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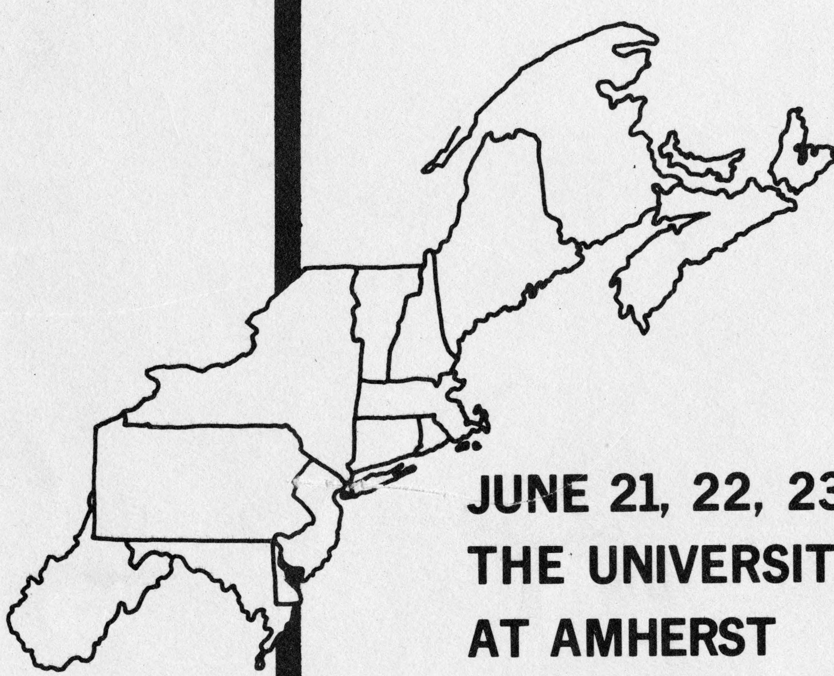

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# THE ECONOMICS OF ENVIRONMENTAL QUALITY - THE IDENTIFICATION OF THE TRADE-OFFS

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A recent article in Saturday Review magazine included the following statement:

> The battle to save the environment is just beginning, but until the nation decides which sector of society will get priority, and who pays the price, ecology is nothing but rhetoric. [22]

This rather simple but eloquent statement tends to capture the essence of the environmental quality problem. Most economists would agree that environmental problems are largely a result of misplaced economic incentives which result in a divergence between private and social costs. Thus, the solution is focused on developing methodology to measure the cost and benefits of production. Difficult? Yes! But there are also difficult, perhaps more difficult, related problems of specifying the beneficiaries and assigning the costs associated with environmental control. Thus, I think the trade-offs can be considered within two highly-related categories--the decisions based on resource efficiency using the calculus of the private market and those requiring an accounting of the "who" variable associated with assigning costs and benefits.

Part of the confusion surrounding the identification of environmental trade-offs is a result of differences in definition. In the next section some of these definitional problems will be examined. Following sections will focus on an evaluation of the major issues of efficiency and equity as they relate to environmental quality problems.

## Definitional Problems

### Pollution

At the last election, the voters of the Commonwealth of Pennsylvania overwhelmingly approved a constitutional amendment which protects the rights of all

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her citizens to pure air and clean water. There are several important problems associated with this approach to improving environmental quality.

First, it tends to place an infinite value on pure air and clean water. In the Pennsylvania example, there was no indication on the ballot about what this activity would cost. In effect, this approach excludes the whole concept of trade-offs when evaluating alternative environmental quality control programs.

Second, the unrealistic goals of many "conservation" oriented groups often hinders rather than promotes needed activity. Wallich reports the reaction of a distinguished New York politician as "there should be no governmental licensing of polluters at all-ever-for any reason." [25] Wallich suggests this is splendid sentiment, "but it's application would make antipollution legislation more ineffectual than Prohibition." Kneese captures the thought beautifully by suggesting in these cases "the 'best' is clearly an enemy of the good." [14]

Third, is the mistaken notion that pollution is wholly the product of man's mis-using his environment. In fact many of the sources of pollution are found as natural phenomena--dust from volcanos and sheet erosion, hydrocarbons from coniferous forests, thermal pollution from forest fires and hot springs, seeps from pyrites in coal, oil slicks from leaking underground reservoirs, organic loadings from tree leaves, and others--are all natural pollutants. In fact, meteorologists tell us that we need foreign matter such as dust or salt to provide nuclei for natural rainfall. Environmental problems arise because these processes are speeded up by man interacting with his environment. 1/ Thus, man is still the culprit, but it is important to think of pollution control as a continuum--cleaner water and purer air--rather than "clean water" or "pure air." The continuum approach also tends to emphasize the trade-offs in cost necessary to move across the continuum--costs which tend to increase at an increasing rate as we move toward the extreme values of the scale.

## Resources

Zimmermann, a geographer, defines resources as substances which help man gain desired ends. [26] He suggests that man is submerged in a "sea of neutral stuff" which includes not only matter and/or energy, but also the relationships between man and his environment. Chapman expands on this definition by indicating that the availability of resources is the result of interactions among:

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1/ Man has of course been ingenuous enough to add a few pollutants on his own with new chemical combinations which result in antibodies, additives, etc.

(1) the nature and size of man's requirement; (2) the physical occurrence of the "matter," and (3) a means of producing it. [7] Thus, the concept of a finite, unchanging mix of resources tends to be a bit misleading.

The following example from Zimmermann's work helps to delineate the problems associated with defining a resource. He suggests that for many years there were native rubber trees in the Amazon Basin of Brazil with little useful output, save perhaps some shade for the natives. Then Mr. Goodyear discovered the vulcanization process which resulted in a demand for the rubber latex--the substance now became an input important in satisfying human wants. The success of this new technology caused the demand for the product to increase and hybrid trees were developed and planted in plantations on Malaysia, Indonesia, Liberia, and other areas where transportation was less difficult. The product from the Amazon Basin could no longer compete--and the trees went back to their natural state.

In the above example one can get bogged down in semantics, but the point is that there was an inherent change in our resource base independent of the physical resources--the trees. Thus, in considering the environmental consequences of resource use, it is important to discuss resources within a philosophic framework rather than in terms of physical limits--i.e., in terms of relative costs (and/or values) rather than physical units.

A closely related question that tends to become an integral part of any discussion concerning environmental quality is the idea that we are running out of resources. The earlier work of Barnett and Morse has shed some light on the subject by empirically showing the decrease in relative prices of natural resource oriented inputs--a conclusion which tends to belie the "running out of resources" argument. [2] Joseph Fisher, President of Resources for the Future, summarizes some of the current thinking on the "running out of resources" question and concludes we can be "guardedly optimistic" concerning the availability of resources. [10] However, Fisher qualifies his analysis by indicating that resources should be considered from two viewpoints: resources as commodities and resources as environment. Even if we are not running out of resources as commodities (which also requires an examination of the import question not attempted by Barnett and Morse) we may be lowering the environmental quality aspect of our resources base. It should be noted, in this regard, very few products are consumed. They are used and then discarded, but the mass of material remains the same. At the danger of oversimplification, the emphasis should be more on the quality of our resources rather than the quantity.

But the Ardrey's [1], Ehrlich's [9], and others of the day have overlooked this point in order to develop an environmental "crisis" which permits action without the hindrance of rational decision making. The funding of action programs which supports one's own viewpoint is easier to attain if the negotiation can take place in a crisis atmosphere. Conversely, it would be foolhardy to completely dismiss the arguments of these predictors of "biological disasters." What are we willing to pay to protect against the possibility of their being right? Research on specifying a penalty function for making a "Type I Error" should receive high priority.

## Internalizing the Externalities

The "solution" to the environment quality problem, it has been suggested is simply to internalize the externalities. The general idea in this approach is to define the decision-making unit so as to include all firms and individuals contributing to the environmental problem. This group could then work together to internalize the benefits and costs not being accounted for in the market. The typical textbook type example starts with the two-firm case and indicates how they can attain an economic optimum by working together. The problem of course is that we do not live in a two-firm world.

Castle has provided a generalized formula which indicates there are $N^2 - N$ possible interrelationships when reciprocal (two-way) externalities exist. [6] Thus, even with only four independent decision making units there are twelve possible externalities to be internalized. If there are fifty economic units, the number climbs to 2,450. As soon as one considers the "rights" of fishermen on a stream the number becomes astronomical. Thus, the concept of internalizing externalities may be useful in a limited number of situations, but, in general, it serves better as interesting rhetoric than as a workable scheme for tackling environmental quality problems.

## Physical Measurement

Another problem is the lack of agreement among physical and biological scientists on the environmental impact of alternative actions. Thus, the social scientist, who must rely on the empirical measurements of the "hard sciences," finds it difficult to develop conceptually meaningful relationships.

The profession recently received a backhanded compliment from Boulding when he stated:

> By comparison with the ignorance and even obscurantism of the natural scientists, economics stands out like a clear beacon of eighteenth century enlightenment. [3]

An example of disagreement among the natural scientists is evident in their discussion of the impact of smog on the environment. [24] Some argue that thick smog will prevent sunlight and solar energy from reaching the earth and thus we are slated to enter another ice-age. Others, argue the rays bouncing off the earth will be trapped in the atmosphere which will result in a heating up of the planet--including catastrophic flooding due to the melting of the polar ice-caps.

One can argue, of course, that either result produces a crisis of major proportions and therefore something to be avoided at all costs. But, the fact remains that it is extremely difficult to estimate the amount of program funds one should allocate to smog removal programs when the physical relationships are so ill defined.

## Examination of Alternatives

Three major approaches seem to attract the most attention as alternatives for controlling the pollution of our natural environment--regulation, standards, and user charges.

In the regulation approach, an "optimal pollution level" is determined and a policy mechanism is developed to enforce the regulations under penalty of law. Operationally, this approach requires frequent inspection to check compliance and brings up the whole problem of "off hour" pollution. There is some evidence, for example, that companies are shifting production schedules to produce items which cause larger emissions of pollutants into the air and streams during the night and on weekends.[2/] Regulation agencies have responded with sophisticated monitoring systems to continuously record the material being emitted. Also, in some areas there has been the implementation of a bounty system for reporting violators during off inspection hours.

The regulation approach calls for specific actions on the part of the polluter--he is required to use precipitators, third stage treatment or some other action directly related to his production techniques. Thus, a major problem in implementing this type of policy is the need for volumes of detailed data on the manufacturing processes at each plant.

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2/ This action may not be categorically bad. The natural assimilation capacity of the environment may be underutilized at night and on weekends. The concept of "off-peak hour" pollution deserves additional study.

From an economic point of view, the system would not provide any incentive for cleaning up beyond the regulation level. Thus, although it may be the only alternative in some cases, it would seem desirable to seek better methods of control.

A second approach is the setting of standards. As in the case of regulation, an acceptable pollution level must be determined, but under this method the firm may use any in-plant procedure it finds feasible in order to meet the standards.

For example, it has been estimated that a single sugar beet processing plant can produce organic wastes equivalent to a city of one-half million population. Yet it is technically possible for a plant producing the same product to be designed to produce almost no waste. Yet once a standard is set, there is no incentive to produce less effluent than that specified by the standard. Boulding terms this the "satisficing" approach which, admittedly, helps to avoid the major pollution disasters. [3]

There is also the question of regional delineation of the standards. Should we use the same standards for all locations? Should the standards in New York be the same as for central Pennsylvania or in the Northern Great Plains? A positive answer would suggest important inefficiencies in resource use.3/

An example from south-central Pennsylvania may be useful in pointing out some of the problems with the stream standard approach. A paper manufacturer in the area is currently spending $2.99 per ton of product for primary and secondary treatment for sewage effluent from his plant. [17] The Federal Water Pollution Control Agency estimated that a "typical plant" producing the same product would spend an average of $1.24 per ton of product for waste treatment. The Pennsylvania plant is now under order from the Sanitary Water Board to meet higher stream standards. In a joint ERS-Penn State study we estimated the costs for sewage treatment will increase to $17.80 per ton under the new standard. [17] Two major components of this increased cost are for color removal and for supporting of "cold water" aquatic life. Yet, if the plant was not pumping effluent, the stream would have a near zero rate of flow and a muddy channel during portions of a normal summer. Thus, the plant is required to meet a standard which is higher (in terms of supporting aquatic life and color) than the natural quality of the stream.

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3/ One must be careful, however, in answering this question. A recent study published by the National Academy of Science reported that the Appalachian region is one of the most pollution-prone areas of the Country. [19]

In the same watershed, a city is under orders to upgrade their municipal system in order to meet the "water contact sport" standard. At the hearings which proceeded the setting of the standard, a consultant testified the city could install 10 olympic-size swimming pools annually for the same funds as needed to make changes in the municipal sewage treatment plant to meet the incremental increase in the stream standard. Granted, this example might be an extreme case, but it emphasizes the type of problems which arise when the stream standard approach is used.

One of the attractions for a standards approach is that everybody in a watershed has to meet the same standard. A certain sense of fairness is involved and thus it may become the preferred system--even though it leaves much to be desired in terms of economic efficiency.

A third method is the user charges approach to pollution control. This approach has been dubbed--"putting a price on pollution." [21]

Under this system, anyone could pollute any amount as long as he paid the price. Thus, the water, air, and other resources used (and polluted) would be priced and become an integral part of the cost structure of each firm and thus promote efficiency in resource use.

An advantage of the user charges approach is that it would permit each individual polluter to adjust their production technique within a profit-maximizing framework. In general, they will adapt new technology up to the point where the cost of the new control systems is equal to the level of the user charges.

The approach, as used in the Ruhr region of Germany, is described by Kneese as follows:

> Waste disposal is managed on a region-wide basis in which advantage is taken of economies resulting from flow regulation and large-scale treatment and recovery of potential waste products. The regenerative capacity of the streams is utilized to the extent consistent with water quality standards which are based on a variety of water uses in the area--industries and cities pay a charge for the effluent they contribute to the waste disposal system based upon periodic tests of the quality and quantity of their effluent. The charge which is levied is not contingent upon whether the wastes are directly handled in treatment plants or not. This independence of effluent charges from the provision of specific facilities is essential if potential gains in efficiency from system design are to be realized. This can perhaps best be illustrated. Economies of scale

> and treatment may mean that wastes from Factory A are given far reaching treatment because it has a large effluent volume and costs per unit of waste removed are comparatively low. Say Plant B has only a very small effluent volume and treatment would be very expensive. Desirable (cost minimizing) stream conditions may be attainable by treating only Factory A's waste at low cost and not treating B's at all. If an appropriate method of assessing costs exists, part of the cost will be paid by B and both A and B can benefit because total costs are lower than they would be if the same results had been achieved by two smaller plants. [13]

It should be noted that user charge approach does not eliminate the need for estimating costs (i.e. prices) nor does it eliminate the need for a regulatory agency to measure the level of pollution output. Also an agency would be necessary to collect and allocate the revenue generated by user charges. Thus, the job is still difficult but the problems are not a great deal more formidable than the first two alternatives, and the results tend to be more efficient from an economic point of view.

A logical question is why have user charge procedures not been implemented to any extent in the United States? One reason is that there are still difficult cost assessment procedures which must be worked out. For example, the natural scientists tell us one of the reasons why the control of phosphorus discharge is important is that it serves as a trigger mechanism for releasing the nitrogen already in the stream. Another problem is that the cost of collective decision-making may exceed the benefits gained from a more equitable procedure of assigning costs and benefits.

A second stumbling block is that people are very reluctant to pay a user charge which is used to clean up a neighboring river or air basin. As noted by Kneese above, one of the requirements for the successful implementation of the user charges approach is the independence of effluent charges from the provision of specific facilities. In the Ruhr Valley this has resulted in stream zoning. The water in one stream is basically used for sewage assimilation and the user charge fees collected from firms using that stream are applied to another stream which receives a very high level of treatment. Also the rather autocratic procedures needed to implement this method tend to conflict with the free enterprise approach.

A third reason can be looked at from two viewpoints. The "conservationist" tends to look at user charges as a license to pollute. From their idealistic frame of mind this is an unacceptable approach to improving the environment. The economist's answer is that this approach could be used to reach the same goal as that desired by the conservationist. It is merely a function of the price assigned to each polluting activity.

A reverse twist on the same theme may be the reason for industries mistrust of a user charge approach. The industrialist tends to favor tax incentives or subsidies rather than user charges. A system that, in general, rewards a company for doing a bad job.

In the subsidy or incentive approach, the costs are assessed on society in terms of the distribution of the tax load rather than assessed to the users of the specific goods and services. Thus, it distorts the relative price of the goods being produced under subsidies and results in an inefficient allocation of resources. However, the political appeal of the tax incentive approach may make it the most feasible means of enhancing environmental quality even though it tends to be a movement away from an economically efficient solution.

## The Distribution Question

It seems the economics profession has done a fairly good job of developing and evaluating the relative trade-offs as they relate to efficiency. But we have done less well in tackling the distributional question. We are too ready to retreat behind the "economics is concerned with efficiency" shield and thus miss the mark in many of the problems of environmental quality control. At a minimum, it seems we have a responsibility to point out the probable economic impact of alternative distributional trade-offs. If anyone except (including?) other economists is going to listen to us it seems imperative that we enter this less stable ground.

James Kunen, a brilliant young writer, expressed his somewhat unorthodox view of the distribution problem after the recent Apollo moon landing.

> The really fine aspect of the trip, as we all know, was that it brought all humanity together--but it's not true. Maybe for ten minutes it did; 20 minutes tops. But in the long run, the only thing we all do together moonwise is chip in for the ticket. And the money is needed for the cities, yes. And to soar to the moon over the faces of starving people is an obscenity, yes. But Americans are reluctant to back programs which will aid some people at the expense of others. The moonshot aided no one at everyone's expense, and thus equitable and perfectly all right. [15]

Now one may well disagree with his evaluation of the worth of the Apollo program, but it is hard to argue the realities of his last sentence. We are concerned, rightly, about the "windfalls" others might receive. Yet we seemingly have little concern about assuming independence of the marginal utility functions in our economic analysis. The following section will briefly examine some of the distributional problems associated with programs of environmental quality control.

Spatial Distribution Trade-Offs

A great deal is yet unknown about the impact of environmental control programs on the spatial arrangement of economic activities. Will Pennsylvania's rather stringent "Clean Streams Law" drive industry to neighboring states with less demanding standards? Solid evidence is not yet available to support the contention that this is happening in Pennsylvania.

Conversely, some of the western states are actively promoting programs designed to limit the influx of economic activity in the name of environmental quality. The Governor of Oregon is closing his speeches to visiting firemen with "come and visit us, but please don't stay."

The preference, of course, would be to have a high level of pollution control in all areas. But one can logically argue that the divergency between private and social cost to society is larger in New York City or Los Angeles than in the more sparsely populated areas of the region and nation.[4/] Thus, the spatial location may have important efficiency as well as distributional implications.

In this regard, one wonders about the usefulness of another of our economic constructs as it is currently being used. Specifically, one sees the "economies of size" concept used to show cost-size relationships without adjusting for quality [16]. For example, consider the cost of municipal sewage systems for towns and cities with various size populations. The results of Downing's [8] study show the traditional decreasing average cost curve for similar treatment levels as city size increases. [8] But what is normally not taken into account is that higher levels of effluent treatment are needed in the larger cities to attain the same water quality in a given stream. In a recent study at Penn State we found that the "economies of size" advantages for the larger cities tended to be offset by the higher levels of treatment required to meet specified stream standards. [12]

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4/ Theoretically one is on shaky ground here because it assumes an unweighted preference function for environmental quality. It is theoretically possible that the disutility from increased economic activity experienced by an isolated Montana rancher may outweigh the increase in utility to the residents of a metropolitan center where the polluting activity was formerly located.

This result is basically due to the more efficient use of the waste assimilation capacity of the stream.

The "economies of size" concept also tends to affect questions of the "optimum" spatial distribution of population. Thompson, [23] and more recently Hansen, [11] have contended that cities of 200,000 to 250,000 provide the minimum critical size for providing self-generating and viable economic growth.

If this be true, one is forced to ask two related questions: (1) why are the mayors of our large cities predicting doom and disaster without federal revenue sharing; and (2) why undermine the vitality of these "self-generating and viable" areas with federal subsidies that have not been needed in the past? 5/ The environmental quality problem is only one component of an admittedly much broader problem, but one wonders if part of the "crisis" is not the wider divergence between private and social cost in the larger metropolitan areas. 6/

## Sector Distributional Trade-Offs

A question of importance in terms of both efficiency and distribution is which sector should carry the responsibility for pollution control. It is a highly inefficient use of resources for each sector to clean up at the same rate. This was suggested in our discussion above of Kneese's user charges approach. The search for least cost strategy in controlling the emissions of sulfur oxides and particulates at the national level has reinforced the idea that inherent inefficiencies result when a uniform abatement strategy is employed. In a study reported on by Carlson, it was found that a general reduction in sulfur oxides by 60-75 percent would cost slightly in excess of one billion dollars annually if the emphasis was on emitters that could do it at the lowest cost. However, if a uniform abatement strategy was followed where all polluters were asked to reduce by the same amount, (60-75 percent), the additional annual cost was estimated to be about $1.3 billion. [5] Thus, the distributional "fairness" associated with each sector being subjected to a proportional reduction in pollution levels is very costly from the standpoint of efficiency in resource use.

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5/ This point is made by Alan Bird in his review of Hansen's book in Agricultural Economics Research, Vol. 23, No. 2, April 1971.

6/ Although I think this is an important point to consider, it should be noted that perhaps the most serious problem facing the large city is the unequitable distribution of the tax load between the suburbs and the central city.

Distribution of Income Trade-Offs

It is indeed difficult to speculate on the impact of environmental improvement programs on the distribution of income unless one is examining a specific proposal. One can, however, make some general observations.

Pollution is not necessarily a product of affluence as many writers would currently have us believe. It is true, that a state of affluence creates a greater demand on resources--four out of every five refrigerators are replacements and electrified paper towel dispensers are not a basic necessity. But as Ruff points out, pollution runs in the streets of India and cautions against drinking the water in exotic lands are well heeded. [21] Thus, the major difference is the affluent countries can afford to do something about environmental deterioration.

It is also interesting to note that many leaders of the "environment improvement at any cost" school tend to be in the $25,000 plus a year income category. After the second car and color TV one can become very self-righteous about the environment. Perhaps it is best summed up in the quote--"the issue of environment brings together those who already consume, not those who aspire to it." [22]

Functional Distribution Trade-Offs

It is also difficult to generalize about the possible distortions in the payments assigned to the factors of production resulting from programs to improve environmental quality. When a productive process fails to account for all costs, there is prima facie evidence of a distortion of factor payments. In terms of the classical tripartite delineation of factors, would the odds be in favor of overpayment for capital, labor, or land? Can some of the methodology used to estimate returns to factor shares in farm management and marketing studies be employed to evaluate the impact of alternative programs designed to enhance the environment? Before one indiscriminately assigns the blame to greedy capitalists, power hungry labor unions, or land speculators, he should note that open sewers and smog can also be found in the communistic bloc countries.

Intergeneration Distribution Trade-Offs

Another interesting trade-off is how do we express our concern for future generations. Are we using up their birthright through riotous living which will result in a plundered planet? Or does the appeal for protecting the needs of future generations provide an unimpeachable reason for irrational action. One editorialist with strong feelings on the subject states:

> The ecology binge provides a cop-out for a populace too cheap or too gutless or too tired or too frustrated or too all of them to tangle harder with some old problems that have proved resistant and emotionally ungratifying to boot. But the cities are still dying, and not just from pollutants; the educational system still needs a real shaking up, and not just in the direction of sex education; the races still can't get along together; the vicious cycle of poverty remains unbroken. [20]

Although Marglin [18] and others have attempted to develop inter-generational preference functions, substantial "gaps" remain in the conceptualization of this difficult problem.

The idea that society must speak for the "unborn generations" is not a new idea associated with the surging interest in environmental quality. In fact, one of the central themes of the whole conservation movement is the selfishness of man and the need for society "to protect the rights of our children and grandchildren." The problem with this approach is that it establishes a uniform cause for exploiting the environment rather than finding the specific reasons for the decline in quality. Also, this approach labels any use of our environmental resources as "anti-social," and thus provides no guidelines as to the appropriate level of action. Both of these problems would tend to foster extreme inefficiencies in resource use. [4]

## Summary

My assignment was to identify economic trade-offs as they relate to questions of environmental quality. The major emphasis in this paper was on environmental quality problems as they relate to the use of our natural resources. The whole question of the size and distribution of population was mentioned only indirectly.

Of the three alternative approaches to environmental control, the user charges method seems the most appropriate when measured against the standard of economic efficiency. There are several important limitations in using this approach--including the high cost of specifying beneficiaries and assessing costs.

The need to evaluate the distributional impacts of alternative environmental quality policies is of central importance. Unless the economist is willing to tackle the important distribution problems, his preferred efficiency solutions are going to "rot on the shelf." This would be a major loss to society--"the environment is too important to be left to the environmentalist." [25]

## References


1. Ardrey, Robert, Social Contract, Atheneum, New York, 1970.
2. Barnett, H. S. and L. Morse, Scarcity and Growth, Johns Hopkins Press, 1963.
3. Boulding, Kenneth, "Discussion: Environmental Pollution--Economics and Policy," American Economic Review, Vol. LXI, No. 2, May 1971, pp. 167-169.
4. Bunce, Arthur, Economics of Soil Conservation, Iowa State College Press, 1942, pp. 97-128.
5. Carlson, Jack, "Discussion: Environmental Pollution--Economics and Policy," American Economic Review, Vol. LXI, No. 2, May 1971, pp. 169-172.
6. Castle, E. N., "The Market Mechanism, Externalities, and Land Economics," Journal of Farm Economics, Vol. 47, No. 3, pp. 542-556.
7. Chapman, John, "Interaction Between Man and His Resources," Resources and Man, Committee on Resources and Man, National Academy of Sciences - National Research Council, W. H. Freeman and Co., 1969, pp. 31-42.
8. Downing, P. B., The Economics of Urban Sewage Disposal, Praeger Special Studies, New York, 1969.
9. Ehrlich, Paul R., and Anne H. Ehrlich, Population Resources Environment; Issues in Human Ecology, W. H. Freeman and Co., 1970.
10. Fisher, Joseph, "Impact of Population on Resources and the Environment," American Economic Review, Vol. LXI, No. 2, May 1971, pp. 392-398.
11. Hansen, Niles, Rural Poverty and the Urban Crisis: A Strategy for Regional Development, Indiana University Press, 1970.
12. Kearns, W. and J. D. Jansma, Criteria for Determining Economic Priorities in Awarding Sewage Facility Construction Grants, The Institute for Research on Land and Water Resources, The Pennsylvania State University. (Forthcoming - July, 1971).
13. Kneese, Allen, "Economics of Pollution Control," Water Resources and Economic Development in the South. North Carolina Policy Institute, August, 1965, p. 105.
14. Kneese, Allen, "Environmental Pollution--Economics & Policy," American Economic Review, Vol. LXI, No. 2, May 1971, pp. 153-166.

15. Kunen, James, "Moon Landing was a Thrilling Job of Animation," Washington Post, August 24, 1969, p. B-2.
16. Lamm, Richard, "Is Bigger Also Better?" New Republic, June 5, 1971, pp. 17-19.
17. Long, Burl. The Relevance of Economic Externality and Related Concepts to Water Pollution, Unpublished Ph.D. dissertation, The Pennsylvania State University, 1969.
18. Marglin, S., "The Social Rate of Discount and Optimal Rates of Investment," Quarterly Journal of Economics, Vol. LXXVII, February 1963, pp. 95-111.
19. National Academy of Sciences--National Research Council, Waste Management and Control, Publication 1400, Washington, D. C., 1966, p. 5.
20. New Republic, "Editorial," New Republic, March 7, 1970.
21. Ruff, Larry, "The Economic Common Sense of Pollution," The Public Interest, No. 19, Spring 1970, pp. 69-85.
22. Schrag, Peter, "Who Owns the Environment?" Saturday Review, July 4, 1970, pp. 6-9, 48.
23. Thompson, Wilbur, A Preface to Urban Economics, Johns Hopkins Press, 1965.
24. Wagner, Richard, Lecture at The Pennsylvania State University, April 29, 1971.
25. Wallich, Henry, "Environment and Poverty," Newsweek, June 7, 1971, p. 87.
26. Zimmermann, E. N., Introduction to World Resources, Harper and Row Co., 1964.