Incentive-Based Land Use Policies and Water Quality in the Chesapeake Bay

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Abstract

The activities conducted on land surrounding the Chesapeake Bay directly affect pollution levels in the Bay, and they do so in complex and varied ways. Policy attention has been focused, for the most part, on modifying these activities within a particular land use category but not on wholesale changes in land use. For example, farmers are encouraged to use "best management practices" (BMPs) that focus on fertilizer use, crop covers, and the like; residential and commercial developers are encouraged to manage stormwater runoff; and wastewater treatment plants are required to meet technology-based standards. But the amount of land in urbanized uses relative to the amount in farming, forestry, and open space has not been given the attention it deserves. In this paper, we discuss the ways that land use affects pollution in the Bay. We then analyze three economic incentive-based policies that could be used to alter land use patterns—purchase of development rights (PDRs), transferable development rights (TDRs), and development impact fees. The strengths and weaknesses of each policy are discussed. Finally, we discuss the issue of policy coordination, i.e., synchronizing policies focused directly on land use, such as TDRs, with input-based taxes. More research on this important policy issue is needed.

Key Words: development impact fees, nonpoint source pollution, purchase of development rights, transferable development rights

JEL Classification Numbers: Q53, Q58, R14

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I. Introduction

With a six-state, 64,000-square-mile drainage basin, the Chesapeake Bay has the highest ratio of land area to water area of any bay in the United States. The activities conducted on this land directly affect pollution levels in the Bay, and they do so in complex and varied ways. Agricultural land management practices; chemical use; population growth and density; the extent of impervious surfaces such as roads; and natural factors such as soils, climate, and hydrology all interact to determine the Bay's water quality conditions and aquatic health.

The policy debate thus far has concerned itself less with the breakdown of land uses into agriculture, forestry, other open space, and urbanized uses than with the activities conducted on those lands. Point and nonpoint source policies are generally established assuming that land uses are fixed and exogenous. Furthermore, the coordination of point and nonpoint source instruments with land use policy instruments and the role that economic incentive-based land use instruments can play in efficiently achieving water quality goals have been given only minimal attention.

Existing policy addresses point sources—sources of pollution that can be attributed to specific, "end of pipe" locations such as wastewater treatment plants—through technology-based standards requiring "best available technology economically achievable." Nonpoint sources, which consist of runoff from agricultural lands, construction sites, and urban areas, as well as septic system leakage and emissions into the air from stationary and mobile sources, are addressed in a variety of ways. Agricultural and stormwater runoff are handled mostly through sets of voluntary "best management practices" (BMPs) while air emissions are addressed through regulatory controls and standards placed on those sources.

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These policies do not consider the broader question of how and where land should be allocated among urban uses, agricultural uses, and forestry and other open spaces to best promote the health of the Bay. State and especially local governments do concern themselves with patterns of land use, employing zoning and other local policy and planning tools to alter land use patterns. However, they do not generally have the Bay's water quality as their primary focus. Moreover, local land policies are set at the county or city level, not at a watershed or even river basin level. Therefore, local policies such as zoning regulations are established to achieve only local goals and ignore the spillover effects on other counties.[1] In addition, land policies tend not to be coordinated with more direct regulations affecting water quality such as those affecting nonpoint and point sources of pollution.

With the movement toward establishment of "total maximum daily loads" (TMDLs), some of this may change.[2] More focus will be placed on nonpoint sources and on the effect of different land uses on actual measured water quality. As more is learned about the effects of different sources of pollution on water quality and as greater levels of control must be achieved, there is also likely to be increasing interest in incentive-based policies and how they can best be utilized in the mix of tools for improving water quality.

In this paper, we explain three land use policy instruments, examine how they work in practice, and highlight their strengths and weaknesses. The three instruments we examine—purchase of development rights (PDRs), transferable development rights (TDRs), and development impact fees—are incentive-based instruments in the sense that they do not require all landowners and other decisionmakers such as developers to meet the same "standards." Rather, they provide incentives to preserve open space, forestry, and farmland but let individual landowners make their own decisions. We focus particular attention on TDRs, an incentive-based approach similar to "cap and trade" emissions permits. Finally, we discuss policy coordination as a way to efficiently address nonpoint source pollution with a combination of input-based or ambient taxes together with land use policies such as TDRs.

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[1] Bockstael and Bell (1998) show that low density zoning in one county can result in more development in adjacent counties.

[2] See Boyd (2000) for more on TMDLs and the legal and economic issues surrounding them.

II. Urbanized Land in the Chesapeake Bay Region

The Chesapeake Bay region is home to over 16 million people, and population is expected to grow by 14% by 2020. In addition, like most regions of the United States, urbanized land area in the Chesapeake Bay region is growing faster than population.[3] This means that farms, forests, and other open space are declining. Table 1 shows the expansion of six urbanized areas in the Chesapeake Bay watershed over the 1970–1990 period. In the table, we refer to this expansion as "sprawl." There are many definitions of urban sprawl, but the simple one used here is that sprawl is the expansion of a city and its suburbs over more and more rural land. Thus the growth in the urbanized land area is a good measure of the degree of sprawl over a period of time. Sprawl comes from a combination of growth in population and growth in per capita land consumption; Table 1 shows the percentage of the increased urbanized land areas that are attributable to each factor in each of these cities.

In all six areas, at least some portion of the overall growth over this 20-year period is attributable to increased consumption of land per person. In Washington, DC, the largest urban area in the region, 53% of the sprawl that occurred between 1970 and 1990 was due to growth in land use per capita; 47% to a rising population. The DC urbanized area grew from 495 square miles in 1970 to 945 square miles in 1990, a 91% increase.

Declining household sizes are part of the reason for increasing per capita land consumption. Nationwide, there was an average of 3.11 persons per household in 1970 but only 2.63 persons per household by 1990, a drop of over 15%.[4] Over the 1970–2000 period, average household size in the Chesapeake Basin area fell by nearly 19% (Chesapeake Bay Program, 2003). However, households are also demanding larger houses and larger lot sizes as incomes rise. To satisfy these demands, many families move farther from city centers, and agricultural, forested, and open lands are converted to residential uses.

[3] According to Census Bureau definitions, an urbanized area is a central city and its contiguously developed suburbs.

[4] These figures are from U.S. Bureau of the Census demographic data; see http://www.census.gov/statab/USA98/dd-ho.txt.

Table 1. The Degree of Sprawl in Urbanized Areas in the Chesapeake Bay Watershed, 1970–1990

Urbanized area	*Degree of sprawl (in square miles)*	*% of sprawl due to population growth*	*% of sprawl due to growth in per capita land consumption*
Baltimore, MD	282.9	28%	72%
Harrisburg, PA	71.4	30%	70%
Norfolk–Virginia Beach, VA	221.4	85%	15%
Richmond, VA	158.1	47%	53%
Scranton–Wilkes-Barre, PA	20.4	0%	100%
Washington, DC-MD-VA	450.1	47%	53%

Source: Kolankiewicz, Leon and Roy Beck. 2000. *Weighing Sprawl Factors in Large U.S. Cities*. Arlington, VA: Sprawlcity.org. Available at www.sprawlcity.org; raw data from U.S. Bureau of Census data on urbanized areas.

Converting land from forestry to urbanized uses increases pollution. Forests capture rainfall and reduce runoff, filter nutrients and sediment, and stabilize soils. They also trap airborne emissions of nitrogen and particulates. The Chesapeake Bay Program's Watershed Model estimates that forests cover nearly 60% of the land in the Bay watershed but contribute only 16% of nitrogen loads, less than 3% of phosphorous, and 19% of sediments.[5] Converting land from agriculture to urbanized uses has a less clear effect. Whether pollution increases or decreases depends on the type of agriculture conducted on the land such as row crops, pastureland, feedlots, and so forth; what management practices the farmer employs and the level of chemical use on the land; and the type of residential and/or commercial development to which the land will be

[5] These results are from the CBP's Phase 4.3 Watershed Model, updated 7/25/02; data available at http://www.chesapeakebay.net/pubs/statustrends/137-data-2002.xls.

converted. The agriculture sector is currently—and has been for a number of years—the largest contributor to both nutrient and sediment pollution in the Bay. In 2000, again according to the Chesapeake Bay Watershed Model, it accounted for over 42% of nitrogen loads, 50% of phosphorous, and nearly 65% of sediments. However, on an average *per-acre* basis, accounting for both point and nonpoint sources, nitrogen loadings are highest from urban and suburban land uses; these contribute twice as much nitrogen as agricultural lands. Urban and suburban lands cover only 9% of the total land area in the Bay watershed but contribute 34% of nitrogen loads and 36% of phosphorous.[6] It is important to keep in mind, however, that there is a great deal of variation within both the urban and agricultural sectors in contributions to the nitrogen load.

Urbanized land contributes to pollution in several ways. First, impervious surfaces such as roads, driveways, rooftops, and the like lead to increased stormwater runoff to streams and other waterways (Schueler, 2000). Several studies show that stream degradation begins to occur when only 10% of the land in a watershed is covered with impervious surfaces (Capiella and Brown, 2001). Second, increased vehicle travel and industry activity lead to greater airborne emissions that eventually settle in the Bay and its tributaries. Third, emissions from either septic systems or municipal wastewater treatment plants are higher when land is in an urbanized use. Septic systems are a particular problem since most do not have nitrogen controls. Moreover, it can be difficult and costly to determine when systems are failing.

These problems are all exacerbated when residential development is sprawling and low density. Several studies show that vehicle-miles-traveled and emissions are negatively correlated with population density, thus low-density development is likely to lead to greater levels of nitrogen in the Bay from airborne NO_x emissions.[7] Septic tanks are much more common in low-density developments. Nationwide, it is estimated that 24% of the population relies on septic systems for their waste treatment, but the figure is much higher in low-density areas. The Maryland Office of Planning (1991) estimates that over 80% of the land developed in Maryland over the 1970–1990 period was outside existing sewer systems. Building a new development over a smaller number of acres—so-called "cluster" development or "open space design"—has been shown to result in less

[6] Phosphorous and sediment pollution on a per-acre basis are highest from agricultural uses. These findings are from the Chesapeake Bay Program model (see previous footnote).

[7] See discussion in Harrington and McConnell (2003) and references therein.

impervious surface in the form of roads and driveways and in the preservation of more forests and habitat area. On a regional scale, building more compact developments can also reduce the number of watersheds affected by development. Schueler (2000) suggests that it is better to accept some degradation of a smaller number of streams rather than impact a larger number, as would be the case with sprawling urbanization.

These facts all suggest that preservation of forested lands, and probably farmland as well, while limiting residential and commercial development to smaller areas—i.e., discouraging sprawl—is likely to improve water quality in the Bay. In addition, actions taken to reduce the effect of any of these land uses on emissions to the Bay can be equally important. In the remainder of the paper, we first review three types of incentive-based policies that can influence land preservation and land development. We then discuss the possible role of such policies to improve water quality around the Bay.

III. Land Use Policies

The most direct way that local governments control the amount, location, and density of development is with zoning. Most counties and municipalities establish commercial, industrial, residential, and sometimes agricultural zoning categories. Residential properties usually face a specified limit on dwelling units per acre, and there may be several different residential zoning categories in a county. For example, a typical suburban county may have areas devoted to relatively high-density use with perhaps 12 to 20 dwelling units per acre, thus allowing apartments, condominiums, and townhouses; areas permitting medium-density, single-family dwellings with perhaps three to four dwelling units per acre; and relatively low-density living with perhaps one unit per two to five acres. Therefore, one of the most straightforward ways of limiting total development is to change zoning to allow fewer dwelling units per acre.

There are several problems with this approach. First, property owners often view "down-zoning" as a form of "takings" since it reduces the value of their land. This may lead to numerous applications for zoning "variances," court battles, and other problems. Second, down-zoning can encourage urban sprawl, because houses are built over a larger area of land. As we explained above, several studies suggest that sprawl contributes to environmental problems; compared with more compact development, sprawl can lead to more vehicle miles traveled and therefore more emissions from automobiles, more impervious surfaces leading to increased runoff, and more use of septic systems with

their lack of nitrogen controls and potential leakage problems. And third, zoning is a blunt policy instrument that is unable to allow for differences in costs of building and preferences of homeowners and the community that might exist within a zoning designation.

Local officials have other options at their disposal that they can use in place of or in addition to zoning. We discuss three in this paper: purchase of development rights (PDRs), sometimes called purchase of conservation easements (PACE); transferable development rights (TDRs); and development impact fees. Both PDRs and TDRs use conservation easements—deed restrictions that landowners voluntarily place on their property—to protect land from certain kinds of development. With PDRs, the government itself or a private land trust buys development rights from the landowner and retires them; with TDRs, private developers (and others) may purchase development rights and use them to develop more intensively on another property. In both cases, the property itself remains in private ownership; only the development rights are sold. Development impact fees are imposed by local government on new development to cover the public service costs of that development.

1. Purchase of development rights

PDR programs pay landowners to protect their land from development. Landowners sell easements to either a government agency or a private conservation organization or land trust; typically, the easements are permanent. Easement programs can differ a great deal, with the design determined by the overall goals to be achieved. One of the biggest differences among programs is whether they want to target properties that are considered particularly valuable in preservation or whether the goal is the total amount of land protected. Some farmland preservation programs simply offer a price per acre for easements, and farmers participate if the easement offer plus the value in farming exceeds the expected value of the land in development. These programs are likely to attract easement sales from owners of large tracts of farmland that have low potential development value, perhaps in outlying areas.

In other farmland PDR programs, each property is assigned an easement value that is the difference between the value of the land in farming and its "highest and best use," which is generally residential or commercial development. Programs decide which properties to purchase with limited funds. Sometimes, purchases are targeted to particular parcels that might have, for example, important environmental value to the jurisdiction. If

a particular parcel of land is near a major river or other waterway, incorporates wetlands, is adjacent to other undeveloped areas, or has other features that make it best left undeveloped, then local government can offer to purchase the development rights for that property even if the easement value is quite high.

In many PDR programs, professional appraisals determine the easement value estimates on which decisions are based. Government funding for PDR programs comes from either the sale of bonds, annual appropriations from general funds, some federal programs such as the U.S. Department of Agriculture's Farm and Ranch Lands Protection Program, or property and real estate transfer tax surcharges.

There are advantages and disadvantages to PDRs. First, because they are voluntary, PDRs allow landowners to make decisions about developing their properties that are in their own best interests. Unlike straight zoning, they do not force all landowners in particular zoning categories to do the same thing but allow some flexibility across parcels. Second, as described above, they can be used to target specific properties for preservation. And, because private ownership of the land is retained, PDR programs achieve preservation at lower cost than programs that purchase properties outright.

Although they are less expensive than outright land purchases, PDRs still impose a heavy financial burden on local government. This is one of their most serious drawbacks. Often, local governments have only a limited budget for land preservation; raising taxes to pay for PDR programs can be politically unpopular and because of the cost of public funds, increases the overall social cost of the program.[8] Moreover, when funds are limited and there are more property owners willing to sell development rights than the county can afford to purchase, it must make difficult decisions about which properties to preserve.[9] Many counties have point systems for such situations, assigning points for particular property characteristics. Usually, some measure of the threat of development on the property is considered—i.e., the greater the risk the property will be developed, the more points assigned to the property and the more likely its development

[8] Because distortionary taxes are used to raise revenues to fund government programs such as PDR programs, the total social cost of the program includes the welfare loss from those taxes.

[9] In a private market, the greater the supply the lower the equilibrium price that will be paid, but in PDR programs, the government is usually required to pay a "fair market value" equal to the difference between the land's value in development and its value in an undeveloped use such as agriculture. Thus, the government needs to find a mechanism for rationing development rights purchases.

rights will be purchased. However, it only makes sense to target these properties if they are also the most valuable in preservation. Targeting properties that are under the most intense development pressure will not stop development from occurring and may just result in a more leap-frog pattern of development. Finally, the appraisals necessary to determine easement values can be difficult and time-consuming to conduct. Some counties set up appraisal review boards or committees that evaluate each property's appraisal, further adding to the cost of the program.

Despite their drawbacks, PDRs are a popular land preservation tool used widely across the country. The first PDR program was instituted in Suffolk County, New York, in 1974, and the American Farmland Trust (AFT) estimates that there are now over 1.3 million acres of farmland that have been preserved through such programs (AFT, 2003). In a recent study of 46 agricultural easement programs, Sokolow and Zurbrugg (2003) find that easement purchase amounts average $2,000 per acre but vary quite widely. More than $100,000 per acre was paid for some properties in suburban counties near New York City, Philadelphia, and Baltimore.

2. Transferable development rights

TDRs transfer development from one property to another. Like PDRs, a permanent easement is attached to the property from which the development rights are sold, but unlike PDRs, those rights are used to increase development on another property. TDRs are bought and sold in a private marketplace with landowners voluntarily selling their rights usually to developers who use the rights to develop more intensively elsewhere.

In theoretical economics studies, TDR markets are usually viewed as working in the following way: the local government decides on a maximum amount of overall residential development, distributes enough permits, or development rights, to landowners to generate that amount of overall development, then allows landowners to trade those permits with each other. If landowners have different opportunity costs of not developing their land, some will end up selling development rights while others will purchase rights and build at a higher density than is permitted with their initial allocation. By giving individual landowners the flexibility of going over or under their initial allocation of rights while maintaining a cap on the overall number of rights, land parcels

with different relative values in development are allocated to their most efficient uses (Mills, 1980, 1989; Thorsnes and Simon, 1999).[10] This conceptual description of TDRs is, in principle, like a tradable emissions permit system in which there is an overall cap on emissions across all polluters but individual polluters are allowed to trade permits with each other (Tietenberg, 1985).

Mills (1989) has pointed out an additional advantage of TDRs over straight zoning. He argues that although zoning may improve efficiency and enhance land values in some cases—for example, when open space provides public good benefits—often those gains are lost as a result of rent-seeking behavior by landowners. Zoning increases economic rents for owners of parcels that are permitted more development, creating incentives for landowners to spend resources to obtain zoning associated with the highest-valued land uses. TDR programs, in theory, mitigate this behavior by allowing the gains from development to be spread more equally across all landowners.

In practice, real-world TDR programs do not operate like the theoretical ideal. For one thing, they are never a substitute for zoning but are used in conjunction with zoning. Most typically, particular areas of a county or other geographical area are down-zoned to relatively low densities in an effort to target those areas for preservation; these are the so-called TDR "sending areas." Down-zoning gives landowners in these regions a greater financial incentive to sell development rights, though they are not required to do so. Other areas are "receiving areas" where TDRs can be used to increase the density of residential development beyond the baseline zoning.

Since TDRs rely on the private market, it is important that there be both a reliable supply of TDRs by landowners willing to sell their development rights and preserve their lands and a reliable demand by developers who feel that the extra revenues from building more houses in a given receiving area will cover the extra costs, including the TDR costs. It is the demand side that has proved to be a problem in many TDR programs. In many regions, baseline zoning in receiving areas— the number of dwelling units allowed per acre without the purchase of TDRs—is perceived as being acceptable with homebuyers

[10] Where the benefits of preservation depend strongly on the location of the land preserved and where those benefits are purely public—for example, wetlands preservation, protection of wildlife habitat, and preserving lands near streams and estuaries—there may be an argument for some government restrictions on which properties may be developed. We address this issue further below.

and higher density undesirable. Demand can be low for other reasons as well. Many programs allow higher density in receiving areas to be achieved through other non-TDR mechanisms such as special zoning variances and the like. And some programs make the cost of using TDRs too high, requiring developers to get approval on each project rather than allowing the higher density by rights when TDRs are used. In some areas, existing residents in receiving areas resist the higher density allowed with TDRs.[11]

There are some potential solutions to the problem of low demand. For one thing, the program should be designed so that increased density in receiving areas can only be achieved through the use of TDRs. Secondly, down-zoning properties in the receiving area can boost demand for TDRs and, at the same time, assuage the fears of existing residents that density will become too high in their areas.

There can still be some drawbacks to TDRs, however. TDRs allow any landowner in a targeted area to sell development rights, but some of these landowners may not have developed their properties anyway, at least in the foreseeable future. For any number of reasons—including personal or family considerations, or the possibility that their land has relatively low current value in development—they may prefer to continue farming, forestry, or other related activities rather than sell to a developer. Since it would be very difficult for government officials to identify such properties ex ante, TDRs are made available to all properties that meet a fairly broadly defined set of criteria. This leads to a type of adverse selection problem that has been identified in other permit programs, most recently in the SO_2 trading program (Ellerman et al., 2000).[12] In the case of TDRs, this problem raises the cost of preservation above what it needs to be. This adverse selection problem can also lead to *more* development than would occur under a straight zoning policy. The TDRs landowners sell are used to build more houses elsewhere, so if properties that would not have been developed anyway are now selling TDRs, more development is occurring in other areas than would have occurred in the absence of the TDR program (Levinsohn, 1997).

Another potential problem with TDRs is the possibility that the market for development rights is "thin." Efficiency in the TDR market requires that development rights be traded at a single competitive price and that this price be the result of

[11] See case study discussions in Pruetz (1997).

[12] This effect may exist in PDR programs as well.

interactions by a large number of buyers and sellers. This outcome may not be achieved in actual TDR markets for several reasons. If one side of the market has some monopoly power, too few permits will be traded (Hahn, 1984). For example, if there are relatively few developers and they have access to information about a large number of potential sellers of TDRs, then those developers may have some monopsony buying power. Field and Conrad (1975) argue that this can occur because developers are likely to be small in number and well organized relative to private property owners. The fact that most TDR programs allow trading only in an individual county or municipality rather than across larger regions exacerbates the thin market problem. Sometimes there is also a program design in which several different types of rights are created and traded, making markets more complex. The Tahoe Regional Planning Agency program is an interesting case in point. Individual properties are assigned to "capability classes," which designate the extent of impervious cover permitted and whether rights can be bought or sold. The program then has markets for five different kinds of rights, all of which are "partial" rights that used alone do not convey an entitlement to development.[13]

Thin markets can also result from high transaction costs in development rights markets. Stavins (1995) has argued that there are two potential types of transactions costs in permit markets: (1) search and information costs, and (2) bargaining and decision costs. The first type of cost is reflected in TDR markets in brokerage or finders' fees, and the second in negotiation costs and lawyers' fees. When there is no centralized broker to facilitate sales, the buyer and seller have to find each other and negotiate a price. In such cases, both search costs and bargaining costs may be high, especially if there is little information about other transactions or the "going" price of a TDR. More complicated programs such as the Tahoe program will have even higher transaction costs. In programs in which real estate agents broker transactions, the fees these agents charge are part of the overall cost of the program.

In practice, TDRs have met with only limited success. Although there are approximately 135 TDR programs in existence in the United States, only a handful have had active markets with numerous trades of development rights each year and a

[13] The five rights are (1) impervious surface coverage, (2) residential development, (3) residential allocation, (4) commercial floor area, and (5) tourist accommodation units. See Solimar Research Group (2003) for a detailed and interesting analysis of the Tahoe program, which is a program designed to limit the extent of impervious cover in the Lake Tahoe basin for purposes of reducing sediment and other pollution. We discuss the program more below.

significant amount of preserved acreage (Pruetz 1997, 1999; American Farmland Trust, 2001).[14] One of the best-known TDR programs is in Montgomery County, Maryland. In 1980, the planning agency there down-zoned a 74,000-acre area of farmland in the western part of the county to one house per 25 acres. Landowners could then either develop at this very low density, or sell TDRs based on the earlier density and preserve their land. The Montgomery program has preserved 40,000 acres of farmland to date.

McConnell, Kopits, and Walls (2003) conducted a detailed analysis of another successful TDR land preservation program in Maryland, the one in Calvert County.[15] This program, which has been in existence since 1979, has some unique features that make it an interesting case study. First, unlike the Montgomery County program that was designed to preserve a large region of contiguous agricultural land and a working farm economy, the Calvert program goal is to preserve the county's rural character. The county's eventual goal is to have about one-third of all lands in preserved farms and forests in areas extending the length of the county. The county planning agency did not begin by down-zoning a large section of the county to very low density levels, but instead relied on the TDR market to allocate land between development and preservation. Property owners with parcels in certain broad areas that have prime agricultural soils can choose between selling development rights and preserving their land or developing to the baseline density of one house per five acres. Property owners in another large rural zoning category, Rural Communities (RC), have the additional option of using TDRs and developing their properties at a higher density than allowed by the one unit/five acres baseline zoning.[16] This overlap in sending and receiving areas that exists in the RC areas appears to be a very unusual feature of a TDR program. Finally, when landowners in Calvert County sell their first TDR, the entire acreage of the property is placed in easement status. Most TDR programs allow properties to retain some development potential until all rights are sold. For example, in the Montgomery County program, many landowners have held onto a few development rights and because of that, they are allowed to develop at a density of one unit/25 acres. At the time the program was established, demand for this kind of very low-density housing was extremely limited, but

[14] Pizor (1986) points out that until 1983, the number of articles written about TDRs exceeded the number of development rights that had actually been transferred in any of the many programs in existence in the United States.

[15] The program also targets land in active forestry, though farmland is its primary focus.

[16] Since 1999, FCD/RPD areas can also be either sending or receiving areas (see previous footnote).

in recent years, there has been increased demand for mini-estates and "farmettes" in this region of the county.

As of 2001, over 13,000 acres of land had been preserved in Calvert County via the sale of TDRs.[17] An average of 540 TDRs were sold per year during the decade of the 1990s, and prices were relatively constant in real terms over this period at approximately $2500 per TDR.[18] In the early years of the program, prices varied significantly across transactions, but since the early 1990s, there has been little variation. In 1992, the county started a PDR program in conjunction with its TDR program. Each year, it purchases a small number of development rights in the TDR market and retires them. The county does not conduct appraisals and pay differentiated prices for different properties; thus, the cost of operating the program is relatively low.[19] McConnell, Kopits, and Walls (2003) conclude that the government's PDR program and its newsletter showing average prices and other information about TDRs have helped to stabilize the private TDR market.

Overall, the Calvert program shows that a relatively free-market, low-cost TDR program can be an effective way of achieving land preservation. The county's PDR program complements the private TDR program in that particular properties can be targeted for preservation and public funds can be leveraged with private dollars to get more preservation per total dollar spent. The Calvert County program has many of the features that economists praise about TDRs in theory: specifically, most landowners are allowed to make preservation/development decisions that are in their own best interests; zoning is not very restrictive, even in the areas deemed to be prime farmland; and the overlap in sending and receiving areas adds even more flexibility.[20] Because of its flexibility, however, the program may not account for spillovers from one type of land use to another.

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[17] Approximately another 13,000 acres had been preserved through other programs such as private land trusts and the many PDR programs run through the state of Maryland. The county's stated preservation goal is 40,000 acres.

[18] Because landowners get roughly 1 TDR per acre of land, the TDR price is approximately equal to a price per acre preserved.

[19] Recently, it has begun to offer small premiums for particular properties.

[20] A common criticism of the Calvert program, particularly among farmland preservation advocates, is that the zoning in the sending areas is not restrictive enough and that development is interspersed to too great an extent with farmland. The program targets an amount of farmland preserved and not a particular location for that farmland.

The Calvert program, and many other programs in Maryland, has the specific goal of preserving prime farmland, regardless of location and regardless of other characteristics of the properties. Not all TDR programs in the United States have a farmland preservation focus. Historic preservation, erosion control, habitat protection, and water quality are a few of the objectives in other programs. The Tahoe program that we mentioned above has water quality in Lake Tahoe as its primary concern and limits development to reduce runoff and sediment pollution in the lake. The Santa Monica Mountains Transfer of Development Credits program tries to limit development because of the steepness of the land in this coastal region and the concomitant erosion problems created by development. It may be difficult, however, to set up TDR programs to achieve multiple goals, especially farmland protection and water quality benefits. We discuss this possibility in Section IV.

3. Development impact fees

Development impact fees are up-front charges applied to new developments to cover the cost of providing public services such as roads, sewers, and schools. The basic premise is that new developments should cover the full marginal costs that they impose on the community; existing residents should not have to pay, in the form of increased property or other taxes, the additional costs of servicing the new developments. In fact, if the added public service costs are covered by property taxes on all properties, the new development is being subsidized by existing residents. Brueckner (1997) theoretically models the growth paths of cities under different infrastructure financing schemes, including both impact fees and shared financing arrangements such as property taxes. He finds that aggregate land value is greatest under an impact fee scheme—i.e., impact fees yield an efficient outcome. In theory, impact fees, if they are indeed based on marginal costs, should discourage new developments from "leap-frogging" over existing developments and away from existing sewers, roads, schools, and other infrastructure. By increasing the relative cost of developing "greenfields," they provide a financial incentive to keep those areas out of development. The burden of the fee is likely to be shared among landowners, developers, and homebuyers depending on the relative elasticities of supply and demand for buildable land (Yinger, 1998).

Twenty-eight states now have legislation that permits the use of impact fees, and the use and amount of these fees are both on the rise. Adams et al. (1999) report that the 1990 national average for impact fees assessed on single-family detached dwellings was $5,729; fees on retail and office developments were lower. Usually fees vary with the

type of dwelling with larger houses, detached houses, and/or houses on larger lots incurring higher fees. Often, separate fees are assessed to cover different services such as schools, fire protection, and sewers.

Impact fees do not always work in practice the way they are conceived in theory. It is difficult to calculate marginal costs, and, thus, average costs are often used instead. When this is the case, the impacts on the land market and the resulting patterns of development are not efficient (Carrion and Libby, 2001). Moreover, implementing an impact fee program can be difficult and costly. Several court cases have determined that impact fees cannot be used to cover operation and maintenance of existing systems but can only be used to cover the costs of providing new services. Developers have the legal right to know exactly what the fees are being used for; thus local government often has to spend time and resources justifying its position (Callies, 1998).

Impact fees have some of the same effects, in theory, as TDRs. Both instruments act like a tax on new development and raise the price of new houses. Impact fees have a more uncertain effect on the preservation of open space than TDRs, however. Legally, the fees can only be set to cover marginal infrastructure costs, but this may not be enough to discourage low-density development of greenfields. Moreover, even if some greenfields are saved, they are not permanently preserved from development as in a TDR (or in a PDR) program. Impact fees also do not distinguish one greenfield property from another. For example, one parcel may be steeper, closer to streams or rivers, and/or may contain wetlands, but as long as it has the same public service costs, it will be assessed the same fee as another parcel less critical for water quality or other environmental concerns.

IV. Using Land Use Policies to Achieve Water Quality Objectives

In this section of the paper, we evaluate each of the three instruments' potential for achieving the specific goal of improving water quality in the Bay. We conclude the section with a discussion of coordination of land use policy instruments and input-based instruments designed to control nonpoint source pollution.

1. TDRs and PDRs

TDRs can be an efficient policy tool for achieving land preservation goals when those goals are not highly dependent on location and individual property characteristics. If a local government wants to maintain a cap on overall development within the jurisdiction to preserve a specific amount of privately owned open space, a TDR program with a relatively straightforward design can be a very good option. As we described in Section II above, it appears that there are environmental reasons, including water quality benefits, for preserving open space from development and for clustering development. The Calvert County program shows that a well-structured TDR program can work well in the real world. Transaction costs appear to be low in the Calvert program, trading is brisk, and prices are relatively constant across transactions.

When the location of preserved properties is of central concern, however, TDRs need to be modified or coupled with other instruments. For example, if a community wants to preserve specific environmentally sensitive parcels of land, it may not want to rely purely on TDRs to achieve that outcome. This is the advantage, in our opinion, of coupling a TDR program with PDRs; the government can use its own funds to target particular properties that it wants to preserve to improve water quality that the private TDR market may not preserve. The economic efficiency properties of a simple TDR program are preserved, while the social benefits of preserving open space in particular areas is achieved. Moreover, the PDR program still allows landowners to make decisions for themselves.

PDRs can be costly, however, and as we mentioned above, it is possible that local governments cannot raise the necessary revenues to fund a PDR program to the extent necessary to accomplish their goals. An alternative would be to structure the TDR program to try to achieve these outcomes. To do this, the allocation of development rights to individual properties would need to vary by property characteristics (other than acreage). For example, properties with stream access, wetlands, or other features relevant for water quality protection could be allocated a smaller number of development rights if they were used on the property, compared to the number that would be sold from the property. In the language of TDRs, they could be given higher "transfer ratios." Until 1999, the Calvert program had transfer ratios of one to one on all agricultural properties in preservation areas. For example, a 100-acre farm zoned at one unit per five acres

would be permitted 20 houses on the property itself or could sell 20 development rights.[21] Some TDR programs have transfer ratios as high as 40 to one. The New Jersey Pinelands program has a transfer ratio of four to one; Montgomery County, Maryland, five to one; and Dade County, Florida, eight to one (Pruetz, 1997). The higher the transfer ratio, the greater the financial incentive for property owners to sell their development rights. A TDR program that targets both an overall amount of open space and the location of that open space may be able to utilize differential transfer ratios to achieve these dual goals.

Interestingly, the state of Maryland may have done some of the work already in classifying properties for water quality purposes. In 1984, the state designated so-called "Critical Areas," lands within 1,000 feet of the Bay's tidal waters or adjacent tidal wetlands. There are three categories of land within Critical Areas: Intensely Developed Areas (IDAs), Limited Development Areas (LDAs), and Resource Conservation Areas (RCAs). There are already some restrictions on these lands. The state requires that new developments built in IDAs implement best management practices that reduce pollutant loads by at least 10% below what they were before the development. In LDAs, developers must retain or replace forests and there is a minimum forest cover requirement. In RCAs, development is limited to a density of one dwelling unit per 20 acres. The general Critical Area designation and the three individual categories within Critical Areas could possibly be made use of in a TDR program with differential transfer ratios.

Even a high transfer ratio may not be enough to induce some landowners to sell their development rights and preserve their land. This is a feature of market-based mechanisms such as TDRs that worries some environmentalists and land preservation advocates. Incentives are provided, but ultimately it is up to the individual property owner to make the final decision. This is true of PDRs as well. An alternative, then, if particular properties are deemed so critical for water quality protection that development should be banned, is for local governments to set restrictions on development on those particular properties.

This tactic is employed in many programs, including the two programs in existence in the United States that have water quality improvements as their primary

[21] There can be some slight adjustments to a calculation such as this based on existing building units on the property.

objectives, the Lake Tahoe program we mentioned above and the TDR program in Lake County, Florida (Pruetz, 1997). Both programs use classification systems for properties to determine the degree to which development would contribute to pollution. In the Lake County program, the county uses a point system to limit densities in a protected area near the Wekiva River and allows property owners in those areas to transfer rights to designated receiving areas. No transfers have taken place, however, because baseline densities in receiving areas are acceptable and because each individual transfer must be approved by the county zoning commission and the board of commissioners. The Tahoe program sets an overall cap on development in the region, thus it has the goal of preserving open space and simultaneously targeting development to those areas that are most capable of handling it. Individual properties are assigned a "capability class" number ranging from 1 to 7 that determines whether development is permitted on the property at all and, if it is, the extent of impervious cover allowed. Property owners who want to develop their property must then purchase an impervious surface coverage right, a residential allocation right, and residential development rights. All of these rights, as well as commercial floor space and tourist accommodation rights, are traded on separate markets. In addition, separate markets exist for transfers from undeveloped properties and transfers from already developed properties.

The Pinelands Transfer of Development Credits (TDC) program in New Jersey also uses an approach in which individual properties are treated differently. The number of TDCs that can be sold from a property varies depending on how many buildable lots the property is deemed likely to support. Farmland is eligible for the most development credits, forested lands next, and wetlands the least. Huntington County, one of the counties in the Pinelands region, goes so far as to use individual topographical and soil characteristics to assign each property that applies to be in the program a specific number of TDCs.

Added complexities such as those in the Tahoe program and the Huntington County Pinelands program add to the administrative and transaction costs associated with using TDRs. Even a simple adjustment such as altering transfer ratios by location can increase the administrative costs that the government incurs with the program. And transaction costs in a complicated program such as Tahoe's, with five separate but interrelated markets, are likely to be quite high, thus mitigating the efficiency of the TDR approach.

Using TDRs to protect water quality in the Chesapeake Bay would have some additional challenges because of the programs that already exist in several Maryland and

Pennsylvania counties. These TDR (and other) land preservation programs are focused, for the most part, on farmland protection. Thus, one challenge if such programs were to include water quality goals would be figuring out how to balance what are often competing interests and objectives.[22]

2. Development impact fees

As we explained above, impact fees assessed on a new development can only be legally set to cover the marginal cost of providing public services to that development. Fees often vary by the type of development—retail, office, and different kinds of residential development—but not by the type and location of land that is being converted to an urbanized use. In order to use fees to discourage building in sensitive areas, it would be necessary to charge higher fees in those areas than elsewhere. If this could be done, impact fees could be a useful policy tool for discouraging development in environmentally sensitive areas. In the same way that transfer ratios in a TDR program could be higher for properties in, say, designated Critical Areas, an impact fee program could charge higher fees for development in such areas. In fact, impact fees and TDRs, as we mentioned above, can have quite similar effects, at least in concept: one is a price-based instrument and the other a quantity-based instrument but both are designed to reach the same outcome.

One potential advantage that impact fees have over TDRs is that they may allow for differential effects *within* a land parcel and not just across parcels. Development rights are necessarily defined over a landowner's total property acreage, some of which may be in a Critical Area or other environmentally sensitive area and some of which may not. In other words, a landowner may have 100 acres, only 30 of which are in areas where development would seriously impact water quality. Generally, rights cannot be sold for a specific section of a property and it would be difficult to structure a TDR program to do that. It may be easier to assess impact fees that vary depending on exactly where development on a property takes place, thus discouraging development on the portion of the property that is within the sensitive area.

[22] The Lake County and Tahoe programs deal primarily with residential development versus undeveloped lands but not agriculture.

This view of impact fees makes them seem more like an input-based policy instrument rather than a land use instrument—i.e., something more like set-aside programs and the like that encourage farmers to protect particular portions of their farm acreage. This brings us to the point that PDRs, TDRs, development impact fees, and other land policy tools that deal just with the broad question of development versus preservation are not, by themselves, going to be able to efficiently address water quality concerns. They do not deal with the question of what kind of development is taking place on the property that is used for residential development, what kinds of agricultural land management practices are used on land that is preserved for agriculture, and a host of other land utilization issues. Residential development techniques can include so-called "low-impact development" designed to limit stormwater runoff by landscaping and limiting impervious surfaces and can be clustered so that open space is preserved (Coffman et al., 1998; http://lowimpactdevelopment.org/). Agricultural landowners can use conservation practices, plant cover crops, limit fertilizer and pesticide use, and employ a host of other BMPs. And BMPs exist for land in managed forestry as well. In the next section of the paper, we discuss the lone article in the extant economics literature that deals with long-run issues of land use and nonpoint source pollution and attempts to identify efficient combinations of policies.

3. Modeling land use and nonpoint source pollution

A number of economists have examined the efficiency of various nonpoint source policy instruments, including input taxes and subsidies, partial land retirement policies, and taxes based on ambient conditions (see, for example, Cabe and Herriges, 1992; Horan and Ribaudo, 1999; Ribaudo, 1989; Segerson, 1988; Shortle et al., 1998). These indirect instruments are analyzed because directly measuring and taxing individual discharges is impossible in the case of nonpoint sources. Thus, these studies search for second-best policy instruments. Land use in these models is typically treated as an exogenous and fixed factor of production. Some researchers have looked at short-run changes in some land uses such as crop rotations and set-asides of certain portions of land parcels, such as through the Conservation Reserve Program and the Wetland Reserve Program, but these effects are within a particular sector, agriculture, and do not address long-run land shifts between land use sectors.

An exception is a recent paper by Sanchirico et al. (2001). In the general equilibrium model developed by the authors, land parcels can be put to alternative uses and pollution-related activity levels can be varied for those uses. Thus the model

addresses the relative amounts of land in, say, agriculture versus residential development, as well as the level of fertilizer use, soil conservation practices, the extent of impervious cover, and so forth. The amount of land in alternative uses is determined endogenously in the model by the relative prices of land that are, in turn, determined by the economic returns from different land utilizations. The authors incorporate the uncertainty associated with nonpoint source pollution by allowing stochastic factors such as the amount of rainfall and unknown factors such as soil permeability and topography to affect runoff and ambient conditions.

Sanchirico et al. assume there is a water quality standard that the government wants to meet in a least-cost manner. They solve for the social planner's outcome, i.e., the least-cost solution, then examine alternative input-based and land use policy instruments that can be used to achieve this solution. They analyze a transferable development rights program in which there is a total fixed number of rights available and a particular number must be surrendered by landowners for each use. The government needs to design the TDR program so that land uses with greater expected negative effects on water quality must surrender more rights. The authors find that it is possible to design the TDR program to achieve the least-cost outcome as long as TDRs are combined with an input tax scheme. Neither instrument alone can yield the least-cost solution. The authors run some simple numerical simulations of the model with two inputs and two land uses to explore the relative cost differences among the policies. They look at a scenario in which not all inputs can be measured and taxed by the government, as well as a scenario in which the government can tax all inputs. They also assess a situation in which there is a positive rent associated with open space land to see whether allocating land to open space helps to achieve water quality goals. As in their theoretical model, they find that combining TDRs with input taxes is best. However, using input taxes alone, in some scenarios, gets close to the least-cost solution, while TDRs alone do not.

The Sanchirico et al. study is a good first step in analyzing how to coordinate input policies and land use policies for purposes of achieving water quality goals. It shows the importance of land markets in a long-run, general equilibrium model of land uses and water pollution. Further work is needed on this topic, however. The simulation results in this study highlight the importance of the real-world situations that policymakers face in that much depends on observability of inputs, the relationship of the different land uses to pollution levels, the effects of open space, and the design of the TDR program. Useful extensions of these simulations would involve more detailed real-world scenarios. The way that TDRs are modeled in the Sanchirico et al. framework is

not the way that TDRs work in practice. In reality, TDRs are used to increase the density of residential development beyond baseline zoning. They are not required for agricultural or other uses; thus, landowners do not need to have a different number of rights for different types of activities on the land, as in the Sanchirico et al model. How a more realistic TDR scenario would affect the results would be worth analyzing. Also, the issue we mentioned in the preceding section remains—it would be difficult to design a TDR program to address multiple objectives such as farmland or habitat protection and attainment of water quality targets. Since existing TDR programs in the Bay watershed focus primarily on farmland protection, any thoughts of using TDRs to also achieve water quality goals would first have to recognize and address this issue. Modifying the Sanchirico et al. theoretical model to incorporate multiple environmental objectives would be useful.

V. Conclusions

Land use surrounding the Chesapeake Bay is of increasing concern for the Bay's water quality conditions and aquatic health. The expansion of urban areas in the past 30 years and the associated impervious surfaces, septic systems, and transportation systems have had an impact on Bay water quality. Similarly, the increased size and intensity of certain agricultural sectors are a major source of excess nutrients in the Bay. The effect of these land uses on the Bay, however, are complicated by the large variation within each of these broad categories, caused by the differences in natural factors such as soils and hydrology, the variety of inputs applied to the land, and the range of different controls undertaken to prevent pollutants from flowing to the Bay. There is evidence that forested and open space areas near or adjacent to the Bay appear to cause less damage to water quality than other land uses. Some types of farmland may be better than urbanized uses; however, more work needs to be done to better understand the effect of combinations of land uses, natural characteristics, and inputs used on the land on water quality.

Land uses and land use change over time have been determined by market conditions but also in important ways by local land use policies, such as zoning and other regulations. Many local government are turning their attention to alternatives to the traditional land use policies. These alternatives include market-based policies, which offer promise, either alone or in concert with other policies, to reduce pollutant levels to the Bay in the future. We have reviewed three of these policies here—TDRs, PDRs, and

development impact fees. We find that each of these instruments has much to recommend them, but none of them is without some shortcomings. TDRs can be used to maintain a cap on overall development in a jurisdiction, directing that development more densely in some areas, and preserving undeveloped land in others. This more clustered pattern of development should result in less water pollution than a more dispersed development pattern. TDRs can also be used to protect large areas of land that might be targeted for protection, for example adjacent to the Bay. Zoning for very low density in these regions, but allowing land owners to sell larger amounts of development rights from the land, gives them the incentive not to develop. This strategy has been used with some success in Montgomery County, Maryland, and in the Pinelands in New Jersey.

When the location of preserved properties is of central concern, PDRs can be used alone or in conjunction with TDR programs. PDR programs can target particular parcels that may be important for water quality and whose owners, due to the voluntary nature of TDR programs, may not participate in a TDR market. The dependence on government funding may limit the extent of PDRs' use.

One of the main problems with any of these land use policies is that they are local in nature, while the water quality problems in the Chesapeake Bay watershed cover a much wider area. The Bay watershed includes not only hundreds of local government jurisdictions that set most of the land use policies, but it includes six state governments as well. Land use policies implemented in one region may have implications in other areas. For example, down-zoning and a TDR market in one jurisdiction may increase housing prices and simply cause development to go to a neighboring jurisdiction. Land use policy must somehow account for this regional aspect of its impact on water quality. The other problem is that land use policies as they are now implemented in the Bay watershed tend to be focused on other issues than water quality, primarily farmland preservation. If there are joint goals that include water quality, then a combination of land use policies and other input policies may offer the best options for achieving both goals. More study of this important issue of policy coordination is called for.

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