WATER AND ENVIRONMENTAL LAW

A Conference

Held At

Dalhousie University Halifax, Nova Scotia 14-16 September 1979.

Organized by

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ECONOMIC CONSIDERATIONS IN THE CHOICE OF INSTRUMENTS FOR REGULATING WATER QUALITY

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This paper is intended to introduce some economic considerations in a conference agenda that focuses on the interface between law and water quality control. Regulation of water quality obviously calls upon the disciplines of basic science for understanding of the processes that cause degradation, and also on law as part of the institutional structure that allows the problem to arise and provides opportunities for its solution. I hope to show that regulation of the use of water, like other resources, is an economic problem and, without detracting from the relevance of other disciplines, that an understanding of the economic implications involved is essential to efficient policy design.

Several trends have converged to aggravate the economic impact of water quality control policies in Canada in recent years. Economic growth has put a relentless and growing demand on the natural resource base and increasingly threatens to tax it beyond its capacity. Populations are not only increasing, but are becoming geographically concentrated where individual actions involving noise or waste disposal impinge on others much more heavily. Modern technology has brought an increased scale of operations and hence new concentrations of industrial and agricultural pollution. It has introduced frightening new forms of pollutants as well. In the face of these pressures, there has been a dramatic emergence of concern for environmental

quality. As a result, provincial and federal governments have been rapidly designing new policies for regulating water quality.

Governments are now spending enormous sums on water treatment works, on pollution control subsidies to industry and local governments, and on regulatory bureaucracies. The private sector spends even more. Yet while industrial spokesmen complain that additional "unproductive" expenditures will make them uncompetitive, and governments strain to reduce spending, public demands for improved pollution control appear undiminished. And there is a good deal of concern that some expenditures on pollution control are misallocated.

Pollution as a Market Failure

To begin, it is helpful to identify how our economic system gives rise to undesirable degradation of water quality, in order to understand the rationale for public intervention and the problems of corrective action.

A primarily capitalistic economic system such as ours depends upon private producers to maximize their profits. To do so, they produce goods and services according to the market demand for them--hence the idea of "consumer sovereignty", meaning that consumers, ultimately, decide the pattern of production. Producers, in pursuit of profits, will strive to meet consumer demands at the lowest possible cost, and so they can usually be depended upon to use society's resources (natural resources, labour and capital) efficiently. Competition in production and the relentless pursuit of profit are essential to ensure that resources are used efficiently and prices are as low as possible to consumers.

Esoteric economic models have been constructed to prove that, under highly restrictive conditions, a purely capitalistic system can achieve the optimum result, namely that the welfare of people will be maximized given the resources and technology available. To the extent that these restrictive conditions do not hold, imperfections in the system will cause the market to fall short of its potential in satisfying human wants.

Imperfections in the economic system can take a wide variety of forms, ranging from insufficient competition to unwanted distortions in the distribution of income and wealth. But the imperfection that deserves special attention here is the failure of the market to measure certain costs and benefits.

The most common examples of environmental degradation are cases in which producers or individuals impose costs on others without having to take account of that cost. Where a meat packer, for example, has his wastes trucked away and buried, he bears the cost of waste disposal. If he is free to dump this waste in the river however, he bears no cost of disposal. Although the cost may be borne by people downstream, he is not required to compensate them, and hence this cost does not enter the production accounts. This is an example of what economists refer to as "external costs" in production; they are real costs to society, but unlike other costs of production they are not borne by the producer but are shifted onto others.

Such uncompensated incidental costs inflicted on others are common, and there is a corresponding variety of beneficial spillover effects. In all cases, the actions of one affect the welfare of others, although the process is not registered in a market transaction. It is this absence of a market transaction that is critical. If, in every case, the party that caused the adverse effect fully compensated the losers, so that they were not left worse off, then the problem would be eliminated. If the amount required to fully compensate others for the damage exceeds the value of being able to continue the damage for the one that causes it, the action would cease. It would continue only if the gain to the one that causes it exceeds the loss to the losers, in which case society as a whole would enjoy a net gain. But because the economy depends upon market signals in the form of prices and costs to guide behaviour, adverse effects will result whenever benefits and costs are incurred, but not priced, in market transactions; where those who gain do not compensate those who suffer.

The result is that the patterns of production and resource use become distorted. If an industry freely disposes of its wastes into a river and the costs are borne by others downstream, it cannot be expected to restrain its disposal activities as it would if it bore the cost itself. It will therefore impinge too heavily on the river's assimilative capacity, the cost of production and price of its output will be too low, and more of its products will be produced and consumed at the expense of other things, to the detriment of aggregate welfare.

Industrialists can legitimately complain that if they are forced to abate their pollution, their costs will increase and their competitive position will suffer. But it should be noted that they do not necessarily bear the full costs of abatement. Governments are heavily involved in

providing collective abatement works, and in providing loans and tax subsidies for private pollution control. It should be noted also that their competitive position is artificially strong if they do not bear the costs of their pollution, and some adjustment in the pattern of economic activity to their disadvantage may improve aggregate welfare. As long as additional expenditure on pollution abatement yields more in other values, whether they are priced in the market place or not, there will be a net social gain. If the increased values are in the form of recreation, amenity, health or other non-priced values, they will not show up in a higher gross national product, but this reflects a failure of our statistical indicators of welfare.

Economic Criteria for Pollution Control

There are two primary dimensions of water as a valuable resource. One is its physical quantity, which is useful in both "withdrawal uses" such as domestic consumption, industrial processes and irrigation, and "in place uses", such as power generation, navigation and recreation. The scarce factor that calls for rationing and regulation on this dimension is the available flow, which can, of course, be augmented in various ways at some cost. The other dimension is the capacity of water to absorb and disperse wastes, and the scarce factor to be rationed in this case is the water's assimilative capacity, which can also be augmented.

These two dimensions of water resources, available flow and assimilative capacity, are obviously related, and the problems they raise for regulation have much in common. But in Canada they typically receive separate legislative and administrative treatment, and this discussion focuses on the problem of regulating assimilative capacity.

The regulation of water quality raises two related economic problems. The first is that of determining the appropriate quality of water to be maintained in particular circumstances, or analagously, the appropriate degree of use of assimilative capacity. There is now extensive literature that addresses this issue in theory. In brief, the optimal level of use is that at which further abatement involves costs that are just matched by the value of the reduced damages that it produces. It is worth noting that in spite of the aversion to the economists' reference to an "optimal level of pollution", this is almost never an all-or-nothing problem, but involves balancing the gains and losses from a little more or a little less. The practical difficulty with these prescriptions is that the costs and benefits are often

difficult to qualify because they are not priced in conventional markets, so that recourse must be taken in subjective judgments or through some process such as public hearings; but the basic criterion is applicable nonetheless.

The second problem is the allocation of this available assimilative capacity among dischargers and particularly, the extent to which the system ensures that the benefits of production and abatement efforts are maximized. The remainder of this paper is primarily concerned with this problem--the economic efficiency of alternative arrangements for regulating the actions of waste dischargers.

The term economic efficiency is used here in the broad sense, to encompass the relationship between all values, whether marketed or not (such as health, recreation and amenity) and all costs (such as pollution). Economic efficiency is not, of course, the only goal sought by governments in designing water use policies; other objectives such as promotion of certain kinds of activity, development of particular regions, or preferential treatment of certain groups are often important political concerns. But although these distributional considerations may be equally worthy, they do not lend themselves to a consistent frame of reference, and in any event, their pursuit calls for evaluation of the benefits and costs involved and hence analysis of their implications for economic efficiency. The distribution of the burden of pollution control is undoubtedly an important policy issue, but while an economist can trace the incidence, he has little to say about what is fair or just--that is a political question. It is sufficient to note here that proposals to "make the polluter pay" are naive, because as long as producers operate in competitive markets they must, in the long run, shift the cost back onto owners of the factors of production or forward onto consumers. The pattern will depend on the circumstances of the case, and little more of a general nature can be said about this. In any event, there is a rich variety of fiscal and other devices available to governments to reallocate financial burdens in any way they choose. The distribution of the gains and losses is thus best dealt with separately, and attention here is focused on the capabilities of alternative regulatory arrangements to achieve improved resource use and the maximum net benefits, regardless of their distribution.

Approaches to Regulation

Economic efficiency in allocating a resource thus refers to the extent to which it is allowed to generate its full potential social value. If the assimilative capacity

of water is to be used efficiently, the system for allocating it must meet certain criteria. First, all potential users must have means of access to it; public and collective uses, industrial, agricultural and domestic demands must be treated without bias. Second, the system must respond to the value of different uses at the margin (not in total) and allow marginal adjustments in use whenever this would improve the aggregate value generated, thus ensuring that the total system is put to its highest combination of uses. Third, the allocation arrangements should minimize the user's insecurity and uncertainty about his right of use, in order to allow efficient investment and operational planning. Fourth, they must be flexible and responsive to changing conditions that alter relative values over time. Finally, they must be economical in their costs of organization, including not only the direct cost of public administration and enforcement, but also the costs incurred by the regulated body in gathering information, compliance, negotiation and protection against arbitrary official actions. These criteria provide a framework for judging the efficacy of alternative regulatory arrangements.

Several distinct approaches to the regulation of assimilative capacity can be found in practice or have been proposed. The economic advantages and shortcomings of each can be summarized briefly.

1. Collective abatement. One possibility is to allow dischargers that use the assimilative capacity of watercourses to go unregulated, and to take collective action to maintain water quality by such means as governmental purification works. This is common, especially in municipal water and sewage systems. It is often much less costly to maintain water quality in this way than to require each of a large number of waste dischargers to take individual abatement measures. In this sense this approach rests on the same justification as governmental provision of highways, lighthouses and national defence.

There are two crucial limitations to this approach from an economic point of view. One is that it is not always more efficient to restore water quality than it is to prevent the waste discharges at source. If collective purification is relied upon, dischargers who can abate some or all of their pollution at very low cost will have no incentive to do so, and so the aggregate social cost of maintaining water quality will be unnecessarily high. Second, the patterns of production and water use will be distorted. As long as the cost of collective restoration is broadly shared by taxpayers, the full social cost of

products, the production of which involves varying amounts of pollution, will not be reflected in their prices. There will be too much production and consumption of goods and services that impose pollution during their production and too little of other things. It is theoretically possible to correct this by financing the public works through levies on polluters according to their waste discharges; but this raises formidable administrative difficulties and in any event, results in a system of regulation better described as fiscal incentives, discussed below.

The remaining approaches involve measures of regulating the behaviour of waste dischargers.

2. Subsidies for abatement. Both federal and provincial governments in Canada have initiated subsidy programmes, often in the form of generous loans, tax credits or accelerated depreciation allowances, to encourage private firms and local governments to install pollution abatement works. The government of Ontario, for example, has a particularly vigorous programme of loans to industries and municipalities for construction of pollution control works (Campbell, Pearse, Scott and Uzelac (1974)). Such subsidies enable the public at large to share directly the cost of improving water quality, and this may be considered especially equitable where public environmental objectives are changing.

One limitation of subsidies as efficient measures to control water quality is that they must usually, for political and practical reasons, be offered undiscriminatingly, at least among firms in a particular industrial category or among local governments. No account is therefore taken of the differences in cost and benefits of waste reduction in different watercourses and regions, so that abatement will be inadequate in some circumstances and excessive in others. Moreover, subsidies do nothing to ensure that assimilative capacity is made available to those who can make the best use of it. Finally, such subsidies are usually based on capital investment in abatement works; this biases control measures toward capital-intensive methods, which may not be the most economical way to reduce discharges. There are likely to be other biases as well, such as the apparent bias in Ontario's subsidy arrangements in favour of collective rather than decentralized abatement works. In short, abatement that results from such subsidy programmes tends to be inefficient and wasteful, because it induces expenditures in the wrong places, in the wrong degree, and of the wrong kind.

3. Equipment standards. It is now common among Canadian provincial regulatory agencies to require waste discharges to adopt certain prescribed procedures or equipment in their production processes to abate pollution. Economists do not favour this approach for several reasons. First, it provides no incentives for socially desirable behaviour other than to adopt the mandatory techniques. Even if a discharger could achieve a higher level of abatement at low cost, he will have no incentive to do so. Moreover, if one discharger could abate at lower cost than another, this approach offers no means of efficiently reallocating their use of assimilative capacity between them. Dischargers will have no incentives to undertake research or innovation in pollution abatement, nor even to seek out the most efficient known method of achieving the desired standard of performance (Settle and Weisbrod 1977).

As for the most serious aspect, regulations involving prescription of equipment and process fail to address systematically the resource that needs to be rationed, namely the assimilative capactity of the receiving waters. Obviously a given amount of waste will cause more pollution in a small stream than in a large one; it will consume more value in assimilative capacity if there are many other dischargers than if there are none, and it will impose more social damage in a city than in a remote area. These measures thus force dischargers to invest in certain techniques regardless of environmental and economic considerations.

Such prescriptions of abatement equipment and processes figure importantly for example, in British Columbia's system of pollution discharge permits, (Campbell, Pearse and Scott (1972)). They are directed more toward ensuring that the "best available technology" is adopted everywhere, than toward efficient allocation of the assimilative capacity of water resources.

3. Discharge standards. Another common feature of pollution control arrangements in Canada is the specification of quality standards for discharges. In both Ontario's discharge approval system and British Columbia's discharge permit system, for example, "objectives" are prescribed for effluents, which specify limits to acceptable concentrations of contaminants in discharged waters. Under the Fisheries Act, the federal government has also devised standards for industrial effluents.

Discharge standards suffer many of the same economic deficiencies as equipment standards, although they have the advantage of allowing dischargers to seek out the

least-cost method of abatement. They provide no incentives for pollution abatement beyond the prescribed maximum concentrations; they do not permit efficient reallocations among users of their use of assimilative capacity and they take no account of varying abatement costs. Like uniform equipment requirements, effluent standards that require the same abatement performance by all force some dischargers to eliminate contaminants that could more economically be eliminated by others, and the aggregate cost would, therefore, be lower with some reallocation of effort.

Finally, effluent standards, based either on the concentration of contaminants in the effluent or the quantity of contaminants discharged per unit of product produced, cannot ensure that assimilative capacity will be effectively utilized or that water quality will be protected at any desired level, because (like equipment standards) they account for neither the variability in assimilative capacity of receiving waters nor the demands on them. As a result, such uniform standards will leave some waters polluted and other under-utilized, with consequent wasteful use not only of assimilative capacities but also of other resources required for abatement.

4. Ambient standards. In contrast, regulation based on prescription of ambient standards of quality for receiving waters focuses attention directly on assimilative capacity and hence on the social objective of protecting water quality. Thus, under Ontario's Water Resources Act the Ministry of the Environment publishes "guidelines" for receiving water quality, which specify desired and permissable concentrations of specific contaminants, suspended solids, acidity and other characteristics for water used for various industrial, agricultural and public purposes (although other regulations, including a "best practicable treatment" rule and the aforementioned effluent "objectives", are superimposed on these receiving water criteria). Similarly, ambient objectives have been established internationally for the Great Lakes system.

This approach raises the problem of establishing the appropriate ambient criteria in the first place, but this is an issue under most regulatory arrangements. Here it is sufficient to note that they are typically based on technical criteria which take little or no account of the varying importance attached various public and private uses of water in different watersheds. Moreover, in most cases ambient standards are uniformly applied, and, therefore, take no account of the value of water in different uses or of the benefits and costs of waste disposal in differing

circumstances. A more responsive mechanism would take account of the inter-related demands on each drainage system, as appears to be envisioned in the water quality management areas in the Canada Water Act and in Ontario's Conservation Authorities Act.

Beyond the question of the appropriate quality criteria for ambient water, there remains the issue of how rights to discharge waste within these limits are to be allocated. If, as in Ontario, permission to discharge waste is granted as long as the quality criteria are met, the burden of abatement will fall on late-comers, regardless of whether established dischargers can reduce discharges more economically. This impedes efficient allocation of assimilative capacity among uses and users. Owners of approved works have little incentive to improve them, and in the face of evolving technological, economic and social conditions, such a system tends to rigidify the structure and location of economic activity which in the long run is likely to result in significant misallocation of water and other resources. However, these inflexibilities depend on the nature of the rights granted to dischargers, especially their transferrability, which is discussed further below.

There remains to be mentioned two other distinct approaches to water quality regulation, fiscal devices and property rights systems. Both have been widely advocated by economists, and both can be shown to be capable, at least theoretically, of achieving the optimal level and distribution of use of assimilative capacity.

5. Effluent charges. Effluent charges involve applying a price, or tax, on the use of assimilative capacity, high enough to constrain total discharges into a particular watercourse to the desired level. Each discharger, facing his unique abatement cost schedule, will undertake abatement as long as it is less costly for him to do so than to pay the effluent charge.

This pricing approach is widely advocated by american economists (Kneese and Bower (1968); Baumol and Oats (1971); Thompson (1973); Fox (1970)). Properly levied, a system of variable charges equal to the marginal social cost of the damage caused by waste discharged by each discharger would ration the assimilative capacity at any point on a watercourse, provide financial incentives for optimal abatement, and guarantee access to those who can make the highest use of the available capacity. However, this approach implies formidable administrative requirements. The appropriate price for pollutants discharged would have

to vary among locations, in order to reconcile demands with varying resource capacities. The whole pattern of charges on a watercourse would have to be reviewed each time any discharger contemplated altering his process or location, each time a new discharger became established and whenever production technology, costs or prices changed. The burden on the regulatory agency for data, econometric research, surveillance, monitoring and enforcement would be extremely heavy. The implications of varying hydrological conditions and synergistic interactions of pollutants along a watercourse would be exceedingly complex. Moreover, the differing prices required of similar users on different watercourses or at different locations on the same river would almost certainly be regarded as unfair and discriminatory, and the recurrent readjustment of charges would impose uncertainty on users and call for a degree of discriminating flexibility in the application of changes that cannot reasonably be expected of most regulatory agencies.

For these reasons, proposals to regulate water quality by means of effluent changes, raised and lowered to suit the circumstances of different places and times, seem naive. The likely outcome of such a policy (as in France and Vermont where this approach has been attempted) would be at best a uniform fee per unit of discharge, regardless of location. This would not be useless. If it is sufficient to cause changes in behaviour at all, it will induce users to seek the least-cost means of abating pollution, and it provides complete transferrability insofar as users can locate in accordance with their costs and markets, as long as they are willing to pay the price for discharges. But a single province-wide or river-basin charge, even if it were the appropriate average level, would leave none of the desired incentives to respond to differing streamflow conditions and demands, so assimilative capacity would be wasted in some circumstances and abatement expenditures wasted in others.

For completeness, it should be noted that fiscal incentives to regulate behaviour can be applied also to final products. By taxing goods that cause pollution in the course of production or consumption, their use can be constrained. We already apply taxes and subsidies on goods that are socially damaging and beneficial respectively, and there is no doubt that they work to change economic behaviour, but as means of regulating pollution they are too indirect. Obviously, their effect is misdirected when goods enter international trade. But more importantly, they cannot respond to the widely varying pollution damage caused

by the production of a product such as pulp and paper in different locations, nor do they provide incentives for abatement.

6. Discharge rights. While a pure effluent charges system does not require any additional licensing mechanism, the rights approach implies a regulatory arrangement based on rights to discharge specified quantities of contaminants, allocated among users up to the limit of the water quality desired for each watercourse. This approach has recently received increased attention from economists, particularly in Canada, as a means of regulating the use not only of water, but of other common property resources as well (Dales (1968); Campbell, Pearse, Scott and Uzelac (1974); Maloney and Pearse (1979)). Like effluent changes, this technique can be shown to be capable of achieving optimal resource use, but it raises much less formidable regulatory problems. It is rarely adopted for water quality control, but many examples can be found in arrangements for allocating use of other natural resources and indeed for regulating the use of water flows (Campbell, Pearse and Scott (1972)).

In its simplest form, rights to discharge wastes into a watercourse, in total consistent with the desired water quality, would be allocated among users. As long as these rights were divisible and transferrable, the method of initial allocation would be of no lasting significance, since they would ultimately be reallocated through the market among those who can make the highest use of them. The rights of each watercourse would assume a value reflecting the scarcity of assimilative capacity relative to the demands on it. Their price would thus provide the desired financial incentive to economize on use of assimilative capacity, and induce users to achieve the socially desired degree of abatement in an efficient pattern and form.

Such a rights system would provide dischargers with security of access to assimilative capacity, yet it would also permit changes in water quality without involuntary infringement on acquired privileges. Where it is deemed that a watercourse is capable of additional discharges, new rights might be issued or sold by the Crown at the prevailing price. Where use is already excessive, or becomes excessive as demands change, rights to discharges can be purchased back by the Crown.

A singular advantage of such an approach is that it allows market forces to serve an important function, which is difficult for a pricing approach or its regulatory

agency to perform administratively, i.e., to achieve and maintain a pattern of water use that responds to costs and values that vary widely between locations, and from time to time. In contrast to the pricing approach, where the regulating agency must be continuously involved in discriminatory and flexible rate-setting, the rights system allows the regulators to concentrate on allowable withdrawals and discharges.

The rights approach also offers scope for the Crown to appropriate the value of the water resources used, as it ordinarily does in granting rights to utilize public timber, minerals and other resources. This might be done by issuing rights at an initial price, and if the demand for rights were highly competitive, an auction price would approach the full value of the resources allocated. Alternatively, rights might be issued without an initial charge, in which case the resource value would be reflected in the private market value of the rights, which might then become the object of a percentage tax. The private market value of a right would be lower to the extent that resource values were subject to the tax, but this partial appropriation would not interfere with the economic forces promoting efficient use.

The term of such rights is not critically important, as long as they are marketable. Long terms, or perpetual rights would offer greater security and certainty, while limited terms would increase flexibility in allocation. Crown revenues could be raised in several ways, as with taxes on the use of land. Holders of rights might be subject to an annual rental charge, or to a percentage tax on the market value of the right. If the rights were limited in term, the Crown might levy a proportionate renewal fee, or sell the rights at an auction.

My conclusion that rights systems offer the most promising approach to regulating the use of assimilative capacity is based on two primary considerations. One is that they are capable of bringing about an efficient use of resources within their capacity constraints, they can provide security to users and they can efficiently accommodate changes in demands, technology and public objectives without causing dislocation. The other is that they are easily manageable, so that their benefits should not be cancelled out by high costs of information, by an expensive adminisistrative bureaucracy and by uncertainty about official actions. Moreover, it lends itself to relatively easy transition from many existing permit systems. Finally, while a system of effluent charges is likely to become

confused with a revenue purpose, there is already considerable familiarity with arrangements for rationing use of common property through the issuance of rights such as those issued to taxi-owners, fishermen, oil producers, graziers, radio and T.V. broadcasters and so on.

The preceeding list does not exhaust all the possible approaches to water quality regulation nor the possible combinations of them; other approaches are examined elsewhere (Kneese and Bower (1968); Fox (1970); Thompson (1973)). It is sufficient, however, to indicate the economic implications of the main alternatives, and to draw attention to the relatively-neglected possibilities of property rights. At the risk of venturing into legal esoterica beyond my competence, the remainder of this paper turns to some more fundamental aspects of property rights and their implications of efficiency in resource use.

Property Rights and Economic Efficiency

I have already observed that the root cause of the water pollution problem is a market failure--the assimilative capacity of watercourses is owned and managed in such a way that it cannot be allocated efficiently through markets like those for most other resources and so users lack the incentives to use it efficiently. It is well established in economic theory that a prerequisite for efficiency in production is that producers be able to control all their inputs, without extra-market interference from others (Coase (1960)). It is not difficult to imagine an efficient allocation, through the market mechanism, of a water system similar to a land system. If it were held by one owner, he could be expected to balance the gains from various possible uses and achieve the best aggregate result for himself. But two considerations impede this possibility. First, because of the interaction of effects on any given watercourse, an owner could internalize all the costs and benefits of his actions only if he owned all of it; but the size and complexity of many water systems preclude single ownership, at least under current political attitudes and arrangements. Second, the benefits of some uses of water such as recreation and aesthetic values are not marketed, so that relative values and priorities are likely to be distorted. A public agency with control over all water uses is in a much stronger position to overcome these obstacles. But there remains the problem of how a regulatory agency is to allocate the available resource among users and hence the form of rights they will enjoy.

Rights to resources can take a wide variety of forms, of course, and these can be classified according to various qualities. From the point of view of economic efficiency, one of the most important qualities of resource rights is the degree of exclusiveness with which the resources available to the holder are defined, thus establishing the extent to which he has an enforceable claim over others and the control that promotes efficient use. Exclusivity in this sense is similar to the concept of "non-attenuation" referred to by certain writers on the law and economics of property, some of whom have shown that a completely non-attenuated structure of rights is a sufficient condition for Pareto-efficiency (Furubotn and Pejovich (1972); Coase (1960); Demsetz (1974)).

Property rights vary widely with respect to their exclusivity. At one extreme is the archtypical freehold, which is the epitome of a corporeal hereditament, providing exclusive possession. It is this form of ownership that is envisioned by theorists of pure market economies but, as mentioned, it cannot easily be adopted for water systems. Indeed, there are few if any examples of freehold ownership of resources where the common law rights traditionally associated with this form have not been attenuated by legislation, regulations, or fiscal arrangements. Less complete are the various forms of incorporeal hereditaments, such as easements and profits à prendre, that typically convey specified and limited rights over the property of another under leases, licences and other usufructs. Any of these forms can provide a user with a sole, exclusive right to a particular resource.

At the other extreme is the absence of property altogether, the res nullius traditionally associated with the high sea, where no user can enforce his claim over another. Between these extremes there is a group of forms collectively referred to as common property (res communes), where rights to exploit the resource are held by persons in common with others. This is the usual case in water resource use.

The economic literature on the inefficiencies that arise from common property exploitation in the context of commercial fisheries, oil and gas, rangelands and water is now extensive, but it appears somewhat confused about the nature of this property form (Hardin and Baden (1977); Ciriacy-Wantrup and Bishop (1975)). There appears to be at least three general forms. Closest to the no property case is that of unrestricted access, where anyone has an enforceable right to use the resource but, concommitently, no power

to exclude other potential users. This frequently is the case for water resources and until recently characterized most commercial fisheries. A second form involves restricted access, meaning that access is limited to those holding explicit rights. The owners of these rights, which may be in the form of licences, heritable rights, or common law privileges based on residence or appurtenances to other property, collectively can claim the right to the specified resources and thereby have power to exclude others. But the rights are co-equal and do not define or limit the amount of the resource that they entitle the individual holders to exploit under the rule of capture.

This is the form of rights now applied in most Canadian commercial fisheries. The third form, which might be regarded as a sub-category of restricted access, is that in which the right of each holder is stinted, or specified with respect to the quantity of the resource he may take. This characteristic is found in a wide variety of natural resource rights--in grazing rights on public rangelands, in "unitized" oil and gas ventures, and in some jurisdictions for water as well. There are intermediate forms in which rights are not quantitatively specified, but are qualified by the rights of others, as in riparian water law, or constrained by other rules of common law. But in terms of the degree of exclusivity of the rights held, stinted rights are closest to sole property, where the number of holders is reduced to one.

The more well-defined property rights are, the more they lend themselves to efficient allocation through market processes. This leads to the earlier conclusion that where private ownership of water resources must be eschewed, for practical reasons, in favour of public ownership, public regulation of water quality can probably be most efficiently achieved by granting users the next most exclusive form of use rights, namely secure, transferrable and divisible quantitative rights to discharge wastes. Once allocated, such rights can ensure efficient use of the available assimilative capacity through market processes and financial incentives, without much further involvement on the part of the regulatory authorities.

The problems of water pollution, and the economic problems of common property generally, arise from the spill-over effects of one party's actions on another when no compensation is made for them. Economists call these "externalities". It is said that "the law loves not fractions of estates, nor to divide and multiply tenures" (Megarry and Wade (1966, p. 411)). Similarly, economists

who must address themselves to primarily market economies view with disfavour institutional arrangements that preclude appropriate market signals from guiding producers and consumers toward socially desirable behavior. Property rights consist of privileges to carry out circumscribed lists of actions, and their form governs the extent to which they can become factors of production amenable to market processes.

Harold Demsetz has offered a theory of development of property rights in which private rights emerge from an original regime of common property, or no property, in response to externalities (Demsetz (1967)). Property rights develop when the gains from internalizing externalities exceed the costs of internalization. Others have redefined and broadened Demsetz's thesis by referring generally to institutions for more efficiently allocating resources, rather than simply private rights (Krier and Montgomery (1973)). Their purpose is to emphasize that the organization costs in establishing private property rights over some environmental resources would be exceedingly high, and in such cases, the appropriate institutional response is some form of governmental intervention to allocate and regulate usage to improve efficiency. Where organization costs, particularly information costs, are high, and resource values low, the regulations are suitably crude; but as resource values and potential efficiency gains rise, more sophisticated property and market arrangements would be expected to develop.

The growing need for management of water quality provides a pertinent context for this hypothesis. In the last few years, the "scarcity" of assimilative capacity has become painfully apparent, and with growing demands for a clean environment, the potential benefits of efficient regulatory machinery has increased dramatically. Moreover, increasing sophistication of public administration and wider appreciation of the needs for resource management have undoubtedly lowered the cost of organizing superior institutional structures.

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