LAND, WATER, AND OWNERSHIP*

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Rôle des droits de propriété du sol et de l'eau dans l'allocation des ressources. Le mécanisme des prix ne peut conduire à une allocation efficace des ressources qui ne font pas l'objet de propriété. C'est ce que nous constatons en comparant l'histoire de l'utilisation du sol et de l'eau en amérique du Nord. La même conclusion va d'ailleurs pour l'utilisation de l'air.

Dans cet article, l'auteur défend la thèse selon laquelle les problèmes de la pollution des eaux seraient réglés plus facilement en établissant une grille des droits d'usage de l'eau plutôt que par l'institution de systèmes complexes de prix témoins. Une solution qui s'impose d'elle-même consiste dans le paiement de droits d'usage des biens libres. On parvient ainsi à la mise sur pied d'un système de prix pour l'utilisation des biens libres dans le cas où l'usage conduit à leur détérioration ou leur destruction. L'auteur n'accepte pas l'idée selon laquelle le système des prix témoins se justifie par l'existence des économies ou des déséconomies externes, et cela pour deux raisons. D'abord l'existence d'un système de prix réels permet de transformer les externalités technologiques nuisibles en externalités pécuniaires acceptables pour la société. En second lieu, la thèse des externalités ignore la mobilité des individus tout en reconnaissant celle des agents de pollution. Enfin l'auteur conclut que, dans le cadre des certains choix collectifs, l'établissement d'un marché des ressources dite libres est non seulement économiquement rentable, mais se traduit par des réductions considérables des frais d'administration.

I

Increasing public concern about the pollution of natural water systems in North America has confronted governments with a new problem in resource administration, and challenged economists to devise an artificial pricing system for water that will itself promote wise use of the resource, thereby greatly simplifying the lives of water administrators. The pricing problem turns out, not unexpectedly, to be a deliciously complex tangle of joint uses, externalities, and peak-load problems. The administrative problem of approximating optimum shadow prices by actual user charges promises to be a nightmare.

The economic and administrative complexity of water problems is commonly explained as being inherent in the nature of a fluid resource. Because of the self-mixing quality of a fluid, one use of water at a given point may affect other uses at the same point; and because water flows through space, use at one point may also affect uses at other points. Opportunity cost pricing is accordingly very complex because of the number of alternative opportunities that may be affected by any one use at any one point, not to mention the complications introduced by time of use, varying stream flow, different rates of self-regeneration of different

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stretches of water, and the chemical interactions of different types of waste after they have been discharged into a natural water system.

Before we submit to this incubus of complexity, however, we might seek comfort in the reflection that the great virtue of a pricing system is that it solves, avoids, mediates, or somehow manages to dispel, all sorts of complexities, particularly those that arise from various interdependencies between uses and users of goods. Yet the existence of a natural pricing system depends crucially on the institution of ownership. What is not owned cannot be priced since prices are payments for property rights or rights to the use of an asset.[1] In the course of allocating property rights to assets among different owners, the price system in fact transforms most potential "technological externalities" into "pecuniary externalities," a synonym for prices. Thus we hear very little about externalities of land use, precisely because property rights to land use are well established and allocated by the price system. It is quite otherwise where water is concerned.

We can now re-formulate the water problem and blame its complexity not on nature and the laws of fluids, but on man and his failure to devise property rights to the use of natural water systems. Economists tend to assume implicitly that it is impossible to own water and therefore seek to devise artificial price systems that are identical to what prices "would be" if ownership were possible. The alternative strategy is to devise an ownership system and then let a price system develop. The purpose of this article is to suggest that there are very considerable advantages to attacking our water problems by means of a system of explicit ownership rather than by a system of shadow prices.

A geographical reflection is also in order. Despite the large numbers of people who live on the St. Lawrence, the Fraser, and the St. John, most Canadians live on lakes, or on rivers that flow into lakes, rather than into oceans, whereas most Americans, despite the large population around the southern rim of the Great Lakes, live on river systems that discharge into salt water. Lakes are much less "mobile" and much less "self-mixing" than rivers. Most of the water in lakes *stays* there for prolonged periods, and recent research has shown that during much of the year the shallow, inshore waters of large lakes are effectively isolated from the very large volumes of water in their deep centres.[2] (Similar propositions apparently apply to oceans; otherwise the serious pollution problems of coastal cities such as San Francisco, New York, and Vancouver would not exist.)

People who live on river systems, as most Americans do, tend to pass on their pollution to the next downstream community, thereby creating vexing externality problems. American literature on pollution has been strongly influenced by the uni-directional flow of rivers, which makes it relatively easy to solve the

[1]One never owns physical assets, but only the rights to use physical assets. Professor Ronald Coase writes that a factor of production "is usually thought of as a physical entity which the businessman acquires and uses (an acre of land, a ton of fertilizer) instead of as a right to perform certain (physical) actions. We may speak of a person owning land and using it as a factor of production but what the land-owner in fact possesses is the right to carry out a circumscribed list of actions. The rights of a land-owner are not unlimited." See his "The Problem of Social Cost," *Journal of Law and Economics*, Oct. 1960, 1–44, reprinted in W. Breit and H. M. Hochman, eds., *Readings in Micro-Economics*, (New York, 1968), 423–56; the quotation is from p. 456.

identification problem of who pollutes whom. River pollution therefore lends itself to economic analysis in terms of externalities, and shadow-pricing schemes to offset them. People who live on lake systems (most Canadians) tend to pollute themselves; because inshore lake water, far from being uni-directional, tends to slosh up and down the shoreline, lake pollution tends to be a sort of Hobbesean war of all against all. It therefore requires economic analysis in terms of social decision-making and social welfare functions rather than in terms of the effects of autonomous upstream communities on autonomous downstream communities. The economics of Canadian water pollution is therefore quite different from the economics of American water pollution.

II

Rent theory has been the traditional vehicle for studying the economics of natural resources, and a review of some of the effects of the ownership-rental system as applied to land highlights the opposite effects induced by the absence of an ownership-rental system as applied to water. Following normal practice, we shall speak of the supply of land (or water) available to any society as fixed by nature. Though fixed in supply when measured in natural units (acres or gallons), the *quality* of land and water can be changed by human action. (Were we to measure the quantity of land in efficiency units of a given quality, its supply would be variable; we conduct the present argument, however, in terms of natural units, fixed supplies, and variable qualities.) Imagine a society where all land is being used and even the poorest of it commands a positive rent (this assumption allows us to avoid those not very illuminating discussions about no-rent land and the relationships between the extensive and intensive margins) and suppose that an initial state of equilibrium exists, and in particular that at existing land values and rents there is neither investment nor disinvestment in the quality of the soil. Population growth when superimposed on this initial state will lead to increases in land values and rents; these increases in turn will lead to economies in the use of soil by means of the substitution of manufactured fertilizers and other intensive farming practices against inputs of natural soil fertility. The process may be described as one of investing in soil fertility, and the equilibrium stock of soil fertility will accordingly rise (or its rate of decline will fall). In a general form, the conclusion is that *the level of rent determines the quality of the soil that it is economic to maintain.* It is also clear, as Ricardo showed, that when man-made inputs are substituted for natural inputs in the food-producing industry the real cost of food increases and the standard of living in terms of food falls. Rising rents, therefore, tend to slow down population growth and lessen the population pressure that produces them.

The working out of these processes in the historical development of the United

[2]See G. K. Rodgers and D. V. Anderson, "The Thermal Structure of Lake Ontario," *Proceedings Sixth Conference Great Lakes Research*, 1963, University of Michigan publication 10, 59–69; P. F. Hamblin and G. K. Rodgers, *The Currents in the Toronto Region of Lake Ontario*, publication (PR 29) of the Great Lakes Institute of the University of Toronto, 1967; and G. K. Rodgers, "Thermal Regime and Circulation in the Great Lakes," in Claude E. Dolman, ed., *Water Resources of Canada* Royal Society of Canada, studia varia 11, (Toronto, 1967), 87–95.

States has been brilliantly described by Bunce.[3] In the early history of the country there was a high ratio of soil fertility to the human demands on it, and rent was accordingly low; "high farming" practices on the European model were therefore rejected, and economic use necessitated soil-depleting practices. In the course of time the man-soil fertility ratio rose, as a result both of population growth and of soil depletion; rents rose; more intensive farming practices became economic, and the rate of soil depletion was thereby reduced. A slowing down in the rate of population growth after 1900 further reduced pressure on the land; it is possible that in general soil depletion has now been brought to a halt in the United States and Canada, and that soil erosion and soil-depleting practices in some areas are balanced by soil-building investments in others.

The contrast between the history of land and of water use on this continent is eloquent. Property rights were established in land, with rent being the payment for the right to use the soil fertility; there were no water rents because property rights to water use were not established. Rising land rents led to more intensive land use and after 350 years there is no problem of population pressure on the land in North America. Water rents were zero; over-use of the water led to continuous reduction in water quality; and there is now a growing problem of population pressure on North American water resources. If we accept a simple dynamic extension of rent theory and assume a direct relationship between the level of rent and the development of improved technologies, the land-water comparison is again suggestive. Rising land rents have been associated with phenomenal improvements in land-use technology; zero rents for water have been associated with virtually zero improvement in water-use technology so far as quality-depleting uses are concerned.

The short-run function of land rent, of course, is to allocate parcels of land among different users and different uses. What is interesting is that potential externalities of land use, for example, the operation of a pig farm in the centre of a choice residential area, seldom materialize. Land being immobile, the ownership-rental system seems to work in such a way as to produce "natural zoning" in land use. Differential rents provide the mechanism for such zoning, and the result is that potential technological externalities are continuously transformed into pecuniary externalities, or prices. It should also be noted that a formal economic description of this process depends on a recognition of space, and particularly of the socially "insulating" quality of space. So long as space exists—and we must remember that in most economic analysis it does not—"zoning" solutions to externalities, or what Mishan has recently called "separate facilities" solutions,[4] are possibilities. Given space, there is no need for pig farmers and business executives to live as neighbours, and therefore no need to devise a system of bribes to compensate one or the other party for damages suffered.

The absence of an ownership-rental system for water has meant that water use has in fact been determined by such things as historical priority, gall, and force and fraud; it cannot be otherwise when property rights do not exist and when the price for the use of a valuable asset is zero. When no pricing process

[3]A. C. Bunce, *The Economics of Soil Conservation* (Ames, Iowa, 1945).
[4]E. J. Mishan, *The Costs of Economic Growth* (New York, 1967), chap. 8.

exists, there is no mechanism to transform technological externalities into pecuniary externalities. Accordingly we *do* observe striking examples of externalities in water use; stinking streams flow through choice residential areas, and anglers experience a mixture of rage and resignation as their favourite streams are polluted by industrial wastes. And then there are the externalities of all against all—householders help to destroy swimming beaches by their use of detergents (which promote algal growth), motorists pollute the air they breathe, and we all promote municipal and industrial pollution by insisting on cheap products and low taxes.

These considerations suggest the enormous social benefits that have resulted from applying an ownership-rental system to land, and, by contrast, the enormous social friction and economic waste that result from not applying an ownership-rental system to water. It has, of course, been relatively "easy" to apply property rights to land because land is both divisible and immobile. The awkward problem remains: is it *possible* to apply an ownership-rental system to the use of our water resources?

III

To speak of owning an asset is to use a convenient abbreviation for a complex interaction between a legal concept and an economic concept. An asset may be thought of as "a bundle of potential utility-yielding services that can be used in alternative ways." In the same vein, ownership consists of "a bundle of legally-defined user rights to an asset." As Coase has pointed out, it is rights, never objects, that are owned, and the rights themselves are always limited by law; "outright" ownership can never, by definition, extend to the use of an asset for illegal purposes.[5]

From the whole spectrum of possible ownership arrangements, we shall pick four major types for brief comment. What we shall call *common-property* ownership is, from an economic point of view, virtually non-ownership. A common-property asset is one that can be used by everyone, for almost any purpose, at zero cost. Examples are the mediaeval commons, the high seas, wild game, freeways, and (until recently in this country) air and water. Common-property ownership is justified economically *only* when the costs of enforcing a more restricted form of property-rights would be greater than the benefits of doing so. H. S. Gordon has shown that, neglecting enforcement costs, common-property ownership of an asset is economically inefficient in that the asset will be over-used by comparison with assets that are subject to more restrictive property rights.[6] Empirically it is clear that if the asset is depletable it will be continuously depleted on the grounds that "everybody's property is nobody's property": mediaeval commons were overstocked; modern freeways (but not toll-ways) quickly become congested; wild animals (but never domestic animals) become scarce or extinct; and the deteriorating quality of our air and water resources has become a matter of widespread concern. The concept of a

[5]See Coase, "The Problem of Social Cost."
[6]H. S. Gordon, "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy*, April 1954, 124–42.

free good has always been a contradiction in terms; it is time we appreciated its sardonic overtones, for anything that is treated as a free good is indeed likely to become a valueless thing.

In general common-property assets are nominally owned by some public body, usually a government, and the owner may restrict use of the property in a variety of ways. Some roads may be used by motorists but not by cyclists or pedestrians; some wild animals may be photographed, but not shot; on some lakes canoes and sailboats may be used, but not motor-boats. It seems reasonable to refer to such property as *restricted common-property;* though the type of use is restricted, it is still common-property in the sense that everyone can use it for designated purposes at zero cost. If uses that deplete the asset in a physical sense are banned, the quality of the asset can be maintained, though "congestion" problems may reduce its value to other users.

When the use of an asset is restricted by law to particular persons, or a particular person, we have what can conveniently be called *status-tenure* or *fixed-tenure* ownership. Such ownership guarantees exclusivity of use to the parties authorized to use the property, but these user rights are not transferable. Though secure right of access to an asset by a limited group of people is valuable, the absence of the right of transferability prevents an explicit price system from developing. Nevertheless implicit prices are likely to appear. If the right to send one's children to a particularly good school is limited to those who live in a particular area, the value of the rights are likely to become reflected in the value of real estate in the area concerned. The "regulatory" branches of modern governments create an enormous variety of valuable property rights that are imperfectly transferable, and that tend to be capitalized and monetized in ways that are usually unsuspected by their creators. The value of tariff protection, a quota to grow tobacco, a licence to transport milk or to operate a taxicab, are reflected in the values of tariff-protected businesses, tobacco farms, milk routes, and taxi fleets.[7] Though the indirect monetization of such rights is seldom illegal, contemporary populations choose to be as hypocritical about the process as mediaevel populations were about the evasions of prohibitions on the payment of interest; social inhibitions about a rational approach to property and prices have outlived social inhibitions about rational approaches to astronomy and sex.

From status-tenure to full *ownership*, in the usual contemporary sense of the term, is but a short step. Once the property right is separated from the person, it becomes transferable, and transfers of assets (rights) then take place at explicit prices. *Transferable* property rights stand in a one-to-one relationship to prices; everything that is owned is priced, and everything that is priced is owned—which is to say nothing about either the form of ownership (transferable property rights to assets may be owned by individuals, corporations, or governments) or about the precise functional relationship between ownership and prices. Ideological hang-ups on concepts of property rights and ownership are understandable because such concepts touch the very roots of society. We have not yet learned to discuss such matters unemotionally. Though we are inclined to take a condescending view of mediaeval man's distrust of full property rights

[7]On this general question, see Charles A. Reich, "The New Property," *Yale Law Journal*, 73, no. 5 (April 1964), 733–87.

to land, we tend to become quite agitated when valuable government-granted rights (licences to import, for example) are traded in the market place, or when suggestions to extend property rights to air and water are put forward for discussion. Property and prices still raise ancient fears that "the rich will eat out the poor."

IV

Since the right to use water is valuable, and since ownership consists of user rights, it should in principle be possible to devise an ownership-rental system for water. As is well known, however, certain characteristics of a natural water system create special problems in ownership.

The characteristics of an ownership system reflect in part the "divisibility" of the asset to which it is applied. Let us define an *asset-unit* as the smallest physical amount of the asset to which it is practicable to apply property rights, i.e., for which it is practicable to enforce exclusivity of use. In land, the asset-unit is very small, perhaps a few square yards; when the asset-unit is small compared to the quantity of the asset available, the asset can be held by a large number of individual owners. In such cases a "private property" form of ownership is likely to work well; decisions about the use of the asset will be decentralized among many owners, and a reasonably competitive market in asset-units will emerge.

In water, the asset-unit is very large. If water were completely "self-mixing," no one would pay anything to own Lake Ontario unless he could also own the whole Great Lakes drainage basin above the St. Lawrence river. As we have seen, however, water, especially in large lakes, mixes only slowly and imperfectly; because of this, and because of the self-purifying characteristic of water, the quality of water in the eastern end of Lake Ontario may be effectively independent of the uses made of the water at the western end of the lake. Even so, it is clear that the asset-unit is very large. It might be possible to divide the Great Lakes water system into, say, a dozen "regions" each of which would be self-contained for practical purposes, but it would certainly be impossible to divide them into a thousand such regions. In a democratic society it would be unacceptable to allow as few as a dozen, or even a score, of owners to control such an immense property as the Great Lakes drainage system. The only sensible alternative is the one actually adopted, namely, monopoly ownership by government. The reverse side of this coin is that the government must decide how its property is to be used and must enforce its decisions—assuming that it wishes to avoid the horrors of the common-property approach to resource management.

The decision about how water shall be used must be an arbitrary one from the standpoint of economics. Let me argue this point on the basis of a simple (but seemingly realistic) classification of water uses.

If we ignore such uses as navigation and the generation of hydroelectric power, which have insignificant effects on water quality, it seems reasonable to classify other uses into two categories: waste disposal, and "all other" uses, which we shall call amenity use. These two uses are competitive. Though it is not true that fishermen, swimmers, industries that use water for processing purposes, and municipal authorities responsible for residential water supplies all have the

same quality demands, it is true that some of these users would be benefited, and none would be harmed, by an improvement in water quality. Waste disposers, on the other hand, would be harmed by such an improvement since it could only occur if less waste were discharged into the water. We thus reduce the many uses of water to two: amenity use and waste disposal. The social problem is then to decide on the division of water services between these two conflicting uses. In principle, the division should be made in such a way that the value of a marginal increment in the one good is equal to the value of a marginal decrement in the other. But since the value of a marginal change in amenity use cannot be measured, the optimum amount of waste disposal cannot be identified. In practice, the decision is made on a political rather than an economic calculus. Once there is a political demand for "pollution control," anti-pollution measures tend to be instituted incrementally until complaints about their cost outweigh complaints about pollution! That sort of solution, applied also to such things as education, road systems, and various social welfare schemes, seems to me to be eminently sensible, *faute de mieux.*

In water quality problems, however, it is important to keep in mind that, within limits, water can be "regionalized" for practical purposes, and that "zoning" solutions to quality problems are therefore possible in some cases. In practice it would probably be wise to provide for different ratios of amenity use to waste disposal use in different water "regions"; the socially insulating quality of space should be utilized wherever possible. People are mobile, and if they can consume the amenity services of water in the upper reaches of a river and the waste disposal services of the same river in its lower reaches, there is no need to force them to decide on the optimum division between amenity uses and waste disposal uses of the water in both the upper and lower parts of the river. But again, alas, economics has little to say about a feasible or desirable delimitation of water "regions"; a sensible "mapping" of water must be left to the good judgment of physical scientists and politicians.

The contention that there exists no economically optimum division between amenity and pollution uses of water will be resisted by exponents of damage-cost pricing.[8] In the classic example of an upstream community polluting a downstream community, an allegation of damage to the downstream user seems to rest on three assumptions: that the downstream community owns its water and in particular owns the right not to have its water polluted by others; that the downstream community gains no advantage from the upstream pollution, i.e., that its residents buy no goods from their upstream neighbours at prices that are lower than they would be if the upstream community were forced to reduce its pollution; and that the upstream residents suffer no disadvantages from the downstream pollution because they never visit the downstream area for fishing, swimming, or other recreational purposes. The property rights assumption has not generally been true in the past in North America, and even to-day it is far from clear that a downstream community has any more right to use the river water for swimming and drinking than the upstream community has to use it for waste disposal purposes. The other two assumptions about the inter-community

[8]A good exposition of damage-cost pricing is to be found in Allen V. Kneese, *The Economics of Regional Water Quality Management* (Baltimore, 1964).

immobility of goods and people are, in general, untenable. The "polluter-pollutee" view of the problem that underlies the recommendation of damage-cost pricing derives from the apparently easy identification of the two parties on a river. Once the mobility of goods and people up and down a river is taken into account, however, identification becomes much more difficult and the problem appears much like the "war of all against all" that is characteristic of lake and ocean pollution.

Even if everyone is at once a polluter and a pollutee, however, the optimum amount of pollution could be achieved if the value of a marginal dose of pollution could be measured. But it cannot be measured, because its value is the value of the amenity use forgone, which cannot be measured. Attempts have been made to measure the recreational value of particular land and water areas, but all such measurements are made on the partial equilibrium assumption that the recreational use of neighbouring areas is held constant. In general, however, a reduction in the amenity capacity of one river or lake will result in increased pressure on the amenity capacities of other rivers and lakes in the same general area. So far as I know, no one has been able to measure the amenity value of an acre-foot of water under general equilibrium assumptions. All we can be reasonably sure about is that the recreational value of water rises as population grows and the standard of living increases.

In brief, it seems to me that it is unrealistic to view water management as a problem in externalities, and that the question of how water should be used is purely a matter of collective decision-making. Economics cannot be of any significant help in making this decision. Even the principle that property rights should be set so as to maximize social product is of no use in the case of water because the values of amenity uses of water—recreation, and the simple aesthetic satisfaction that most of us gain from looking at, or even merely contemplating the existence of, clean water—cannot be measured, though such values are certainly part of any society's gross national welfare. Social welfare functions, community indifference curves, and benefit-cost analysis are ways of visualizing the social decision-making problem, but not of solving it.

What is special about the ownership of water, therefore, is that the owner must decide, without the benefit of economics, how his asset is to be divided among different uses. (When asset-units are small relative to the amount of the asset available, as in land, decentralized ownership is possible and the amount of the asset devoted to different uses is, for practical purposes, determined by market forces.) But this special quality of water (and air) ownership does not make it impossible to apply a rental system to water management.

V

If economics has nothing useful to say about the ownership decision of how water should be used, it has a great deal to say about how the decision, once made, should be implemented. What the government-owner of a natural water system must decide is how many equivalent tons of wastes may be discharged into the waters of each water region. The decision has at least three arbitrary components. Since in given circumstances a ton of one waste is likely to be more

injurious than a ton of another, some equivalence must be established between different waste products, and since circumstances differ widely I assume that some average equivalence is chosen for each region in order to simplify the problem and reduce administrative difficulties. The other two sources of arbitrariness from the economic point of view, the mapping of regions and the choice of the amount of pollution in each region, have already been discussed. Let us now suppose that the owner has decided that during the next five years no more than x equivalent tons of waste per year are to be dumped into the waters of region A, and that x represents a 10 per cent reduction from the amount of waste that is currently being discharged into the region's waters. How can the government-owner enforce this decision?

The government can enforce its decision in one of six main ways. It can *regulate*: (1) a waste quota can be assigned to each waste discharger and set so that the sum of the quotas does not exceed x; or (2) an across-the-board regulation that each discharger must reduce his waste discharge by 10 per cent may be promulgated. It can *subsidize*: (3) dischargers can be subsidized to reduce their wastes, either individually or (4) on an across-the-board basis of so much per ton of waste discharge reduced. It can *charge*: (5) an effluent charge can be levied on dischargers, either individually, or (6) on an across-the-board basis of so much per ton of waste discharged.

I suggest that it is intuitively obvious that the *individual*, or point-by-point, procedures would involve staggering administrative costs. Yet it should be noted that politicians and civil servants seem to favour point-by-point *regulation*, and that economists who recommend damage-cost pricing favour point-by-point *charging* schemes. It seems intuitively obvious that in practice no point-by-point procedure could distribute the cost of reducing pollution among polluters in an economically optimal way, i.e., in a way that would minimize the total cost of reducing pollution by 10 per cent. To suppose that optimality in this sense is possible is to suppose that the administrative authority is able to solve a set of thousands of simultaneous equations, when the information required to write the equations in numerical form is not only not available, but also often unobtainable. It is also obvious that an across-the-board regulation to the effect that all dischargers must reduce their wastes by 10 per cent would results in a non-optimal distribution of the cost burden.[9]

Let us then examine the across-the-board schemes of subsidization and charging. Both possess the advantages of low administrative costs relative to the point-by-point schemes, and both would result in an optimum distribution of costs among dischargers; all dischargers would reduce their wastes up to the point where the marginal cost of doing so equalled the subsidy provided, or the charge levied. Both schemes have two disadvantages: a certain amount of experimentation would be necessary to establish the level of subsidy, or charge, that would produce a 10 per cent reduction in waste discharge; and the levels

[9]Paul A. Bradley, "Producers' Decisions and Water Quality Control" (Background Paper D 29–3 in *Pollution and Our Environment*, papers presented at a conference held in Montreal, Oct. 31 to Nov. 4, 1966, by the Canadian Council of Resource Ministers) discusses various possible reactions of individual firms to the regulation of effluent standards and to a system of effluent charges. Standards, charges, and subsidies are discussed extensively in Kneese, *Economics of Regional Water Quality Management*, chaps. 4 and 8.

would have to be varied annually to take account of industrial and demographic growth (or decline) in the region in order to keep to the target of x equivalent tons of waste discharge. The subsidy scheme, however, has two disadvantages that the charging scheme does not have. First, if a subsidy of so much per ton of waste reduced is set, extra profits will accrue to those firms that can reduce their wastes at a cost per ton that is less than the subsidy provided, and no change in relative prices of goods is necessary. In the charging scheme excess profits will not be generated, and there will necessarily be a change in relative prices of goods, which in turn will result in a socially desirable adjustment of consumption patterns to reflect the differential costs of waste disposal as between different goods. Second, the subsidization scheme provides no incentive to choose production methods that reduce the amount of waste generated (and may indeed have the opposite effect!), whereas the charging scheme provides incentives both to reduce waste and improve the technology of treating waste before it is discharged. The across-the-board charging scheme is therefore clearly the best of the six possible ways of implementing the government's decision.

Its victory is made decisive by the fact that it lends itself easily to a market mechanism, whereas the subsidy scheme does not. The government's decision is, let us say, that for the next five years no more than x equivalent tons of waste per year are to be discharged into the waters of region A. Let it therefore issue x pollution rights and put them up for sale, simultaneously passing a law that everyone who discharges one equivalent ton of waste into the natural water system during a year must hold one pollution right throughout the year. Since x is less than the number of equivalent tons of waste being discharged at present, the rights will command a positive price—a price sufficient to result in a 10 per cent reduction in waste discharge. The market in rights would be continuous. Firms that found that their actual production was likely to be less than their initial estimate of production would have rights to sell, and those in the contrary situation would be in the market as buyers. Anyone should be able to buy rights; clean-water groups would be able to buy rights and not exercise them. A forward market in rights might be established. The rights should be for one year only, the price of one right for one year representing the annual rental value of the water for waste disposal purposes.[10] (There is no reason, though, why speculators should not gamble in one year on the price of rights in later years.) The virtues of the market mechanism are that no person, or agency, has to *set* the price—it is set by the competition among buyers and sellers of rights—and that the price in the market automatically "allows for" the regional growth (or decline) factor. If the region experiences demographic or industrial growth the price of rights will automatically rise and induce existing dischargers to reduce their wastes in order to make room for the newcomers. The government should make it clear that it reserves the right to alter the allowable level of pollution (the number of rights it issues) at stated time intervals (say, every five or ten years). All that is required to make the market work is the inflexible resolve of the government not to change the rights issue during the interval, no matter

[10]Professor Neufeld has suggested that it would be desirable to issue rights of different durations; more complicated schemes than the one outlined in the text could easily be arranged.

what the political pressures to do so may be, and to enforce rigidly the requirement that a ton-year of waste discharge *must* be paid for by the holding of one pollution right for one year. Pollution rights are fully transferable property rights, and any welching on the enforcement of the right would be a breach of trust.

The automaticity of the market mechanism reduces administrative costs by relieving administrators of the necessity of setting the charge for rights and changing it periodically to reflect economic growth or decline. The administrative costs of enforcement would remain, of course, but they would be no greater than the costs of enforcing any of the other implementation schemes that we have considered. Technological change in the form of automatic monitoring devices to measure the volume of effluents from discharge points promises to reduce the costs of policing for all anti-pollution schemes.

Compliance with any point-by-point regulatory or subsidization scheme of pollution control establishes a sort of *status-tenure* property right. The right inheres to the discharger that earns it, and is only transferable (at the capitalized value of its implicit price) when the property to which it applies is sold. The market mechanism of the across-the-board charging scheme separates the property right to water use from the other assets of the discharger, and thereby makes the property right *fully transferable*. Full transferability and explicit prices are, as has been noted, considered preferable to status tenure and implicit prices by contemporary populations in Western democratic societies.

VI

Having puffed the merits of the across-the-board *cum* market mechanism scheme of pollution control, I must now take note of its deficiencies. There are four arbitrary elements: the mapping of water regions; the setting of waste equivalents; the choice of the allowable amount of waste discharge; and the choice of time interval during which the number of pollution rights is fixed. By comparison with some ideal, Pareto-optimal scheme laid up in Heaven, each of these decisions is bound to introduce elements of non-optimality into the arrangements I have proposed. In each case, however, I suggest that the saving in administrative costs is likely to outweigh the loss in terms of resource misallocation, measured from some theoretical optimum that ignores administrative and other transactions costs—notably the cost of acquiring enough information to administer an optimal pricing system.[11]

The question of the possible effects of pollution charges on the location of industries (and population) requires special comment. It is often suggested in the literature that waste discharged into a large, lightly populated river system does less damage than if it is discharged into a small, thickly populated river system, and that accordingly pollution charges for use of the former ought to be lower than for use of the latter. This reasoning assumes that the only costs of

[11]A referee for this paper wrote that my scheme requires "that the questions of how much pollution, where pollution is to be allowed, how it is to be measured . . . etc., are all answered beforehand. But *these* are the really big questions." I agree. I don't think that economic analysis can answer these questions; it can, however, point to the best means of implementing the given answers.

waste discharge are the objective, measurable, costs to residents in the area, or more generally—if people are allowed to live in one area and vacation in another —that the damage done to amenities by an extra ton of waste is everywhere the same. A system of charging that equalized marginal measurable costs as between water systems would then minimize the objective costs of disposing of a given tonnage of wastes over all the water systems in an area. But this argument does *not* hold if the goal is to minimize *total* costs of disposing of a given tonnage of wastes.

In general, as one river system (or one part of a lake) becomes more polluted, the amenity value of neighbouring unpolluted waters rises. Moreover, when pollution reaches a level that is inconsistent with all recreational uses, added waste discharge has no recreational cost, while added pollution (that destroys swimming even if not, say, boating) in a popular vacation area probably has a very high recreational cost. The demand for amenity uses of water is certainly not a continuous function of water quality. Not enough is known, or perhaps knowable, about the demand for amenity uses of water to devise a fully optimal use of water in an "*n*-region system." In general, though, when congestion problems arise—when people begin to realize the existence of a spatially generalized pollution problem—it is clear that as pollution levels in one area rise the amenity value of relatively clean water in neighbouring areas rises; thus the opportunity cost of using such waters for waste disposal purposes also rises. This consideration by itself, therefore, suggests that pollution charges should be *higher* in areas where pollution is currently at low levels than in areas where it is at high levels —the reverse of the pricing system usually recommended. The system of low pollution charges for a low pollution level tends to spread pollution evenly over the countryside. I prefer the opposite system of high pollution charges for a low pollution level; it tends to create the separate facilities recommended by Mishan.

In any event, in the present state of knowledge about amenity values of water, it is obvious that the spatial pattern of pollution, or the price differentials between regions for pollution rights, will reflect an arbitrary decision by government. In the scheme outlined in this paper initial differentials in the prices of pollution rights will probably not be large if waste disposal were to be reduced by 10 per cent in each region. As time goes on, however, price differentials will tend to change as other forces lead to the centralization or decentralization of industries and populations. These tendencies can be offset, or encouraged, by the government's decision about the absolute and relative numbers of rights made available for sale in different regions. Thus the government-owner of a water (or air) system must decide not only the over-all quality of his asset, but also the quality of the asset in each region.

It should be noted, finally, that the market in pollution rights is not a "true" or "natural" market. In natural markets price creates two-way communication between sources of supply and demand and affects amounts supplied as well as amounts demanded. (Where supply is fixed in natural units, as in the land market, price affects the equilibrium quality of the asset, and mediates between the users of land on the one hand and the users of the products of land on the other.) My market provides only for one-way communication. It transmits the government-owner's decisions about the use of water to the users of the asset,

but there is no feedback from the users to the owner. A rise in the price of a pollution right signals that the waste disposal use of water is becoming more valuable; but this does *not* mean that the supply of allowable waste disposal capacity should be increased, for the value of the competing amenity use of water is also likely to be increasing under the impact of the same growth forces that make the waste disposal use more valuable. The price signals that the government gets from the market are "false," in the sense that they are largely echoes of its own arbitrary decision about the supply of rights. The market proposed in this paper is therefore nothing more than an administrative tool. But administrative tools that have some *prima facie* claim to efficiency should not be ignored in an increasingly administered society.