorous objectivity, compounds the guessing and the oversimplifying.

Mr. Forrester himself is careful to hedge his conclusions with the assertion that such research into the future is still quite primitive and can never avoid uncertainty and imprecision. His book ends with no dire warnings, only a plea to extend and improve upon his approach to studying world environmental problems.

Two Cosmic Notions

But his attempts are of interest because they reflect two cosmic notions which may not be firmly grasped by those who have to make decisions about population and environment policy, or will in the near future. The notions, furthermore, lead to some subtle and serious speculations.

The first notion is that the whole world should be thought of as a giant "world system" in the recently fashionable management sense. Each element is intimately involved with others. Nothing occurs independently; each activity of one element affects and disrupts others.

The second is that this world system has for all of history accommodated its most disruptive element—human growth and activity—but it can no longer do so; the time has come to stabilize the world system by bringing man into a state of equilibrium with it.

This unprecedented state of transition from growth to equilibrium, let it be noted, is not the subject of debate, only how it will occur. For it will occur somehow: Man will

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understand what is happening to him and change and control himself to reach the state of equilibrium as safely as possible. Or he will reach it after great turmoil and suffering. Or he will not survive it—the world system will stabilize itself by exterminating him.

These two cosmic notions, furthermore, lead to two more practical ideas. The first is simply that a solution which would permit man to remain a part of a stable world system will prove a lot more complex than people now like to think.

Mr. Forrester's final graphs reflect his efforts to alter his formulas so that the computer prints out straight, horizontal, parallel lines, signifying equilibrium. As the previous graphs have implied, this requires drastic action on several fronts rather than just one.

Specifically, he contends, to bring the system into equilibrium by 1980 would require the reduction of current pollution generation by 50%, but also the reduction of capital investment generation by 40%. It would require the reduction of the birth rate by 30%, but also the reduction of food production by 20%. And the natural resource usage rate would have to be curtailed by 75%.

The second practical idea is that achieving the equilibrium in these complex terms presents staggering moral problems.

For though the computer deals in gross measurements of population and wealth, they are not spread evenly over the world. Alter ing them will create heavy social strain between different groups.

Consider, for example, the implications of the computer's prescription that capital investment be reduced by 40% to quell the drain on natural resources and help limit pollution.

Capital investment produces industrialization and a higher standard of living, the great pride of developed societies of the West, the driving aspiration of millions in poorer areas.

Yet, Mr. Forrester can conclude on the basis of his studies, "A society with a high level of industrialization may be nonsustainable . . . From the long view of a hundred years hence, the present efforts of the underdeveloped countries to industrialize may be unwise."

In fact, he suggests, such countries "may be in a better condition for surviving forthcoming world-wide environmental and economic pressures than are the advanced countries," since advanced countries are so dependent on their industrialization for order and comfort.

And he adds that "the present disparity between the developed and underdeveloped nations may be equalized as much by a decline in the developed countries as by an improvement in the underdeveloped countries."

Yet what moral leader could accept this analysis in its entirety? It is sometimes fashionable to tell the wealthy to give up their wealth for the common good, but who would tell the poor to abandon their hopes for a better life in the same spirit?

And what about food? The computer prescribes the 20% reduction in food output as a limit on population. This is necessary, Mr. Forrester explains, because history has shown that greater food production does not end starvation and malnutrition; it simply causes population to increase to a higher marginal level, where there are more who are well fed, but also more who are undernourished.

Yet for the past decade or so foundations and governments have been striving, and succeeding to a certain extent, to increase food production for developing countries, to create a "green revolution." There is even evidence that success of the green revolution in some areas has relaxed the pressure for birth control and portends the release of funds once devoted to agriculture for industrialization.

The relevance of Mr. Forrester's graphs thus begins to look painfully obvious, yet what political leader—what well-fed political leader—will tell hungry nations to stop growing more food?

The Insect World

Mr. Forrester's terrible computer, in fact, adds an indirect bit of support to the theories of Nils Hellstrom, known to moviegoers as the fictional narrator of "The Hellstrom Chronicle."

In the movie, Mr. Hellstrom argues that man is engaged in a war with insects for control of the earth's life supporting resources. And he contends that the insects stand a good chance of winning. For insects have much of man's capacity for social organization, but none of his morality.

They do not worry much about why or how they should live, he tells viewers; they are driven only to survive at all costs; a group of bees or termites willingly and thoughtlessly sacrifices its individual members to the common defense against nature or enemies. Indeed, he observes, insects have succeeded in living far longer than man on a hostile earth not by trying to cure themselves of savageness or rising above the most brutal of subsistence economies, but simply by focusing all their energy, resourcefulness and adaptability on the single goal of survival as a species.

And the vague, threatening implication, of Mr. Hellstrom as of Mr. Forrester, is impossible to discount: To survive, man may find himself having to give up his aspirations to decency and civilization; he may have to forget the notion that people ought to be free, and they should have compassion for the weak and the helpless, and that a single human life is intrinsically valuable. No wonder it takes a machine to make such a prediction. No wonder the modern mind finds it hard to fathom.

Well, for the moment there is not that much to do in the face of such ideas; the choice of extinction or survival by dehumanization remains vague rather than final or imminent. All one can do is to keep one's particular faith; for his part, Mr. Forrester and his colleagues are trying to bring more depth and precision to their macabre mathematics.

But if their extended implications are still subject to refinement, Mr. Forrester's graphs at least remind us of an important fact about the environment problem: Our survival as anything like civilized people will depend as much on the true depth of our realism as on the prowess of our technology—on our capacity to understand life's complexity, which, let it be well remembered, is often as hideous as it is normal.

Mr. Anderson is a member of the Journal's editorial page staff.

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A Choice of Futures—Black or Gray

by William Bowen

This year will probably not see the publication of a more important book than Jay W. Forrester's *World Dynamics* (Wright-Allen Press)—or a book more certain to arouse dislike. A profoundly pessimistic study of possible futures, it collides thuddingly with cherished suppositions, values, and expectations.

Professor Forrester tries above all to awaken his readers from the dream of growth. Despite recent discouragements, a great many people, from futurists trained in hard sciences to yoghurty utopians, suppose that economic growth will go on and on, eventually bringing material abundance and leisure for all. Even the nations now poor, it is widely supposed, can follow the industrialization road to affluence. From this notion, among other sources, has come the great restlessness called the revolution of rising expectations. But Forrester calmly tells us that industrial growth in the world as a whole will come to an end within a century, quite possibly in the lifetimes of our children. "The question is only a matter of when and how growth will cease, not whether it will cease." We may even now, despite all the audible discontent, be living in a "golden age," from which things will go downhill. As for the underdeveloped countries, there may be "no realistic hope" that they can ever attain even the present standard of living of industrialized countries.

Looking ahead to 2100

If *World Dynamics* had appeared, say, three years ago, many of its readers would have found it inaccessibly remote from their assumptions and convictions about the nature of the world. But much has happened in the past few years to prepare readers to take *World Dynamics* seriously, if not to like it. In the changing social landscape, a discerning eye can pick out signs that we are entering upon a revolution of *declining* expectations. Public-opinion surveys detect what for the traditionally optimistic U.S. is a startling degree of gloominess about at least the short-term future. Few notable personages over thirty have lately said for publication that today's discontented young people are the forerunners of a utopia. Dust has begun gathering rather rapidly upon much recent writing about things to come. Faith in the capacity of government to sustain economic growth has distinctly receded. So has faith in the value of economic growth. Most important of all, the ecology boom has made many people aware for the first time—it was obvious enough before, but outside their zone of perception—that the earth is finite and thus can support only limited growth.

While some of Forrester's conclusions are akin to things ecologists have said about limitations on growth, his methods are quite distinctive. *World Dynamics* is basically a description of an elaborate computer simulation in which human activity and its environmental setting are regarded as a unified global system.

An electrical engineer by training, Forrester, now fifty-three, was a leading figure in the development of the digital computer, and the inventor of the random-access magnetic-core computer memory. For the past fifteen years, as professor of management at M.I.T., he has concentrated on computer simulation of complex systems. In his controversial *Urban Dynamics*, published two years ago, he used simulation to study the effects of alternative policies on a hypothetical urban area. (See Books & Ideas, FORTUNE, November and December, 1969.)

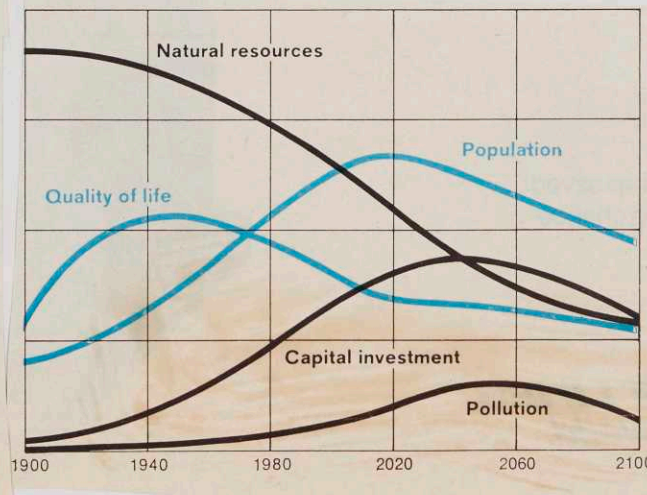
A computer model of human activity over the globe obviously entails extreme simplification. In the *World Dynamics* model, there is no recognition of political or geographical subdivisions—population, capital, and other aggregates are treated in effect as if they were evenly spread around the earth. Still, many readers will find the model complex enough. A detailed description of it takes up a large part of the text of *World Dynamics*.

The variables that the book emphasizes are population, pollution, capital investment, natural resources (specifically, nonrenewable resources in the earth such as metallic ores), and a "measure of performance" labeled quality of life. In Forrester's model, quality of life is a precisely defined concept, a composite that is affected by material standard of living, crowding, pollution, and food supply. The concept illustrates both a virtue and a defect in computer modeling. In everyday discourse, "quality of life" takes on different meanings from one speaker to another, whereas in *World Dynamics* it can be precisely plotted on a graph. On the other hand, the model's definition misses much of what almost anybody means when he says "quality of life." The model gains precision at the loss of richness and nuance.

Faults and all, Forrester's model was put through numerous computer runs, which traced out interactions to the year 2100. On various runs, to simulate assumed changes in policies or conditions, the researchers altered the numerical value of one or more variables. When the basic, unaltered model was run through, the computer delivered a somber scenario in which growth is halted and reversed by pressures arising from the increasing scarcity of "natural resources." World population starts declining around 2020. (See illustration.)

To observe how the system would behave if the pressures from scarcity of resources were relieved, Forrester drastically reduced the numerical weight of natural resources in the model. What the computer then gave forth was an even darker picture, of a world in which growth is suppressed by pollution. One fundamental assumption here is that increasing pollution will "poison and impede" the natural processes by which pollution is absorbed. In this scenario, the first half of the next century sees a catastrophic pollution crisis, and in a few hellish decades world population drops to one-sixth of its peak total.

So it goes in the grim world of *World Dynamics*. Sooner or later, growth is halted, if not by depletion of resources or pollution overload, then by crowding or scarcity of food. And the same kinds of futures, Forrester maintains, threaten in reality. The best future mankind can hope for is a global equilibrium. "The battle between the forces of growth and the restraints of nature may be resolved in a number of ways. Man, if he under-



Dark prospects for the future of mankind are traced in this graph, drawn from one of the computer print-outs in Professor Forrester's book. In this scenario, growth is halted by scarcity of natural resources. The labels of the curves are those used in the book. "Quality of life" in particular carries a special meaning, precise but somewhat narrow (see text). The curves are drawn to a variety of scales, and no significance should be read into the height of one relative to another.

stands well enough and acts wisely, can choose a path out of the conflict of world pressures that is more favorable than present actions, attitudes, and policies portend. Such a path must be toward a non-growing and balanced condition of the world system. The challenge is to choose the best available transition from the past dynamics of growth to a future condition of world equilibrium."

In very dark clouds

Is *World Dynamics* convincing? In details, no. In over-all thrust, yes. That growth will eventually come to an end has been implicit all along in the nature of things. We should be grateful to Forrester for reminding us of this. We should be grateful, too, for the hardness of mind that he shows in his task. He does not make any self-protective bows to current pieties. He does not try to spare us by softening or blurring what he has to say. On the contrary, he hammers at the fundamental point that the end of growth means not only the end of population growth but also the end of industrial growth. And it is quite clear that a halt in industrial growth in the world as a whole would mean *declines* from peak industrial output for some of the present advanced nations, particularly those heavily dependent on imported raw materials. Above all, we should be grateful to Forrester for refusing to weaken at the end and suggest that we may yet find an easy way out. There has been too much of that over the years.

After I have said this, it may seem craven of me now to suggest the possibility of silver linings in some of these very dark clouds. While a transition from growth to global equilibrium would certainly be attended by terrible stresses, the state of equilibrium itself, the absence of growth in population and material output, would have some consolations—though not for everyone, to be sure. In recent years we have caught intimations of a much-predicted world without the disciplines of scarcity, and what we have glimpsed has not been altogether pretty. In its effects upon the quality of human beings and the quality of the lives they lead, economic growth has been distinctly disappointing. (This, of course, is partly what the counterculture is about.) As one observer put it not long ago, the inventor of the telephone booth could hardly have imagined that when you opened the door urine would run out.

Much has been gained as industrial societies have grown affluent—let nobody deny it—and much has been lost or impaired: courtesy, craftsmanship, and quiet, to mention only a few things. An end to growth in material output, moreover, would not necessarily be incompatible with economic growth of kinds not well measured by our present stock of indicators, notably growth in the quality of goods and services. With a renaissance of craftsmanship, of pride in work, of willingness to serve, a society poorer than ours by some statistical measures could enjoy goods of greater durability and higher aesthetic quality, and services performed with more courtesy, cheerfulness, and competence. And stability in material growth, finally, would not necessarily be incompatible with individual excellence, with devotion to one's craft, with love for one's children, with high achievement in the arts, with eloquence, with precise thought or careful expression, with enhanced sense of community, with deepened religious faith, or with care for the scarred yet still nurturing earth itself.

But all this strays far from Forrester. He warns us that even the shadowed, autumnal state of equilibrium may prove to be beyond reach. The achievement of global equilibrium would require global cooperation to a degree not now imaginable. Even more difficult, perhaps, it would require sustained attention to the long run, to policies and programs measured by decades rather than years. "The short run," Forrester says, "is more visible and more compelling. It speaks loudly for immediate attention. But a series of actions all aimed at short-run improvement can eventually burden a system with long-run depressants so severe that even heroic short-run measures no longer suffice."

And if we fail to find and follow a path into equilibrium, what then? Then, Forrester says, "the world system will make a system-determined choice for us." END

Worldwatch Paper 1

The Other Energy Crisis: Firewood

Erik P. Eckholm

September 1975

Worldwatch Institute

Worldwatch Institute is an independent, non-profit research organization, created as an "early-warning system" to identify emerging threats to human well-being and to encourage a reflective, deliberate approach to global problem solving. Directed by Lester R. Brown, Worldwatch is funded by private foundations and United Nations and governmental agencies which share concern for problems of the future. Worldwatch papers are written for a worldwide audience of decision makers, scholars and the general public.

The Other Energy Crisis: Firewood

Erik P. Eckholm

Worldwatch Paper 1
September 1975

This paper is adapted from the author's forthcoming book *Losing Ground: Environmental Stress and World Food Prospects* (W. W. Norton, 1976). It may be completely or partially reproduced with the written permission of Worldwatch Institute.

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Preface

The Other Energy Crisis: Firewood, by Erik P. Eckholm, is the first in a series of papers to be issued by the recently established Worldwatch Institute. This and other papers to follow are part of an effort by the Institute to identify emerging threats to human well-being and bring them to public attention. Forthcoming papers will examine such issues as the global politics of food, the rationale and techniques for energy conservation, the status of efforts to slow world population growth, and the changing political status of women.

Erik carried out research for this Worldwatch Paper during a trip to the Asian subcontinent and Africa in Spring, 1975. The paper is part of a broader project, sponsored jointly by Worldwatch and the United Nations Environment Program, investigating the ecological undermining of food production systems caused by overfishing, deforestation, overgrazing, desert encroachment, soil erosion, and the silting of irrigation systems. This research program will culminate in a book by Erik, *Losing Ground: Environmental Stress and World Food Prospects,* to be published in the United States by W. W. Norton in Spring, 1976.

The scarcity of firewood directly affects that one third or so of mankind which uses wood as fuel. Indirectly it affects everyone, putting pressure on fossil fuel reserves and, as it diverts animal manure from fertilizer to fuel use, further aggravating the global shortage of food. Thus, in a world of deepening interdependence, even local resource scarcities can have a global impact.

Lester R. Brown
President

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Dwindling reserves of petroleum and artful tampering with its distribution are the stuff of which headlines are made. Yet for more than a third of the world's people, the real energy crisis is a daily scramble to find the wood they need to cook dinner. Their search for wood, once a simple chore and now, as forests recede, a day's labor in some places, has been strangely neglected by diplomats, economists, and the media. But the firewood crisis will be making news—one way or another—for the rest of the century.

While chemists devise ever more sophisticated uses for wood, including cellophane and rayon, at least half of all the timber cut in the world still fulfills its original role for humans—as fuel for cooking and, in colder mountain regions, a source of warmth. Nine-tenths of the people in most poor countries today depend on firewood as their chief source of fuel. And all too often, the growth in human population is outpacing the growth of new trees—not surprising when the average user burns as much as a ton of firewood a year.[1] The results are soaring wood prices, a growing drain on incomes and physical energies in order to satisfy basic fuel needs, a costly diversion of animal manures for cooking food rather than producing it, and an ecologically disastrous spread of treeless landscapes.

The firewood crisis is probably most acute today in the countries of the densely populated Indian subcontinent, and in the semi-arid stretches of central Africa fringing the Sahara Desert, though it plagues many other regions as well. In Latin America, for example, the scarcity of wood and charcoal is a problem throughout most of the Andean region, Central America, and the Caribbean.

An Economic Burden

As firewood prices rise, so does the economic burden on the urban poor. One typical morning on the outskirts of Kathmandu, Nepal's capital city, I watched a steady flow of people—men and wom-

en, children and the very old—trudge into the city with heavy, neatly chopped and stacked loads of wood on their backs. I asked my taxi driver how much their loads, for which they had walked several hours into the surrounding hills, would sell for. "Oh wood, a very expensive item!" he exclaimed without hesitation. Wood prices are a primary topic of conversation in Kathmandu these days. "That load costs 20 rupees now. Two years ago it sold for six or seven rupees." This 300 percent rise in the price of fuel wood has in part been prompted by the escalating cost of imported kerosene, the principal alternative energy source for the poor. But firewood prices have risen much *faster* than kerosene prices, also reflecting the growing difficulty with which wood is procured. It now costs as much to run a Kathmandu household on wood as on kerosene.

The costs of firewood and charcoal are climbing throughout most of Asia, Africa, and Latin America. Those who can, pay the price, and thus must forego consumption of other essential goods. Wood is simply accepted as one of the major expenses of living. In Niamey, Niger, deep in the drought-plagued Sahel in West Africa, the average manual laborer's family now spends nearly one-fourth of its income on firewood. In Ouagadougou, Upper Volta, the portion is 20-30 percent.[2] Those who can't pay so much may send their children, or hike themselves, out into the surrounding countryside to forage—if enough trees are within a reasonable walking distance. Otherwise, they may scrounge about the town for twigs, garbage, or anything burnable.

In some Pakistani towns now, people strip bark off the trees that line the streets; thus meeting today's undeniable needs can impoverish the future. When I visited the Chief Conservator of Forests in Pakistan's North West Frontier Province at his headquarters in the town of Peshawar, he spoke in a somewhat resigned tone of stopping his car the previous day to prevent a woman from pulling bark off a tree. "I told her that peeling the bark off a tree is just like peeling the skin off a man," he said. Of course the woman stopped, intimidated by what may have been the most personal encounter with a senior civil servant she will have in her lifetime, but she doubtless resumed

". . . deep in the once heavily forested Himalayan foothills of Nepal, journeying out to gather firewood and fodder is now an *entire day's* task."

her practice shortly, for what else, as the Chief Conservator himself asked, was she to do?

It is not in the cities but in rural villages that most people in the affected countries live, and where most firewood is burned. The rural, landless poor in parts of India and Pakistan are now facing a new squeeze on their meager incomes. Until now they have generally been able to gather wood for free among the trees scattered through farmlands, but as wood prices in the towns rise, landlords naturally see an advantage in carting available timber into the nearest town to sell rather than giving it to the nearby laborers. While this commercialization of firewood raises the hope that entrepreneurs will see an advantage in planting trees to develop a sustainable, labor-intensive business, so far a depletion of woodlands has been the more common result. And the rural poor, with little or no cash to spare, are in deep trouble in either case.

With the farmland trees and the scrubby woodlands of unfarmed areas being depleted by these pressures, both the needy and the entrepreneurs are forced to poach for fuel wood in the legally protected, ecologically and economically essential national forest reserves. The gravity of the poaching problem in India has been reflected in the formation of special mobile guard-squads and mobile courts to try captured offenders, but law enforcement measures have little effect in such an untenable situation. Acute firewood scarcity has undermined administrative control even in China, where trees on commune plantations are sometimes surreptitiously uprooted for fuel almost as soon as they are planted.[3]

Trees are becoming scarce in the most unlikely places. In some of the most remote villages in the world, deep in the once heavily forested Himalayan foothills of Nepal, journeying out to gather firewood and fodder is now an *entire day's* task. Just one generation ago the same expedition required no more than an hour or two.[4]

Ecological Consequences

Because those directly suffering its consequences are mostly illiterate, and wood shortages lack the photogenic visibility of famine, the fire-

wood crisis has not provoked much world attention. And in a way there is little point in calling this a world problem, for fuel-wood scarcity, unlike oil scarcity, is always localized in its apparent dimensions. Economics seldom permit fuel wood to be carried or trucked more than a few hundred miles from where it grows, let alone the many thousands of miles traversed by the modern barrel of oil. To say that firewood is scarce in Mali or Nepal is of no immediate consequence to the Boy Scout building a campfire in Pennsylvania, whereas his parents have already learned that decisions in Saudi Arabia can keep the family car in the garage.

Unfortunately, however, the consequences of firewood scarcity are seldom limited to the economic burden placed on the poor of a particular locality. The accelerating degradation of woodlands throughout Africa, Asia, and Latin America, caused in part by fuel gathering, lies at the heart of what will likely be the most profound ecological challenge of the late twentieth century. On a global basis, an ecological threat to human well-being far more insidious and intractable than the industrial pollution of our air and water—which has preempted thinking on environmental quality—is the undermining of the productivity of the land itself through soil erosion, increasingly severe flooding, creeping deserts, and declining soil fertility. All these problems are accentuated by deforestation, which is spreading as lands are cleared for agriculture and as rising populations continue their search for firewood. Rainwater falling on tree-covered land tends to soak into the ground rather than rush off; erosion and flooding are thus reduced, and more water seeps into valuable underground pools and spring sources.

The Dust Bowl years in the Great Plains of the thirties taught Americans the perils of devegetating a region prone to droughts. The images provided by John Steinbeck in *The Grapes of Wrath* of the human dislocation wrought by that interaction of man, land, and climate could easily describe present-day events in large semi-arid stretches of Africa along the northern and southern edges of the Sahara, and around the huge Rajasthan Desert in northwest India. Overgrazing by over-sized herds of cattle, goats, and sheep is the chief culprit, but fuel-wood gathering is also an important contrib-

utor to the destruction of trees in these regions. Firewood is a scarce and expensive item throughout the sub-Saharan fringe of Africa, all the way from Senegal to Ethiopia, but citizens in towns like Niamey are paying a much higher price than they realize for their cooking fuel. The caravans that bring in this precious resource are contributing to the creation of desert-like conditions in a wide band below the desert's edge. Virtually all trees within 70 kilometers of Ouagadougou have been consumed as fuel by the city's inhabitants, and the circle of land "strip-mined" for firewood—without reclamation—is continually expanding.

Similar pressures of overgrazing and deforestation in North Africa are having the same consequences. H. N. Le Houérou of the United Nations Food and Agriculture Organization figures that 100,000 hectares of land are lost to the desert *each year* due to human activities in Algeria, Morocco, Libya, and Tunisia.[5] In an interesting experiment, the Libyans and others have tried spraying oil on the sand dunes to hold them back, but most arid countries will have to follow Algeria's recent lead in undertaking a massive tree-planting campaign if they hope to stop the sand. India, too, is forfeiting farmlands and rangelands to desert sands, while vaster dry regions, which stretch eastward from the Rajasthan Desert and constitute perhaps a fifth of the country, now present a nearly treeless landscape. Wind erosion is chronic and the agricultural yields extracted from the infertile subsoil are either falling or have finally stabilized at a low level.

Dangerous Substitutes

In the Indian subcontinent, the most pernicious result of firewood scarcity is probably not the destruction of tree cover itself, but the alternative to which a good share of the people in India, Pakistan, and Bangladesh have been forced. A visitor to almost any village in the subcontinent is greeted by omnipresent pyramids of hand-molded dung patties drying in the sun. In many areas these dung cakes have been the only source of fuel for generations, but now, by necessity, their use is spreading further. Between 300 and 400 million tons of wet dung—which shrinks to 60 to 80 million tons when dried—is

annually burned for fuel in India alone, robbing farmland of badly needed nutrients and organic matter. The plant nutrients wasted annually in this fashion in India equal more than a third of the country's chemical fertilizer use. Looking only at this direct economic cost, it is easy to see why the country's National Commission on Agriculture recently declared that "the use of cow dung as a source of non-commercial fuel is virtually a crime." Dung is also burned for fuel in parts of the Sahelian zone in Africa, Ethiopia, Iraq, and in the nearly treeless Andean valleys and slopes of Bolivia and Peru, where the dung of llamas has been the chief fuel in some areas since the days of the Incas.[6]

Even more important than the loss of agricultural nutrients is the damage done to soil structure and quality through the failure to return manures to the fields. Organic materials—humus and soil organisms which live in it—play an essential role in preserving the soil structure and fertility needed for productive farming. Organic matter holds the soil in place when rain falls and wind blows, and reduces the wasteful, polluting runoff of chemical nutrients where they are applied, thus increasing the efficiency of their use. These considerations apply especially to the soils in tropical regions where most dung is now burned, because tropical topsoils are usually thin and, once exposed to the harsh treatment of the burning sun and torrential monsoon rains, are exceptionally prone to erosion, and to losing their structure and fertility.

Peasants in the uplands of South Korea have found another, equally destructive way to cope with the timber shortage. A United Nations forestry team visiting the country in the late 1960s found not only live tree-branches, shrubs, seedlings, and grasses being cut for fuel; many hillsides were raked clean of all leaves, litter, and burnable materials. Raking in this fashion, to meet needs for home fuel and farm compost, robs the soil of both a protective cover and organic matter, and the practice was cited by the U.N. experts as "one of the principal causes of soil erosion in Korea." Firewood scarcity similarly impairs productivity in Eastern Nigeria, where the Tiv people have been forced to uproot crop residues after the harvest for use as fuel. Tradi-

tionally, the dead stalks and leaves have been left to enrich the soil and hold down erosion.[7]

A Closing Circle

The increasing time required to gather firewood in many mountain villages of Nepal is leading to what the kingdom's agricultural officials fear most of all. For, once procuring wood takes too long to be worth the trouble, some farmers start to use cow dung, which was formerly applied with great care to the fields, as cooking fuel. As this departure from tradition spreads, the fertility of the hills, already declining due to soil erosion, will fall sharply. In the more inaccessible spots there is no economic possibility whatsoever of replacing the manure with chemical fertilizers.

And so the circle starts to close in Nepal, a circle long completed in parts of India. As wood scarcity forces farmers to burn more dung for fuel, and to apply less to their fields, falling food output will necessitate the clearing of ever larger, ever steeper tracts of forest—intensifying the erosion and landslide hazards. Even Nepal's key economic planning body, the National Planning Commission, now says that if present trends continue, a "semi-desert type of ecology in the hilly regions" will be created.

Though most dramatically apparent in Nepal, this same cluster of phenomena threatens the future habitability of the entire stretch of Himalayan foothills, from Afghanistan through northern Pakistan, India, and Nepal to Burma. And the negative consequences by no means stop at the base of the hills. When soil washes away it must relocate somewhere, and the rising load of silt carried by Asia's rivers is choking up expensive reservoirs and irrigation works. Most threatening of all to food-production prospects on the Indian subcontinent, where nearly one in every five human beings lives, is a rise in the frequency and severity of flooding in Pakistan, India, and possibly Bangladesh, the result of denuded watersheds off which rainfall rushes quickly, and of the excessive load of sediment from upstream that builds up river beds, reducing their capacity to channel water.

"Even if we somehow grow enough food for our people in the year 2000, how in the world will they cook it?"

Firewood scarcity, then, is intimately linked to the food problem facing many countries in two ways. Deforestation and the diversion of manures to use as fuel are sabotaging the land's ability to produce food. Meanwhile, as an Indian official put it, "Even if we somehow grow enough food for our people in the year 2000, how in the world will they cook it?"

B. B. Vohra, a senior Indian agricultural official who has pushed his government ahead on numerous ecological causes, shook his head as we talked in his New Delhi office. "I'm afraid that we are approaching the point of no return with our resource base. If we can't soon build some dramatic momentum in our reforestation and soil conservation programs, we'll find ourselves in a downward spiral with an irresistible momentum of its own." Without a rapid reversal of prevailing trends, in fact, India will find itself with a billion people to support and a countryside that is little more than a moonscape. But the politicians, in India and other poor countries, will soon start taking notice, for they will begin to realize that if the people can't find any firewood, they will surely find something else to burn.

A Renewable Resource

The firewood crisis is in some ways more, and in others less, intractable than the energy crisis of the industrialized world. Resource scarcity can usually be attacked from either end, through the conservation of demand or the expansion of supply. The world contraction in demand for oil in 1974 and early 1975, for example, helped to ease temporarily the conditions of shortage.

But the firewood needs of the developing countries cannot be massively reduced in this fashion. The energy system of the truly poor contains no easily trimmable fat such as four to five thousand pound private automobiles represent. Furthermore, a global recession does little to dampen the demand for firewood as it temporarily has in the case of oil. The unfortunate truth is that the amount of wood burned in a particular country is almost completely determined by the number of people who need to use it. In the absence of suit-

able alternative energy sources, future firewood needs in these countries will be determined largely by population growth.

The simple arithmetic of exponential growth suggests the immensity of the fuel-wood challenge facing many poor countries. As Table 1 shows, 99 percent of Tanzania's population burns an average of 1.8 tons of wood per person each year. Since Tanzania's population is now just over 15 million, about 27 million tons of wood will be burned for fuel in 1975. But if Tanzania's population should continue growing at the present rate of 2.7 percent annually, it will multiply *14-fold in a century*. If the proportion of wood users should remain constant, the consumption of wood for fuel would also multiply 14-fold to reach 370 million tons per year.

Per capita wood use in Thailand, at 1.1 tons per year, is somewhat lower than that in Tanzania. Yet Thailand's current population growth rate will produce a 16-fold increase in its population of 42 million in a hundred years, resulting in a total of 672 million people—more than now live in India. It is difficult to envisage how Thailand's rich tropical forests could survive pressures of this magnitude.

Table 1: Fuel Wood Consumption in Tanzania, Gambia, and Thailand

	Fuel Wood Consumption Per Capita (tons/year)	Fuel Wood as Share of Total Timber Consumption (percent)	Fuel Wood Users as Share of Total Population (percent)
Tanzania	1.8	96	99
Gambia	1.2	94	99
Thailand	1.1	76	97

Source: Adapted from Keith Openshaw, "Wood Fuels the Developing World," *New Scientist*, Vol. 61, No. 883, 31 January 1974.

Even if the demographers are surprised by quick progress in slowing population growth over the next few decades, the demand for basic resources like firewood will still push many countries to their limits.

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Fortunately trees, unlike oil, are a renewable resource when properly managed. The logical immediate response to the firewood shortage, one that will have many incidental ecological benefits, is to plant more trees in plantations, on farms, along roads, in shelter belts, and on unused land throughout the rural areas of the poor countries. For many regions, fast-growing tree varieties are available that can be culled for firewood inside of a decade.

The concept is simple, but its implementation is not. Governments in nearly all the wood-short countries have had tree-planting programs for some time—for several decades in some cases. National forestry departments in particular have often been aware of the need to boost the supply of wood products and the need to preserve forests for a habitable environment. But several problems have plagued these programs from the beginning.

One is the sheer magnitude of the need for wood, and the scale of the growth in demand. Population growth, which surprised many with its acceleration in the post-war era, has swallowed the moderate tree-planting efforts of many countries, rendering their impact almost negligible. Wood-producing programs will have to be undertaken on a far greater scale than most governments presently conceive if a real dent is to be made in the problem.

The problem of scale is closely linked to a second major obstacle to meeting this crisis: the perennial question of political priorities and decision-making time-frames. What with elections to win, wars to fight, dams to build, and hungry mouths to feed, it is hard for any politician to concentrate funds and attention on a problem so diffuse and seemingly long-term in nature. Some ecologists in the poor countries have been warning their governments for decades about the dangers of deforestation and fuel shortages, but tree-planting programs don't win elections. This phenomenon is of course quite familiar to all countries, not just the poorest. In the United States, resource specialists pointed out the coming energy crisis throughout the 1960s, but it took a smash in the face in 1973 to wake up the government, and as of late 1975 the country still can hardly be said to have tackled the energy challenge head on.

"Most of the regions with too few trees also have too many cattle, sheep, and goats."

Despite these inherent political problems, India's foresters made a major breakthrough a few years back as the government drew up its five-year development plan for the mid to late seventies. Plans were laid for the large-scale establishment of fast-growing tree plantations, and for planting trees on farms and village properties throughout the country.[8] A program is going ahead now, but there have been some unexpected events since the projects were first contemplated two or three years ago: the quintupling of the world price of petroleum, the tripling in price and world shortages of grains and fertilizers, a wholesale diversion of development funds just to muddle through 1974 without a major famine and a total economic breakdown. India's development efforts were set back several years by recent events, and forestry programs have not been immune to this trend.

Political, Cultural, and Administrative Tangles

Even when the political will is there and the funds are allocated, implementing a large-scale reforestation campaign is an unexpectedly complex and difficult process. Planting millions of trees and successfully nurturing them to maturity is not a technical, clearly boundaried task like building a dam or a chemical-fertilizer plant. Tree-planting projects almost always become deeply enmeshed in the political, cultural, and administrative tangles of a rural locality; they touch upon, and are influenced by, the daily living habits of many people, and they frequently end in failure.

Most of the regions with too few trees also have too many cattle, sheep, and goats. Where rangelands are badly overgrazed, the leaves of a young sapling present an appetizing temptation to a foraging animal. Even if he keeps careful control of his own livestock, a herdsman may reason that if his animals don't eat the leaves, someone else's will. Marauding livestock are prime destroyers of tree-planting projects throughout the less developed world. Even if a village is internally disciplined enough to defend new trees from its own residents, passing nomads or other wanderers may do them in. To be successful, then, reforestation efforts often require a formidable administrative effort to protect the plants for years—not to mention the

monitoring of timber harvesting and replanting activities once the trees reach maturity.

16 Village politics can undermine a program as well. An incident from Ethiopia a few years back presents an extreme case, but its lessons are plain. A rural reforestation program was initiated as a public works scheme to help control erosion and supply local wood needs. The planting jobs were given to the local poor, mostly landless laborers who badly needed the low wages they could earn in the planting program. Seedlings were distributed, planting commenced, and all seemed to be going well—until the overseers journeyed out to check the progress. They found that in many areas the seedlings had been planted upside down! The laborers, of course, well knew the difference between roots and branches; they also knew that given the feudal land-tenure system in which they were living, most of the benefits of the planting would flow one way or another into the hands of their lords. They were not anxious to work efficiently for substandard wages on a project that brought them few personal returns.[9]

In country after country, the same lesson has been learned: tree-planting programs are most successful when a majority of the local community is deeply involved in planning and implementation, and clearly perceives its self-interest in success. Central or state governments can provide stimulus, technical advice, and financial assistance, but unless community members clearly understand why lands to which they have traditionally had free access for grazing and wood-gathering are being demarcated into a plantation, they are apt to view the project with suspicion or even hostility. With wider community participation, on the other hand, the control of grazing patterns can be built into the program from the beginning, and a motivated community will protect its own project and provide labor at little or no cost.

An approach like this—working through village councils, with locally-mobilized labor doing the planting and protection work—is now being tried in India. This approach too has its pitfalls; Indian villages are notoriously faction-ridden, and the ideal of the whole community working together for its own long-term benefit may be somewhat

utopian. But if it can get underway on a large scale, the national program in India may succeed. Once given a chance, fast-growing trees bring visible benefits quickly, and they just could catch on. The Chinese have long used the decentralized, community labor-mobilizing approach to reforestation, apparently with moderate success.

Alternative Fuels

Whatever the success of tree-planting projects, the wider substitution of other energy sources where wood is now being used would, if feasible, contribute greatly to a solution of the firewood problem. A shift from wood-burning stoves to those running on natural gas, coal, or electricity has indeed been the dominant global trend in the last century and a half. As recently as 1850, wood met 91 percent of the fuel needs of the United States, but today in the economically advanced countries, scarcely any but the intentionally rustic, and scattered poor in the mountains, chop wood by necessity anymore. In the poor countries, too, the proportion of wood users is falling gradually, especially in the cities, which are usually partly electrified, and where residents with much income at all may cook their food with bottled gas or kerosene. Someone extrapolating trends of the first seven decades of this century might well have expected the continued spread of kerosene and natural gas use at a fairly brisk pace in the cities and into rural areas, eventually rendering firewood nearly obsolete.

Events of the last two years, of course, have abruptly altered energy-use trends and prospects everywhere. The most widely overlooked impact of the fivefold increase in oil prices, an impact drowned out by the economic distress caused for oil-importing countries, is the fact that what had been the most feasible substitute for firewood, kerosene, has now been pulled even farther out of reach of the world's poor than it already was. The hopes of foresters and ecologists for a rapid reduction of pressures on receding woodlands through a stepped-up shift to kerosene withered overnight in December, 1973, when OPEC announced its new oil prices. In fact, the dwindling of world petroleum reserves and the depletion of woodlands reinforce

"Nothing . . . would be better than a dirt-cheap device for cooking dinner in the evening with solar energy collected earlier in the day."

each other; climbing firewood prices encourage more people to use petroleum-based products for fuel, while soaring oil prices make this shift less feasible, adding to the pressure on forests.

The interconnections of firewood scarcity, ecological stress, and the broader global energy picture set the stage for some interesting, if somewhat academic, questions about sensible disposition of world resources. In one sense it is true that the poor countries, and the world as a whole, have been done a favor by the OPEC countries, who through price hikes and supply restrictions are forcing conservation of a valuable and fast-disappearing resource, and are not letting the poor countries get dangerously hooked on an undependable energy supply. In a sensibly organized world, however, taking into account the total picture of energy, ecology, and food, the oil distribution picture would look far different. The long-term interest in preserving the productive capacity of the earth and in maximizing welfare for the greatest number of people might argue for lower prices and a rapid *increase,* not a halt, in the adoption of kerosene and natural gas in the homes of the poor over the next two decades. This in turn would be viable for a reasonable time period only if the waste and comparatively frivolous uses of energy in the industrial countries, which are depleting petroleum reserves so quickly, were cut sharply. It is not so far-fetched as it might first seem to say that today's driving habits in Los Angeles, and today's price and production-level decisions in the Persian Gulf, can influence how many tons of food are lost to floods in India, and how many acres of land the Sahara engulfs, in 1980.

Fossil fuels are not the only alternate energy source being contemplated, and over the long term many of those using firewood, like everyone else, will have to turn in other directions. Nothing, for example, would be better than a dirt-cheap device for cooking dinner in the evening with solar energy collected earlier in the day. But actually developing such a stove and introducing it to hundreds of millions of the world's most tradition-bound and penniless families is another story. While some solar cookers are already available, the cost of a family unit, at about $35-$50, is prohibitive for many since, in the absence of suitable credit arrangements, the entire

price must be available at once. Furthermore, no inexpensive means of storing heat for cloudy days and for evenings has yet been devised.[10]

Indian scientists have pioneered for decades with an ideal sounding device that breaks down manures and other organic wastes into methane gas for cooking and a rich compost for the farm. Over eight thousand of these bio-gas plants, as they are called, are now being used in India. Without a substantial reduction in cost, however, they will only slowly infiltrate the hundreds of thousands of rural villages where the fuel problem is growing. Additionally, as the plants are adopted, those too poor to own cattle could be left worse off than ever, denied traditional access to dung but unable to afford bio-gas.[11] Still, it is scientific progress with relatively simple, small-scale devices like solar cookers and bio-gas plants that will likely provide the fuel source of the future in most poor countries.

In terms of energy, Nepal is luckier than many countries in one respect. The steep slopes and surging rivers that cause so many environmental problems also make Nepal one of the few remaining countries with a large untapped hydroelectric potential. The latent power is huge, equaling the hydroelectric capacity of Canada, the United States, and Mexico combined. Exploitation of this resource will be expensive and slow, but would relieve some of the pressures being placed on forests by the larger towns of Nepal and northern India. On the other hand, cheap electricity will only partly reduce firewood demands, since the electrification of isolated villages in the rugged Himalayas may never be economically feasible.

Back to the Basics

Firewood scarcity will undoubtedly influence governmental perceptions of the population problem in the years ahead. It spotlights the urgency of slowing population growth through action on several fronts: making family planning services universally available; encouraging the liberation of women from traditional roles; meeting the basic social needs such as rudimentary health care, adequate nutrition, and literacy that are usually associated with reduced fertility; and reorienting social and economic incentives to promote smaller families.

The firewood crisis, like many other resource problems, is also forcing governments and analysts back to the basics of man's relationship with the land—back to concerns lost sight of in an age of macroeconomic models and technological optimism. Awareness is spreading that the simple energy needs of the world's poorest third are unlikely ever to be met by nuclear power-plants, any more than their minimum food needs will be met by huge synthetic-protein factories.

Firewood scarcity and its attendant ecological hazards have brought the attitude of people toward trees into sharp focus. In his essay "Buddhist Economics," E. F. Schumacher praises the practical as well as esoteric wisdom in the Buddha's teaching that his followers should plant and nurse a tree every few years.[12] Unfortunately, this ethical heritage has been largely lost, even in the predominantly Buddhist societies of Southeast Asia. In fact, most societies today lack an ethic of environmental cooperation, an ethic not of conservation for its own sake, but of human survival amid ecological systems heading toward collapse.

This will have to change, and fast. The inexorable growth in the demand for firewood calls for tree-planting efforts on a scale more massive than most bureaucrats have ever even contemplated, much less planned for. The suicidal deforestation of Africa, Asia, and Latin America must somehow be slowed and reversed. Deteriorating ecological systems have a logic of their own; the damage often builds quietly and unseen for many years, until one day the system collapses with lethal vengeance. Ask anyone who lived in Oklahoma in 1934, or Chad in 1975.

Footnotes

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(Reviews and Critiques)

OK

an end to all this

we have handed our heirs an ecological time bomb that birth control alone cannot defuse

article By RICHARD M. KOFF

WITH THE CAREFUL DISREGARD of their respective governments, two dozen eminent men were gathered last June in one of the great old *grande luxe* Swiss hotels. They strode familiarly down wide, carpeted halls—an Italian industrialist, a Belgian banker, two university presidents, a professor at MIT, the director of a major Swiss research institute, a Japanese nuclear physicist, a science advisor to an international economics organization, several economists whose pessimism, if quoted in the press, could cause a stock-market crash.

They moved purposefully toward a conference room. They did not drift, though side conversations delayed several members of the executive committee. Their one common characteristic was a certain firmness about the lips and jaw indicating an intention to get things done. They were activists in the most responsible meaning of the term. Each had been invited to join the group, called the Club of Rome, by its founder, Aurelio Peccei, himself a member of the management committee of Fiat, vice-president of Olivetti and managing director of Italconsult. Each served quietly, without compensation nor even paid expenses, as a full-fledged member.

They represented the best analytical minds of the world, with considerable influence to make funds available if a promising approach could be found to stop the suicidal roller coaster man now rides. Their concern during the two days in Bern was formidably titled A Project on the Predicament of Mankind. The predicament is simply stated: World population is growing by 70,000,000 people every year. This is the fastest growth in man's history, and the rate is still accelerating. We will number four billion in 1975 and, if current trends continue, we can expect to reach eight billion well before the year 2000. This population is making more and more demands on its environment. We are taking fresh water out of the ground roughly twice as fast as natural processes replace it. The demand for electric power in the U. S. is doubling every ten years, and most power comes from the heavily polluting combustion of coal. We are building 10,000,000 cars a year—twice as many as we made only 17 years ago, and cars burn gasoline, grind rubber tires to dust, wear asbestos brakes into an acrid powder.

Until 1970, these figures were considered proud evidence of progress. After all, it was reasoned, if power demands, automobile production and water consumption are increasing even faster than population, then the standard of living of each individual must be improving; and for the advanced countries, this is certainly true. Edward C. Banfield, professor of urban government at Harvard, wrote a few years ago: "The plain fact is that the overwhelming majority of city dwellers live more comfortably and more conveniently than ever before. They have more and better housing, more and better schools, more and better transportation, and so on. By any conceivable measure of material welfare, the present generation of urban Americans is, on the whole, better off than

ILLUSTRATION BY KERIG POPE

JULY, 1971

any other large group of people has ever been anywhere."

It's not surprising, then, that the industrialized nations consider progress synonymous with economic growth and that the underdeveloped nations share that article of faith. The world wants and expects more people, more and faster jet planes, more television sets, more dishwashers. If one car in the garage is good, two must be better.

But consider the price of this plenty: Death due to lung cancer and bronchitis is doubling every ten years. The U. S. incidence of emphysema has doubled in the past five years. Crime in large cities has also doubled in the past five years.

Population biologist Paul Ehrlich describes an experiment in which a pair of fruit flies is put into a milk bottle with a small amount of food. In a matter of days, the population of fruit flies has multiplied to the point where the bottle is black with them. Then the limited food and their own effluvia raise the death rate, and the population drops suddenly down to zero. After 10,000 years of uninhibited propagation, mankind is beginning to sense the confines of its bottle. Man is beginning to realize that he's going to have to stop multiplying his numbers and gobbling up his world —and do it soon—because if the decision isn't made by him, it will be made *for* him by the laws of mathematics and nature.

The trouble is that man has never been very successful in controlling the destruction of community property. We have laws that keep a man from raping his neighbor's daughter, but we have few that keep him from despoiling his air. We have tried governmental action to remedy social ills before, but, as Banfield writes, "Insofar as they have any effect on the serious problems, it is, on the whole, to aggravate them."

This was the "predicament" facing the Club of Rome that June day. MIT professor Jay W. Forrester was a relatively new member of the club. He was lean, graying and spoke with the dry, didactic factuality of the trained lecturer. His theory was startling in its directness—that governmental inadequacy is an example of predictable and consistently self-defeating human behavior. His studies had suggested that the human mind is not adapted to interpreting the behavior of social systems, that human judgment and intuition were created, trained and naturally selected to look only in the immediate past for the cause of a problem. The hot stove burns the finger, not the curiosity that made one reach out to touch it.

All human solutions tend to be that simplistic. We see thousands of people in rat-infested, leaky-roofed tenements. Our traditional answer has been to tear down the tenements and put up large, low-income housing projects. The Pruitt-Igoe project in St. Louis was built to solve this problem and now 26 11-story glass-and-concrete apartment buildings are being boarded up a scant 15 years after they were built—and long before they were paid for. Vandalism, physical deterioration and an impossible job of maintaining essential services made the project a social, architectural and financial disaster. Elevators stalled, windows were broken faster than they could be replaced, residents were assaulted in the halls, apartments were broken into and doors never repaired. The poorest of the poor refused to live there and vacancies climbed even as surrounding housing became more scarce. The buildings now stand vacant as monuments to governmental waste.

Our streets and highways are bumper to bumper with cars, so our answer has been wider and longer highways. But more highways attract more traffic, until the density is the same as—if not worse than—before. No highway system has ever caught up with the traffic it carries. When a rapid-transit system is in financial trouble, fares are raised to produce more income. But this only persuades more people to use cars, which clog the roads even more and provide less net income to the transit system. And it takes longer to drive through a modern city in a 300-horsepower automobile than it did in a one-horsepower buggy 100 years ago.

Forrester had his first hint of this social nearsightedness while analyzing corporate problems. "Time after time, we have gone into a corporation which is having severe and well-known difficulties—such as a falling market share, low profitability or instability of employment," he says. "We find that people perceive correctly what they are trying to accomplish. People can give rational reasons for their actions. They are usually trying in good conscience to solve the major difficulties. Policies are being followed on the presumption that they will alleviate the difficulties. In many instances, it then emerges that the known policies describe a system which actually *causes* the troubles. The known and intended practices of the organization are fully sufficient to create the difficulty, regardless of what happens outside the company. A downward spiral develops in which the presumed solution makes the difficulty worse and thereby causes redoubling of the presumed solution."

The same destructive behavior appeared when Forrester studied the solutions to urban problems. Actions taken to improve conditions in a city actually make matters worse. The construction of low-cost housing such as the Pruitt-Igoe project eventually produces more depressed areas and tenements, because it permits higher population densities and accommodates more low-income population than can find jobs. A social trap is created in which excess low-cost housing attracts low-income people to places where even their low incomes cannot be maintained. "If we were malicious and wanted to create urban slums, trap low-income people in ghetto areas and increase the number of people on welfare, we could do little better than follow the present policies," says Forrester. And, further, "The belief that more money will solve urban problems has taken attention away from correcting the underlying causes and has instead allowed the problems to grow to the limit of the available money, whatever that amount might be."

Forrester's approach differs from that of ecologists, economists or demographers, because he does not narrow his attention to a single, specific cause-and-effect relationship. In his study, he was trying to make an all-encompassing, quantitative measure of the city as a social and biological system. It is a macrocosmic view that weaves the statistics of birth and death with the economics of mass production, variations in the job market with the realities of real-estate-investment returns. It is a complex, highly interrelated system of analysis that recognizes that you cannot break a city down into its component parts without distortion so extreme as to make the effort useless.

He had never tried to analyze the entire world, but his studies of the dynamics of corporations and of cities showed why programs begun in good faith worked out as badly as they often did. Why shouldn't the method be expanded to deal with the dynamics of the whole world system?

When men of action agree, obstacles disappear. A European foundation was happy to make a sizable grant to support the project. Two months later, under the direction of Professor Dennis Meadows, a team of nine researchers at MIT was being recruited to examine Forrester's theories in detail, expand the analysis and see what mankind could do to avoid the seemingly inevitable. As this article is written, almost a year into the project, it is confirming everything Forrester predicted.

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an end

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quantitative influences. We know that the death rate is directly affected by food availability, pollution levels and crowding. Experts can even reach consensus on how the material standard of living—meaning health services and housing, as well as the other fruits of technology—sharply reduces the death rate as it climbs above some minimum level necessary to sustain life. But further improvement in the standard of living doesn't do much to reduce the death rate, no matter how high it goes. Similarly, deaths caused by 1970 pollution levels are almost negligible when compared with the effects of the other factors. But if pollution levels climb ten or a hundred times higher than they have reached already—and pollution *will* reach such levels if current trends continue—we can anticipate a death rate high enough to make the worst plagues in history seem like mild outbreaks of flu.

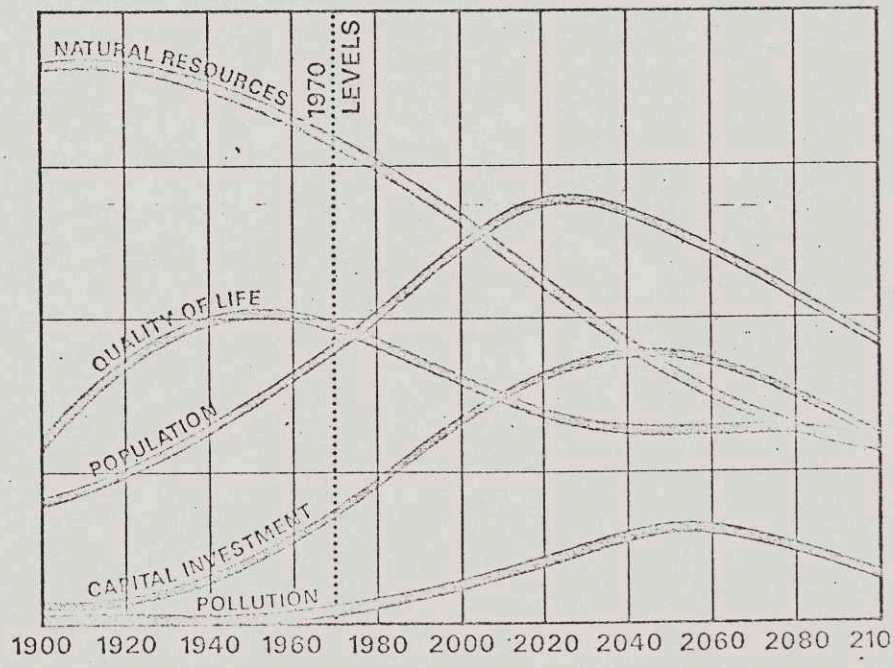
Crowding also has its effect on the death rate. In the extreme case, people will kill one another for room to stand, but long before that limit is reached, the psychological effects and social stresses of crime, war and disease will do their damage. Garrett Hardin of the University of California writes of a more subtle effect of crowding. The cyclone that struck East Pakistan in November 1970 was reported to have killed 500,000 people. The newspapers said it was the cyclone that killed them. Hardin says crowding was the cause. "The Gangetic delta is barely above sea level," he says. "Every year, several thousand people are killed in quite ordinary storms. If Pakistan were not overcrowded, no sane man would bring his family to such a place. . . . A delta belongs to the river and the sea; man obtrudes there at his peril."

Birth rate is calculated in a similar way. Food production, pollution levels, crowding and material standard of living have their separate and predictable influences on the rate of growth. The difference between births and deaths establishes net population gain; and, given the current figures for standards of living, food availability, pollution and crowding, total population can be recalculated at annual intervals as far into the future as you like.

It isn't necessary to go into all the details of Forrester's method: The analysis includes all the effects mentioned here, plus such factors as natural-resource usage (dependent on population and capital investment) and capital investment (dependent on population, material standard of living, and discard or wear-out time of capital equipment). Forrester also calculates something he calls quality of life. This goes up when there are adequate food, medical service, housing and consumer goods, and low levels of crowding and pollution.

The amount of calculation necessary overloads the human brain. It would take 1000 men at 1000 calculators to work out the numbers year by year, following the labyrinthine relationships of the system. But it takes only a few seconds to run the projection on a computer. With the relationships agreed to up front by agricultural and industrial experts, census takers and financial and economic advisors, Forrester pushes the start button and lets the computer plot out curves that start with the year 1900 and go to 2100. The results offer some object lessons in how close man is to committing suicide.

The first thing we learn is that the enemy is our love of growth. Enormous pressures are now appearing on all sides that will act to suppress growth. Natural resources are being depleted; pollution levels, crowding and inadequate food supplies, either separately or in concert, are going to arrest and reverse population growth forcibly and disastrously. Exactly which will deliver the *coup de grâce* is unclear, but the curves show the possible alternatives. It is for man to decide which he prefers.



In this first projection (above), Forrester showed mankind running out of natural resources. He assumed that irreplaceable coal, oil, gas and metal ores will require more and more effort to tear out of the earth and that technology will not find quick substitutes for them. Compared with some of the others, these curves look almost tolerable. This projection shows population rising steadily until about 2020, when natural resources start falling sharply. The world is already running out of easily mined ores and fuel for power that drives mass-production machinery and raises agricultural yields. But a growing population needs more resources—at first just for the amenities of life, later for survival. The industrialized nations are growing rapidly and are placing ever-increasing demands on the resources that often come from underdeveloped countries. What will happen when the resource-supplying nations start to hold back because they see the day when their own demands will require available supplies?

In this projection, the material standard of living (not graphed) will climb until about the year 2000; capital investment per person will continue to increase until then—before the depletion of natural resources has had a chance to make itself felt. Then, in about 2050, industrialization will turn down as resource shortages become grave. Pollution will rise to approximately six times 1970 levels, but this won't be high enough to create a runaway pollution catastrophe. There will, however, be widespread dissatisfaction because the quality of life will drop slowly as pollution grows and as crowding adds its irritations.

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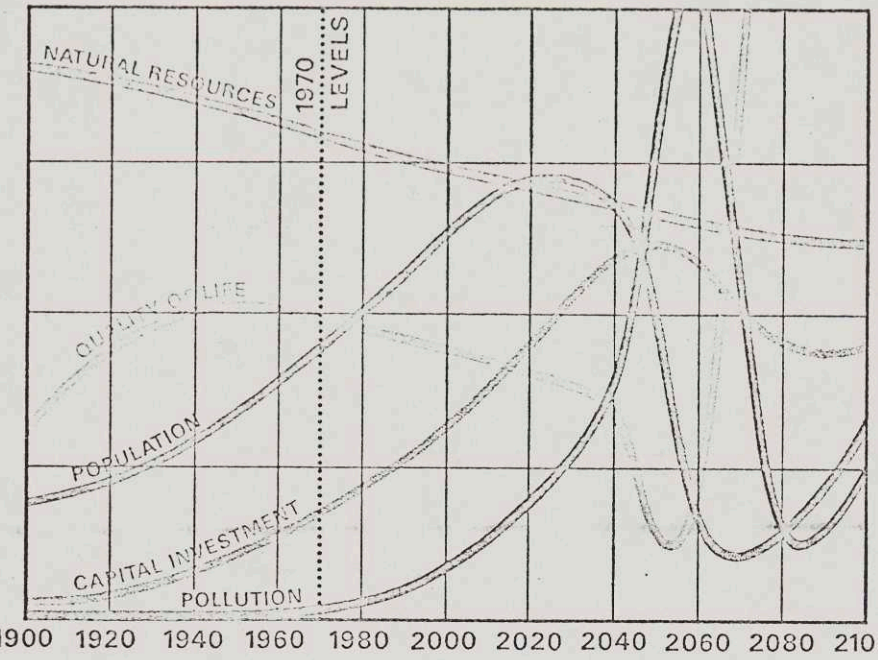


the computer with the natural-resources-depletion rate after 1970 reduced to 25 percent of its former value (above).

In this case, capital investment and population grow until pollution levels get so high that death rate, birth rate and food production are drastically and dangerously affected. Population goes to almost six billion by 2030 and then, in a scant 30 years, drops to one billion. This is a world-wide catastrophe of mind-boggling proportions. War, pestilence, starvation and infant mortality turn the world into a morgue. The highly industrialized countries probably suffer most, because they are least able to survive the disruption to the environment and to the food supply.

Some writers have suggested that before we experience a catastrophe of this magnitude, mankind will stop the pollution-generating process by legislation or even revolution; but this is not very likely. The most important generator of pollutants is industrialization, which is also the major contributor to a higher standard of living. It is difficult to imagine underdeveloped nations agreeing to a curtailment of their industrial growth. The rich nations cannot say to the poor ones, "OK, we've gone as far as we can go. Let's hold still right here." It is just as impossible to say to the poor of our own country, "We've really got to stop. Sorry, you can't have shoes for the children, an indoor toilet, a gas stove, a hearing aid for grandma." Yet, if the poor of all nations were to move up to the standard of living now enjoyed by a majority of Americans, we would have a pollution load on the environment ten times today's level.

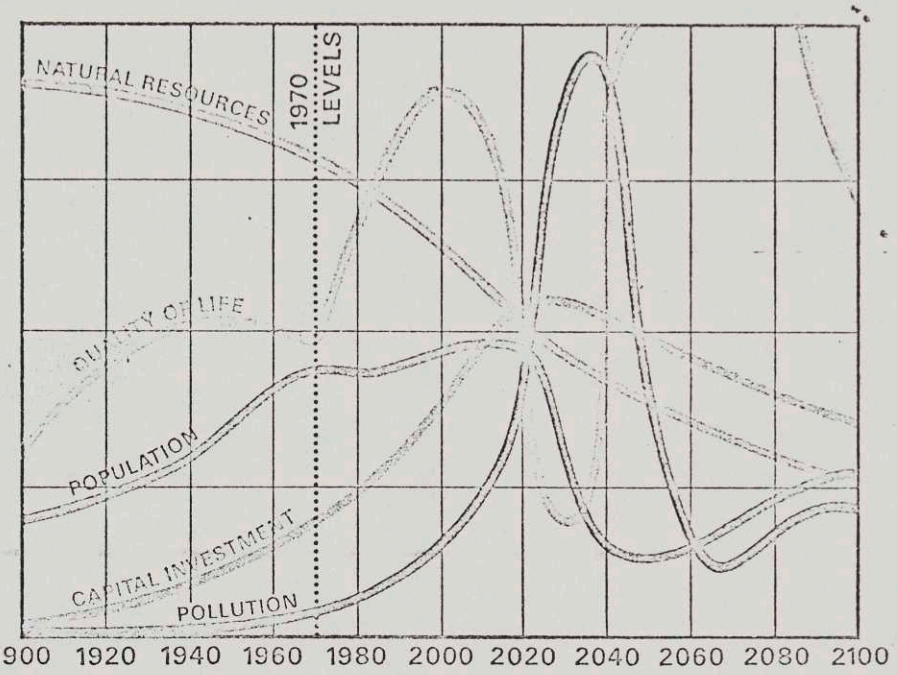
The conclusion is inescapable. If the world is to achieve equilibrium at a material standard of living at or close to the level now enjoyed by the developed nations, world population and industrialization must be considerably lower than the current averages. And that is political dynamite.

This projection demonstrates a vitally important characteristic of the world system: It is going to reach equilibrium one way or another. We are entering a turbulent time, a time when the dedication to growth in the advanced nations will have to give way. It is impossible for every citizen of the world alive today to enjoy the standard of living that has been taken for granted in the West. The goals of our civilization will have to change, and when goals change, traditions no longer serve. We can predict a period of great unrest and uncertainty, with a frighteningly greater possibility of world war, unless enough people see that the true enemy is the system, not one another.

A second discouraging characteristic of the system is that major scientific achievement in the form of reduced depletion of natural resources has the effect only of postponing the date of catastrophe. It permits greater overshoot of industrialization and population and will actually magnify the catastrophe when it finally comes.

With this firmly in mind, it is relatively easy to predict what will happen if the next solution is attempted. Suppose we agree with the underdeveloped nations that their material needs should be met, and they agree to join us in trying to curb population growth. That

means we increase capital investment (to give them a better standard of living) but apply extreme moral and economic pressure to hold down the birth rate. In this projection (at right), Forrester assumed we cut the birth rate in half in 1970 and increase capital investment by 20 percent. For the first few years, things look good. Food per person increases, material standard of living rises and crowding is held close to present levels. But the more affluent world population ends up using natural resources too fast. Capital investment zooms and the pollution load on the environment reaches the critical level even earlier than it did in the previous run.



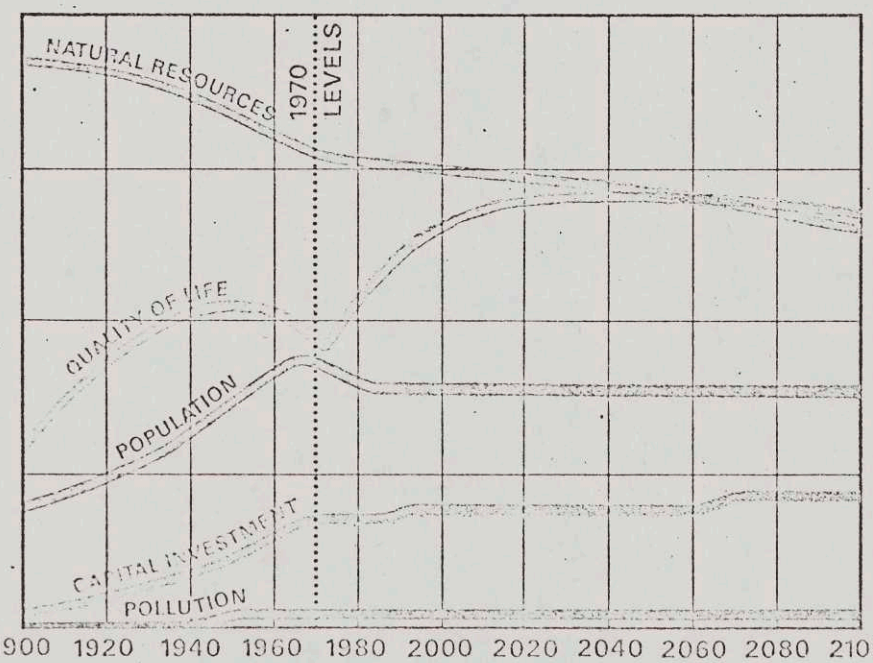
The reduction in birth rate temporarily slows population growth, but lower death rate, greater food production and eased crowding conditions soon encourage the population to start up again, and it is now a richer and more polluting population. This shows the curious interrelationships of what systems analysts call negative feedback. By starting a promising birth-control program, we simultaneously release other natural pressures that help defeat the program. Here is the core of the nature of systems. When one pressure or combination of pressures is lightened, the result is likely to be the substitution of a new problem for the old. Often the new problem is more difficult to solve or less tolerable to live with than the old one. Advanced societies have come to expect technology to solve their problems. Technology works well when there are unlimited natural resources and geographical space to expand into; but in the real world, we reach limits. Ehrlich's milk bottle is close around us.

The projections also demonstrate the trade-off between short-term and long-term consequences of a decision. The developed nations all achieved their higher material standard of living by devoting a generation or two to building up a store of capital equipment. They used the productive capacity of labor to make machines and factories rather than food and other consumable goods. Robber barons did it for England during the Industrial Revolution and for the U. S. during the early expansion phase of its growth. The Soviet Union achieved the same result by arbitrarily denying its citizens the immediate fruits of their labor.

But there are few social mechanisms in the underdeveloped nations to defer short-run benefit for long-term return. The scarcity of such mechanisms may turn out to be a good thing, because it has the desirable effect of keeping average world capital investment under control. If we can simultaneously reduce capital investment, agree to hold the material standard of living at present levels, reduce the birth rate to half its current level, reduce pollution generation to half its current level (by a cutback in industrialization and by application of science to the problem), perhaps hold back on food production somewhat (if population is stabilized at or below the current level, we won't be needing much more food than is now produced), then, for the first time, we see the possibility of reaching equilibrium without catastrophic overshoot and population decline (left).

On the surface, it seems anti-humanitarian to reduce capital investment and stop the effort to raise food production. Such drastic measures couldn't possibly be accepted without years of study and discussion. But the alternatives are dire and inescapable. The population explosion and pollution are direct descendants of old gods—industrialization and science. Without drastically changing its priorities, world population will collapse in less than a century from the effects of pollution, food shortage, disease and war.

Forrester emphasizes that his analyses are not intended as literal year-by-year predictions; but he does insist that man's viewpoint must become world-wide and centuries deep if the species is to survive. Dennis Meadows and nine clean-cut young researchers, meanwhile, study dull books of statistics, scribble numbers on lined pads and occasionally push a few buttons on a computer console in what surely must be the least dramatic attempt ever made to save the world.



an end to all this

we have handed our heirs an ecological time bomb that birth control alone cannot defuse

article By RICHARD M. KOFF WITH THE CAREFUL DISREGARD of their respective governments, two dozen eminent men were gathered last June in one of the great old *grande luxe* Swiss hotels. They strode familiarly down wide, carpeted halls—an Italian industrialist, a Belgian banker, two university presidents, a professor at MIT, the director of a major Swiss research institute, a Japanese nuclear physicist, a science advisor to an international economics organization, several economists whose pessimism, if quoted in the press, could cause a stock-market crash.

They moved purposefully toward a conference room. They did not drift, though side conversations delayed several members of the executive committee. Their one common characteristic was a certain firmness about the lips and jaw indicating an intention to get things done. They were activists in the most responsible meaning of the term. Each had been invited to join the group, called the Club of Rome, by its founder, Aurelio Peccei, himself a member of the management committee of Fiat, vice-president of Olivetti and managing director of Italconsult. Each served quietly, without compensation nor even paid expenses, as a full-fledged member.

They represented the best analytical minds of the world, with considerable influence to make funds available if a promising approach could be found to stop the suicidal roller coaster man now rides. Their concern during the two days in Bern was formidably titled A Project on the Predicament of Mankind. The predicament is simply stated: World population is growing by 70,000,000 people every year. This is the fastest growth in man's history, and the rate is still accelerating. We will number four billion in 1975 and, if current trends continue, we can expect to reach eight billion well before the year 2000. This population is making more and more demands on its environment. We are taking fresh water out of the ground roughly twice as fast as natural processes replace it. The demand for electric power in the U. S. is doubling every ten years, and most power comes from the heavily polluting combustion of coal. We are building 10,000,000 cars a year—twice as many as we made only 17 years ago, and cars burn gasoline, grind rubber tires to dust, wear asbestos brakes into an acrid powder.

Until 1970, these figures were considered proud evidence of progress. After all, it was reasoned, if power demands, automobile production and water consumption are increasing even faster than population, then the standard of living of each individual must be improving; and for the advanced countries, this is certainly true. Edward C. Banfield, professor of urban government at Harvard, wrote a few years ago: "The plain fact is that the overwhelming majority of city dwellers live more comfortably and more conveniently than ever before. They have more and better housing, more and better schools, more and better transportation, and so on. By any conceivable measure of material welfare, the present generation of urban Americans is, on the whole, better off than

ILLUSTRATION BY KERIG POPE

JULY, 1971

any other large group of people has ever been anywhere."

It's not surprising, then, that the industrialized nations consider progress synonymous with economic growth and that the underdeveloped nations share that article of faith. The world wants and expects more people, more and faster jet planes, more television sets, more dishwashers. If one car in the garage is good, two must be better.

But consider the price of this plenty: Death due to lung cancer and bronchitis is doubling every ten years. The U. S. incidence of emphysema has doubled in the past five years. Crime in large cities has also doubled in the past five years.

Population biologist Paul Ehrlich describes an experiment in which a pair of fruit flies is put into a milk bottle with a small amount of food. In a matter of days, the population of fruit flies has multiplied to the point where the bottle is black with them. Then the limited food and their own effluvia raise the death rate, and the population drops suddenly down to zero. After 10,000 years of uninhibited propagation, mankind is beginning to sense the confines of its bottle. Man is beginning to realize that he's going to have to stop multiplying his numbers and gobbling up his world —and do it soon—because if the decision isn't made by him, it will be made *for* him by the laws of mathematics and nature.

The trouble is that man has never been very successful in controlling the destruction of community property. We have laws that keep a man from raping his neighbor's daughter, but we have few that keep him from despoiling his air. We have tried governmental action to remedy social ills before, but, as Banfield writes, "Insofar as they have any effect on the serious problems, it is, on the whole, to aggravate them."

This was the "predicament" facing the Club of Rome that June day. MIT professor Jay W. Forrester was a relatively new member of the club. He was lean, graying and spoke with the dry, didactic factuality of the trained lecturer. His theory was startling in its directness—that governmental inadequacy is an example of predictable and consistently self-defeating human behavior. His studies had suggested that the human mind is not adapted to interpreting the behavior of social systems, that human judgment and intuition were created, trained and naturally selected to look only in the immediate past for the cause of a problem. The hot stove burns the finger, not the curiosity that made one reach out to touch it.

All human solutions tend to be that simplistic. We see thousands of people in rat-infested, leaky-roofed tenements. Our traditional answer has been to tear down the tenements and put up large, low-income housing projects. The Pruitt-Igoe project in St. Louis was built to solve this problem and now 26 11-story glass-and-concrete apartment buildings are being boarded up a scant 15 years after they were built—and long before they were paid for. Vandalism, physical deterioration and an impossible job of maintaining essential services made the project a social, architectural and financial disaster. Elevators stalled, windows were broken faster than they could be replaced, residents were assaulted in the halls, apartments were broken into and doors never repaired. The poorest of the poor refused to live there and vacancies climbed even as surrounding housing became more scarce. The buildings now stand vacant as monuments to governmental waste.

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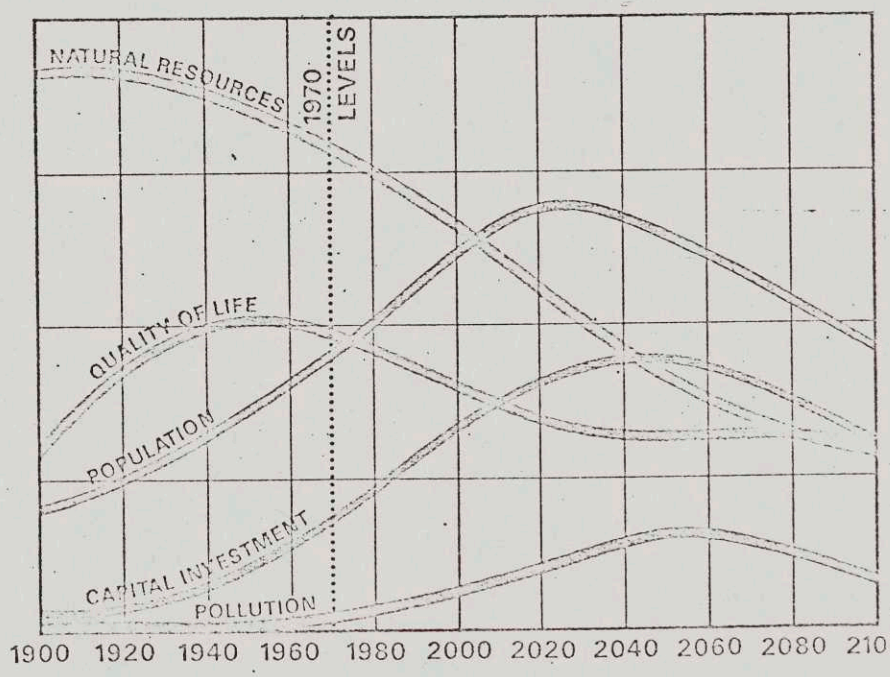

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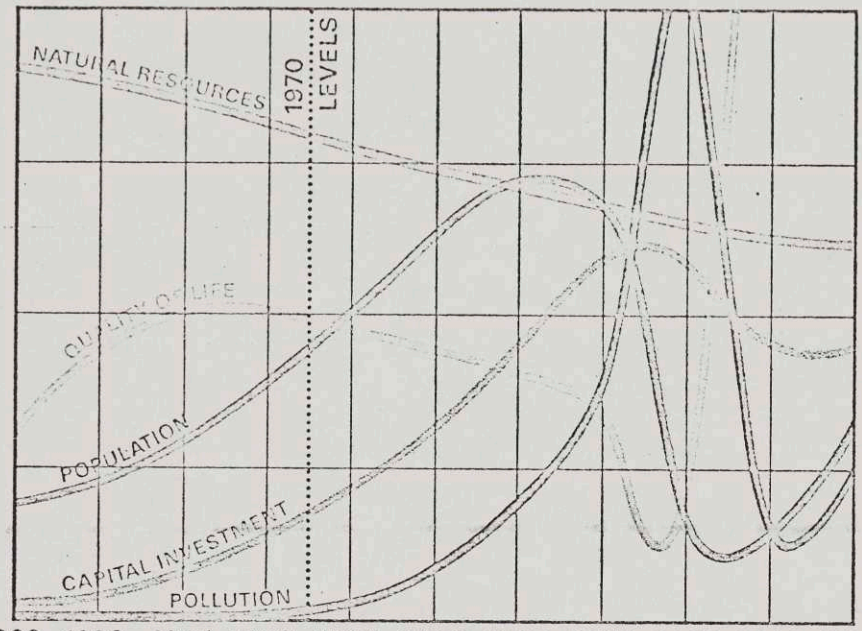

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The conclusion is inescapable. If the world is to achieve equilibrium at a material standard of living at or close to the level now enjoyed by the developed nations, world population and industrialization must be considerably lower than the current averages. And that is political dynamite.

This projection demonstrates a vitally important characteristic of the world system: It is going to reach equilibrium one way or another. We are entering a turbulent time, a time when the dedication to growth in the advanced nations will have to give way. It is impossible for every citizen of the world alive today to enjoy the standard of living that has been taken for granted in the West. The goals of our civilization will have to change, and when goals change, traditions no longer serve. We can predict a period of great unrest and uncertainty, with a frighteningly greater possibility of world war, unless enough people see that the true enemy is the system, not one another.

A second discouraging characteristic of the system is that major scientific achievement in the form of reduced depletion of natural resources has the effect only of postponing the date of catastrophe. It permits greater overshoot of industrialization and population and will actually magnify the catastrophe when it finally comes.

With this firmly in mind, it is relatively easy to predict what will happen if the next solution is attempted. Suppose we agree with the underdeveloped nations that their material needs should be met, and they agree to join us in trying to curb population growth. That

means we increase capital investment (to give them a better standard of living) but apply extreme moral and economic pressure to hold down the birth rate. In this projection (at right), Forrester assumed we cut the birth rate in half in 1970 and increase capital investment by 20 percent. For the first few years, things look good. Food per person increases, material standard of living rises and crowding is held close to present levels. But the more affluent world population ends up using natural resources too fast. Capital investment zooms and the pollution load on the environment reaches the critical level even earlier than it did in the previous run.

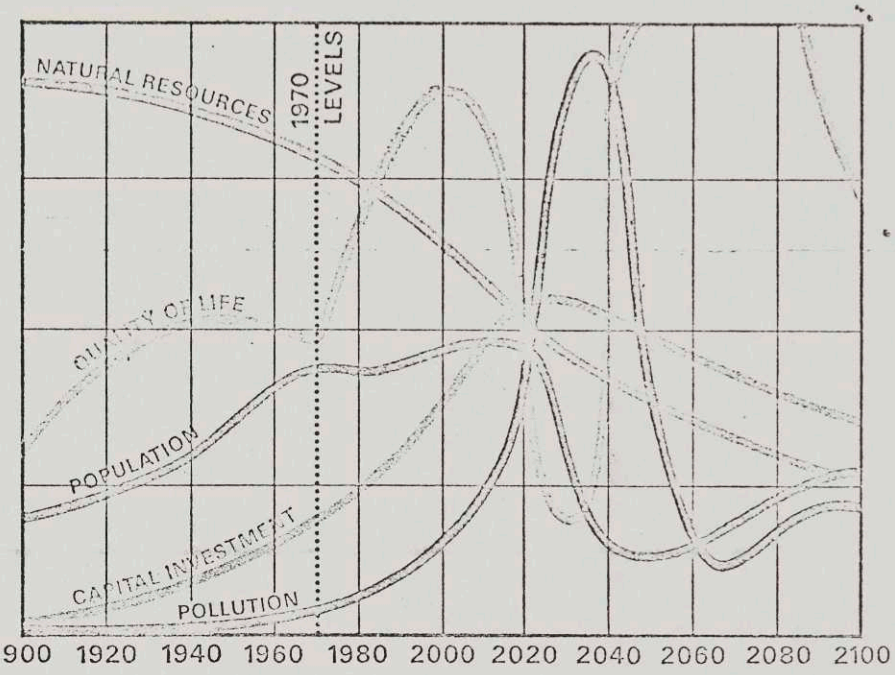
The reduction in birth rate temporarily slows population growth, but lower death rate, greater food production and eased crowding conditions soon encourage the population to start up again, and it is now a richer and more polluting population. This shows the curious interrelationships of what systems analysts call negative feedback. By starting a promising birth-control program, we simultaneously release other natural pressures that help defeat the program. Here is the core of the nature of systems. When one pressure or combination of pressures is lightened, the result is likely to be the substitution of a new problem for the old. Often the new problem is more difficult to solve or less tolerable to live with than the old one. Advanced societies have come to expect technology to solve their problems. Technology works well when there are unlimited natural resources and geographical space to expand into; but in the real world, we reach limits. Ehrlich's milk bottle is close around us.

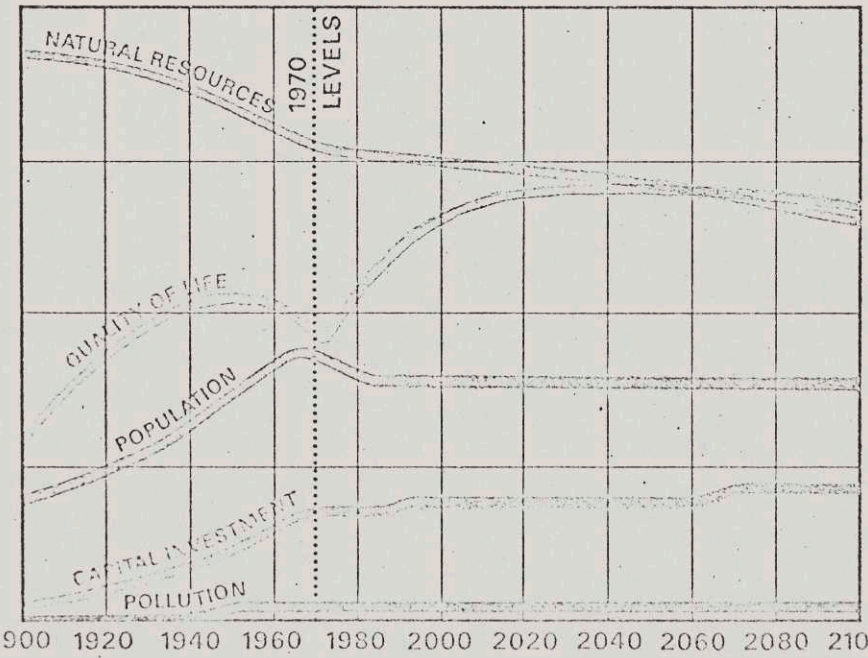
The projections also demonstrate the trade-off between short-term and long-term consequences of a decision. The developed nations all achieved their higher material standard of living by devoting a generation or two to building up a store of capital equipment. They used the productive capacity of labor to make machines and factories rather than food and other consumable goods. Robber barons did it for England during the Industrial Revolution and for the U. S. during the early expansion phase of its growth. The Soviet Union achieved the same result by arbitrarily denying its citizens the immediate fruits of their labor.

But there are few social mechanisms in the underdeveloped nations to defer short-run benefit for long-term return. The scarcity of such mechanisms may turn out to be a good thing, because it has the desirable effect of keeping average world capital investment under control. If we can simultaneously reduce capital investment, agree to hold the material standard of living at present levels, reduce the birth rate to half its current level, reduce pollution generation to half its current level (by a cutback in industrialization and by application of science to the problem), perhaps hold back on food production somewhat (if population is stabilized at or below the current level, we won't be needing much more food than is now produced), then, for the first time, we see the possibility of reaching equilibrium without catastrophic overshoot and population decline (left).

On the surface, it seems anti-humanitarian to reduce capital investment and stop the effort to raise food production. Such drastic measures couldn't possibly be accepted without years of study and discussion. But the alternatives are dire and inescapable. The population explosion and pollution are direct descendants of old gods—industrialization and science. Without drastically changing its priorities, world population will collapse in less than a century from the effects of pollution, food shortage, disease and war.

Forrester emphasizes that his analyses are not intended as literal year-by-year predictions; but he does insist that man's viewpoint must become world-wide and centuries deep if the species is to survive. Dennis Meadows and nine clean-cut young researchers, meanwhile, study dull books of statistics, scribble numbers on lined pads and occasionally push a few buttons on a computer console in what surely must be the least dramatic attempt ever made to save the world.





THE OBSERVER (JUNE 27, 1971)
(Reviews and Critiques)

'he more we try, the worse it will be' by Gerald Leach.

Shock findings on the environment crisis

THE first attempt ever made to put the world's environmental crisis on a computer has produced such shattering results that the sponsors of the project have started urgent talks with Heads of State in several countries.

The computer has shown that almost every 'obvious' policy now being followed to improve man's lot or the environment—such as investing more in growing food or in cutting pollution—leads only to the build-up later of new and even worse pressures.

More daunting, it shows that most attempts to reduce these new pressures will bring on an even worse crisis. Several of the computer 'scenarios' include a catastrophic and sudden collapse of population.

For example, one predicts that today's situation of declining natural resources will eventually force a steady reduction of population and a falling 'quality of life.' But if the drain on the earth's resources is cut—either by saving critical materials or finding more of them (as with last week's North Sea oil development)—the result may be a runaway pollution crisis which brings population crashing to a fraction of its former level (see graphs).

Yet if pollution is controlled, the computer predicts that a 'crowding crisis' will develop which will steady population growth but drag down the quality of life severely.

Other major conclusions of the study—which comes from the prestigious System Dynamics Laboratory of the Massachusetts Institute of Technology and has just been published in the United States as a book called 'World Dynamics'—are:—

O Global population growth and industrialisation are very rapidly approaching the limits of the earth's capacity to support them.

O We may now be living in a 'golden age' when the average quality of life is higher than it ever was in the past or will be in future.

O Industrialisation and capital investment disturb the world's environmental capacity more than population growth does. Highly industrial societies may be 'self-extinguishing,' either from resource exhaustion or international strife over pollution and resource rights.

O Developing countries are in a closer environmental balance than industrial ones, and may be in a far better condition to survive coming crises as long as they don't industrialise heavily (as they are trying to).

O Programmes to control population may be inherently self-defeating. If they work and lead to higher material standards and food supplies for each person, as is hoped, these very improvements may relax the pressure on numbers and trigger another population spurt.

But by far the most disturbing conclusion is that to achieve improvements in the long run, the world has to adopt policies that make life much harder in the immediate future. 'This is especially treacherous,' the book's author,

(*Continued on page 2*)

THE OBSERVER

160 Queen Victoria St., London EC4V 4DA. 01-236 0262. 27 June 1971

Environment shock

(*Continued from page 1*)

Professor Jay W. Forrester, writes. 'We are at the point where higher pressures [on growth] in the present are necessary if insurmountable pressures are to be avoided in the future.'

The full scale of the treachery is revealed by the 'best' long-term solution provided by the computer: quality of life—defined in the computer programme as a combination of material standard of living, the degree of crowding, available food and pollution—is kept at approximately today's level while population growth is halted.

To achieve this optimum, the rate at which natural resources are used up must be cut by a staggering 75 per cent, pollution generation must be reduced by 50 per cent, capital investment slashed by 40 per cent, birth-rate reduced 30 per cent. Most significant of all, food production must be reduced 20 per cent, since hunger has always been the most effective brake on economic and population growth.

More than 10,000 copies of the computer's findings have been sent to high-level decision-makers throughout the world.

These sensational forecasts are certain to be attacked heavily once they become widely known, especially by politicians committed to the short-term beneficial policies that the computer predicts will cause long-term crises. The sharpest attacks are bound to be on the crude over-simplification of the 'world environmental system' that was fed into the computer before it churned out its forecasts. This considered only the level and growth rates of five key factors—population, capital investment, natural resources, pollution, and quality of life.

These factors were each broken down into several 'indicators'—such as the fraction of investment going to food production, to pollution control and to raising material living standards. All the indicators were then linked by a total of 45 equations in such a way that altering one indicator had a pre-set effect on the others.

Given this 'world model,' the computer was then told to forecast how the five key factors would behave up to the year 2100 if one took different assumptions for 1970: for example, 'increase capital investment by 20 per cent.'

Though crude, computer models like this are good at reflecting the behaviour of real-life systems, like a business or a city. They are far too complex for human minds to follow, so that their conclusions are usually totally unpredictable.

Defending his world model, Professor Forrester insists that, however over-simplified, it is still more complete and explicit than the mental models now being used as a basis for world and national planning.

An international team at MIT, headed by Professor Dennis Meadows, has spent the last year improving the model, hunting out errors and adding many more indicators to bring it closer to what happens in the real world. Last week he told me that none of these alterations had made any major difference to the crisis forecasts or the crisis measures needed to avoid them.

It is for this reason that he and the sponsors of the MIT project are now urgently contacting decision-makers up to Head of State level to warn them where their present policies might be leading.

The MIT group has also started a series of computer studies which look only 10 to 20 years ahead. The idea is that if world leaders can't grasp the importance of taking the 130-year view of the main study, they might be prepared to act on the short-term forecasts. These will also be much more narrowly focused to make a sharper impact on politicians, legislators and technologists.

One of the most significant aspects of all this activity is the powerful and growing role being played in national and international affairs by the semi-secret Club of Rome—the sponsors of the MIT computer project. Started about two years ago by a handful of eminent industrialists and academics who were worried about the lack of response to what they saw as a looming environmental crisis, the club now consists of an international network of some 75 members.

They see themselves very much as did Edgar Wallace's 'Four Just Men'—shadowy background figures whose mission is to save the world by infiltrating their ideas into the corridors and dining tables of power.

According to Professor Meadows, in the last two months Club of Rome members armed with the MIT computer's forecasts of crisis have made a 'tremendous' impact and have reached the highest levels in several countries, including some in the Soviet bloc. 'Don't expect any immediate public announcements,' he warned, 'but you can take it that a lot of rethinking is going on.'

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JWF - Home File

THE OBSERVER

27 JUNE 1971

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Population and pollution: 'The more we try, the worse it will be'

Shock findings on the environment crisi

by GERALD LEACH, our Science Correspondent

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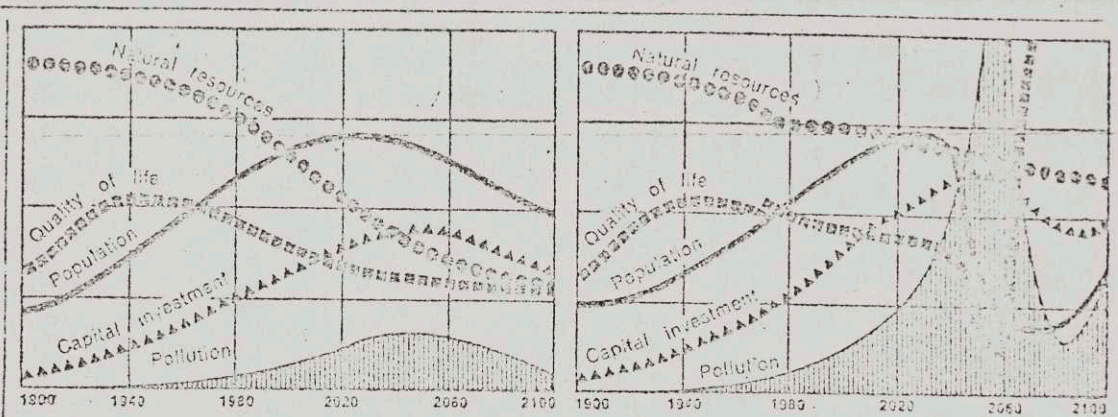

The computer predicts (left) that declining natural resources will reduce the quality of life. Yet halting the drain on resources could bring (right) runaway pollution and a population collapse—but a higher 'quality of life' for the survivors.

Pollution shock

(*Continued from page 1*)

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THE CHRISTIAN SCIENCE MONITOR
(Reviews and Critiques) OK

JWF Home File

The Christian Science Monitor, 7 August 1971

By Pete Main, photo staff

Christian Science Monitor August 7, 1971

Doomsday prophet or man with a message

An interview with Jay W. Forrester

By Richard A. Nenneman

Business and financial editor of
The Christian Science Monitor

Cambridge, Mass.

IF WE HAVEN'T SEEN HIM ON THE STREET corner in person, we've all at least seen cartoons of the man with the sign on him saying, "Prepare for the end of the world." No one loses any sleep over that.

The high-school or college dropout, particularly if it is a young person turning against the kind of middle-class background we had assumed to be the world's ideal, causes thoughtful people more concern. Even if we don't agree with the young person, we begin to wonder if there is something about the way we live that he sees through, something he can see that we can't.

Now a representative of the establishment has just as disturbing a message as the street-corner prophet of today's turned-off generation. The message is that a thousand years of thought processes, centered around the attractiveness of growth and progress, are coming to an end. Society is entering a new era, in which equilibrium, a balancing of the main influences on a society's development, will replace growth. And the message, further, is that we can no longer count on technology to solve our problems.

Aggravating stimulation

The man who bears this message is Jay W. Forrester, a pioneer in devolpment of the digital computer and a professor at the Sloan School of Management at Massachusetts Institute of Technology. An extremely mild-mannered, middle-aged professor, Mr. Forrester reminded me of the kind of friend who can be aggravating because he is so sure of himself, yet so stimulating one can't get enough of him.

Professor Forrester, who admits that mankind's transition from growth orientation to equilibrium orientation will be a difficult passage, has come to these startling conclusions:

- We may be living in the "golden age." That is, the quality of life may be better now on average than it ever has been or ever will be again.
- Industrialization may at the moment be doing more harm to the world than population growth.
- Birth control alone may be self-defeating. If it results in more food and a rise in the standard of living, the very pressures that made birth control acceptable will be relaxed, and population would begin to climb again.
- The underdeveloped countries probably can never reach our standard of living. The pollution and natural-resource load accounted for by each person in an industrial nation is 20 to 50 times greater than in an underdeveloped nation, Professor Forrester estimates. "Capability appears not to exist for handling such a rise in standard of living." In fact, he asserts, the present disparity between the rich and the poor nations "may be equalized as much by a decline in the developed countries as by an improvement in the underdeveloped countries."
- A highly industrialized society may be "non-sustainable." Viewed from a century in the future, "the present efforts of underdeveloped countries to industrialize may be unwise." Professor Forrester says he thinks they may be closer than America and Western Europe are "to an ultimate equilibrium with the environment. . . ."

'World Dynamics' conclusions

Mr. Forrester came to his conclusions about society—and he is talking about global society—in his just-published book, "World Dynamics." The book is the immediate outgrowth of the interest of the Club of Rome in a project it had called "The Predicament of Mankind." The club is a private group of 75 members from many countries, who are trying to understand better the changes going on in the world and to interpret their findings to a wide enough audience to influence the course of action.

Last summer Professor Forrester described to them the methodology that he had developed at MIT for describing the action of dynamic systems with a computer model. With their interest, and the financial backing of the Volkswagen Foundation in Germany, Professor Forrester and a small research group at MIT embarked on a project to extend and verify the information about social systems that he had been developing already.

The social system, says Professor Forrester, is a multiloop feedback system. What this means in longer, everyday language is that there are many influences on the social system and that these influences have interacting effects on each other. For instance, we often say in describing some one change, "All other things being equal . . ." even while knowing that all other things will not be equal or remain static.

Attracting a ghetto

In the field of urban problems, this same reasoning had supplied Professor Forrester with the answer to why all the efforts to improve the ghetto seemed to have little effect. "We built low-income housing to take care of the poor," he noted, "without understanding that the creation of low-income housing attracted more poor into the inner city."

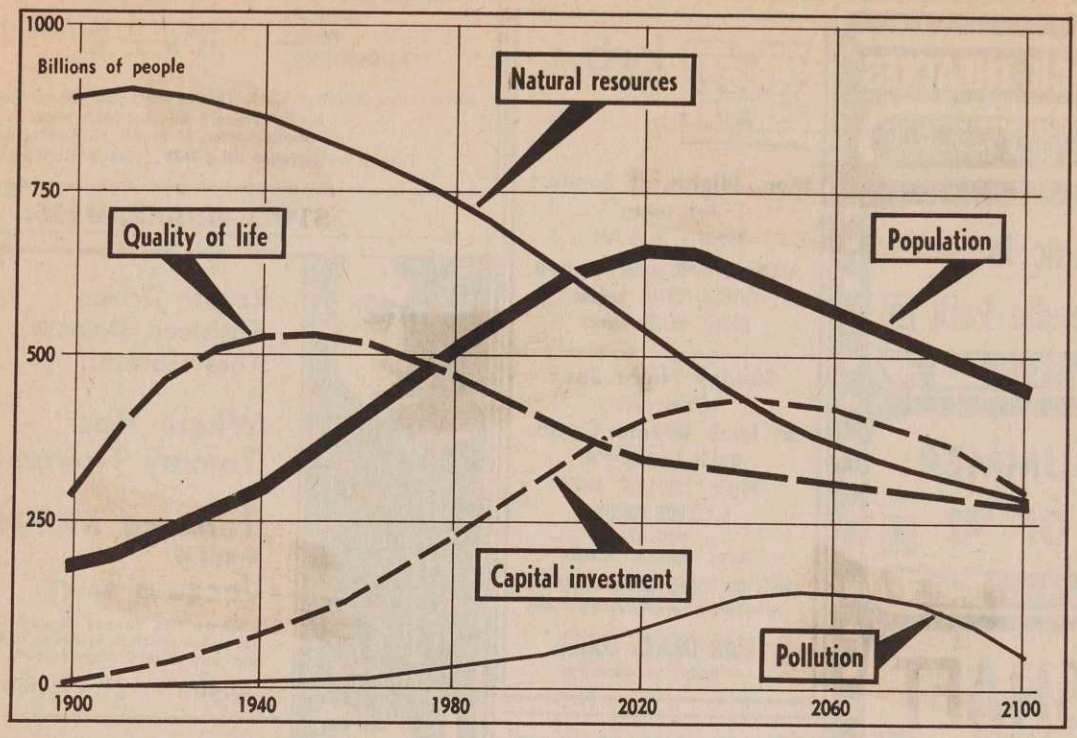
The world social system, as Mr. Forrester describes it, has five elemental factors: population, natural resources, pollution, capital investment, and the fraction of capital investment devoted to food production. The interaction of these individual "systems" on each other results in what he calls the quality of life. Quality of life is a catchall phrase in which he includes the material standard of living, food supply, degree of crowding, and pollution.

There is no particular disagreement, he asserted, as to the primacy of the above factors in describing what goes on in the socio-economic world. And the experts he talked with in setting up his computer model were agreed as to how one factor could influence another. The birth rate, for instance, is affected by the food available, by the crowding ratio, by pollution, and by the material living standard.

Mental picture inadequate

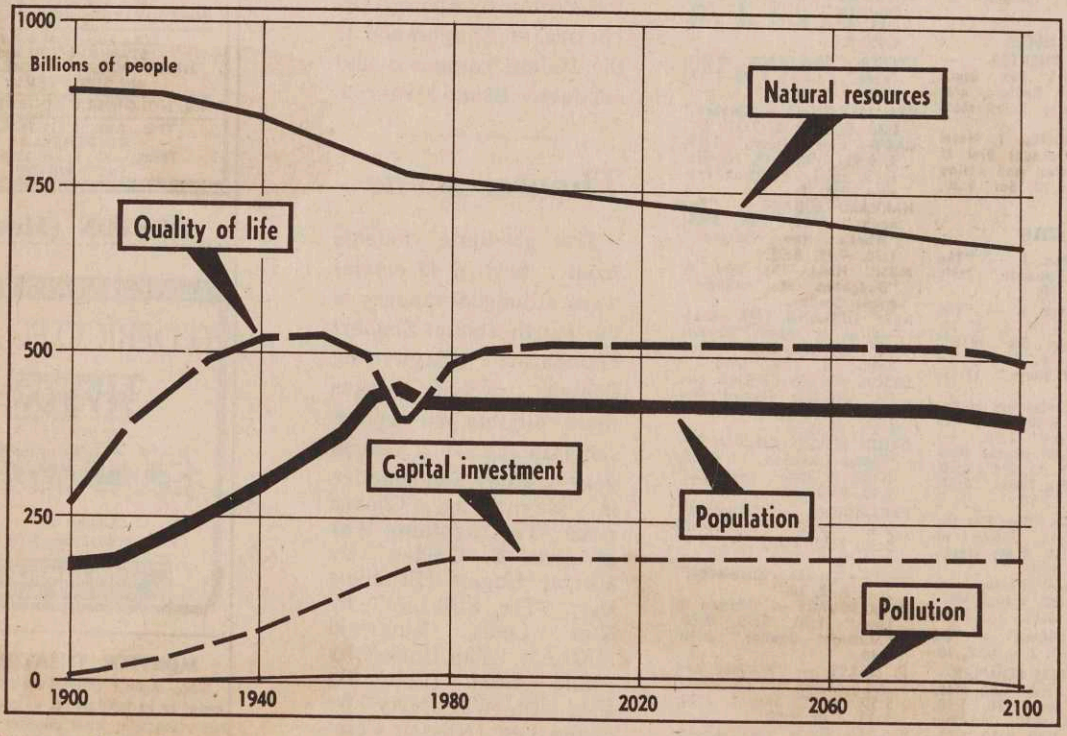
But Professor Forrester maintains the mental model that the human mind carries around is not adequate. We aren't able to judge how this whole "system" functions through time, or how one change sets up other compensating changes.

And this is just what the computer can do so well. As for the argument that his computer description



Charts adapted from Jay W. Forrester's book, "World Dynamics" by Henry Benson, staff artist

Basic behavior of the world model, showing the mode in which industrialization and population are suppressed by falling natural resources.



Normal birthrate reduced 30 percent in 1970 along with natural-resource-usage rate reduced 75 percent, pollution generation lowered 50 percent, capital investment generation dropped 40 percent, and food production reduced 20 percent.

of the social system is too simple, he claims it is better than any mental model. And yet we use the mental model as the basis for passing reform legislation that doesn't correct what it sets out to do, and wonder why.

Professor Forrester says simply that exponential growth cannot continue in a world that has limits—limited land, limited natural resources, and limited capacity to dissipate pollution. Using known statistics from the years 1900 and 1970, his computer model makes projections up to the year 2100. It indicates that the world system is already approaching the outer limits of growth. The big question for Mr. Forrester is whether mankind will move swiftly enough to establish an equilibrium that would sustain something like today's quality of life.

2020—year of crisis

To continue as the world now is doing, there would be some kind of crisis around the year 2020, Mr. Forrester says. Natural resources, which on average he judges to be sufficient for 250 years, would be the "culprit" in this case. An increasing population would consume them at an ever faster rate, and the "consequences of impending shortage" would begin to be felt long before the shortage itself. Note, he says, the tougher line the Middle Eastern countries are already taking on oil.

Falling natural resources would lower the effectiveness of new capital investment and lower the standard of living. Finally, the quality of life would drop low enough on a worldwide basis that population would begin to decline.

But suppose there were some way to avoid a natural-resource crisis—that substitutes could be found, and the material living standard kept high. Then, his model forecasts a pollution crisis caused by the high rate of capital investment and industrial growth. "I don't know if the year will be 2030—that's unimportant. It may be 2060, and then again it may be 1985," said Mr. Forrester.

Five interacting systems

His basic argument about technology no longer being the answer becomes clearer at this point. Substituting one material for another, trying to hurry up capital investment, avoiding for a while a pollution crisis — all these are attempts to deal with only one "system" of the five in his social model. A few decades of time are gained in some cases, but in any long-run look there is still an end to growth and still a population crisis. In his pollution-crisis model, population goes in a 30-year period from 6 billion down to 1 billion.

Is there, then, no happy ending? Not, he implies, if we insist on thinking in terms of growth. But if one replaces a growth "model" in his thought with an equilibrium model, there is a way out. This, says Professor Forrester, is to reduce the birth rate by 30 percent, which reduces population slightly from its 1970 level. But in combination with this, food production would also be reduced 20 percent and new capital investment by 40 percent. The industrialization that makes the crowding and the pollution, but is also one basis for sustaining more people, levels off.

Food-supply leverage

It appears cruel to talk about less food production, when part of the world is near starvation, I said. Yes, admitted Professor Forrester, but many more people may starve or at least go hungry in the future if the world isn't stabilized now. His computer equations assume that population has always been directly affected by food supply. A good part of mankind has always lived in hunger. As food supply increases, so—at least in the past—has population increased.

Natural-resource usage in this optimum model would slowly drop, but lower capital investment would minimize that problem for a long time to come. Most important, the quality-of-life line levels off slightly higher than Mr. Forrester's model figured it for 1970.

I asked if international trade was not one way of reducing shortages that he feared. This is just another example of looking for the technological answer, he replied. It masks the basic fact of some shortage somewhere. By means of international trade, he said, all nations can overcome their shortages for a while. But ultimately, "they all hit the barrier at once." The realization of limited resources becomes even harder to cope with if the day is postponed, he said.

Four traps of society

In fact, he added, this was an example of one of the four "traps" into which all the obvious, intuitive answers to social problems fall.

1. They relieve one problem by creating another (as in substituting a pollution crisis for a natural-resource crisis).
2. They neglect the long-term consequences of policy changes that may have short-run benefits (as in the case of international trade I had mentioned).
3. They ignore the conflict between the "goals of a subsystem and the welfare of the broader system." For instance, nations try to maximize economic growth. Partly this is for the welfare of their citizens, partly to increase their influence abroad. Yet, this kind of national striving may "deepen the distress of the world as a whole and eventually . . . the crises in the individual nations themselves."
4. They attack the social system at some point that is "inherently insensitive." Professor Forrester includes in this category efforts to reduce hunger by producing more food.

Pessimism before optimism

"This must make you a pessimist," I suggested to Professor Forrester. "No," he replied, "but one has to be pessimistic about what we are doing now before he has the incentive to do the things that can make me optimistic about the future." In the U.S., he suspects the approaching squeeze will have to be felt somewhat before we are willing to cut back on population or retrench in any other ways.

He told of a recent day when he had two conferences: one with the board chairman and six executives of a large corporation, the other with a group of students somewhat more antiestablishment than most at MIT. After he had explained his thesis and what the computer told him, the questions and the reactions of both groups were nearly identical, he said. The right and the new left are in agreement on many points in looking at the future, he claimed.

One sits in Professor Forrester's office and wonders if he is exaggerating. (He makes no claim for precision with the present computer model but does maintain that it accurately describes the dynamics of the social system and predicts that growth is inexorably coming to an end.)

Charles, blue but polluted

Outside his window flows the Charles River, blue on the bright day I visited him, but so filled with the pollutants he talks about that the worst thing that can happen to an amateur sailor is to fall into the river. And beyond the Charles, all those symbols of growth and expansion — Boston's new Prudential Center, the steel beams of the new 60-story John Hancock Tower climbing into the sky. But there at MIT are those computers, saying that a millennium in which growth gradually became the keyword of society is drawing to a close.

One may not believe the doomsday prophets. And he may well have an ambivalent attitude toward the mixed message of the youth culture. But here are some ideas that, as radical as they are and as disturbing to the "set" of our minds, seem to beg for further exposure to daylight — and debate.