Letters

Understanding Growth

As a piece of drama criticism, Robert Gillette's artfully written report (News and Comment, 10 Mar., p. 1088) on the *Limits to Growth* (*1*) controversy can hardly be faulted. There is no doubt that the tactics of those involved with the study invited such treatment. Nevertheless, although Gillette's article is eminently fair given his basic approach, his decision to treat the controversy as theater was inappropriate.

Many of the expressed doubts about the assumptions of the model, the level of aggregation, the data, and so forth, may turn out to be more or less justified. After all, even the authors admit that the model is only a crude first approximation. But the model rests on a firmer foundation than Gillette seems to allow. In the first place, it is an outgrowth of Forrester's earlier work (*2*), and thus the basic outline of the study has been previously made public in the approved scientific fashion. Furthermore, even if one were willing to grant that the model was somehow the province of economists alone (surely it is of equal concern to ecologists, agriculturalists, technologists, and many others), it seems fair to point out that some economists—for example, Boulding, Daly, and Mishan (*3*)—have been questioning the ideology of growth that is characteristic of their discipline for some time and have reached conclusions that generally agree with those of Meadows *et al.* More importantly, however, the Meadows model, whatever its faults, is simply an attempt to present mathematically what environmentalists have been trying to say all along: exponential growth is pushing us up against natural limits much faster than we realize; technological solutions are insufficient, and sooner, rather than later, we shall be obliged to live in a "steady-state society" (*4*), which will require major changes in our way of life; given the momentum of growth and the inertia of societies operating under growth-oriented assumptions, we must begin planning for the transition now while we still have some room to maneuver, in order to avoid grave difficulties and possibly agonizing choices in the not-very-distant future. In other words, most environmentalists—and by no means just those usually thought of as "Doomsayers" (*5*)—have constructed mental models of the future based on their present knowledge of our ecological situation that resemble very closely what Meadows and his colleagues have tried to express in a more formal way. For this reason alone, their work deserves respect. They are not likely to get it if *Science* chooses to treat the affair as Pop-Science.

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References

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2. J. W. Forrester, *World Dynamics* (Wright-Allen, Cambridge, Mass., 1971).
3. K. E. Boulding, in *Environment: Resources, Pollution, and Society*, W. W. Murdoch, Ed. (Sinauer Associates, Stamford, Conn., 1971), p. 359; H. E. Daly, in *Patient Earth*, J. Harte and R. H. Socolow, Eds. (Holt, Rinehart, & Winston, New York, 1971), p. 226; E. J. Mishan, *The Costs of Economic Growth* (Penguin, Harmondsworth, England, 1969).
4. R. Dubos, *Science* **166**, 823 (1969).
5. P. Medawar, *Encounter*, December 1970, p. 90; G. T. Seaborg, *Sat. Rev.* 6 March 1971, p. 53.

Gillette asserts that the inputs to the model in *The Limits to Growth* are not revealed. Many of the basic features of the model structure and assumptions are set forth in detail in chapter 3 of *World Dynamics* (*1*). All of the most important assumptions are described in that book, and the quantitative relationships are plotted and open to challenge and change. Key numbers, such as the amount of global arable land and the cost of opening land in unsettled areas, are official data from the Food and Agriculture Organization of the United Nations and are cited in *The Limits to Growth*. If the critics have better data, may they please come forward.

Contrary to what some critics have asserted, the authors of *The Limits to Growth* do not ignore the relief which science and technology can provide to world problems. Figure 10, on page 50 of *The Limits to Growth*, shows the assumed relation of population to arable land at present productivity levels. Also shown in the same figure are the effects of doubling and quadrupling present global average agricultural productivity. Even a doubling of global productivity would require a technological advance many times greater than that of the so-called "Green Revolution."

Further illustrations of the effects of science and technology are found throughout chapter 4. Figure 36 shows model behavior with natural resource reserves doubled. Figure 37 shows the results with "unlimited" resources: figure 39 shows behavior with unlimited resources and pollution controls beyond any that are presently available or planned in any country in the world. In figure 40, doubled agricultural productivity is added to the information in figure 39. In figure 42, "perfect" birth control is added to the assumptions in figure 40. The assertion that the inputs are not revealed (and open to debate and change) and the charges that technological advances are ignored are simply not true. The "advances" tried in the model are vastly greater than any which science and technology have produced in the past 25 years.

Gillette scolds the authors for presenting the results in *The Limits to Growth* before publication of their full technical report, which is scheduled for June 1972. Much has been said and written recently about the responsibility of scientists to be concerned about the social implications of the results of their work. It has been repeatedly asserted in the pages of *Science* that society expects scientists to do more than merely publish in scientific journals and pursue a leisurely debate among narrow specialists.

Publication of *The Limits to Growth* is certainly sparking a debate. It is to be hoped that the focus of that debate will move away from sarcastic name-calling to a major examination of methodologies for study of the dynamics of the behavior of social systems.

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References

1. J. W. Forrester, *World Dynamics* (Wright-Allen, Cambridge, Mass., 1971).