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THE ECONOMICS OF ENVIRONMENTAL QUALITY *

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THE ECONOMICS OF ENVIRONMENTAL QUALITY

R. T. Jaske

I would like to begin by thanking the sponsors of this fine undertaking for the opportunity to make these remarks. We at Battelle have had an unusual opportunity to participate in the changing scene of our times, and we are pleased to be able to share some of our experiences and observations with you this evening. A discussion of environmental quality cannot be complete without some introduction of the scope of the impact man has had on the environment, and I shall attempt to establish credentials with you by answering a question asked by many.

"What have been the environmental effects of technological change?"

"Our fragmented society has outrun our methods of deciding how to use it. Unless we invent means of dealing with technology's side effects, they will bury us."

Max Ways Fortune, February 1970

An appraisal of the environmental effects of technological change is an appraisal of the development of man himself; for since the beginning of time the most significant material successes of organized society have coincided with efforts to separate mankind from nature. Those works of man which have received the highest acclaim are those which seek to free man from the natural prison to which we are all enslaved and which permit man more and more exercise of individuality and personal choice in the conduct of life on earth. Some types of societal organization have reflected this tendency more than others. Many writers, notably Western, have equated the unique technological

success of Western society with the religious roots of that society, roots which cleanly separate man from his environment in the development of philosophical concepts. Consequently, Western society in particular has developed a unique view of the relation of material progress, a sort of tunnel vision which seeks, in the satisfaction of human needs, the creation of a kind of heaven on earth, isolated "in utero" from the unpleasant reminders of the surrounding world. Nature is an object to be defeated, harnessed, enslaved and put to work for the benefit of man. There is little wonder then, that the effects of material progress on the environment have been viewed as through a thin veil obscured not only by the difficulties of scientific measurement but also by the philosophical and institutional structure which contributes to the difficulty of clear and precise vision.

Suddenly, the dimensions of extent to which material progress has contributed to change begin to be perceived, not by imaginative and scientific breakthrough, but by the simple process of standing still long enough to note the change and having the courage to document and conclude from the documentation the salient facts which are around us, some of them have been so for some time.

What then are the environmental effects of technological change? What is the environment? Webster 7th Collegiate Edition says "1. something that environs; SURROUNDINGS, 2a; the complex of climatic, edaphic, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival, b; the aggregate of social and cultural conditions that influence the life of an individual or community." We shall examine the question from

the standpoint of 2,a although 2,b could very well suffice except for a minority of individuals whose motivation is such as to successfully permit operation without substantial interaction with the social and cultural conditions of the community.

In fact, change is all about us. It has been said that a squirrel could have traveled by leaping from tree to tree from Philadelphia to Springfield, Illinois in 1650 without touching the ground. Yet at that time, the vaunted cedars of Lebanon had already disappeared. North Africa the granary of Rome lay a choking desert of drifting sand sifting between the abandoned columns of once glorious temples. Were these the result of technology or simple neglect? The ancient water master of imperial Rome held power of life and death in his administration of water rights, yet he did not have time to observe the relationship between head and flow from his carefully inscribed orifices. Perhaps as suggested before, the ability of Western man to detach himself from his cultural surroundings gives impetus not only to change, but to the measurement of change.

Measurement and communication science now permit us to quantify environmental change. What do we find?

We find strains upon the already inefficient food chain of the biosphere to the extent that temporary oxygen depletion occurs in systems. Decay is then shifted to processes which are incomplete and yield organic gases, amines and hydrogen sulfide. The equilibrium is shifted more frequently to the disadvantage of all other species in a man dominated world. An increasing fraction of the total energy incident on the earth is being diverted to the direct support of man

in concentrated patches of high intensity usage surrounded by increasingly large sterile areas representing metropolitan areas. The complex natural food chains of a near-saturation eco-system are replaced with unstable, man controlled systems which require increasingly large inputs of energy to maintain a precarious transient equilibrium. The simplification of the earth's ecosystem produced by intensive agriculture, and selective eradication of natural species by toxic substances is reducing the ability of the earth to counter natural disturbances such as fire, flood, drouth, earthquakes and volcanic eruptions because the interactions between aquatic and terrestrial systems is being unfavorably modified. The trend of evolution towards the building of complex, integral, stable eco-systems is being reversed.

There is however, no immediate crisis. While the ratio of species may be changed, and carbon dioxide content may increase general phyosynthetic activity, no short-term oxygen shortage to threaten man's existence is anticipated by even the most pessimistic observers. The question that needs deterministic settlement is exactly what fraction of the total energy content of the bio-sphere can be dedicated to the single purpose of supporting man? An explanation of the meaning of this question lies in further examination of the changes which have occurred from the principal activities of man. These are: agriculture, mining and metallurgical processing, metropolitan development and atmospheric modification by products of combustion and particulate emissions.

Agriculture and its companion industry, forestry, can take the greatest credit for environmental effects of technological change.

For example, the fixation of nitrogen for fertilizer has permitted great increases in unit productivity of agriculture. The majority of the fixed nitrogen enters the system as a farm or municipal waste and remains as a nutrient to the growth of phytoplankton in lakes and reservoirs thereby compounding the natural rate of eutrophication of these limological systems. More nitrogen has been fixed since 1950 for application to the ground than was produced by terrestrial ecosystems since the beginning of the biosphere billions of years ago. Yet the denitrification rate has scarcely changed because it is related to natural processes, principally bacterial. The results of this large increase in fixed nitrogen inventory are not all clear, but imply significant deterioration of the stability of the food chain system and increased dependence on man for regulation.

We are all too familiar with the situation concerning the use of DDT and related pesticides and the current situation in regard to use of mercury as a fungicide in seed grains. The pattern of these uses has been made abundantly clear. While rejected at the lowest trophic levels by species which have evolutionary history of resistance to toxic substances, they are accumulated in successively higher levels until over specialized, highly stable species are threatened with extinction from existing world inventory. The same ocean circulating currents which are responsive to the thermal energy balance also circulate these toxic substances to the very corners of the earth; we are alarmed to find significant concentrations of these substances in the flesh of higher mammals and birds thousands of miles from known sources. In the end however, whether these species have sufficient

value to man to be permitted to survive is not the point we wish to make, rather that the survival of these species is directly related to man in a way which requires inclusion of these values in the socio-economic systems analysis related to the use of toxic substances.

The impoundment of waters for increased irrigation has been accompanied by a number of unresolved modifications of the natural environment. These range from redistribution of saline minerals and sediments to the spread of the dreaded shistosamiasis among agricultural workers.

In terms of balance, agriculture and the supporting technology of agriculture is causing more top soil to be removed than is being deposited. Much of the soil ultimately washes into the sea. Man's activities have so accelerated these natural losses of productive soil as to raise serious questions regarding the ability of the present level of population to be sustained without a quantum jump in the dependence of man on artificial energy releases from nuclear fission, a step which further decreases the stability of the biosphere and increases the dependence of the remaining species on the actions of man. Whatever measures are taken, there is growing doubt that the agricultural ecosystem can be expanded to accommodate the needs of additional billions of people and still satisfy elementary needs of personal freedom of choice and a generally better diet. Technology in permitting the revolutionary increase in birth and survival rate now raises a new question. No longer do we worry only about producing enough food, but whether we can tolerate the environmental consequences of doing so.

Turning from agriculture to metropolitan concentration of man's

activities we find additional evidence of the changes brought about by technology. Here however, the emphasis is on the metropolitan area as a near point source rather than the global scale of the energy, carbon, nitrogen, oxygen and mineral budgets of the agricultural sector. Here the effects of technological changes are measured in terms of the direct effect on man himself rather than his support system. No more striking example exists than the generation of micro-climates in the atmosphere surrounding our major metropolitan centers. As poorly conducting and evaporating vegetable surfaces are replaced by well conducting, essentially dry, surfaces of high heat capacity and low albedo, the result favors a higher thermal balance in urban areas relative to rural areas. As thermal releases increase from energy decay, human sources including metabolic sources, industrial and transportation activity are concentrated, and the surface roughness of the urban landscape increases, a relatively stable low pressure area develops which prevents normal nocturnal circulation and concentrates the effluents of the urban aggregation. The energy budget of the metropolitan area has been profoundly affected by prodigious production of pollutants. Ultra-violet radiation is much reduced, and net incoming radiation is concentrated in upper air masses instead of being distributed. These redistributed fractions of the energy spectrum then react with the trapped chemical ejecta of our man made volcano to produce a vast array of photo-synthetic products known to be injurious to all higher plants and animals. The major substantive change affecting large regional segments of the atmosphere, if not ultimately the entire atmosphere, can be traced to the release of chemical pollutants and

particulates associated with various combustion processes. In addition to photochemical transformations, this material acts as condensation and freezing nuclei in ways not fully understood, but with effects which are becoming of growing scientific concern. All of these affects when stabilized by growing quantities of thermal energy released in rapidly expanding metropolitan areas have resulted in rapid modification of the climatic weather base in these areas to the extent that data collected at the majority of urban airport centers is no longer representative of the regional system but rather of the unique urban micro system. Recent forecasts that energy releases in the Boston-Washington corridor will reach 30 to 40% of the incident solar energy for that specific surface area reinforce a cautious attitude towards the climatological consequences of the present course of environmental modification resulting from technological change and development.

In summary, it seems appropriate to conclude that based on available measurements, the environmental effects of technological change have been profound. The data suggest, that our ignorance of the total integrated effect of man's activities in altering the energy budget and biosphere to its present condition is profound, and that the unknown or yet to be evaluated effects may be greater than those we are presently willing to accept on a purely statistical basis. If all this is true, it appears both desirable and necessary to ask further questions regarding the reasons why such massive and enveloping environmental change has not been fully related to the private values of individuals.

"Do these effects operate to everyone's disadvantage?"

Given the commonly held understanding that we are slow and imprecise

in coming to grips with such issues as equity in income distribution, many question the related matter of the distributional impact of particular public problems and programs. The amount of solid evidence to support such an examination is remarkably slight, and the question turns out to be remarkably complicated. It involves such abstract matters as tax policy and capitalization of property value. Such evidence as exists has been reviewed by Freeman 1971, who makes the following observations:

"With respect to the cost of reducing environmental pollution, the situation seems to be about as follows: if the cost burden is put upon industry and municipalities as efficiency would seem to require, and if most of it is passed along in the form of higher prices for products and increased service charges, the effect is likely to be regressive. By regressive I mean that it would tend to hit the poor harder relative to their income than the rich. This effect would tend to be at least partially cancelled by the reductions in rental-type incomes which would probably also occur, (i.e. returns on fixed assets used in the production of high residual commodities). If public subsidies were provided, much would depend upon how they were financed. Since the federal tax system is generally progressive, federal subsidies would tend to mitigate regressive effects. On the other hand, state and local tax systems are generally regressive, so the distributional effects of subsidies from those levels of government are unlikely to favor lower income groups."

"As to the distribution of the benefits of improved air and water quality, the situation seems to be roundly as follows: the poor and

blacks are exposed to polluted air more than affluent whites. Accordingly, improved air quality in center cities would directly affect the poor more than the rich. The final effects as far as the distribution of income and welfare are concerned are complicated by questions of property ownership and capitalization-- but nevertheless on balance the improvement would probably be pro-poor. The main, readily identifiable benefits from improved water quality are recreational and aesthetic. Since water-based outdoor recreational activities and willingness to pay for the aesthetic improvement of surroundings rise more than in proportion to income, at least over a considerable range, it would appear that these improvements would disproportionately favor the more affluent. This tendency is modified, however, by the fact that major improvements would often be centered in and near large cities, thus improving the environment close to where poorer people are concentrated. It seems likely that, efforts to achieve distributional equity through subsidy arrangements would come at the expense of large losses in efficiency."

On the basis of the remarks above it seems safe to conclude that distributional considerations will play little role in the development of general national environmental policy as long as the present institutional arrangements for the planning and zoning of growth in metropolitan areas continue.

"What is the cost of present programs to improve the general environment?"

Large numbers of economists and engineers have contributed efforts to estimate the costs of improving environmental quality to levels

thought achievable by the nations leadership. These estimates have one thing in common, they are very large and as a corollary are often imprecise. They frequently are based on ambiguous, different goals and generally lack comparability. However, from a number of sources to which Battelle contributed, the noted economist A. V. Kneese has assembled the following speculative estimate.

Table 1. A Collection of Rough Estimates of Increase in Costs During Period 1970-75 to Achieve "Substantial" Reductions in Environmental Pollution
(Estimates in billion of dollars and including investment and operation cost)

WATER

Treatment of municipal sewage	\$12
Reducing non-thermal industrial wastes	6
Reducing thermal discharges	3
Sediment and acid mine drainage control	3
Reducing oil spills, water craft discharges, and other miscellaneous items	1
Added reservoir storage for low flow regulation	1
Separating storm and sanitary sewers	<u>40</u>
Total	\$66
Total without last item (industry share of this may be 50%)	\$26

AIR

Controls on stationary sources (1/2 industrial)	\$ 5
Mobile sources--	
To modify refining and distribution of gasoline	2
Engine modifications	2
Added fuel costs	<u>1</u>
Total (industry share of this may be 2/3)	\$10

SOLIDS

Increased coverage of collection	\$ 1
Increased operating cost, including environmental protection costs	<u>3</u>
Total (industry share? Nothing included for increased recycling of autos and other things)	\$ 4

OTHER

Control of heavy metals (mercury, cadmium, etc.), stopping the use of persistent pesticides, improving water treatment, control of pollutant-bearing soil runoff, control of feedlot operations, etc. (a sheer guess)	\$15
TOTAL (% of GNP increase about 35)	\$95
TOTAL without storm sewer separators (% of GNP increase about 20)	\$55

Source: Drastic rounding and other heroic judgments by the author,
A. V. Kneese in "Economics of Environmental Pollution in the
United States, for Atlantic Council, Washington, D.C. December 1970.

In support of his summary, Dr. Kneese makes the following observations:

"It appears that for the period 1970 to 1975, expenditures for making substantial improvements on all fronts (air, water, solids--including a lot of cleaning up of problems inherited from the past) might run between 20 percent and 35 percent of the increase in GNP which could be expected over this period. These figures are loosely based on goals which have been seriously put forward for this period. The figures probably err on the high side because they are mostly based on simple administrative approaches to the problem rather than sophisticated management approaches. As is explained in section VI below and illustrated in Appendices C and D, the difference in cost of major components, if the latter were adopted, might be very large, perhaps by a factor of 2 or more. Also, there is a lot of capital investment for catching up in these estimates, especially if one includes the separation of storm and sanitary sewers. Probably more than three quarters of the expenditures would be investment. Accordingly, expenditures could "hump" and then drop off considerably. Perhaps one should not overstress this point, however, because some further steps could be extremely costly. To take perhaps the major example, it has been estimated that to remove or recycle nutrients from all treated sewage effluents to protect streams and lakes from excessive enrichment and eutrophication might cost \$90 billion."

"A few words of explanation should be inserted here about the separation of sanitary and storm sewers because the cost magnitudes are so large. In most of the older cities of the United States, at

least a portion of the sewage is carried in the same passages that are used for storm water runoff. During dry weather there is no problem, but when there is substantial storm runoff, treatment plants cannot accommodate the large volume of water, and at least part of the sewage must be discharged, with the storm water, to the watercourse without treatment. In some large old systems, this is a frequent event. In New York and Boston, bypass occurs on the average of about once a week. To rebuild the sewers so as to prevent this condition from occurring periodically is extremely costly and therefore presents a difficult problem of social choice."

"In any case the estimates shown in the table suggest that while achieving major environmental improvements is likely to be very costly, the amounts are not so great as to preclude a substantial growth in product available for other purposes--especially since the projected expenditures are heavily investment."

"This is a short-run conclusion, valid for perhaps a few decades. The implications of very long continued growth in population and material and energy conversion could be quite different."

The principal question which is beginning to concern both the political and technical leadership is the growing anxiety over the meaning and implications of the use and consequences of the use of power and energy in the American economy. On the one hand, it is pointed out that the viability of the economy is based on the availability of increasing amounts of power, and on the other hand grave questions are raised concerning the implications of unrestricted power growth. The gravest of these concerns is the fate of energy itself. All energy, no

matter in what form it is released, ultimately is converted to heat which enters the general environment and must be dissipated to space in order to maintain environmental balance on the surface of the earth. While natural processes are admirably adapted to such balancing, the scale of energy releases forecast for some of the metropolitan areas of the Northeast, the Middle West and the Los Angeles area amount to sizeable fractions of the sun's radiation to the earth--30 to 40%. The effects of such energy concentrations have been detailed in the introductory answer; the full meaning to society in terms of the goals of metropolitan life and the future of the life plan of the United States remain to be developed. It is entirely possible that research will show that there exists an upper limit in the amount of energy which can be released in restricted regions without totally unacceptable weather modification and other related environmental modification. The acceptance of such a verdict, far from the dooms day implications of some investigators, could in fact presage the beginning of a new era of building of new decentralized communities. Such communities built along the routes of large water diversion and transportation nets could bring a new level of sophistication and opportunity to the presently limited outlook for the large central community. Large scale environmental management and renovation offers the nation an opportunity to restore our capacity for innovation and to use our great natural resources for our own benefit.

Is Environmental Management Practicable?

Environmental management recognizes that the effects of the environment on people are additive and complementary. That is, the

effects of less-than-healthy air to breathe would be compounded in the human being with the effects of a less-than-healthy water supply to drink. The aesthetic impacts of a fouled urban atmosphere resulting from air pollution are compounded with the aesthetic impacts of urban blight and degradation. High degrees of quality, in the long run, are necessary in each of the major components of our environment-- the air, the land, the water and the national spirit.

There is evidence that the nation as a whole is beginning to think in terms of multiple objectives--i.e., there is more to securing our future than just national development, national growth and enrichment, and a bigger future. The crises in the environment, the disparity that exists in our society between those living in poverty or wealth, and the social and political unrest of our times are brutal indications that all of the objectives toward improved quality of life are far from being met. It is one thing to formulate in concept what our guiding objectives ought to be; it is another matter to translate these objectives into working rules and policies and to insure that they are carried out. One of the goals and challenges for the 70's is to define and state these objectives and to identify the means for them to be achieved. Total environmental balance, is likely to be the kind of long-term objective which will be uppermost in the public and private policies of governments, corporations, and individuals.

For several reasons, our present system is not organized for adaptation of the concepts of total environmental management. First, our technology is designed to treat environmental disorders as by-products or nonaccountable results of the application of technology.

Secondly, objectives must be broadened beyond just increasing the national productivity and expanding the gross national product. And, finally, and probably most difficult of all, the institutions of economic and political power must be modified to facilitate the implementation of the concepts of total environmental management.

One of the major difficulties in achieving total environmental management is the lack of economic and social incentives within the present system for individuals, corporations, or government, itself, to behave in a manner consistent with this objective. Basically, there are four institutional mechanisms through which such incentives can be provided by the federal government or some other national body. These are:

- (1) Laissez-faire capitalism - free enterprise, i.e., allowing each party to behave in the manner to best meet self-interest objectives;
- (2) Economic rewards and incentives, i.e., tax incentives, grants, depletion allowances, etc.;
- (3) Punishment and regulation of activities;
- (4) Direct control.

Alternative (1), total reliance on the free enterprise system, fails to provide the incentives for individuals and corporations and units of local government to operate in any manner other than that which will contribute most directly to self-economic growth. On the other hand, alternative (4), direct control of all activities supposedly through centralized government, is neither economically practical, politically feasible, nor socially desirable. This essentially leaves the middle ground of economic incentives and rewards, regulations, and punishments

as being the areas within which government may operate in establishing the mechanisms for achieving total environmental management. It would appear that it is possible to achieve an effective measure of environmental management through these mechanisms, providing that government, itself, has the direction and the objectives upon which to operate. Thus, in line with the adaptation of multiple objectives for the conduct of government activities, including environmental management as one of those objectives, public policies at all levels must be established in accordance with these objectives.

At the present time, there is an appreciable lack of central or direct policy at most levels of government in many of the key areas of public activity that have a significant impact upon environmental quality. Among these activities, we would consider at a minimum the following to be of great importance: land use, transportation, energy, population size and distribution, living space, food and agricultural production, resource exploitation and material balance, and economic policy.

Many of these areas of activity have no clear-cut formulated national policy; many have no policy at all on local and state levels of government. The first requirement for the achievement of total environmental management is that such policy be derived for each of these areas. Furthermore, policy should be formulated in such a way as to achieve consistency between all levels of government, and national policies in each of these major areas must be consistent with each other for the achievement of all national objectives, including that of achieving environmental quality.

Progress toward formulation of policy will depend on a better understanding of the technical, economic, political-institution, and social and health aspects, as well as ecological processes. In the conclusions that follow emphasis is on the major problems concerned with the physical environment and ecological imbalances, realizing, however, that many related factors are of equal or, in some cases, greater importance in solving problems of environmental quality.

Conclusion

The problems of the environment will not be solved without conflict and some deep change in American institutions. They will not be solved with more legislation nor with the creation of more councils, offices and committees. They will not be solved with just more money, as many suggest. And they will not be solved with just enforcement and penalties alone, since this approach will be no more effective than was Prohibition.

Accomplishment will be evident only when we stop introducing new wants and needs that may bring about ecological imbalances and move to a culture in which we do not constantly increase what we have to consume. We must move beyond the notion of undifferentiated growth to make distinctions about what we do or do not want and what we can do without. In the area of economics, society must make critical decisions concerning the levels of environmental quality for which it is willing to pay. Wise choices must be made, taking into account numerous factors such as efficient land use, accelerated industrial growth, and conservation of limited natural resources.

It is imperative that all available technology for problem solving be fully utilized and that investigations to develop new knowledge on assessment and control, as well as management, be accelerated. Penalties, if any, have to be applied with discrimination over a period of time against the background of a market strategy that enables companies to stop pollution and still stay in business. And, last, there must be patience, because environmental reform is going to be harder to achieve than many of its advocates suggest. Results will not be visible for many years, even though considerable money will be spent in the interim.

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