Letters

Bad News: Is It True?

Julian L. Simon's article "Resources, population, environment: An oversupply of false bad news" (27 June, p. 1431) starts with a tale about exaggerations of the magnitude of the Sahel drought, and he deserves credit for ferreting out this loose use of numbers. Aspects of the article, however, are quite questionable. For instance, he "refutes" a *Newsweek* article about the spread of deserts by pointing to an increase in arable land worldwide. These two phenomena are not mutually exclusive. Semi-nomadic Tuaregs may be pushed back a mile by the encroaching sands while a million Bengali farmers plant yet another row of rice each in an increasingly marginal swamp to feed their ever-larger families. Arable land may thus be increased in the aggregate, but both Tuaregs and Bengalis are worse off. The Bengalis may have more land under cultivation, but population growth has more than consumed the fruits of this extra resource. Bengal, once the breadbasket of British India, has had a food deficit for many years now.

Simon summarizes the increase in arable land at 0.7 percent in the decade up to 1974. Population growth in that period was nearly three times that, but he addresses the population question only to say that larger population generally does not mean more pressure on the land. His argument supporting this position simply does not track. He states: "In all the higher-income industrialized countries in Europe and North America, and in Japan, a smaller absolute number of farmers are producing much more food and feeding much larger populations than in the past." In mid-paragraph he has switched from per capita consumption to worker productivity. There is no relation between worker productivity in industrialized countries and the fact that arable land is increasing at a much slower rate than population worldwide. It is argument by non sequitur. The economic costs—the costs of infrastructure, inputs, and new technologies—he ignores completely. Japan, for instance, could afford these costs; a developing country often cannot.

There is another and more pervasive problem with the article: argument by analogy. Analogies are slippery devices at best. Simon slides back and forth between problems of the underdeveloped world and European, American, or Japanese experience with entirely too much facility. For example, his model shows that additional persons, although they initially lower per capita production, cause an increase in per worker output in 30 to 70 years in developed countries, 100 years in developing countries. The model is based on data from "more-developed countries." Such projections are unacceptable not only because they are based on completely different economic and social conditions from those in developing countries but also because of different time frames. U.S. productivity, for example, is much higher now than in the post-World War I immigration boom of 60 years ago. One might even be able to establish a causal link between that influx of workers into a rapidly industrializing United States, then populated by 100 million people, and subsequent prosperity. To argue from these circumstances to the case of, say, Bangladesh, where 90 million people currently try to eke out a living from an area the size of Louisiana, and almost totally bereft of natural resources, stretches the power of analogy past the breaking point.

STEVE SINGER
Office of Evaluation, Bureau for Program and Policy Coordination, Agency for International Development, Washington, D.C. 20523

. . . Simon's good news that the world total of arable land has been increasing does not disprove that many farm families are suffering severely from the effects of soil erosion, soil salinity, and desertification.

His good news that the world total of food production per capita is rising—derived by averaging the overfed and the underfed—does not disprove the fact that millions of people are undernourished.

His good news that natural resources are cheap in price is presented with no recognition of how multinational corporations, mining companies, and plantation owners ordain that situation by paying exploitative wages of a few dollars a day in Africa, Latin America, and Asia. Nor is there mention of the curious economic dogma that minerals in the ground have zero value and acquire value only insofar as work is performed upon them.

Geological processes put 3 trillion barrels of recoverable petroleum in the earth's crust (*1*). Every barrel withdrawn and consumed diminishes that amount correspondingly. If Simon is correct in stating that energy "has been getting more plentiful . . . in basic economic terms," he is saying something about the limitations of an economic perspective. Walter W. Heller, as president of the American Economics Association, confessed to those at the December 1973 convention: "The energy crisis caught us with our parameters down. The food crisis caught us, too" (*2*).

The statement that cost is "the only meaningful measure of scarcity in peacetime" is also unsupportable. One of several erroneous reasons why raw material scarcities are not expected by traditional economists to increase is that they project that the three-fourths of the world's people living in southern continents will continue to stay poor, consume few materials (*3*), and sell their raw materials cheaply to the industrial North—a self-serving, unreal hope. Such views prevail, as Robert L. Heilbroner observed, because few modern economists have examined the relation between economics and politics (*4*). . . .

ALLAN F. MATTHEWS
Developing Country Courier,
963 Saigon Road, McLean, Virginia 22102

References and Notes

1. M. K. Hubbert, in *Resources and Man* (Freeman, San Francisco, 1969).
2. Washington *Post*, 3 January 1974, p. A23.
3. W. Malenbaum, "World Demand for Raw Materials in 1985 and 2000" (Department of Economics, University of Pennsylvania, Philadelphia, 1977).
4. R. L. Heilbroner, *Hist. Political Econ.* **11**, 192 (summer 1979).

. . . Probably the most striking misconceptions in Simon's article are those embedded in its treatment of the scarcity of minerals.

Certainly he is right that delivered services, not supply of raw materials per se, is what well-being is all about. The point he seems to miss is that, historically, availability of many raw materials in cheap abundance led (by economically rational choices) to the delivery of services by materials-intensive or energy-intensive means; with equal economic ra-

tionality, such means are now being replaced with materials- and energy-frugal ones precisely because of the emerging scarcities that he denies. Such (economic) responses to scarcity make society better off than it would be in the absence of the responses, but not, in general, better off than it would be in the absence of the initial scarcity (*1*).

Simon would have us believe that the OPEC (Organization of Petroleum Exporting Countries) price for oil says nothing about oil scarcity, inasmuch as that price is far above OPEC's production cost. The fact is that OPEC is able to maintain its price largely *because* of increasing scarcity of oil (and a lack of immediately available alternatives) in most non-OPEC countries. This scarcity precludes meeting demand entirely from sources with production costs below the OPEC price, and ensures that the last units bought are bought on OPEC's terms. Substitution of alternatives—increased efficiency, synfuels from coal and shale—may gradually bring down the quantity of oil demanded at today's OPEC price; but these alternatives are more expensive than oil used to be and they can only ameliorate, not eliminate, the costs of the scarcity of oil.

Simon offers the price of electricity as "an interesting measure of the consumer cost of energy" and, by implication, a measure of energy scarcity. He says the price of electricity rose "after 1973" owing to the "improved market power of coal and uranium suppliers" in the wake of OPEC oil price rises. Then, dismissing this with the statement that "the long-run cost of electricity clearly has been downward," he concludes, "In short, the data show that energy has not been getting scarcer in basic economic terms, but rather has been getting more plentiful." The fact is that real electricity prices bottomed in 1971 and were already up 18 percent from that low point in 1972, before OPEC's actions (*2*). The fact is that OPEC's price hikes and the "improved market power" of coal and uranium *both* reflected a new reality based on emerging scarcity of oil and natural gas (*3*).

What follows Simon's errors about the economics of scarcity is a discussion of the physical underpinnings of the subject in which he tells us that "the term 'finite' is not only inappropriate but downright misleading in the context of natural resources," because, among other reasons and examples, "copper can be made from other metals." Indeed! Perhaps Simon here has in mind the technique of elemental transformation by bombard-

ment with subatomic particles in accelerators. Producing microgram quantities of copper by this means would be a gargantuan feat. Any implication that production in industrial quantities might be economically or energetically feasible is preposterous, as are his further assertions on this general topic (for instance, "Even the total weight of the earth is not a theoretical limit to the amount of copper that might be available to earthlings in the future. Only the total weight of the universe . . . would be such a theoretical limit. . . .").

With respect to food, Simon is enthusiastic about expanding land under cultivation by, for example, "irrigating deserts." But he does not discuss at all the constraints placed by lack of water on food production from arid and semiarid lands (*4*). The withdrawal of water for existing irrigation schemes already has drained some major rivers, such as the Colorado, nearly dry, and rapid depletion of "fossil" water supplies is of enormous concern in areas such as the plains of Texas. Interregional water-transfer schemes are staggeringly expensive and usually beset with political obstacles (*5*), not to mention their environmental liabilities. Desalination remains too expensive in energy and in dollars for use on staple crops (*6*). And in times of prolonged drought, which are certain to occur in the future as they have in the past, nations relying too heavily on irrigated arid lands for food will be crippled.

On the environmental side, irrigated arid lands are subject to salt-clogging, which reduces and eventually destroys their productivity; this problem plagues arid-land agriculture in the southwestern United States as well as in less-developed countries (*7*). Bringing more land under the plow by deforesting hilly terrain in temperate and tropical regions can lead to severe erosion, whereby the extra carrying capacity temporarily gained is literally washed away. On some tropical soils, the benefits of land clearing for agriculture are even shorter lived, as laterization turns the exposed soil to rock. And if deforestation for agriculture proceeds on a large enough scale, the resulting pulse of carbon dioxide may combine with that from increasing fossil-fuel combustion to alter global climate in a way that undermines food production to an unprecedented degree (*8*).

Simon proposes that it is not only possible but proper to appropriate all the earth's resources (and more!) for the direct support of human beings. This notion is not unprecedented (*9*, *10*). Per-

haps economics cannot deal with concepts as resistant to monetization as the rights of nonhuman species to exist (*10*) and the aesthetic poverty of a world with no room for unmanaged environments. But even if one were to accept the maximization of the mass of human protoplasm sustainable on earth as a goal superordinate to all others, it would be a monstrous error to think that this goal could be realized without the services derived from largely unmanaged biogeophysical processes.

Today such processes regulate climate and the availability of water, screen out harmful radiation from the sun, maintain soil fertility and the chemical quality of air and water, control most potential crop pests and agents and vectors of human disease, and maintain a library of genetic information uniquely useful for the protection of existing food crops and the development of new ones, the development of new drugs and vaccines, the development of new industrial materials, and the understanding of life itself (*11*). The intricacy and the immensity of these processes preclude replacing them or their services with technological substitutes on any interesting time scale. . . .

JOHN P. HOLDREN
Energy and Resources Group, University of California, Berkeley 94720
PAUL R. EHRLICH
ANNE H. EHRLICH
Department of Biological Sciences, Stanford University, Stanford, California 94305
JOHN HARTE
Energy and Environment Division, Lawrence Berkeley Laboratory, University of California, Berkeley

References and Notes

1. The general nature of the responses is to substitute, for the increasingly scarce resources, inputs that are less expensive than the scarce resources now are but more expensive than those resources used to be. Thus, installing insulation may save oil at a cost equivalent to paying $10 a barrel for the oil saved; this is a saving compared to buying world-market oil at $30 a barrel, but a net cost (due to oil's increasing scarcity) compared to the cost of keeping warm when oil was $3 a barrel.
2. S. Schurr, J. Darmstadter, H. Perry, W. Ramsay, M. Russell, *Energy in America's Future* (Johns Hopkins Press for Resources for the Future, Baltimore, 1979), p. 93.
3. Interestingly, this turning point was predicted accurately (on basic physical grounds) more than two decades in advance of the event. See, for example, M. K. Hubbert, *Science* **109**, 103 (1949); and President's Materials Policy Commission, *Resources for Freedom* (Government Printing Office, Washington, D.C., 1952).
4. H. E. Dregne, Ed., *Arid Lands in Transition* (American Association for the Advancement of Science, Washington, D.C., 1970).
5. J. Hirshleifer, J. DeHaven, J. Milliman, *Water Supply* (Univ. of Chicago Press, Chicago, 1969).
6. M. Clawson, H. H. Landsberg, L. T. Alexander, *Science* **164**, 1141 (1969). Developments since 1969 have not altered this assessment's conclusion.
7. Council on Environmental Quality, *Environmental Quality—1978* (Government Printing Office, Washington, D.C., 1978), pp. 472–474.
8. Because agriculture is highly adapted to existing climatic patterns, it is far more likely that any major change will reduce food production in the short term than that it will improve it. See, for example, S. H. Schneider and L. Mesirow, *The Genesis Strategy* (Plenum, New York, 1976).
9. See, for example, C. Marchetti, *Energy* **4**, 1107 (1979); H. Kahn, W. Brown, L. Martel, *The Next 200 Years* (Morrow, New York, 1976).
10. D. Ehrenfeld, *The Arrogance of Humanism* (Oxford Univ. Press, New York, 1978).
11. P. Ehrlich, A. Ehrlich, J. Holdren, *Ecoscience* (Freeman, San Francisco, 1977).

Overall, Simon's reassurances concerning world population and resources are at best unconvincing. His article begins very well with an example of a U.N. demographer's report being misconstrued. In the rest of the article he shows us (unintentionally) why such reports are so easily misconstrued by the formats and arguments he uses in presenting his own data.

For instance: The U.N. Food and Agriculture Organization (FAO) published data on per capita food production from individual countries. Simon evidently recognized that he could best serve his argument by tabulating the data on a worldwide basis. His table shows a 1969 index of 119 rising to 128 in 1976. However, FAO data show that Africa (the subject of Simon's first reassuring tale) suffered a decline from index = 100 in 1969 to 94 in 1976 and was at 90 in 1977 and 1978. In addition, FAO data show that the per capita food *supply* (often higher than food production in underdeveloped countries) has dropped for the countries termed "most severely affected" by food shortages, from 2040 calories in 1962 to 2030 in 1973. This tells a different tale from one that would be produced by Simon's technique, the worldwide food supply having increased during that same period from 2410 to 2550 calories. . . .

RODGER BODOIA
Department of Physiology and Biophysics, University of Washington, Seattle 98195

As practitioners of geography, a discipline which has raised questions about areal variations in resources, population, and environment since the Yu Kung resource analysis of China in the 5th century B.C., we question some of Simon's use of linear conclusions from aggregate statistics.

Simon says that news stories "originating from" a book by Eric Eckholm (*1*) "clearly imply a more general proposition: that the world's supply of arable land is decreasing. Yet the truth is exactly the opposite." First, it should be made clear that Eckholm nowhere makes this general proposition. He specifies the location of his examples of loss-

es of arable lands such as the Thar Desert of Rajasthan, the Gamu Highlands south of Addis Ababa, or the Kosi catchment area of eastern Nepal. Eckholm's findings are empirical, and those who have viewed the environmental degradation on the ground or even from an airplane will corroborate his evidence.

Eckholm is careful not to use the often biased aggregate statistics of national governments. Moreover, Simon's source, Joginder Kumar, documents the limitations of government statistics on arable land.* Simon, determined to use the evidence as good news, omits caveats.

Simon implies that the aggregate figures showing the increase in the percentage of both arable and cultivated arable are not bad news. Eckholm avoids mention of poorly defined concepts like arable or cultivated land. Perhaps Eckholm was more aware that when discussing arable land, as Kumar carefully documents, there is little exactness in the "truth." Eckholm focuses his analysis on the underlying processes: "the incipient breakdown of sustainable agricultural systems." The processes seem to be of little importance to Simon, who does not mention Kumar's other finding (*2*) that fallow land decreased by 8 percent between 1950 and 1960. This lessening of the degrees of freedom—as people begin to use petroleum-dependent irrigation in areas where water (a critical resource Simon does not consider) is scarce and where slopes are prone to soil erosion—may indeed be bad news. . . .

Not only, as Kumar suggests, are "data on arable land classified in several ways," but also differences in technology may change the amounts of arable land; for example, no-till agriculture may permit the cropping of former pastures and woodlands on steep slopes. On the other hand, increases in energy costs may diminish the acreages that can be irrigated by pumping in poorer countries, such as Bangladesh, which are becoming increasingly dependent on deep agricultural tube wells.

Simon has standardized world per capita food production between 1948 and 1976 in his table 2. World production per capita certainly increases, but it is poor evidence of the food situation in developing countries. A report from the Asian Development Bank entitled *Rural Asia* (*3*) chronicles the decline in real wages through the 1970's and increasing unemployment or underemployment in its developing member countries. Raj Krishna, of the Indian Planning Commission, sums up the situation: "Food surpluses are bogus when the malnourished have no purchasing power" (*4*). Neither cost nor price is a comprehensive measure of scarcity for the starving family that has no purchasing power. Chen and Chowdhury (*5*) and Currey (*6*) have shown that there need be no per capita food shortage in Bangladesh to have a famine and widespread starvation. Bhatia (*7*) illustrated the same situation in India, and Habicht (*8*) found the same situation in Indonesia. . . .

JOHN M. STREET
GARY A. FULLER
Department of Geography, University of Hawaii, Manoa, Honolulu 96822

BRUCE CURREY
Department of Geography, University of Hawaii, Manoa, and Resource Systems Institute, East-West Center, Honolulu 96822

**Editor's Note:* The reference for the source of data in Simon's table on land use was misnumbered. The intended reference was to the book by Kumar (*2*) cited in the text of the article.

References

1. E. P. Eckholm, *Losing Ground: Environmental Stress and World Food Prospects* (Norton, New York, 1976).
2. J. Kumar, *Population and Land in World Agriculture: Recent Trends and Relationships* (Population Monograph Series No. 12, University of California, Berkeley, 1973).
3. Asian Development Bank, *Rural Asia: Challenge and Opportunity* (Praeger, New York, 1977).
4. R. Krishna, personal communication, January 1979.
5. L. C. Chen and R. H. Chowdhury, *Popul. Dev. Rev.* **1** (No. 2), 201 (1975).
6. B. Currey, thesis, University of Hawaii (1979).
7. B. M. Bhatia, *Famines in India, 1860–1965: A Study in Some Aspects of the Economic History of India* (Asia Publishing House, Bombay, ed. 2, 1967).
8. J. P. Habicht, personal communication, June 1980.

We applaud Simon's article for its systematic reconsideration of much of the "false bad news" which is fed to the public in the guise of careful analysis. In particular, we enthusiastically endorse his criticism of the Paddock brothers' *Famine—1975!* (*1*) and of the reprehensible notion that a policy of "triage" should determine the allocation of aid to less-developed countries.

One segment of the article, however—the discussion of the relation between population growth and economic growth—leaves an impression that seems to us to be quite unwarranted. It is certainly true that this relation is complex and poorly understood. That the zero-order correlation between population growth and per capita income growth is low is one indication of this complexity. It is our view that in some circumstances rapid population growth can be quite detrimental to a country's development prospects, while in other circumstances it may even be helpful. One question on

the frontier of our discipline is how to distinguish between these two cases.

Simon's simulation model is not very helpful in addressing this question. First, it lumps all less-developed countries together. Second, it makes a number of assumptions which appear to us to be of questionable applicability to many less-developed countries (*2–4*). One dubious feature of the model is the assumption that members of large families will work harder and therefore produce more. "Certainly in countries like India or Bangladesh," as one of us has said elsewhere, "where population growth is exacerbating the progressive fragmentation of holdings and the increase in the number of landless laborers, it seems much more likely that increased population pressure in rural areas will lead to further reduction in calorie intake and impaired capacity for work among the poor" (*2*, pp. 886–887). Another questionable feature of the model is that social overhead capital in it "drops like manna from heaven whenever the labor force grows" (*3*, pp. 98–99).

The news about the relation between population and economic growth does not all come from the media or from individuals or institutions looking for their own financial gain. Government policymakers in countries accounting for some 90 percent of the world's population have now adopted policies to promote family planning even though it is recognized that the issue is politically sensitive. This is, of course, consistent with a recognition that progress in improving per capita well-being is a function of changes in both the numerator (production) and the denominator (population) and that development policies need to be concerned with improving the rate of growth, the distribution, and the composition of output as well as with slowing the increase in population. The reversal of policy in the People's Republic of China is of particular interest (*5*). . . .

WARREN SANDERSON
Economics Department,
Stanford University,
Stanford, California 94305

BRUCE F. JOHNSTON
Food Research Institute,
Stanford University

References

1. W. Paddock and P. Paddock, *Famine—1975!* (Little, Brown, Boston, 1967).
2. B. F. Johnston, *J. Econ. Lit.* **15**, 879 (1977).
3. W. C. Sanderson, *FAO (F.A.O.U.N.) Popul. Agric. Dev. Pap. No. 4* (1978).
4. _____, *Economic-Demographic Simulation Models: A Review of Their Usefulness for Policy Analysis* (RM-80-14, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1980).
5. C. Muhua, *Fam. Plann. Perspect.* **11** (No. 6), 348 (1979).

. . . There is no justification for Simon's implied assumption that a trend of the past will continue into the future ("raising our standard of living from what it was 20,000 years ago, 200 years ago, 20 years ago, to what it is now"). He quotes a work of 1682 to support his thesis that the more people there are on earth the larger the number of innovative minds to further economic progress. Population and resource usage today are scarcely comparable to what they were in 1682. Nor is there justification, on a finite planet whose surface area and mineral wealth per person must decrease with each population increment, to imply as Simon does that because a larger population gives us more potential for producing a "supermarket clerk who develops a quicker way to stamp the prices on cans" it will improve our material well-being. If absolute numbers reflect the numbers of "ingenious curious" minds, and if "additional persons . . . lead to an increase in per worker output," then the intellectual and productive leadership among nations would show China and India at the top, and Bangladesh leading Norway by an order of magnitude.

Economist Simon seems not to recognize the law of diminishing returns. He seems to imply that if x babies born today become productive in 25 years, nx, resulting in population growth, would be desirable ("additional children have positive long-run effects upon the standard of living"). This is no more logical than taking two dozen aspirin when the doctor prescribes two. One does not have to be an animal ecologist (as I am) to recognize that human beings, like any other species, have the biological ability to overrun the carrying capacity of their habitat.

With regard to mineral resources Simon brings up a new version of a tired old argument long advanced by economists who seem to know nothing about geology: when supplies get low prices rise, exploration increases, and supplies rebound; increasing efficiencies in mining and processing drive prices down, creating disincentive for exploration until scarcity looms again. Once again we have the implied assumption that because this has happened in the past it will happen in the future. But geologists recognize that, with few exceptions, mineral resources are unevenly distributed. As lodes are depleted it becomes ever more difficult to find replacements. When the silver mines of Idaho play out, production cannot be restored by explorations in Kentucky, no matter how high the price of silver may be.

Regarding energy scarcity, Simon says

advancing technology has lowered the cost of oil production to $0.05 to $0.15 per barrel. From this fact he concludes that the "long-run downward trend in the price of oil will resume its course." That conclusion defies logic. The significant cost is not the pumping cost but the cost of finding as a replacement another barrel of oil or a comparable energy source. This cost has been rising dramatically. Like many other people, Simon confuses oil production with oil consumption. No one is producing any significant amount of oil these days, because the cost of producing it from recent photosynthetic products is greater than the price of OPEC oil. Rather, we are consuming that which was produced by natural forces in a past geological era. We have not solved our problem of declining oil reserves by increasing the efficiency of our pumping technology. . . .

WAYNE H. DAVIS
School of Biological Sciences, University of Kentucky, Lexington 40506

. . . Simon repeatedly commits the same fallacy he notes in others: past trends are simply extrapolated into the future. It is worth recalling the story of the person who leaped from a very tall building and on being asked how things were going as he passed the 20th floor replied, "Fine, so far."

GEORGE L. COWGILL
Department of Anthropology, Brandeis University, Waltham, Massachusetts 02254

I do not say that all is well everywhere, and I do not predict that all will be rosy in the future. Children are hungry and sick; people live out lives of physical or intellectual poverty, and lack of opportunity; war or some new pollution may finish us. What I *am* saying is that for most relevant economic matters I have checked, aggregate *trends* are improving rather than deteriorating. And I doubt that it helps the world's troubled people to say that things are getting worse though they are really getting better.

On only two points did letters challenge my data's accuracy:

1) In response to my statement that "long-run cost of electricity clearly has been downward," and that prices rose after 1973 due to OPEC pricing, Holdren *et al.* write: "The fact is that real electricity prices bottomed in 1971 and were already up 18 percent from that low point in 1972, before OPEC's actions."

I was taken aback; Holdren and Harte are energy scholars. I checked Fig. 1 and other sources but could see no sign of

Open Forum

Sponsored by the AAAS Committee on Science, Engineering, and Public Policy

- Major Future Science and Technology Issues
- Policy Directions for Science and Technology Under the New Administration
- Project on NSF's Second *Five-Year Outlook*
- Current Science Issues as OMB Circular A-21

Representatives of congressional committees concerned with science and technology will participate.

WHEN: Monday, 5 January 1981, 6:00 p.m. to 7:30 p.m.

WHERE: Sheraton Centre/Dufferin Room

No-host Reception Follows

The Open Forum gives members of the science and engineering communities an opportunity to express their views on Public Policy issues to the AAAS.

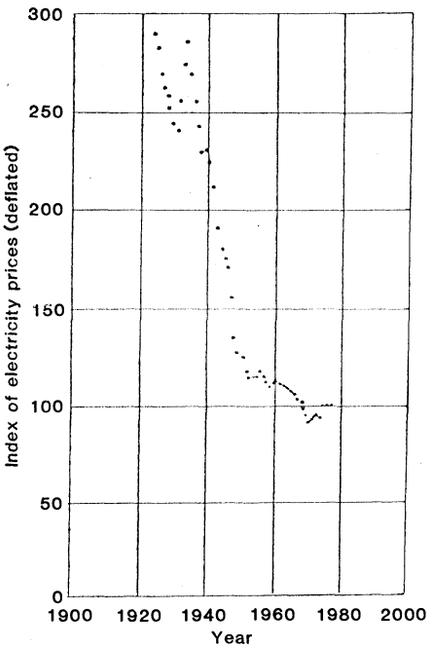

Fig. 1. Price of electricity relative to consumer price index (*9*).

their 18 percent. I therefore called the senior author of their reference (*1*), and Schurr's assistant read these index numbers: 1967, 100; 1970, 91; 1971, 80.2; 1972, 94.9; 1973, 93.8; 1974, 99.9; 1975, 103.6; 1976, 104.2; 1977, 104.3.

To find out more about the 1971 figure, the basis of the Holdren *et al.* assertion, Schurr's assistant suggested calling coauthor Darmstadter. He, too, was puzzled. Upon investigation, the 1971 number (80.2) proved a typographical error and should have been 93.3. So much for Holdren *et al.*'s "fact."

Central here, however, is not the typo. Even if correct, it would seem scientifically imprudent to rely for any general conclusion upon a single number against the contrary evidence of a sweep of data three-quarters of a century long (Figure 1) that tells a radically different story, especially when widening the inspection slightly would have changed their conclusion entirely.

Upon this one incorrect number, concerning just one among practically all raw materials for which the data show long-run price falls, Holdren *et al.* build their case that I make "errors about the economics of scarcity." Does not this unfounded bad news reinforce the central point of my article? Perhaps this example and the next will convince some that my arguments are not simply defective scholarship or improper data selection.

2) A letter originally set in galleys, but omitted after I responded, called "incorrect" my statement that there have been "sharp improvements [in environmental quality] in the last decade." As evidence the author reproduced a recent *Scientific American* graph of Likens *et al.* (*2*) which he said shows "an overall deterioration in air quality due to sulfur dioxide" from 1974 to 1976. (My graph stopped at 1974.) But Likens *et al.*'s graph does not refer to air quality, but rather to SO_2 emissions; one is not an index of the other. And the lastest Environmental Protection Agency data about SO_2 and air quality show continued improvement in "national trends" (*3*).

If specialists can believe that the long-run trends in electricity prices and in U.S. air quality are worsening despite easily accessible data, what *will* convince people that things are getting better even when they are? In July 1980, an Associated Press article mentioned "the 1972–74 drought, when 300,000 or more died in Ethiopia and the Sahel belt South of the Sahara" (*4*), a mortality figure higher than ever despite evidence discrediting even much lower figures.

Several letters criticize using aggregate global data. Bodoia says: "Simon evidently recognized that he could best serve his argument by tabulating the [food] data on a worldwide basis" (an insulting insinuation too typical of the letters.) And Street *et al.* refer to the data I use as "biased aggregate [land] statistics." Of course aggregated food and land data contain inaccuracy, maybe more than most economic data. But I believe that such aggregates are more reliable for statements about the world as a whole than Eckholm's anecdotal pick-and-choose technique which Street *et al.* recommend.

Holdren *et al.* and others had a good laugh about alchemy and making copper from other metals. Even if what I wrote was physically impossible (which it is not), the point would not bear importantly upon the argument, and therefore it is simply a debating device questioning my competence. However, I am not in error in principle, as Holdren *et al.* note; rather, they claim it is "preposterous" because it is impractical now. But—this is my point—so was electricity considered impractical a century ago. And in perhaps the first full-scale attempt by a great social scientist to evaluate the future energy situation, Jevons (*5*) concluded in 1865 that oil could never relieve the coal crunch he predicted would strangle Great Britain's economic growth about 1900. (England now exports both coal and oil.)

A letter originally scheduled for publication counterposed the *Global 2000 Report*'s conclusions of which "Simon seems to be unaware." My forthcoming

article (*6*) details the absence of the trend data upon which *Global 2000* claims to be based and shows that its conclusions mostly run counter to the historical facts. Furthermore, volume III, which is to give technical explanation of the "models," has not been published.

About "the rights of nonhuman species to exist" in Holdren *et al.*: Our values differ. In tradeoffs between human beings and the rest of nature, my sympathies usually lie with people. But of course I do not hold "the maximization of the mass of human protoplasm . . . as a goal superordinate to all others," if only because human life and welfare are too complex to be jammed into such a simple formula. Nor do I think of people as "human protoplasm," a term which draws attention away from peoples' minds, feelings, personalities, and very humanity.

Cowgill and others think it unreasonable to extrapolate past trends because now is a time of structural discontinuity, a "new reality" for Holdren *et al.* People have commonly made the same assertion of discontinuity in the past, and yet the long-run resource cost trends continued downward.

Sanderson and Johnston address my less-developed countries simulation, although I emphasize the more-developed countries simulation. Their theoretical criticisms are developed elsewhere; given opportunity, I'll happily dispute them. Most important, however: We agree there is no empirical relationship between economic and population growth rates.

Perhaps the most general matter at issue is what Holton calls a "thema" (*7*). The thema underlying much thinking in the letters is fixity or finiteness of resources in the relevant system of discourse, like your July paycheck's size. But the thema concerning resources underlying my thinking (and that of a significant minority) is that the relevant system has a long enough horizon that it makes sense to treat the system as changeable, and not finite in any operational sense, like the number of thoughts people may eventually have. Which thema is better for thinking about resources and population is not subject to scientific test. Yet it profoundly affects our thinking.

Davis questions the relationship between population size and the number of "ingenious curious minds." Figure 2 suggest that in ancient Greece and Rome population size and/or growth had a positive effect on the incidence of great discoveries. And nowadays, countries with more people produce proportionally more scientific knowledge, assuming equal income (*8*).

Space is exhausted, so I'll summarize: My original assertions about the long-run trends of resource scarcity and of pollution in the United States survive the challenges. My other assertions about trends in land, food, the environment, and the effects of population growth were not challenged statistically. I emphasize aggregate data because one can find special situations that are consistent with any viewpoint one likes. I wonder: What will open people's minds to these facts?

JULIAN L. SIMON
Department of Economics,
University of Illinois,
Urbana 61801

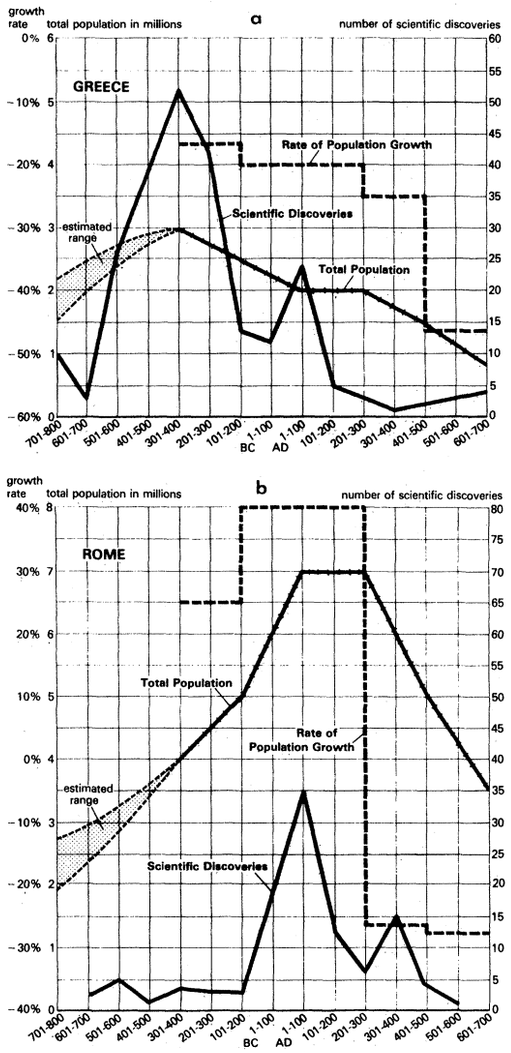

Fig. 2. (a) Population and scientific discoveries in ancient Greece (*10*). (b) Population and scientific discoveries in ancient Rome (*10*).

1. S. Schurr *et al.*, *Energy in America's Future* (Johns Hopkins Press for Resources for the Future, Baltimore, 1979), p. 93.
2. G. E. Likens, R. F. Wright, J. N. Galloway, T. J. Butler, *Sci. Am.* **241** (No. 4), 43 (1979).
3. Council on Environmental Quality, *Tenth Annual Report* (Washington, D.C., December 1979), pp. 45 and 52.
4. A. Torchia, Arizona *Daily Star*, 10 July 1980, p. F 1.
5. W. S. Jevons, *The Coal Question* (Macmillan, Cambridge, England, 1865).
6. J. L. Simon, *Public Interest*, in press.
7. G. Holton, *Thematic Origins of Scientific Thought* (Harvard Univ. Press, Cambridge, Mass., 1973).
8. D. Love and L. Pashute (pseudonym for J. L. Simon), in *Research in Population Economics*, J. L. Simon, Ed. (JAI Press, Greenwich, Conn., 1978).
9. Bureau of the Census, U.S. Department of Commerce, *Historical Statistics of the United States: Colonial Times to 1970* (Government Printing Office, Washington, D.C., 1976).
10. C. Clark, *Population Growth and Land Use* (St. Martins, New York, 1967); C. McEvedy and R. Jones, *Atlas of World Population History* (Penguin, New York, 1978); P. Sorokin, *Social and Cultural Dynamics* (Little, Brown, Boston, 1937).
11. Two attributions in my original article need correction. The remark that when a calf is born per capita income goes up, while when a baby is born it goes down, which I thought I had read in Wilfred Beckerman's work, was by Peter T. Bauer in *Dissent on Development* (Harvard Univ. Press, Cambridge, Mass., 1976). And the final remark by Philip Handler was made in his testimony before the congressional subcommittee on science, research, and development on 21 July 1970. It was quoted by Abel Wolman in his review of *Population, Resources, and Environment* by Paul R. Ehrlich and Anne H. Ehrlich (Freeman, San Francisco, 1970) in the *Milbank Memorial Fund Quarterly*, vol. 49, January 1971, part 1, p. 97.
12. This reply would not appear in the form it does without the dedication to free scientific dialogue of S. Friedman and J. H. Willis. R. Simon and M. Singer gave me valuable advice. And I am grateful for the scores of encouraging letters that people wrote in connection with this article.