Limits to growth: Debating the future

MIT group's projections of a disastrous future are vulnerable to criticism but do provide a first attempt to assess consequences of present trends

by Richard H. Gilluly

The enlightened and liberated man is "one with cause and effect."—From a Zen Buddhist Koan (parable)

Ernest Hemingway once said the best equipment a man can have is a "crap detector." Never was he more right than now. Assertions and counter assertions about the fate of mankind are flying thick and fast—and the average citizen is hard put to know whom to believe.

A group of systems-dynamics specialists at the Massachusetts Institute of Technology have told the world that if current trends in industrial and population growth continue, the human race is doomed. The implication of their computer-simulation based study, *The Limits to Growth,* is that current competition-oriented value systems and their material spinoffs are taking mankind to disaster, and that new value systems are desperately needed (SN: 3/11/72, p. 165).

Systems dynamics is a new field of study underlying some of the more sophisticated uses of modern computers. Its purpose is to construct mathematical models of some part of the real world, or, in this case, the entire world. An essential premise of the new science is that "everything is connected to everything else" and that one factor—such as industrial growth—can affect every other aspect of the world in ways often heretofore unperceived. It is a non-linear science; it recognizes that the multitude of possible effects from interacting factors can be exponential in both negative and positive ways, through "feedback loops." An essential corollary is that incremental changes in an ailing system, no matter how well-meaning, can sometimes actually make it worse. Securing a higher rate of industrial investment can, for instance, provide short-term gains for the economic well-being of many people. But the long-term result might be, say the systems dynamicists, an aggravation of the original problem. Industrial growth produces short-term capital surpluses to deal with pollution problems, for instance, but ultimately it adds to the total pollution burden and thus to the economic malaise of many people. Growth can postpone the day of reckoning; but when that day comes, problems are too large to handle.

But fascinating an intellectual exercise as systems dynamics may be, it is useless without a reliable data base. If facts and figures on increasing pollution are unreliable, then the entire model might be fatally flawed (although not necessarily). The same is true for other quantities cranked in. The question now is: How reliable is the MIT data base? This general question promises to be the subject of continuing debate for the rest of this century—until the prophets are proven wrong or until they are proven right. The latter could occur with mankind accepting the prophets and mobilizing to save itself, or it could occur with mankind muddling itself over the edge of the precipice the prophets say lies just ahead.

1	2	3	4			5	6
Resource	*Known Global Reserves* [a]	*Static Index (years)* [b]	*Projected Rate of Growth (% per Year)* [c]			*Exponential Index (years)* [d]	*Exponential Index Calculated Using 5 Times Known Reserves (years)* [e]
			High	*Av.*	*Low*		
Aluminum	1.17×10^9 tons [j]	100	7.7	6.4	5.1	31	55
Chromium	7.75×10^8 tons	420	3.3	2.6	2.0	95	154
Coal	5×10^{12} tons	2300	5.3	4.1	3.0 [k]	111	150
Cobalt	4.8×10^9 lbs	110	2.0	1.5	1.0	60	148
Copper	308×10^6 tons	36	5.8	4.6	3.4	21	48
Gold	353×10^6 troy oz	11	4.8	4.1	3.4 [l]	9	29
Iron	1×10^{11} tons	240	2.3	1.8	1.3	93	173
Lead	91×10^6 tons	26	2.4	2.0	1.7	21	64
Manganese	8×10^8 tons	97	3.5	2.9	2.4	46	94
Mercury	3.34×10^6 flasks	13	3.1	2.6	2.2	13	41

Some nonrenewable resources: At current rates of use (3) and with projected exponential increases (6).

The debate will be on many levels, ideological and material. The fundamental aspect the MIT researchers deal with is the material. On this level, it is between those who say that mankind must proceed unequally toward universal affluence through economic growth, with the benefits "trickling down" to the poor, and those who say that economic growth of today's kind can only bring collision with finite resources and exacerbation of divisions between the rich and poor. It is also between those who say technological progress proved Malthus wrong once and it will again, and those who say technological progress purchased mankind a century or so of grace once but it cannot do so again.

There is no dating the beginning of the debate. John Stuart Mill, Barry Commoner and Paul Ehrlich, among many others, tried early to get it going. But perhaps the first three months of 1972 mark the real beginning in terms of large-scale involvement of many people, including some with great prestige. In January, the British publication THE ECOLOGIST published "Blueprint for Survival," a mainly conceptual, as opposed to quantitative, exposition of the world crisis its authors foresee (SN: 2/12/72, p. 100). Thirty-three prominent British scientists endorsed its broad conclusions. Then on March 2, the Club of Rome and MIT systems specialist Dennis L. Meadows introduced *The Limits to Growth* to a large audience for the first time. The symposium in the original Smithsonian Institution building brought together advocates on both sides of the debate and delineated their broad positions clearly.

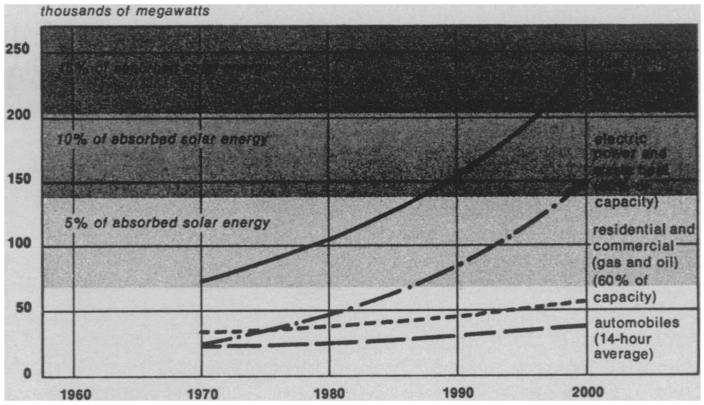
Philip Abelson, editor of the journal SCIENCE, was perhaps the most unequivocal opponent of the new views, although even he admitted large-scale changes in man's use of materials are needed, and that "unlimited growth cannot go on." Abelson was particularly critical of the MIT group's projections of pollution resulting from exponential industrial growth. He contended pollution problems are sometimes merely "problems of poor housekeeping" that can be solved with an expenditure of a very small part of the gross national product.

There is no doubt Abelson hit a weak spot in the MIT data base, not in the costs of pollution abatement but in the effects of pollution. Abelson's statement that only carbon dioxide, particulates, and perhaps DDT, are global pollutants has been fairly clearly refuted by evidence of lead concentration gradients in Greenland ice, of PCB levels in the oceans (SN: 1/8/72, p. 30) and of other apparent persistent worldwide pollutants. The problem lies in determining whether any of these are really harmful; the MIT authors admit there is little conclusive evidence one way or another. And Abelson insisted that with adequate energy for recycling and processing low-grade ore, collapse due to resource depletion, another standby of the MIT authors, "is absolutely no problem." He added: "I am convinced we will solve the energy problem"—through such innovations as fusion power.

The MIT authors present convincing cases against Abelson's contentions on the costs of pollution and the depletion of resources. On the costs of pollution, support comes from an unlikely quarter. Paul W. McCracken, then chairman of the President's Council of Economic Advisers, testifying in December against a bill that would require perfect cleanup of water pollution, said the problem is that the nearer you get to perfection the higher the costs. For instance, he said, it will cost $0.7 billion per percentage point of further cleanliness to make the nation's waters 85 to 90 percent cleaner than now. Then the next 10 percentage points will cost $6 billion each. The final few points will cost $60 billion each.

Sen. Edmund Muskie, author of the bill, wants the water *perfectly* clean, and probably neither Abelson nor the MIT researchers would say this should be the goal. But the expected growth in industrial investment in the United States is expected to be 10.2 percent in 1972; if such a rate continues, as it has more or less in recent years, the doubling time of industrial capacity is about every seven years. Thus if technology is 85 percent effective in pollution abatement for existing plants, this gain is only 70 percent as effective

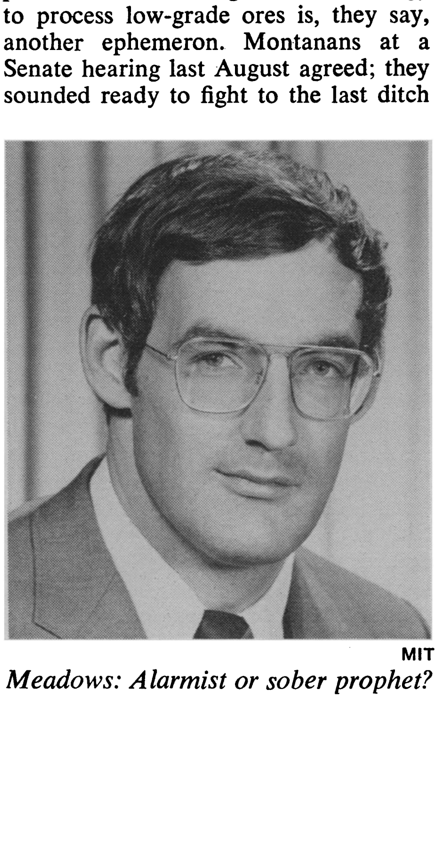
Waste heat generated in the Los Angeles Basin: current and projected.



Graphs: "The Limits to Growth," Potomac Associates

in reducing *total* pollution seven years later and only 40 percent as effective in another seven years. After another seven-year doubling, actual levels of pollution would be 120 percent of the amount 21 years before without abatement, and so on. Exponential growth in industrialization makes it essential that very near perfect pollution controls be achieved even if only an *adequately* clean environment is the goal. The costs are prohibitive. (This analysis has some flaws and oversimplifications, the researchers concede. In highly industrialized societies with saturated hard goods markets, for instance, services and software investments are growing at a faster rate than pollution-causing investments—although the analysis still holds for a worldwide aggregation.)

Likewise, say the researchers, the easy promise of "clean" new energy sources may be pie in the sky. The heat waste incident to energy use—already easily measurable in "urban heat islands"—may soon cause insuperable local, and perhaps worldwide, problems. And using low-cost energy to process low-grade ores is, they say, another ephemeron. Montanans at a Senate hearing last August agreed; they sounded ready to fight to the last ditch



MIT

Meadows: Alarmist or sober prophet?

to prevent mineral companies from wreaking the environmental havoc concomitant to mining low-grade ores in their state (SN: 10/2/71, p. 235).

But pollution is still the weak link in the MIT researchers' chain. It is also one of the most important factors bearing on their total credibility. The book presents several alternate models (besides the standard collapse and stability ones). All assume continued exponential industrial growth but assume also the beneficial control by man over other factors involved in the world crisis. Collapse still comes, largely because of pollution, in all of these models. For instance, in the world model in which all the other factors are controlled (it assumes unlimited resources, pollution controls, increased agricultural productivity, and perfect birth control) collapse in food production begins around the middle of the next century due to overuse of land and consequent erosion or other land loss. But the coup de grâce is delivered by pollution—which either kills people outright or destroys crops. "The application of technological solutions has prolonged the period of population and industrial growth, but it has not removed the ultimate limits to that growth," say the researchers. Four other models assume control of various factors, or combinations of factors, other than industrial growth. All of them end in collase, in three of them due in large part to pollution.

These five models are used to argue against the belief that technology will somehow enable man to escape the limits of a finite world. All but one of them see pollution as a basic cause of the collapse. Although it seems fairly reasonable to *conjecture* that levels of pollution four or five times the present ones will certainly kill people, plants and animals in large numbers, still the data are not included in the models. The reason, according to the researchers, is that the data are not available. Their models will be faulty until the imprecision regarding pollution effects is remedied. But they insist that "the behavior mode of the entire model is not altered by changes in the curve [of surmised pollution effects]" and that estimates of global pollution effects are "conservative." Local pollution effects, not considered, would be far more severe.

Other details of the models have been criticized, but much of the criticism is not convincing. "Population, capital and pollution grow exponentially in all (sic) models," say Allen Kneese and Ronald Ridker of Resources for the Future in a review of *Limits* in the Washington Post, "but technologies for expanding resources and controlling pollution are permitted to grow, if at all, only in discrete increments." There is no reason to assume these correctives would grow any other way but in discrete increments. Current exponential growth of population, industry and pollution requires virtually no innovations; left to themselves they will certainly keep growing, like Topsy, till they reach natural limits. The technological correctives will not grow without help, if at all. They require a high, and perhaps unachievable, degree of devotion of capital to research and development, of availability of highly trained researchers, of innovation and new discovery. Maybe these will all become available. Or maybe only magic will produce them.

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There is another argument, espoused by the authors of "Blueprint" and stressed by the executive committee of the Club of Rome, as well. "The crux of the matter," say the six members of the committee, "is not only whether the human species will survive, but even more whether it can survive without falling into a state of worthless existence."

This raises an entirely new area of discussion. The critics of modern civilizations say many men already are in a state of "worthless existence" through technological excesses, through crowding in cities, through unbridled aggression and competition. Undoubtedly, socio-psychological features of society are connected to the material features through their own feedback loops, says Jay W. Forrester, Meadows' mentor at MIT. The study of these connections offers a vast new field for behavioral science research.

And the implications for human values will be immense. Said Elliott Richardson, Secretary of Health, Education and Welfare, at the March 2 symposium: "We would like at least to believe if we must contemplate an equilibrium in which growth is ruled out, let it be an equilibrium in which equality has not forced the destruction of freedom and liberty." There are those who are saying now that a society in which every man and woman is regarded as having equal human value is the only society that is really free. □

April's western sky brilliant

by James Stokley

Venus, now approaching greatest brilliance, dominates the western sky in April. It remains visible for about four hours after sunset. Mars and Saturn are nearby, but much fainter. They are so low their light is dimmed by absorption as it passes through earth's atmosphere. On the 16th the crescent moon will pass close to all three planets, making a striking display.

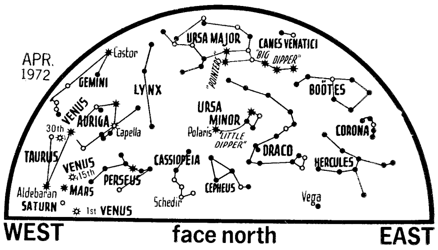
The maps show the skies at 10 p.m., local standard time on April 1, 9 p.m. on the 15th, and 9 p.m. (daylight saving time) on the 30th. The positions of Venus, Saturn and Mars are shown for April 15. Those of Venus, which is moving rapidly across the sky, are also shown for the 1st and 30th.

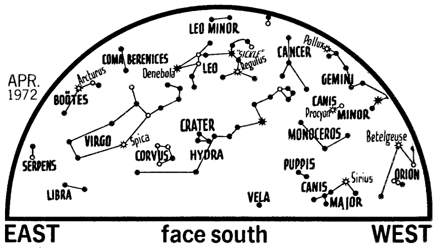
Soon after midnight, as April begins, Jupiter rises. It is about one-seventh as bright as Venus. The moon, then at last quarter, will pass south of Jupiter on April 6.

Venus has sometimes been called the earth's twin. This was principally because the two planets are nearly the same size: Earth's diameter is 7,927 miles, Venus' 7,526 miles. No other pair of planets in the solar system compare so closely. The mean distance of Venus from the sun is 67.2 million miles—25.7 million miles closer than the earth.

Until recent years practically nothing was known about surface conditions on Venus, because it is continually covered by clouds, which optical telescopes cannot penetrate. But the telescope does show that Venus changes phase like the moon. Although you can't see through the clouds that shroud Venus, astronomers have been able to penetrate them in recent years with radar (SN: 2/12/72, p. 102). A brief pulse of radio waves is accurately aimed at the planet, which sends back an echo. Precise measurement of the time for the echo to return (perhaps eight minutes) tells the distance, because radio waves, like those of visible light travel about 186,000 miles per second.

When Venus is as brilliant as it will be during the coming weeks, you may be able to see it cast a distinct shadow. This will, however, require favorable conditions. You will need an otherwise dark sky, no lights around you, and a light surface on which to see the shadow. And you must have been in the dark long enough—perhaps 15 or 20 minutes—for your eyes to become





☼ ✸ ○ ● Symbols for stars in order of brightness

adapted to such faint illumination.

On April 1 Venus will be 71 million miles away, considerably closer than the sun's distance of 92.9 million miles. Thus we can see less than half of the bright hemisphere, and it is in a crescent phase. As it approaches even closer it will appear bigger and brighter. In May it will be about 20 percent brighter than in April.

Then it will continue to enlarge but the crescent will become narrower and narrower so it will lose brightness. In early June it will be about a third fainter than now and will set very soon after sunset, making it hard to see. On June 17 it will pass between sun and earth and in July will be to the west of the sun. Rising before sunrise, it will be a brilliant "morning star" at dawn in late summer. □

CELESTIAL TIMETABLE

April	EST	
1	2.00 am	Moon farthest, distance 252,350 miles
		Mars passes north of Saturn
5	12:00 pm	Moon passes south of Jupiter
6	6:44 pm	Moon in last quarter
7	7:00 pm	Venus farthest east of sun
8	6:00 am	Venus passes north of Saturn
11	10:00 pm	Mars passes north of Aldebaran
13	3:31 pm	New moon
14	1:00 pm	Moon nearest, distance 222,000 miles
	9:00 pm	Venus passes north of Aldebaran
16	9:00 am	Moon passes north of Saturn
	9:00 pm	Moon passes south of Venus
	11:00 pm	Moon passes north of Mars
20	7:45 am	Moon in first quarter
22	3:00 pm	Venus passed north of Mars
28	5:00 am	Moon farthest, distance 252,550 miles
	7:00 am	Mercury farthest west of sun
	7:44 am	Full moon