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INSTITUTIONS AND ECONOMICS OF POLLUTION TRADING

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Institutions And Economics of Pollution Trading

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INTRODUCTION

A number of methods apply to controlling point source pollution. The most widely used are direct control methods that restrict or regulate amounts of pollutant discharged to surface waters. Regulations to police the environment may be considered because pollution can result from negligent or willful acts. Regulation of pollution occurring as an externality, however, implies a need for economic analysis. Externalities may occur when a firm, operating in a competitive environment, produces pollution along with products. In competitive markets, producers are price takers. Competitive conditions may not allow producers, such as farmers, to pass along costs of controlling pollution, yet it is costly to clean up the environment by users beyond the polluting firm.

In recent years the use of market forces to control pollution from point sources has become increasingly identified as an alternative to direct control.(Hanley and Moffatt, 1993,) The underlying theory of the market is that flexibility can be achieved in use of resources required to control pollution. Flexibility will mean that each resource used for pollution abatement could find its optimum use which may not be possible in the rigidity of a regulatory environment. There is growing interest in the economics of these methods and their applications (Atkinson and Tietenberg, 1991, Eheart et al., 1987, Hanley, 1993, Krupnick et al., 1983, McGartland and Oates, 1985, National Academy of Public Administration, 1994, O’Neil et al., 1983, Opschoor and Vos, 1989).

The advantage of market forces as compared to direct control methods of pollution control is the possibility of achieving a target level of pollution with an efficient social cost. Economists have argued that a promising method of pollution control is “tradable pollution permits” which creates a permit market for controlling pollution externality (Beckerman, 1990). Unfortunately, these permits are frequently and wrongly referred to tradeable pollution rights. There should be no principle of pollution control that defines a right to pollute. The disadvantage of using market forces is their absence. This paper briefly reviews market concepts and suggests the role of new institutions needed to apply market concepts.

Trade Model

Trading in pollution permits obeys the same rules of the market as any other commodity. The process of achieving equilibrium price in the market is explained by Walarasian tatonnement (Mas-Colell at al. 1995). If we consider an exchange economy formalized by means of excess demand function z(.) and suppose that we have initial price that is not an equilibrium price vector, so that $z(p) \neq 0$. Then the demand-and-supply principle suggests that price will adjust upward for goods in excess demand and downward for those in excess supply. This principle was put in differential equation form by Samuelson (1947) and it takes the form:

$$dp_l / dt = c_l \, z_l \, (p) \qquad \text{for every good } l \qquad \textbf{(1)}$$

where:

dp_l / dt is the rate of change of the price for the lth good

$c_l > 0$ is a constant affecting speed of adjustment.

If, for example, pollution permits are in excess supply, pollution discharge will be high and pollution abatement costs will be low; likewise the price of pollution permits, if traded, would be low. The cost basis of this relationship is shown in Figure 1 where a decrease in pollution discharge would be equal to pollution abatement for one firm in a watershed..

It is costly for a firm to restrict pollution discharge (resources have to be allocated that could have been used in production) but benefits from pollution abatement for the firm itself are minimal to none. (Tisedll ,1993) In order to make the firm restrict pollution, the level of pollution discharge must be set by a pollution control agency. Assuming that the current level of pollution discharge (pollution permits) for the firm has been set at X2 (Figure 1), then corresponding Marginal Abatement Costs are MAC2. If a pollution control agency decides to further restrict level of pollution (amount of pollution permits issued) for the firm, say to X1, then Marginal Abatement Costs for firm will increase to MAC1. Because every firm has a

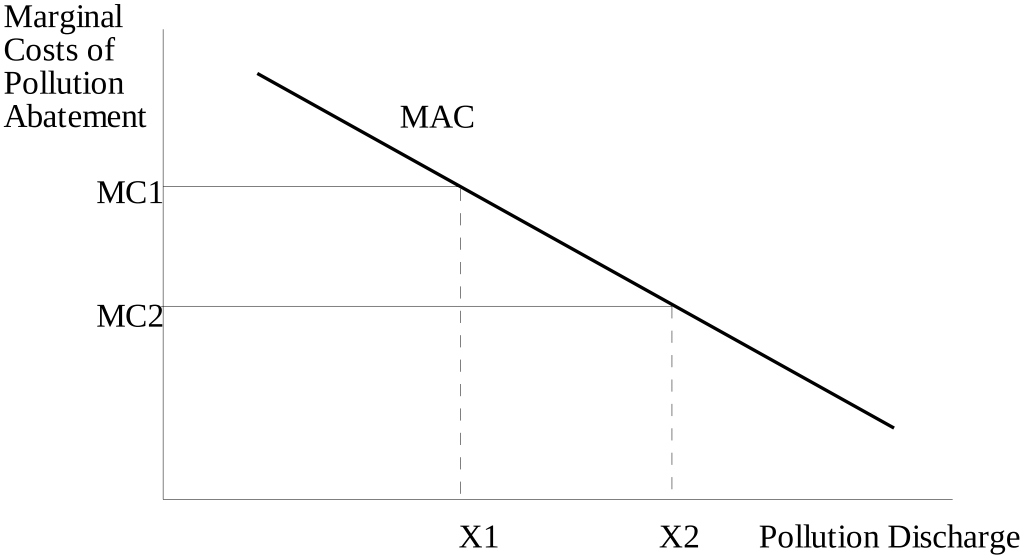

Figure 1. Marginal Costs of Pollution Abatement at Various Levels of Pollution Discharge

different Marginal Abatement Cost function, firms will trade among themselves if trade in pollution permits is allowed. The reasons for trade are shown in Figure 2 which considers only two firms, but the principle would be the same for many firms in a watershed with limited pollution permits.

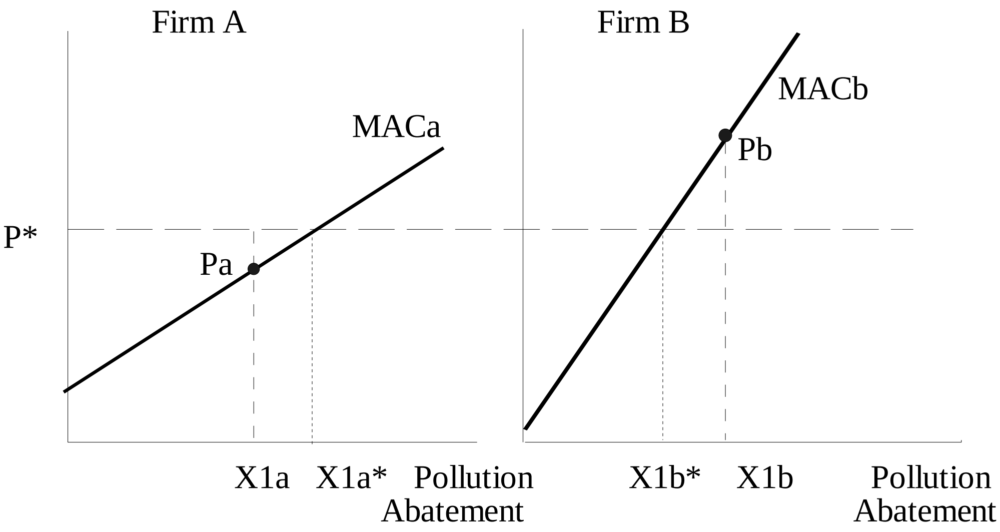

Figure 2. Pollution permits trading

Consider two firms in a watershed with different marginal abatement costs (MACa and MACb) per unit of pollution abatement and the required watershed reduction in pollution is, as in Figure 1, from X2 to X1, but for two firms, X1= X1a + X1b. Firm B has a high marginal cost of pollution abatement, Pb, and firm A has a low marginal cost of pollution abatement, Pa. Market forces (Figure 2) should bring the price of pollution rights to equilibrium P*. Equilibrium price P* is reached because the high cost firm B buys the rights to reduce pollution abatement costs to P* whereas firm A sells the rights to a low abatement costs Pa and takes on additional pollution abatement which raises costs to P*. The amount of abatement bought is measured in permit units (X1b -X1b*) must be equal to amount of permit units sold (X1a* -X1a) and at the equilibrium cost, P*, there is no more incentive to trade. Agency allocation of permits X1a and X1b to reach a target pollution level X1, based on historical discharge data, will be inefficient if costs are not considered. The pollution discharge goal for the watershed will be reached because X1(before trade) = X1*(after trade) where X1* = X1a* + X1b* but X1* is cost efficient for the watershed.

The desirability of this equilibrium from the watershed point of view is that costs, or use of resources for the target level of pollution abatement, have been minimized for the watershed.

POINT AND NONPOINT TRADING OF COSTS AND BENEFITS

Point and non-point trading to minimize costs implies that point and non-point sources are both contributors to a common pool of pollution within a given watershed. Within a watershed there is also the possibility that costs incurred at a point or non-point source will result in a benefit or a reduced cost at an alternative point or non-point source. The relationship of agriculture, non-point, and water treatment plants could be an example. Applying best management practices (BMP's) or reducing input use, say fertilizer, might provide a benefit by enhancing water quality for drinking or other environmental uses. Application of BMP's has historically been viewed as a voluntary management practice; however, if significant non-point pollution can be measured and verified then pressures may arise to make BMP's mandatory and as such significant economic impacts may be expected. An economic analysis framework will be needed to examine all of the policy implications. The analysis would examine point and non-point trading in a cost-benefit framework where a BMP cost, at a point or non-point in the watershed, changes cost or provides a benefit at another point or non-point. Target pollution goals and pollution permits are not a requirement for cost-benefit analysis..

Best Management Practices (BMPs). A BMP describing an environmentally friendly technology is a part of the production function of any firm (not just agriculture as commonly viewed). Such a view represents the tradition of economic analysis and recognizes that BMP technology can have both private property and social effects. Perhaps importantly, a general framework of analysis exists to evaluate the economics of BMPs.

The private firm manager will in general ask if a BMP technology is output increasing, decreasing, or has no output effect on costs or profit. On the cost side, is BMP technology one that will substitute for an existing technology with more or less cost, or is it simply an addition to costs? This same framework of thinking also applies to social costs and benefits. The concept of social costs and benefits refers to the externalities, down-stream in the case of rivers, that may be generated by decisions made at the firm level. Down-stream refers not only to those private firms immediately down the river but also to multiplier effects on distant populations and distant generations.

The most likely scenario for application of BMP technology is shown in Figure 3. In Figure 3, applying a BMP technology is expected to decrease environmental degradation but is likely to increase costs (Moving from Pollution Technology at point A to BMP technology at point B). Other scenarios are possible. No-till planting is possibly a BMP that both decreases private costs and decreases environmental degradation. Reducing environmental degradation via use of BMP technology reduces downstream costs of cleaning up water for further use and reduces possible harmful and costly effects to human health (Moving from point C with polluting technology to point D with BMP technology). Downstream costs will be directly related to the type of environmental degradation affected by the BMP.

The modeling committee of Governor Zell Miller's RiverCare 2000 study has recommended documentation of degradation measures. Environmental degradation axis of Figure 3 is a multi-dimensional concept whose dimensions may be viewed in field 14 of a BMP data base currently under construction (www.agecon.uga.edu/~ecologic/finddb.htm). A simple example of the degradation dimension would be level of coliform bacteria but any one of the measurable degradation variables which include nutrients such as nitrogen and phosphorus, salts, alkalinity, heavy metals, sedimentation, pathogens, toxin, COD/BOD, temperature, light conductivity, quantity of water, flow and timing of water flow and drinking water quality could be placed, or measured on the vertical axis of Figure 3. For another example, see Peters et al. 1997.

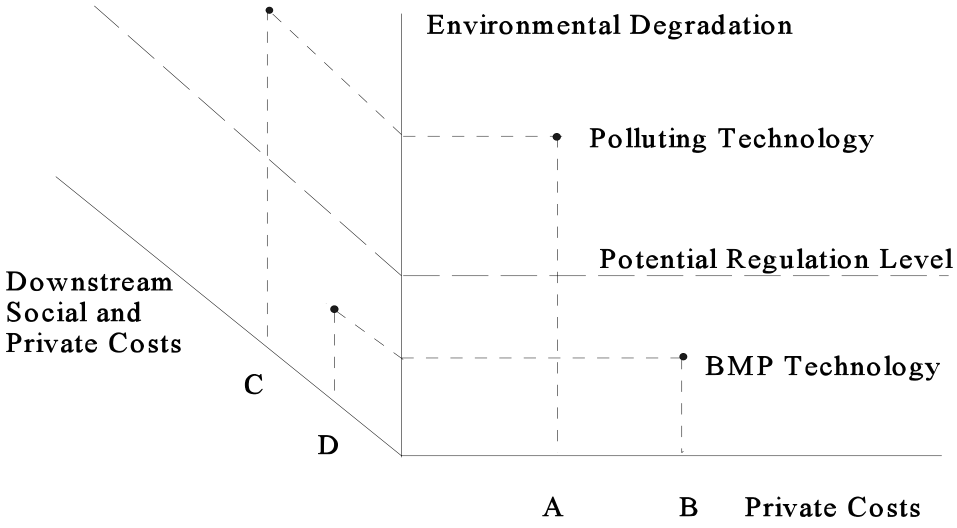

Figure 3. Environmental Degradation and Economic Costs Arising from Use of Water and Land as Inputs to Production

THE COST-BENEFIT MODEL

Theory of Regulation, Incentives and BMPS.

From an operational point-of-view, private effects, as opposed to societal effects, are more easily addressed; furthermore, collecting the description of BMP technology is much easier than collecting expected costs and possible returns implied for the firm. Collection efforts for the current data base of BMPs confirms this; very little information exists on the costs of BMPs (from A to B in Figure 3) and none on possible economic benefits. Macroeconomic questions of social costs and benefits are much more difficult than similar questions asked at the firm level. It seems almost impossible to estimate in a quantitative way what the future down-stream societal benefits will be from adopting BMPs. On the other hand, it may be possible to count the reduced costs of cleaning up the down-stream environment if BMPs are used (going from C to D in Figure 3)..

Economic analysis of costs and returns of BMPs at the firm level and environmental clean-up costs at the societal level appear to have the most operational promise for action programs. Appealing to economic theory of efficiency in a market economy means that applying BMPs that have minimum net cost (net of quantifiable returns) to obtain a specified and measurable level of environmental quality would be a valid public policy goal. Goals can be specified and measured via the list of variables in the BMP data base. Biological and physical scientists have abilities to recommend specified levels of environmental quality (i.e, field 14 of BMP data base) and firms could be required to meet these goals by conforming to new laws and regulations demonstrated by the Pollution Regulation Level shown in Figure 3. A crucial policy question emerges, however, from Figure 1. Will a public policy be cost effective that requires firms, by threat of fines, to adopt BMPs that conform to laws and regulations? From a long-run point of view, can laws and regulations be enforced that are seen as arbitrary? Extensive monitoring an measuring of environmental impact of management practices will be required if BMPs are adopted as regulatory tools.

The cost-benefit model can apply to an effective public policy that operates at or below the floor of regulation (as defined in Figure 3). Operating below the floor significantly differentiates a cost-benefits model from the cost minimization model of so-called pollution rights trading which requires a regulated level of pollution control. Cost-benefit analysis is a much broader model which could include but can go beyond regulation. Cost-benefit analysis will depend on the ability and willingness of citizens to pay net costs of applying BMPs either through (1) regulation costs (at a level defined in Figure 3) of program administration, litigation and enforcement of laws (including possible incarceration?), or (2) by establishing a public policy of paying BMP costs through incentive programs financed by taxes, or (3) by paying BMP costs through incentive programs financed by user fees. User fees open the door to a wide range of programs generally defined as “market based”; i.e, will consumers in the economy pay a fee for using environmental resources that will maintain those resources at a sustainable level?

A goal of economic analysis is to suggest how BMPs may accomplish more than regulation and do so in a less onerous and more economically efficient way. Because of altruistic goals of improving the ecology, citizens may adopt BMPs whose value is far greater than relatively small incentives that cause their adoption.

<u>Effects of Market Structure and Market Characteristics</u>. Cost-benefit analysis does not suggest that legal limits, or regulation, are not important. Technologies for which there are essentially no options, or alternative management practices, must be regulated. If, for example, a society’s only alternative to nuclear fuel is no fuel there will be no opportunity to pay for an alternative. Technologies with no apparent alternatives are also a special case of the more general problem of monopoly power in a market economy. Regulation of monopoly power is an accepted practice in a market economy. Although they are not profit maximizers, government monopolies (all tax supported service and product producing organizations) at federal, state and local levels will also need to be regulated to minimize tax expenditure for environmental clean-up. An additional feature of monopolies and near monopolies, such as municipalities, mining and certain mill operations in a given watershed, is that pollution can usually be defined as coming from a definite geographical point where regulation can be targeted.

Beyond monopoly, firms in competitive markets are not likely to adopt BMPs because: one, they are likely to be costly and a single firm, say a farm, adopting a costly BMP could not pass the cost along to consumers, and two, competitive firms respond to a "free rider" principle which means that members of the industry are hoping that a few altruistic firms through volunteer efforts will control environmental degradation to a level that will not require a total industry effort. Agriculture, construction trades and forestry are examples of competitive industries with pollution externalities. Voluntary BMPs will be important but may or may not reach a targeted regulation level (Figure 3).

Hypothesis

A clean environment may be obtained at a lower public cost through payment of incentives and collection of user fees as compared to costs of regulation and enforcement. The use of incentives as a preferred public policy is a likely result in a society moving toward high environmental objectives and having low esteem for government regulation and legal requirement.

Role of the Market in Determining Effective Incentive Programs

Land and water are primary inputs to the agriculture and forestry sectors of the economy and are the most likely sectors where two important preconditions exist for the application of public policy. One, markets in these sectors are likely to be highly competitive and no single firm can pass along the costs of pollution reducing BMPs. Two, environmental degradation is likely to be characterized as non-point pollution which by definition is difficult to monitor by source and, therefore, difficult to regulate by enforcement of law.

Traditional market theory supports the hypothesis of a downward sloping demand curve for land and water. The two principal sources for this effect are well known studies of downward sloping demand curves for the products of agriculture and forestry and decreasing productivity of continuously increasing the amounts of land and water used in production. These two important sources result in the downward sloping aggregate demand marked “Demand for Goods and Services from Using Environmental Inputs,” Figure 4, which shows that the market value of land and water decreases as their use increases.

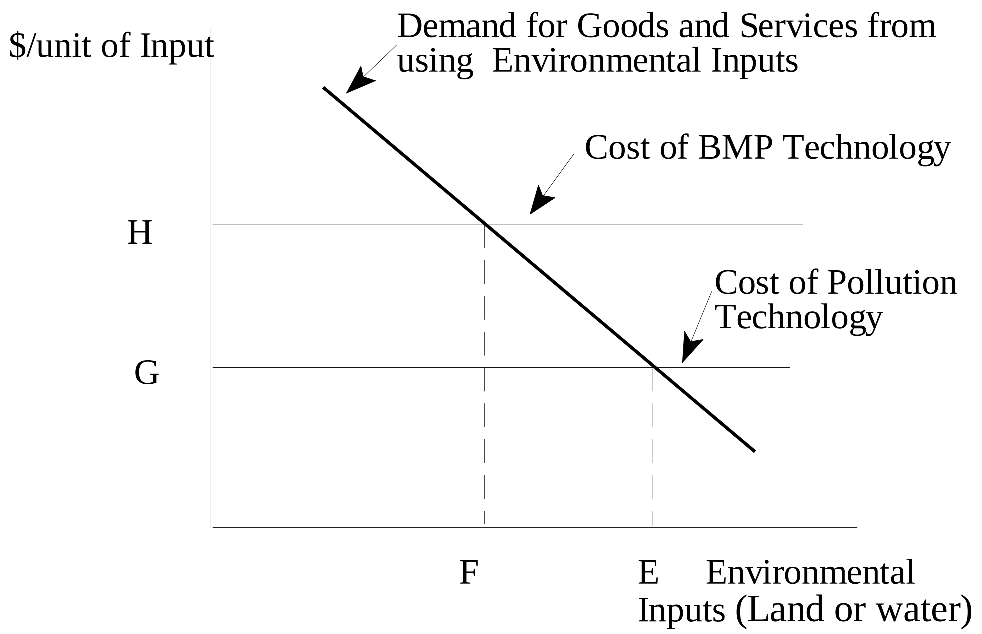

Figure 4. Demand and Private Costs of Using Land or Water with BMP Technology

BMP technology for reducing environmental degradation is likely to be cost increasing for the use of water and land as shown in Figure 4 where the cost per unit of land and water used recognizable environmental savings and environmental enhancement that result in downstream reductions in cost of using environmental inputs. Reduced costs like the movement from L to M in Figure 5 result from less effort in removing pollutants from water to cost savings at a larger societal level of decreased costs of maintaining public health from a cleaner environment. Reduced cost at the downstream level will mean, however, that land and water will be more attractive for increased use resulting in a potential increase in environmental input use from J to K, Figure 5. An unintended effect of applying a BMP upstream might cause greater environmental pressure downstream thereby increasing environmental degradation (as defined in Figure 3). Taxation (fees), might be one approach to keeping downstream use in a steady state.

The reduced cost from L to M in Figure 5 is the source of potential tax or user fee revenues. An essential tenant of economics is that an environmental input earns a surplus, or rent, that can be collected as a tax or fee without distorting production incentives, say producing drinking water by a local government monopoly. Collecting a tax or fee downstream by the amount of saving in environmental costs (L to M) could result in downstream environmental use remaining constant at level J with no loss in production of goods and services. If level J of environmental input use is sustainable, the economy can continue to produce at an acceptable level of environmental quality, and if the taxes, or fees, collected exactly equal incentives paid to induce BMPS at the upstream level, this might be called an effective, operational and even optimum, public policy.

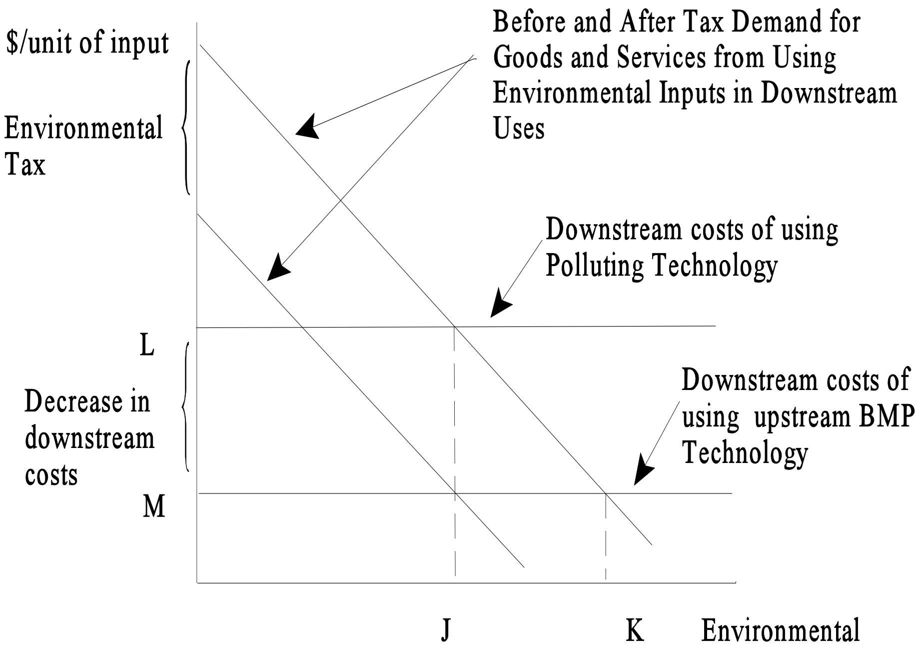

Figure 5. Environmental Tax Paid by Downstream Users of Environmental Inputs Improved by BMP Technology J - Sustainable steady state use of inputs at downstream level

The various scenarios of implications arising from input use J not being sustainable or from an environmental tax or fee that will not pay the incentive required for upstream BMPs are beyond the scope of this paper. Estimating sustainability, regulation levels, taxation and incentive levels, and BMP costs will require empirical analysis and environmental monitoring which may not be currently available, but this paper provides a general model into which many hypotheses may be tested. Empirical analysis of costs of BMPS and how BMPs impact other costs, such as drinking water processing, will be necessary.

TAX SUPPORTED POLLUTION TRADING INSTITUTION

Pollution trading has been suggested as applicable to trading among point sources. A challenge exists to model both point and nonpoint sources of pollution, such as agriculture. The goal is to develop a model that would bring all polluters to the same market, i.e. allow for pollution trading between nonpoint sources and point sources of pollution. This market does not exist but an institution can be created that can substitute for the market by receiving environmental taxes and targeting environmental problems at local levels.

This artificial market will allow for exchanging pollution permits among polluters in a given watershed. Pollution permits would be issued to point source polluters as well as to nonpoint source polluters. Permits for point source polluters need to be in the form of discharge allowances that specify total maximum daily load of specific pollutants. Permits for nonpoint polluters, on the other hand, could be in the form of allowance of input uses that contribute to pollution on an acreage basis.

Some basic functions of a tax supported trading institution would be:

1. Measure current pollution and determine a target level of pollution reduction and the initial distribution of these permits between point and nonpoint sources.

2. Determine a permit trading ratio between point and nonpoint sources of pollution that will lead to cost minimization for the target level of pollution reduction.

3. Distribute incentive payments when there is a cost-benefit justification.

At a minimum, the controlling agency must have the following information for trade between point sources and a nonpoint source such as agriculture:

- watershed effects of pollution discharge from point sources on water quality;
- watershed effects of restricted inputs use, say via BMP's (including cultivation practices) in agriculture on surface water quality;
- cost of pollution abatement for point sources of pollution (Marginal Abatement Costs);
- cost of restricting input in terms of forgone production returns and costs of implementing BMP's in agriculture.

The following model could be utilized to determine initial distribution of pollution permits on a watershed level.

Minimize: $C = C_p + C_{np}$ **(2)**

Choose: X_p , X_{np}

Subject to: $Y <= X_p + X_{np}$, *and* $MAC_i = MAC_j$

Where:

C = total pollution abatement costs for a given watershed

C_p = pollution abatement costs for point sources where these costs are subject to economies of scale at point sources

C_{np} = cost of restricting input and/or BMP implementation costs for nonpoint sources.

Y = required level of pollutant in surface water

X_p = pollutant contribution from point sources

X_{np} = pollutant contribution form nonpoint sources

MAC = Marginal Abatement Cost

If one of the X's is zero the problem reduces to either a nonpoint or point source model, the distribution of permits among sources would still have to be determined by minimizing overall pollution abatement costs for all sources. A tax supported market could implement a number of polices:

- allow point sources to trade among themselves within a given watershed,
- allow farmers to trade among themselves within a watershed, (e.g. a farmer that is going to apply less input that established by controlling agency limit could sell his rights to another farmer that would like to apply more input that the limit),
- allow for a tradeoff between restricted input use and specific BMP's or tillage practices, (a farmer that implements given BMP could use extra input on his fields),
- compensate farmers with incentive payments for income loss due to restricting input use (in some countries biodynamical farmers get fixed amounts of money per acre of land),
- compensate (or tax) point sources for restricting (not restricting) discharge of pollutants,
- allow for trade between farmers and point sources of pollution,
- accept contributions from public and business sources to buy pollution permits from point source pollution and compensate farmers to further restrict use of polluting inputs, or vice versa.
- allow banking of pollution permits whereby a firm could get credit for pollution abatement, or environmental enhancement, that could equal a debit for increasing

pollution, or environmental degradation, in another area of the same watershed (sometimes referred to as mitigation banking).

- increase monitoring of selected non-point sources where increased monitoring might result in non-point sources being identified as point sources. Concepts of trading and banking (mitigation banking) could be applied. Point sources, such as industrial hog farms, could be identified as non-point sources if monitored levels fall below a threshold point.
- identify concentrations of fed livestock (the hog farm example), or confined animal feeding units (CAFU), when the number of animals reaches a critical level. Such critical levels must have a scientific basis normally determined by a monitored level of pollution that could change a non-point source to a point source and vice versa.

- establish BMP incentive payments where benefits to society outweigh the costs
- set up demonstration programs to help educate land managers about better ways to manage through BMPs.
- expand educational programs on the health risks of material used in agriculture, forestry, and the home.

Concluding Observations

This paper has briefly surveyed the concepts of tradeable permits, cost-benefit analysis of BMPs and incentives, and the potential creation of a new institution to substitute for market forces required for trade and achievement of voluntary and compensated BMPS. By necessity, a new institution must be the recipient of tax revenues and must have the scientific expertise to identify and target the most significant environmental problems. When problems are identified in a scientific and objective manner, economic tools of analysis including trading and cost-benefit, can be brought to bear and can result in socially efficient solutions.

A new institution to apply the flexible tools of basic science and economic analysis needs neither the police power of regulation or nor the hammer of land retirement. Developing and policing regulations, negligable we hope, are best left with EPA and EPD. The hammer of land retirement should continue to be regarded with suspicion. A new institution that is market efficient will need the authority to spend tax revenue and provide incentives when appropriate. Such an institution will need broad public oversight and advisory and will need broad support from existing tax supported institutions, such as the United States Department of Agriculture, the State Department of Natural Resources and The University of Georgia; all have responsibilities for environmental management. Private institutions including the land trusts, environmental activist foundations, private universities and private research foundations (ie. the Jones Ecology Center) will find that a new public institution applying science and flexible market-like approaches to problem solving is consistent with their goals.

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