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RESOURCES

Some findings and conjectures from recent research into resource development and use

The greatest gift is the power to estimate correctly the value of things.
—François de la Rochefoucauld, *Maxims,* No. 244

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Measuring Quality of Life

THOUGH THE evidences of discontent are perhaps not so conspicuous now as a couple of years ago, there is still reason to wonder why the unprecedentedly high incomes of present-day Americans coexist with so many manifestations of discontent and despair. Some dissatisfaction with the social order, and with leadership in institutions of all kinds, is evident on all sides. The 1960s were a period when real incomes grew unusually rapidly, yet by the end of that decade there was more evidence of dissatisfaction with the social order—not only government, but universities and other institutions and authorities—than there had been for some time. When one looks across societies, it is by no means obvious that Americans are more contented with their lot than Europeans, though there can be no doubt that they have higher real incomes. When one looks at the sweep of history, it is by no means clear that periods of economic growth were the most quiescent politically; they were often periods of protest and even of violence. A glance at suicide rates, at the proportion of the population whose level of satisfaction is so low that life no longer seems worth living, suggests if anything that the higher-income countries have higher suicide rates than the poor ones. Nor does the number who are unable to cope with life or who suffer mental illness show any tendency to diminish as incomes increase (though tranquilizers have permitted a reduction in the population in asylums).

If we cannot be at all sure that rapid economic growth will diminish discontent, there is a reason to ask: What really happens when the economy grows? Does it make everyone happier or better off? Or is it associated with subtle forces which reduce well-being in some dimensions just as it improves it in others? Do the obvious manifestations of discontent in rapidly growing and high-income societies simply misrepresent a general increase in contentment, or is there at least a part of the population that is worse off in some sense than it would have been had the economic growth not taken place? Even those who believe, as I do, that economic growth is on balance highly desirable, should want to understand why it fails to diminish proportionately, if at all, the evidence of discontent and social pathology.

Any effort to look in an integrated way at economic growth and its relation to contentment and discontent must take account of the fact that income

statistics tend to include most of the things that are readily brought under the "measuring rod of money" and to leave out most things that are not. Economics was in fact defined by Alfred Marshall as the study of that which is readily measured by money, so that the economist in particular must be concerned about what it is about a phenomenon or good that makes it readily so measurable.

Some people suppose that what keeps a good from being measured monetarily is that it is "priceless." But only rarely are people willing to give up "everything" for a given good or purpose. And if one good were literally priceless for a person, a second good could not possibly be, because the person might then be confronted with a situation in which he could not have more of the one good without less of the other, and the trade-off would indicate that he put a finite price on at least one of the goods.

Normally, it is not pricelessness that keeps a good from being measured in monetary terms, but rather the fact that an individual cannot take more or less of it as he wishes. If an individual takes more or less of some good, he reveals, by what he has to give up (*e.g.*, money), how much it is worth to him. We know how much apples and oranges are worth to a shopper because we know what he has to give up in money (and thus other goods) to get another dozen.

Many things, and some that are precious to many people, are not available to the individual in greater or lesser quantities. Family and friendship relations, for example, do not exist at all if there is only a minimal level of interaction. A man cannot, for example, have "half of a wife." He could of course have a casual or intermittent relationship with a woman, but that would be a different thing—in the economist's language, a different "good." Similarly, an acquaintance is not a half or a tenth of a friend, but something qualitatively different. When a relationship involves continuity and a substantial commitment, people do not regularly reveal how much a given relationship is worth to them. An individual who obtains a divorce reveals that he or she finds a given relationship is, on balance, not worth the cost or sacrifice it entails; but the person who does not obtain a divorce may place an extraordinary value on the relationship or may be nearly indifferent. In either case, his behavior does not reveal the "price" he puts on the relationship. It is not possible to take a little more or less, and thereby to reveal what one would or would not give up for it.

If the outside observer cannot know what price people put on the satisfactions or goods their families, friendships, and social groups produce, we cannot readily tell whether there is a deterioration (or even absence of improvement) in the satisfactions people get from familial and personal interactions that could make them, on balance, less contented after a period of economic growth than before. The tangible goods we buy in the stores are available in even greater quantities. What of the more abstract goods we obtain from our families and friends?

It seems probable that most people value at least reasonably stable or relatively continuous personal and group relationships. Certainly there is evidence that some degree of stability in the personal environment is necessary for children. What is the effect of economic growth on the continuity of personal relationships?

Economic growth requires technological change or capital accumulation. It requires doing things in new ways. It means reconstituting work groups, often in new locations. It requires incentives that enable some to rise in the social order and cause others to fall. In modern times, it often requires huge and therefore impersonal organizations and workplaces.

The change, the social and geographical mobility, that economic growth involves may therefore to some degree lessen the continuity of personal relationships. As a society, we may purchase the goods we buy in the marketplace *partly* with the goods produced by stable personal relationships. This does not mean that economic growth is bad, as some have thoughtlessly suggested. It means rather that it may have a social as well as an environmental cost. This is a cost of which we need to be aware, even if it cannot readily be brought under the measuring rod of money.

—*MANCUR OLSON*

U.S. POPULATION DISTRIBUTION

THE OBSERVED change in population trends in the past decade, if they persist, will have a profound effect on transportation problems. It may well be that a reconsideration of transportation problems will be necessary, since many such problems now with us could disappear or be reduced in importance, while others, not now apparent, may emerge.

This piece is concerned with patterns of change in population which will affect many aspects of life, but are reviewed here primarily in terms of their impact on urban transportation. For the most part it is a review of trends in total population growth, and in the distribution of population by locale. Some of the major points I wish to make at the outset are: (1) There has been a rather long downtrend in population growth, and population forecasts may well remain too high; hence, neo-Malthusian concerns seem grossly overstated. (2) Growth of large population centers has slowed appreciably, so that concern about large urban size also seems overdrawn. (3) High growth areas include Florida; the Pacific southwest, exclusive of very large metropolitan areas; the West, more generally; and middle-sized areas in Texas. If we look at these high growth areas statistically, we find a clear inverse relation between size of place and rate of growth, and an absence of other regional growth differentials for the rest of the south and for the northeast regions. Because the south has a disproportionate number of small metropolitan areas and the northeast a disproportionate number of large areas, the inverse relation of population and growth explains the observed growth differentials for these regions. (4) The population shift from central cities to suburbs is continuing, but there may be some-

thing of a historical reversal of of migration streams so that there are now net population flows from metropolitan to nonmetropolitan areas. (5) There is some evidence that suburban sprawl is approaching a limit, and that there will be increased density in many urban areas experiencing growth. (6) The slowdown in total growth, the shift away from large areas, and the shift to relatively uncongested areas with good highway facilities suggests the need for less investment in transportation facilities than has been anticipated. In sum, almost all these changes appear to move in the direction of mitigating urban transportation problems.

Since 1960, the annual increase in U.S. population has shown a rather steady decline, dropping from around three million in 1960 to half that figure in 1970. There was some reversal of the trend in the period 1968-1970, but the decline was reestablished thereafter, as shown in Table 1.

If a trend line is mechanically fitted to the data by least squares, as in Figure 1, zero population growth (ZPG) is reached in fairly short order. A linear fit yields a ZPG date of 1989, while a logarithmic function, with a bit more explained variance, moves the date to 1993. In each case, maximum population is only 226 million, given a January 1974 population of 211 million. The mechanical fit might be viewed as a limiting case, since it seems plausible that the downtrend will taper off somewhat. The Census Bureau, recognizing the trend, has made substantial reductions in its population projections,

Table 1
Annual Growth in U.S. Population

Year	Population growth (in 000)[a]	Year	Population growth (in 000)[a]
1960	2901	1967	2072
1961	2955	1968	1952
1962	2771	1969	2089
1963	2655	1970	2223
1964	2555	1971	2017
1965	2316	1972	1628
1966	2197	1973	1499

Source: U.S. Bureau of the Census, *Current Population Reports, Population Estimates and Projections,* Series P-25, No. 513, February 1974, 2.

[a] From January 1 of listed year to January 1 of following year. Population includes Armed Forces overseas.

reflecting a sharp decline in birth expectations of young wives during the past five years. Yet there are some indications that the Census Bureau has not gone far enough in recognizing the trend. In previous projections, average number of births per woman upon completion of childbearing were alternatively set at 3.1, 2.8, 2.5 and 2.1, to yield projections respectively labeled the B, C, D and E series. Late in 1972, the Bureau dropped the B series, and added an F series, which assumed 1.8 births per woman. For the year 2000, the midpoint population projection for the initial set of alternatives was 296 million. For the revised series, the midpoint projection now is 275 million. The E series corresponds to eventual ZPG, for 2.1 births per woman is the exact replacement level; if that level held indefinitely, population would stabilize at 320 million in 70 years. But actual experience in 1972-1973, as shown in Table 1, squares best with the F series, which assumes a level of births below the replacement level. For the year 2000, the E series projection is 264 million, while that for the F series is 250 million. In the F series, projected annual growth first increases to 1.8 million and then declines to around 1 million by the year 2000. Peak population is around 270 million. Thus, the F series decline is not nearly as drastic as that obtained by straight-line projections, but nonetheless represents a considerably reduced rate of growth, relative to recent expectations.

Some neo-Malthusians expect a growth turnaround, or even dispute the Census figures; but this appears to be taste for a battle that has already been won. Given the Pill and abortion on request, a marked reversal of trend seems unlikely. In retrospect, the furor over ZPG in the United States seems somewhat surprising in the light of the downtrend of Figure 1. Perhaps both ideology (ZPG enthusiasm) and mores (changing lifestyle) follow technology (improved birth control).

The deceleration in population growth has led to overcapacity in such areas as pediatrics and elementary education, and similar problems are conceivable in transportation. However, the considerable lag between time of birth and time of independent travel should yield enough lead time to adjust transportation planning to changed circumstances. It must be added that the reduced birthrate should add more women to the labor force, and thus *increase* trip-making for a considerable period. Increased participation of women in jobs outside the home has increased the labor force and the number of journeys to work, and for many families the additional income obtained makes a second car feasible. In fact, John Fisher, in a background paper for a National Academy of Sciences Forum on Energy (cited in *New Scientist,* February 28, 1974, p. 561), suggests that working women are the major cause of the past decade's increased energy demand.

CONCERN ABOUT population distribution generally focuses on urban growth and the possibility that cities are too "large"; some ZPG enthusiasts shifted their interest to such topics when declining national growth became evident. Here again, trends appear to be preempting the problems. The trends include: (1) little growth or even

declining population in the largest metropolitan areas; (2) more generally, an inverse relation between growth and size; (3) a continuation of shifts from the older northeastern and north central urban areas to those in the south and west, which typically also involves a shift to places with better highways; (4) continuation of the shift from central cities to suburbs; but (5) some apparent reversal of internal migration flows from nonmetropolitan to metropolitan places.

However, most immigrants from abroad settle in metropolitan areas, countering the internal shift somewhat.

According to recent census data, the population had this estimated percentage distribution in March 1970 and in March 1973:

	March 1970	March 1973
Central cities	32.20%	30.21%
Balance of SMSAs	36.69	38.34
Outside of SMSAs	31.11	31.45
	100.00%	100.00%

[SMSAs are standard metropolitan statistical areas.]

The increase for the nonmetropolitan percentage contrasts with a previous long-term decline. Thus, between 1960 and 1970, the nonmetropolitan population as a percentage of the total declined from 33 to 31 percent. If the estimated March 1970 and March 1973 percentage distributions are taken as given, and applied to estimated total resident populations for the respective periods, the estimated distributions of number of people, in thousands, is:

	March 1970	March 1973	Ratio: 73/70
Central cities	65,394	63,239	0.967
Balance of SMSAs	74,513	80,257	1.077
Outside of SMSAs	63,180	65,834	1.042
	203,087	209,330	1.031

The central cities show a decline in total population of 3.3 percent, while the "suburbs" (balance of SMSAs), grew somewhat faster than the remainder of the country (7.7 percent versus 4.2 percent). These percentages contrast with respective percentage growth between 1960 and 1970 of 5.3 percent, 28.2 percent, and 6.5 percent for the three locales. The increase in central city population in the 1960-1970 period may well reflect annexations rather than growth within city limits as defined in 1960. (Cities that annexed no territory showed a small population decline in the period.) Hence, the *decline* in central city population can well be viewed as a continuation of earlier trends. However, the relative shift to nonmetropolitan location seems substantial; if not a reversal of earlier trends in population growth, it does represent a considerable shift in relative strength of those trends.

Much of the nonmetropolitan growth probably involves a form of urbanization and reflects (1) growth in the "far suburbs" around existing metropolitan centers, but outside the county lines defining SMSAs, (2) development of industrial complexes at intersections of major highways at some distance from metropolitan areas, and (3) expansion of service industry employment in rural counties, possibly a variant of category (2). In all cases, improved highway transport is probably a major underlying cause for the shift.

Some perspective on regional migration flows can be obtained from Table 2, which shows the ratio of in-migrants to out-migrants for recent interstate migration flows—people moving from one state to another—classified by region and locale. Central cities in all regions had net outflows of migrants between March 1970 and March 1973, though the change was most pronounced in the northeast and north central regions, with only limited net losses in the south and west. Suburbs in the first two regions had net outflows, but there were net inflows of migrants in the south and west. For nonmetropolitan areas, however, all regions except the northeast had inflows.

For all locales, the ratio of in-migrants to out-migrants was lowest in the northeast. It was highest for central cities and nonmetropolitan areas in the west, and for the balance of SMSAs in the south. For regional aggregates, the order was south, west, north central, and northeast, for both the ratio and the total net inflow of migrants. It is plausible that the same pattern, albeit in less pronounced forms, holds for total population changes.

Applying some recent census information on individual metropolitan areas, we can pick out patterns of recent population change for those areas. From April 1970 to July 1972, the population of all SMSAs combined grew 2.18 percent compared with nonmetropolitan area growth of 2.27 percent, which squares with the pattern discussed above. It is noteworthy that growth for the fifteen largest SMSAs, with populations over 2 million, averaged less than 1 percent, with small declines registered for five of the group (New York City, Los Angeles, St. Louis, Pittsburgh, and Cleveland). For almost all of the others, growth was less than the U.S. average. Only Washington, D.C., grew by a shade more than 3 percent. In contrast, 52 of 235 smaller areas grew by more than 5 percent.

Metropolitan areas in three small regions grew at a significantly faster rate than those in the rest of the country. The regions, with 13 SMSAs in each, were: (1) Pacific southwest "desert and shore," consisting of Arizona, Nevada, and California SMSAs below 2 million population, but excluding the California Central Valley SMSAs, which typically had somewhat lower growth rates; (2) all Florida SMSAs, save for Melbourne–Titusville–Cocoa, which lost population

Table 2
Interstate Migration Flows of Population
Three Years Old and Over, March 1970 to March 1973

Region	Number of in-migrants divided by number of out-migrants, March 1970-March 1973			
	Central cities	Balance of SMSAs	Outside of SMSAs	Regional totals
Northeast	0.361	0.830	0.927	0.684
North Central	0.500	0.923	1.181	0.834
South	0.908	1.869	1.062	1.220
West	0.989	1.342	1.221	1.183
U.S.	0.701	1.224	1.103	1.000

Source: Derived from data in U.S. Bureau of the Census, *Current Population Reports, Mobility of the Population of the United States: March, 1970 to March, 1973,* Series P-20, No. 256, November 1973, Table 4.

Table 3
SMSA Population Growth by Size and Regional Grouping

SMSA population size class (1970 population in 000)	Average ratio of 1972 to 1970 population		Number of SMSAs in each class	
	SMSAs in 3 high-growth subregions	All other SMSAs	SMSAs in 3 high-growth subregions	All other SMSAs
Under 150	1.0790	1.0228	9	59
150 — <250	1.0668	1.0224	8	39
250 — <500	1.0641	1.0197	11	52
500 — <1,000	1.0664	1.0190	4	34
1,000 — <2,000	1.0615	1.0158	7	12
Over 2,000	—	1.0073	0	15

Source: Derived from data in U.S. Bureau of the Census, *Current Population Reports, Population Estimates and Projections,* "Estimates of the Population of Metropolitan Areas, 1971 and 1972," Series P-25, No. 505, September 1973.

because of cutbacks in the space program; and (3) Texas metropolitan areas in the "middle range" of population size, ranging from 150,000 to 2 million in 1970 population. When we have accounted for the high growth rate of Florida and Texas, the remainder of the south shows no significant difference in growth from the rest of the country. The west, however, does exhibit a higher regional growth rate.

Some detailed analyses of the individual area statistics were carried out by calculating the ratio of 1972 to 1970 population for each SMSA and then relating the ratio to population size, both for the three high-growth regions as a group and for the remainder of the country. Six population size classes were set up, and the average value of the 1972 to 1970 ratio is shown in Table 3 for each class. An inverse relation between size and growth rate occurs for both the fast-growing group and the remainder of the country, though this is most evident for the latter set of cases. The significance of the relationship was confirmed by statistical test.

THE RESULTS can be summarized as follows: In the United States, rapid growth tends to be localized to sunny regions, presumably with high amenities; however, with increasing size there is an increasing drag on growth. Both relationships may involve migration of retired persons to pleasant places (the sunny coasts) and/or to places with lower cost of living. Since cost of living is higher in the north and increases with size of place, people on fixed incomes have higher real incomes in the south, and their real incomes increase the smaller the locale in which they live. Assuming that similar migration patterns also hold for labor force participants, it can be inferred that real "net" wages are higher in areas with highest rates of growth. It seems plausible that the level of highway services is a factor in both the regional and the urban size pattern of growth. The larger the urban area, the greater the cost of operating a car (e.g., parking costs, insurance, and accident costs not covered by insurance), the longer the journey to work, and the greater the traffic congestion and pollution. Such costs may help limit the growth of large areas. Further, the newer urban areas of the south and west typically have much better highway networks than those of the northeast and north central regions.

A number of conclusions can be drawn from the examination of these trends. First, the problems of growth, at a national level and in terms of the burgeoning of "too large" urban areas, appear to have been grossly overstated. At the national level, in fact, it is likely that lack of growth will eventually be seen as a problem, giving rise to concern about labor "shortages." At the level of the individual urban area, there is evidence to support the contention that there are eventual diseconomies of scale, in terms of increased congestion and pollution effects. But people can and do vote with their feet, and move to more pleasant—and generally smaller—places.

The shifts in population can be viewed as part of an equilibrating process, alleviating congestion problems in dense areas and making them somewhat worse in places that are presently less dense and congested, but with net gains for the system as a whole.

The slowdown in total growth and in growth of large areas and the shift of population to less congested places, both in terms of urban size and regional distribution, should indicate a considerable slowdown in highway construction "needs." The Department of Transportation has estimated a "need" in 1990 for approximately 18,000 miles of additional freeways and expressways within urbanized areas, compared with about 8,000 miles in 1968. That estimate may well be too high if earlier growth patterns were used in its development. In sum, present population trends suggest a future in which there is a considerable reduction in pressure for solutions to urban transportation problems.

—IRVING HOCH

ENVIRONMENTAL POLLUTION AND THE ECONOMY

Excerpted from a banquet address delivered before the Royal Society of Canada, Ottawa, in April 1974 by Allen V. Kneese, director of RFF's program of studies in Quality of the Environment.

A FALSE impression could easily be gained from the rather frantic tone of discussions of environmental pollution during the late environmental crisis—now displaced by the energy crisis, which is itself soon to be displaced by the protein crisis. The impression is that we are suddenly confronted with a totally new problem. This is not true. But the nature of the pollution situation has certainly changed over time and, in some ways, it has become more ominous.

To illustrate that it is not a new problem, one can readily uncover horror stories about environmental conditions in medieval and even relatively modern times. The deplorable history of pollution in the city of London is especially well documented. In the fourteenth century, butchers had been assigned a

spot at Seacoal Lane near Fleet prison. A royal document about this reads, "By the killing of great beasts, from whose putrid blood running down the streets and the bowels cast into the Thames, the air in the city is very much corrupted and infected, whence abominable and most filthy stinks proceed, sickness and many other evils have happened to such as have abode in the said city, or have resorted to it." Five centuries later, Charles Dickens is reported to have been moved to say of London, "He knew of many places in it unsurpassed in the accumulated horrors of their long neglect by the dirtiest old spots in the dirtiest old towns, under the worst old governments of Europe."

That the situation was not limited to London is illustrated by an old poem about the Rhine:

"The River Rhine it is
well known
doth wash the city
of Cologne.
But pray dear Gods,
what power divine
will henceforth wash
the River Rhine?"

It is apparent that in developed countries environmental conditions that directly and immediately affected the daily lives of the mass of humanity improved immensely, at least until the middle of the twentieth century, leaving aside some major aberrations like the Great Depression and the World Wars, during which the quality of life dropped sharply in many areas. What then has happened to make us rather suddenly so acutely aware of environmental pollution?

Aside from the growth of world population, a major topic in itself, three things which have come upon us slowly, but more or less simultaneously, are chiefly responsible.

First, recent decades have seen immense increases in industrial production and energy conversion. Associated with this are massive flows of materials and energy from concentrated states in nature to degraded and diluted states in the environment. This has begun to alter the physical, chemical, and biological quality of the atmosphere and hydrosphere on a truly massive scale. Furthermore, we now have the means to detect even very small changes in these natural systems, so that we are much more aware of what is happening than was the case in the past.

Second, "exotic" materials are being introduced into the environment. The near-alchemy of modern physics and chemistry has recently subjected the world's biological systems to strange, unnatural inputs to which they cannot adapt (at least not quickly), or to which adaptation is highly specific among species and therefore disruptive.

Third, ordinary folk have come to expect standards of cleanliness, safety, and healthfulness in their surroundings that were the exclusive province of the wellborn or rich in earlier times.

What is to be done in the face of these profound new forces in the world? And why do our institutions seem to be coping with them inadequately? A first step is understanding the basic sources of the pollution problems that exist in economies such as those of North America.

In 1835, that remarkably acute man Alexis de Tocqueville said, "If you do not succeed in connecting the notion of right with that of personal interest, which is the only immutable point in the human heart, what means will you have of governing the world except by fear?"

The writers of the Federalist Papers and framers of the United States Constitution were very much aware of this point and by and large were successful in wedding de Tocqueville's two notions in their time. The social engine which they created, and which, at least in broad outline, is very similar to that which evolved from the parallel English culture in Canada, was built largely on the concepts of private property and individual freedom, with a framework of laws to keep the channels of commerce open. This reflected the conviction that private ownership, freedom of individual choice, and the profit motive would direct resources to the most productive uses, given individual preferences for various goods and services and the income of the population. This conviction, plus fear of losing personal freedom, have underlain our assumption that collective action through government should be held closely in check.

Of course, the need for some degree of collective action regarding the allocation and use of resources has been realized by almost everyone for a long time. Public works and defense have always had strong support. People recognized that a certain minimum amount of collective action was needed to realize gains from cooperation. Accordingly, we have used public funds to build roads and dams and schools, and generally for those activities where economies of large scale dictated huge investments, or where investments would yield widespread public gains which private enterprise could not capture.

With a few major exceptions, like the Great Depression, this mechanism has worked very effectively toward the rapid exploitation of our basic resources and a rapidly growing GNP. The levels of human welfare achieved by means of it should not be forgotten or minimized.

What has happened? Why do we perceive that this system is not now serving us well? The central reason, simply put, is that a major flaw has developed in our system of economic incentives. But why is this so?

To gain insight into why this growing divergence between private ends and social ends has come about, it is useful to invoke one of the most basic physical principles, that of mass balance. When ma-

terials—minerals, fuels, gases, and organic materials—are extracted and harvested from nature and used by producers and consumers, their mass is not altered in these processes, except in trivial amounts. Material residuals are generated in production and consumption activities, and their mass must be about equal to that initially extracted from nature. The services these material objects yield are used, and the market works to allocate these services to those who desire them most, but their physical substance remains intact.

The important implication for the allocation of resources in a market system is that while most extractive, harvesting, processing, and distributional activities can be conducted relatively efficiently through the medium of exchange of private ownership rights, the inevitable residual mass returned to the environment goes heavily into what the economist calls common property resources. The same is true of residual energy.

Common property resources are those valuable natural assets which cannot, or can only imperfectly, be reduced to private ownership. Examples are the air mantle, watercourses, complex ecological systems, large landscapes, and the electromagnetic spectrum. When open and unpriced access to such resources is permitted, the result is apparent. From careful study of particular common property or common pool problems like oil pools and ocean fisheries, it is well known that unhindered access to such resources leads to overuse, misuse, and quality degradation. Market forces, while marvelously efficient in allocating owned resources, work to damage or destroy common property resources.

The laws of conservation of mass and energy have no doubt always held. But at lower levels of population size and economic activity, the return of "used" materials and energy to the environment has only localized effects, most of which could be dealt with by means of ordinances and other local government measures to improve sanitation in and around the immediate vicinity of cities. Thus the butchers can be moved, sewers can be installed, and the streets cleared of trash and offal.

But as economic development proceeds, more and more material and energy tend to be returned to the environment *pari passu* with the production of material objects. Indeed, some forces press in the direction of increasing residuals as a proportion of final usable output (resort to progressively lower quality ores is a case in point). Larger "problem sheds" are affected and greater numbers of people more remotely located in both space and time suffer adverse impacts. Common property assets which cannot enter into market exchange are progressively degraded because their use as "dumps" appears costless to the industries, even though important values from other uses of the asset are degraded or destroyed.

IN SUMMARY, a profound asymmetry has developed in the effectiveness and efficiency of our system of economic incentives. On the one hand, it works well to stimulate the exploitation of basic resources, to process and to distribute them, but it fails almost completely with respect to the disposal of residuals to common property resources.

These market failures are substantially aggravated, at least in the United States, by government tax policies, such as depletion allowances and other special treatment measures, and by government regulation policies, which discriminate against recovered materials and in favor of virgin resource exploitation. In addition, our system of taxes and public expenditures has enormous subsidies built in for large families, especially for the relatively well-to-do, and discriminates severely against single people and childless couples. All of these are holdovers from the time when single-minded development was the order of the day.

The sum total result of market failures and government policy is that the economic incentive system makes virgin materials too cheap, stimulates too much materials-flow through the system, generates inadequate reuse of secondary materials, and produces a vastly excessive discharge of dispersed and degraded materials to environmental media.

Since World War II the federal government has become increasingly active in passing laws intended to deal with environmental pollution, The trend has been toward heavy federal subsidization of certain pollution control programs, centralization of control efforts, and greater and greater reliance on uniform emission standards. The basic fault with this program is that enforcement of regulations must leave room for due process. As a result, enforcement is reduced to a process of bargaining with each individual source of waste discharge in a context where most of the advantages lie with the dischargers. The magnitude of delaying litigation that has followed enforcement efforts indicates that polluting industries have been quick to take advantage of the many handholds the enforcement processes provide for delays and obstruction. In the meantime, common property resources continue to be used—and degraded—free of charge.

ONE MAY generalize by saying that national environmental policy in the United States has never recognized the economic sources of, and remedies for, the problem. Clearly,

it has not recognized the problem for what it is—a large-scale failure of the economic incentive system, requiring rectification if common property resources are to be protected, allocated to their best uses, and used efficiently.

There is still, despite more than twenty years of federal legislation, a clear need to develop a positive program for turning the system of economic incentives around and letting it work for the environment rather than against it. I think the following are the main elements of an effective strategy for doing this:

1. Immediately develop as complete a list as practical of possibly deleterious substances in effluents. Require all dischargers of substantial size to sample their effluents and report them.
2. Develop a list of substances, the discharge of which to the environment will be forbidden on the grounds that the overall deleterious effects clearly outweigh any benefits (cost saving) associated with the discharge. Numerous toxic persistent organics (like DDT) would be candidates, as would all of the heavy metals.
3. For those substances, the discharge of which is not entirely forbidden, levy national effluent or emission taxes at such a level as to provide a substantial incentive for control. Where emission taxes cannot be practically collected, inputs leading to discharge of deleterious substances should be taxed instead. It must be recognized, however, that this narrows the range of possible responses. These national effluent taxes would be a first step toward reversing the economic incentives adverse to the environment. They would not be as efficient as charges tailored specifically to environmental and specific source circumstances, but they would have several desirable properties. First, they could be set on a level that would stimulate rapid progress on environmental pollution problems. Second, they would establish the principle of payment for the use of common property resources everywhere. Third, they would be much more efficient than uniform standards, because the economic incentive would be to exercise most control of discharges at those sources where costs are lowest. Finally, and perhaps most important, they would avoid most of the enforcement problems associated with the permit approach.
4. Increase the burden of proof on producers of new products or processes to identify and report any substances associated with them that might have adverse ecological or health effects, and require such producers to bear any environmental costs which might result. The Price–Anderson Act, which provides publicly subsidized insurance for nuclear power plants in the United States, and other "bail out" types of legislation, should be repealed and avoided in the future. This could have important effects on the nature and direction of technological change.
5. Use the proceeds of the emission taxes and other appropriated federal funds to encourage the establishment of regional environmental pollution management agencies. Requirements should be laid down to assure that interdependencies among gaseous, liquid, and solid wastes are appropriately recognized and that efficient regional programs of control can be pursued. In heavily developed areas, integrated environmental management agencies should be strongly encouraged. Once regional agencies are duly established, the task of collecting emission taxes would be turned over to them, and the proceeds would be available for their use. They would be permitted to raise some or all of the emission taxes, to tailor them to specific purposes, but not to reduce them below the national level. Research—including a case study of the Delaware Estuary region—by the Quality of the Environment Program at RFF has demonstrated that the economic, technological, environmental system, and even political aspects of the interrelated solid, liquid, and gaseous waste problems, can be successfully modeled and analyzed in a complex region. National governments should sponsor demonstration projects of this kind for their major problem sheds.
6. To attack the incentives problem at the other end, so to speak, repeal depletion allowances and other special and discriminatory tax treatment of virgin materials. A further step would be to encourage the institution of substantial severance taxes on materials extraction to encourage improved durability, maintenance, and recycling of materials. This would contribute not only to conservation, by countering tendencies which the market may have to discount the future at too high a rate, but would also discourage the generation of waste materials which damage the environment.

A program with these general features would make the economic incentive system a powerful and all-pervasive force for conservation and environmental improvement. I can only regard it as astounding that a government would hope to accomplish these ends, involving literally millions of decisions by individuals, firms, and small units of government, by issuing largely unenforceable orders.

POPULATION AND NATURAL RESOURCE ADEQUACY

A LONG-TERM assessment of resource adequacy is important as a basis for establishing the proper degree of urgency with which the population problem should be viewed. But it is a difficult topic because of our ignorance about the material content of vast regions of the earth and about the nature and timing of future technological developments.

Whether resources will or will not be adequate in the future also depends in large measure on our time horizon. If population and material economic growth were to continue without abatement, and if we rule out the possibility of importing materials and energy from outside the earth (or exporting people) on an ever-increasing scale, it is certain that the earth would eventually run out of resources, environmental carrying capacity, or space. The

second law of thermodynamics, the entropy law, makes this quite certain. Indeed, this same law makes it certain that even a constant rate of economic activity cannot be maintained forever, unless that level of activity is sufficiently low to permit mankind to live within the limits imposed by the flow of solar energy he is able to tap. The qualification is important, for the amount of solar energy received by earth is enormous relative to terrestrial stocks of energy. Hard to believe though it may be, the entire terrestrial stock of energy is estimated to be equal to only four days of sunlight. In principle, this could permit man to live for another five billion years (the remaining estimated active life of the sun) at a reasonably high standard of living, provided population growth ceased during the next century or so. But as a practical matter, with technologies and ways of life we can imagine evolving and spreading throughout the world in the foreseeable future, this indefinitely sustainable standard of living is probably significantly below the level at which most of humanity exists today. Technological breakthroughs may make it appear to be possible to continue growth forever. But this illusion arises from man's myopia. No amount of scientific knowledge can repeal the laws of nature; they can only postpone their consequences. No matter how closely we approach it, there is no such thing as a perpetual motion machine.

But knowledge that growth must eventually cease is of no practical significance by itself. Just how much time do we have? If we have hundreds to thousands of years, as the technological optimists believe, there is room for nonresource considerations to play an important role in determining how forcefully measures to limit growth should be applied. In this case, it is easy to imagine policy makers deciding to continue to encourage economic growth while limiting family planning activities to those which help parents reduce the gap between desired and actual family size. On the other hand, if we on this earth, or at least on parts of it, have no more than, say, 50 to 150 years before these limits are aproached too closely for comfort, as those who argue against reliance on technological "fixes" and new discoveries maintain, far more stringent policies are called for.

Comprehensive reviews of projected worldwide demands and estimates of reserves for individual natural resources were undertaken by the U.S. Bureau of Mines in 1970 and more recently by Resources for the Future. Concentrating on the next half century, these projections can be characterized as surprise-free and conservative in the sense that they assume no significant changes in tastes, technology, institutions, or relative prices, and fairly rapid increases in population and economic growth. The demands of the rest of the world are based more or less on an extrapolation of trends in consumption during the past two decades, while those for the United States are derived from a dynamic input-output model of that economy. Reserve estimates incorporate the judgment of experts about the world's "known and potential reserves," a term that includes concealed deposits for which there is specific geologic evidence and for which the specific location can be described, but which makes no allowance for ore in unknown structures or undiscovered districts, or for "paramarginal and submarginal reserves" which would require sizeable increases in prices to be considered commercially valuable.

Of the nineteen nonfuel minerals reviewed in the RFF study, worldwide reserves as now estimated appear inadequate in the cases of aluminum, lead, zinc, tungsten, and sulfur to meet the "high" projections of cumulative demand between now and the year 2000. By 2020, copper, manganese, nickel, molybdenum, and titanium would be added to this list. For example, worldwide consumption of copper, estimated at 7.4 million tons in 1968, is projected to be 20 to 39 million tons in 2000 and 37 to 116 million tons in 2020 (the differences between the high and low numbers indicating just how poor these estimates are), or in cumulative terms, 792 to 1,180 million tons for 1968-2000 and 2,277 to 4,974 million tons for 1968-2020. By contrast, the world's principal commercial resources of copper, in metal content, are estimated at 808 million tons.

But the significance of these findings differs considerably among minerals. Only modest price increases would be necessary to turn a deficit of sulfur and aluminum into a surplus. In other cases, somewhat greater increases in price, sufficient to increase exploration and stimulate some substitution and additional recycling, would be necessary to close the gap between demand and supply. The most serious case is tungsten, for which it is difficult to establish a reserve picture that promises adequacy. Here, main reliance might have to be placed on technological changes that permit the gradual phasing out of this metal in applications that can get along with substitute materials and processes, though perhaps at higher cost.

World energy demand and supply projections depend so heavily on technological changes that projections in this case have been limited to the year 2000. For that period fossil fuel reserves appear quite adequate to meet the expected fourfold increase in demand, even without including oil in shale and tar sands. Nuclear fuels should also be adequate, particularly if breeder technology is fully developed. But the situation is not quite so favorable when environmental problems are included, problems that pervade all stages of energy use, from extraction through conversion and use. So far, for example, no one has a completely satisfactory solution to the problem of storing radioactive wastes from fast breeder reactors. Such problems could result in a significantly slower increase in supply than is needed to meet demand without substantial price increases. On the other hand, if the world learns how to tap fusion, solar energy, or geothermal sources on a significant scale, we may not have to worry about global shortages of energy for some centuries to come.

—RONALD G. RIDKER

AN EXCHANGE OF VIEWS

March 14, 1974

Editor:

Over a long period of time I have found *Resources* of assistance in gaining an objective overview of current resource problems and questions. Among its major strengths have been its accuracy and avoidance of judgmental terms, or at lease identifying clearly why those judgments have been made. The recent issue tends to follow that pattern except for the very last column of the very last article. Several aspects of that strike me as being overdrawn and possibly inaccurate. The following are specific points with which I would argue:

1. In the concluding portion of the sentence on the top of page 23, last column, the comment is made—*"with a newfound sense of duty to the future."* There has been a long-term concern for future populations among substantial segments of the American population. The same attitude of new discovery occurs in the first sentence of the last paragraph.

2. The suggestion that the developed nations are increasingly attempting to pull back from involvement in world affairs. *"Those segments . . . are accelerating the rate at which they relinquish their relative participation in world affairs."* I would like to know the substantiation for that statement. Recognizing one can find indicators of that (although hardly conclusive proof) it seems to me most of those indicators are not of the developed nation's own making. For example, lessened involvement and influence by the United States in the United Nations is surely due as much to the increasing desire of the developing countries to assume a more important role.

The final sentence in the article I feel is a gross generalization easily made and difficult to staunchly defend. Would the author argue that those people who preserved natural wonders through establishing the National Park System did not anticipate succeeding generations' needs or values? Would he suggest that those building a substantial national defense base failed to discern succeeding generations' needs and values; that the Constitution framers were wrong in forecasting that the citizens in this country would value freedom of press, speech, religion, etc.? That sentence is a gross oversimplification, highly argumentable, and I think caps off the weaknesses which strangely enough present themselves, in my view, primarily in the latter part of the article.

I would be interested in comments the author and editor might have on the above views.

Sincerely,

Bruce T. Wilkins

Associate Professor
Department of
Natural Resources
Cornell University
Ithaca, New York 14850

March 27, 1974

Dear Dr. Wilkins:

Your letter addressed to the Editor of *Resources* has been referred to me for reply, since I was the author of the material with which you take issue.

I am constrained to concede most of the points you make, since, as you correctly point out, the statements in the section in question are in the nature of generalizations and expressions of judgment, for any of which contradictory as well as supporting evidence may be adduced. The section was deliberately impressionistic and was intended to counterbalance some of the prevailing assumptions which seemed to me without any firmer foundation to be permeating a good deal of current thinking about demographic and economic growth and about America's place in the world. It has actually not been the policy of *Resources* to exclude such judgmental generalizations, and the broader they are in scope the less practical it usually is to provide the supporting detail.

That there have been "substantial" segments of the American population long concerned both about the natural resource endowment and the environmental heritage left to future generations and about the limits of growth, I would readily admit. I would argue, however—and on no firmer a basis than general observation—that it is only in recent years that the concern has become so fashionable and widespread as to lead to popular adoption of the idea of family limitation and growth curtailment *as a duty to others* rather than for benefit of family and self. In the general sweep of recent history, in fact, it seems not very long ago that the elite of this country were more impressed with the duty to *augment* their contribution to society by having *larger* families instead of maintaining the convenience (to themselves) of a small number of children.

In referring to relinquishment of position in world affairs, I was alluding largely to this attitude of voluntary population limitation on the part of the more developed societies. Such an attitude, howsoever otherwise meritorious its rationale, does have the effect of insuring that a preponderance of the world's near-long-term population growth

will take place among less developed societies. To me this signifies a dilution of the world's ratio of intellectual, managerial, and material capital to the aggregate size of the demographic and welfare problem to be dealt with. Combined with a fading of the growth-exportation ethic, it also signifies further geographical and social disproportion between the loci of human and material capital and the points of greatest need for application of such factors. True, the immobility of such productive factors is due at least in part to the distrust, on the part of less advantaged groups and nations, of established elites, and a desire to rely more heavily on their own human resources. The pressure of the less developed nations, which you cite, to assume a more important role in the United Nations is but one manifestation of this not new, but more aggressively pursued, attitude. I would hardly argue that developed nations like the United States should resist such pressure for self-reliance, even if we should be convinced that it is not in the less developed societies' best interests. Nor would I argue that societies which are currently less advantaged do not have the potential for developing complements of human and physical capital comparable to those which exist in the more favored societies. At best, however, this process has to be long and probably painful, and I consider it a correct inference that in the meanwhile the world in the aggregate will have a diminished ability "to deal with its problems."

With regard to the remarks in the last part of your letter, I would certainly agree that the judgments you cite have all proven to be correct assessments of relatively lasting values. They happened also to be the values of the generation that sought to safeguard them for posterity. But would you give the same weight to the judgments of earlier generations regarding the value of superhighways, of a materials-abundant existence, of compulsions to succeed, of the "straight" life, of social insurance, of a liberal-arts education, of suburban living? Would earlier generations have been wise to conserve our stocks of coal, so that we should not run out of heat and gas light? Or to preserve the original acreage of our forests, lest we run out of fuel wood? Or to go easy on lead, lest we run out of plumbing? Or to go easy on copper, because ore grades were down to 1 percent? The point is not that in some of such judgments they would have been wrong; even with hindsight it is not always possible to say what would have been right, or might have been right for the wrong reasons (we might, for example, have been well advised to better conserve whales, even if we did not need a continuing supply of their oil for lamplight). The point is that any given generation should not give undue weight to needs which are perceived to exist only in so distant a future that tastes and technology may by then well have changed.

To summarize, it was my intent—and I still think not a misguided one—to stimulate greater depth of reflection and not to lead anyone astray.

Sincerely yours,

Leonard L. Fischman

Research Associate
Resources for the Future

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Address correspondence concerning *Resources* to Mark Reinsberg, director of publications.

RESOURCES FOR THE FUTURE, INC.
1755 Massachusetts Avenue, N.W.
Washington, D.C. 20036