agriculture is the need to provide an economic environment that will encourage the farmer to expand agricultural production. This economic environment encompasses a host of factors, including input availability, favorable input/output ratios, credit and marketing facilities, as well as physical and institutional infrastructure.

The People's Republic of China has gone so far as to compromise its political goals because it realizes that the farmers need the profit incentive to produce. Profit rather than altruistic motives impelled the Pakistani Punjabi to provide the tubewells, diesel engines, and other agricultural machinery necessary for success with high-yielding-variety seeds. It could only have been the attraction of higher incomes that motivated Philippine farmers to increase the acreage planted to high-yielding varieties of rice from 204,000 acres to 4.3 million acres over the period 1966 to 1973.

Regarding Mr. Carroll's first point, it may be premature to judge the two-year-old "Masagana 99" program, but it has provided the necessary elements of the economic environment referred to above. Also, latest U.S. Department of Agriculture figures show that currently in the Philippines more than 9 million acres of rice are harvested compared to 1.3 million acres of sugar cane and that the harvested rice area increased by 7 per cent as compared to 3 per cent for the sugar cane area last year. In addition, a bumper 1975 rice crop, an increase of 250,000 acres of irrigated land over the last year, and the widespread use of the new high-yielding variety of rice, IR-26, indicate some initial successes stemming from the "Masagana 99" program.

With reference to Mr. Carroll's last point—the widening gap between the rich and the poor, a survey conducted in 1971-72 covering six Asian developing countries, including the Philippines, revealed that the introduction of high-yielding varieties of grains on some 2,400 farms in more than thirty villages was not making the rich richer and the poor poorer. These villages were selected for "visibility" of both positive and negative impact of the Green Revolution. Rather, the use of high-yielding varieties resulted in the employment of more labor, important in countries with large rural labor forces, and thereby increased incomes and effective demand—elements essential to increasing food production.

The Limits Model

To the editors: In his review of *Mankind at the Turning Point* (*Worldview*, September, 1975) R. W. Behan simultaneously indicts its predecessor *Limits to Growth*. In so doing, however, he has both misrepresented the contents and philosophical bent of *Limits* and reinforced a serious misimpression of the purpose and capabilities of simulation models.

Behan asserts that *Limits* is a "physical-environment, antipollution argument for the cessation of global growth and economic development." He implies that *Limits* ignores social forces and the role of such intangible variables as human perceptions and values. Nothing could be more untrue, as anyone can discover for himself by reading the book and examining the published model. The model in fact explicitly represents the role of values and perceptions in making decisions about, for example, consumption and childbearing. Nor does *Limits* anywhere support a "freeze" on the "global distribution of wealth and guarantee that the problem of underconsumption in most of the world would last forever." To the contrary, the book explicitly calls for a redistribution of wealth, and argues that a viable steady-state can be achieved only if the rich nations are willing to sacrifice some of their higher material standard of living for the benefit of the poor.

Behan next maintains that *Limits* focuses only on "symptoms" and that the book "played exceedingly well the compound-interest game, if present trends continue." If exponential population growth and ever greater exploitation of finite resources to sustain economic growth—the express concerns of *Limits*—are only symptoms, then what are the causes? Behan would have us believe that "inequitable and intolerable distribution of the world's wealth" is the cause. But Behan surely has cart before horse in his argument. The poverty of the majority of mankind is a direct consequence of two major long-term phenomena: the presence of too many and ever increasing numbers to share a finite pie in the poor nations, and simultaneously the insatiable extraction of the world's riches to sustain a high living standard in the rich nations. These two trends in fact are inseparably related. All the equitable distribution possible cannot improve life in impoverished countries that continue to experience exponential population growth. That would be possible only in a world of infinite resources, food, and pollution-absorption capacity. At the same time, further exploitation by the rich countries is rapidly destroying the means by which the poor nations can move to check population growth. Not merely symptomatic, but the very heart of the matter, is whether or not "present trends continue." Among the alleged shortcomings of both *Limits* and the Pestel-Mesarovic book Behan identifies a shared disposition to "erect a fairly strict dichotomy of man vs. nature" and to assume "a rigid finiteness and fixity of natural resources." Behan never explains what he means by a dichotomy between man and nature, nor how *Limits* supposedly introduces the dichotomy. Considering that population, human food consumption, and human capital investment are three major social variables in the world environment as described by *Limits*, I am at a loss as to where Behan sees a dichotomy. With respect to the question of resource availability, it seems to me that we can argue all day about how much zinc, petroleum, and coal are buried in the earth, but one thing we shall all have to agree upon is that there is only so much—in fact, a finite amount. Unless Behan has privy information that the world's resource deposits are periodically increased from some extraterrestrial source, I don't see how he can say that the assumption of finite resources is "demonstrably wrong." On the contrary, to maintain otherwise seems to me to be demonstrably absurd.

Aside from misrepresentation of *Limits* and logical non sequiturs, Behan reinforces a commonly held, but unjustified, impression of the purpose and capabilities of simulation models, at least with respect to social system simulations. The fallacious impression is that complexity equals sophistication. Behan describes the

Pestel-Mesarovic model as "an entire order of magnitude more sophisticated than the *Limits* model." What are his criteria for sophistication? Apparently the fact that Pestel and Mesarovic have divided the world into ten regions, each of which can exhibit unique behavior. My point is not to fault Pestel and Mesarovic. To the best of my knowledge they have not actually published a *model*, but only a book based on their model, so neither Behan nor I are in a position to evaluate their model's sophistication. Instead, I am taking aim at the compulsive reductionist mentality which requires ever more elaboration and complexity in their models. We are all quite familiar with the extreme example of this point of view—the investment of fortunes of time and money in constructing monstrous "black box" models whose behavior and output cannot be explained but only taken on faith. The less virulent form of the disease is exemplified by those who worship at the altar of disaggregation. The bigger the model, the better. The more disaggregated, the more accurate and reliable. But size, complexity, and level of aggregation are poor indicators of a model's accuracy and usefulness. A model is by definition a simplification. Therefore, since we can never have a social model that perfectly represents reality, the important question when building a model is just what do we gain from further complexity and disaggregation. One thing that seldom increases with model size is intelligibility. After all, there is something to be said for being able to explain how the structure of one's model actually leads to its behavior. The *Limits* model represents a giant forward step on that account.

University of Pennsylvania demographer Etienne van de Walle captured the essence of the *Limits* model in his recent *Science* book review (September 26, 1975) of *Dynamics of Growth in a Finite World*, the formal model employed in *Limits to Growth*. Van de Walle observes that "the value of the book resides in the explicit statement of the assumptions behind World 3 (the *Limits* model)....for the same public of generalists to which *Limits to Growth* was addressed. In expounding these assumptions the authors set standards for clear exposition and present an enticing philosophy for model builders and a guide to understanding complex systems through model building."

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R.W. Behan Responds:

Mr. Sweeney's articulate discomfort with my review of *Mankind at the Turning Point* is astonishing. I agree so strongly with many of his assertions that our diametric "bottom-line" disagreement is difficult to understand.

My indictment of *Limits to Growth*, for example, was indeed "simultaneous," not specific and exclusive. Having said in the January, 1974, issue of *Worldview* ("The Liturgy of the Environment") and in detail that the *Limits* argument was "unfair if not fraudulent," I felt little need to make anything more than a "simultaneous" case in the present book review.

I did indeed assert that *Limits* is a "physical-environment, antipollution argument for the cessation of global growth and development," and I did indeed imply that human variables were ignored. And I did indeed, contrary to Mr. Sweeney's veiled accusation, read the book. On page 142, as a matter of fact, I found the authors saying: "The model contains dynamic statements about *only the physical* aspects of man's activities" (italics mine).

The man/nature dichotomy I spoke of in the book review also was treated in some depth in my '74 *Worldview* article. Put it this way: If nature supplies man's needs, as *Limits to Growth* assumes, then man is seen as dependent on, and separate from, a beneficent nature. Each man is only a consumer, a passive receiver from a natural environment, and it may well be we're in deep trouble. But if we see man, adopting some randomly occurring substances and forces, supplying his own needs—through radically altered "natural ecosystems" called "agriculture," for just one example—then we see each man also as a producer. And we are dependent on a man/nature unity: the man/nature dichotomy disappears.

If we conceive of a man/nature simultaneity, then "resources" are seen to be the products of "natural" substances *and* the human ingenuity to transform them into satisfactions. The two elements are separated by only the most arbitrary semantics—or by unexamined assumption, as in the *Limits* book.

"Naturally" occurring substances and forces are certainly finite, as Mr. Sweeney alleges. I might point out, incidentally, that the magnitude of that finiteness is often incomprehensible. There is sufficient solar energy stored in the Gulf Stream each year, for example, to supply seventy-five times the annual energy needs of the entire U.S. And we have the tested technology to tap it.

My rejection of the assumption of finite resources, however, does not depend on staggering magnitudes. Rather it depends on the simultaneous man/nature concept of resources, and the intertemporal changeability of the "natural" component. Mr. Sweeney suggests this view is "demonstrably absurd." I fear that suggests that Mr. Sweeney is demonstrably unread. Ignoring, should he prefer, my own article in *Worldview*, Mr. Sweeney might look at Zimmerman's seminal book *World Resources and Industries*, Barnett and Morse's standard work *Scarcity and Growth*, and Derr's newly revised book *Ecology and Human Need*. All of them discount resource scarcity, and several make explicit a functional (i.e., man/nature unity) concept of "resources." To argue that resources so defined are scarce and/or finite is to argue that human ingenuity is exhausted.

Mr. Sweeney admits he is unable to evaluate the Pestel/Mesarovic model; it has not yet been published. Perhaps I can help, with elementary inference. The *Limits* model took the globe as a homogeneous unit; the Pestel/Mesarovic book spoke of ten regions, disaggregated from the whole. From this I infer a model more sophisticated by an order of magnitude, i.e., by a factor of ten. And I found that appealing, for it illuminated problems and opportunities that the aggregated model in *Limits* failed to discriminate.

But Mr. Sweeney is impatient with my enthusiasm for disaggregating the whole. I am reminded of the old trapper with one bare foot in his campfire and the other in a snowbank: in the aggregate he claims to be comfortable. Perhaps, with his penchant for aggregation, Mr. Sweeney would care to replicate the old trapper's experiment.