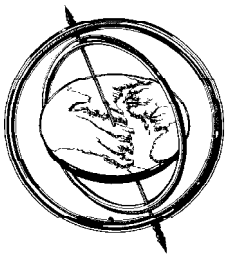

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SUSTAINABLE DEVELOPMENT FOR THE CHESAPEAKE: LAND SETTLEMENT CONNECTION

Leonard Shabman
Virginia Polytechnic Institute and State University

INTRODUCTION

Land settlement, more than foreseeable population and economic expansion in the Bay region, is the sustainable-development challenge. The Year 2020 panel defined two landscape visions that I will use for my working definition of sustainable development (Year 2020 Panel).

First there were urban places where the population lived in geographically compact cities and towns, with residential, employment, shopping and public services within short distances of each other. Meager urbanized land use, served by facilities to handle waste from human activities, minimized adverse environmental effects. In addition, public service costs were in line with tax receipts.

These compact communities small and large were surrounded by "extra-urban" farmland and forestland providing landowners with a competitive economic return, even as production practices reduced soil and nutrient runoff and maintained wildlife habitat. Within these natural areas and open spaces unsuitable for agriculture or commercial forestry (or reserved from these uses), abundant recreation opportunities were available for all the population while supporting ecotourism jobs. Meanwhile, a renewed Bay provided a robust income for commercial watermen.

Today, the Bay's fisheries are under stress, but some stocks are recovering. Much farmland and forestland is no longer in active production, although many productive lands continue to offer income opportunities. However, of most concern is the new landscape pattern that is emerging. Commercial and residential activity is relocating beyond original city and town centers. Land is being used to separate the following:

- Individual homes on large lots in the name of privacy.
- Places of residence, places of work, and public facilities in the name of preserving neighborhoods or in the name of enjoying the "country life."
- Socioeconomic classes from each other by the development of new and remote population centers at the "edge" (Garreau, 1991) of older central places, as images of crime and congestion make spatial separation appear to be an escape from the pathologies of urban areas and inner suburbs.
- First and second homes in the name of quality leisure time.

Linking these separated pockets of distinct land uses is a network of roads forcing reliance on the automobile for long commutes as well as for the most modest household or business errands.

This separated land use pattern is commonly called "sprawl." Concerns over the "costs of sprawl" motivated the Year 2020 Panel, and then subsequent growth management studies in the Bay states. Virginia now has a Chesapeake Bay Preservation Act and Maryland has a Critical Areas Program, both to regulate land use at near-shore edges of the watershed. However, the economic and environmental consequences of separated land settlement may occur far from the water's edge.

Sprawl development is said to threaten the food supply, to raise tax burdens, to diminish the quality of public services, to increase the price of housing, to reduce the competitiveness of the economy, to degrade air and water quality and to fragment the landscape in ways that destroy fish and wildlife habitat.

Is all this true? I'm not sure, and the empirical evidence is mixed (Shabman, 1991). I will not

challenge these assertions here. Nor, as you might expect from an economist, will I discuss the social costs and benefits of different land settlement patterns. Suppose I provided such a benefit/cost analysis, and suppose I told you that sprawl was indeed "uneconomic." The Bay resource managers would still be without an understanding of their policy alternatives for addressing sprawl.

They might even turn to the typical type of policy recommendations, represented here by the text from a recent report on the Chesapeake Bay Program. (Similar sentiments can be readily found in most "growth management" reports.) The report said that the Chesapeake Bay Executive Council should "actively advocate the passage of state legislation that provides strong guidance and incentives for improved land use planning, including measurable criteria for development, as well as implementation schedules and enforcement measures."

This call for more planning, followed by "tougher" zoning, jumps past the critical first step in the making of land settlement policy understanding why we are settling and using the land as we are. The failure to analyze why we settle the land as we do explains why regulatory zoning has not proven effective in achieving a landscape described by the Year 2020 Panel.

Economists' most important contribution to making of land settlement policy is to provide a systematic understanding of peoples' land use choices in the presence of incentives and constraints created both in markets and by public policy. One economist, (Hite 1979), has put it this way. In any advanced society, land use patterns are an inevitable result of government policies toward basic social institutions. If those patterns are economically wasteful or environmentally unwise, the remedy lies in institutional reform on a broad scale. Conventional land-use planning and zoning are merely symptomatic prescriptions that fail to correct the underlying institutional flaws responsible for the problem.

Economics can offer many valuable insights on the land settlement issue. However, the complexity of the topic means a short paper can only illustrate the economic way of thinking about the problem. Indeed, I will need to simplify and generalize in many ways as I address three questions:

- What are the barriers to geographically compact settlement?
- What are the barriers to the economic prosperity for extra-urban lands?
- What policy approaches are necessary to move closer to the Year 2020 Panel's landscape vision?

What Are the Barriers to Compact Urban Settlement?

A preference for a sprawled settlement may be rooted in our nation's culture and history (Jackson, 1985). Many of the early suburban enclaves are today viewed as cities. For example, the Yonkers area near New York City and the Chevy Chase area north of Washington, D.C., were suburbs that grew along early public transportation arteries. However, these suburbs used little land in their creation because transportation from a public transit station by foot or carriage limited the spread away from each train or trolley stop.

The association of suburbanization with low density settlement and separation of land uses is a phenomenon of more recent decades. The trend toward more land-consuming suburbanization arose, according to Anthony Downs (1989), after World War II as a result of a particular vision of how U.S. metropolitan areas ought to be developed to meet the preferences of the population. And, those preferences called for the dedication of more land to residential, transportation, commercial, and industrial uses and to separation among and between uses.

Downs describes a living arrangement aspired to by nearly all American households – the ownership of detached, single-family homes on a spacious lot. In more recent times, with increased leisure, and with those in retirement having more income and greater health, people have moved to the coastal areas where they can gain access to the waterfront, perhaps by owning a piece of the shoreline. The movement of retirees to the coast has been a striking demographic feature of the last two decades.

This residential aspiration is accompanied by the desire to own and use a personal automobile. Indeed, Kenneth Jackson (1985), in describing America's world position in transportation systems, argues that we have always had the best personal transportation that technology had to offer. First, it was public transportation that made our cities function and the early suburbs grow. That public transportation system has been replaced by the world's finest system of private transportation as our society has devoted vast resources to the "comfort" of the private automobile.

With separated homes and access to roads and the automobile, the ideal workplace and commercial center could consist of predominantly low-rise office or industrial buildings or shopping centers, in attractively landscaped, parklike settings. The access to these places was not the pedestrian walk,

but rather the generous, in both size and cost, parking opportunity. It has been said that one element of the success of Walmart stores has been the hospitality each store's entrance design seems to offer to the automobile (Larimer, 1991).

Downs then concludes that overlying this ideal vision is a governance system with roots that go back to the founding of the nation. Americans want to live in small communities, where governments are responsive to the wishes of existing residents. Communities are places where people are of like mind and social class. Not surprisingly, communities act to keep out those activities that are deemed incompatible with their goals be those activities low income housing, racial groups, landfills, recycling centers, or any number of other LULUs (locally unwanted land uses). The NIMBY (not- in- my-backyard) syndrome, where regional and national consequences of local land use decisions are not expected to be a consideration for local communities, has become part of the American vision (Kenyon, 1991). In today's America, the concept of community does not have an extended geographic reach.

This description of the American vision of settlement, transport, and governance applies to people in all regions. Thus, from the small town along the Bay to the Virginia suburbs of Washington, D.C., pattems of land settlement are emerging that, at first analysis, provide evidence for the existence of the strong demand for separation. In fact, these benefits of separation yield higher land prices in economic models that control for other factors that influence the land market (Coulson, 1991). However the land market is not a free standing institution. Market outcomes are influenced and supported by public policies. Also, people's preferences are not fixed, but evolve, in response to new information, new living opportunities, and new technologies.

How people's preferences for living arrangements are formed and then realized through the land market and through public policy is something we areonly beginning to understand. Still, although complex models of land settlement tend to break down, the application of simple economic logic offers powerful insights into how public polices can create incentives for the current pattern and density of land settlement. This economic reasoning can be illustrated with discussion of a few selected public policies.

National Mobility Policy

For the individual landowner, the price of separation is the cost of travel between her residence, other people's residences, and commercial and employment sites. The cost of travel includes both financial outlays and the value and inconvenience of the time spent traveling. Standard economics (and common sense) tell us that the amount of separation demanded will be inversely related to its price the cost of travel. Therefore, changes in policy that reduce the cost of travel will increase the demand for distance.

Not well recognized, but obvious, is that improvements in automobile comfort – seating, sound systems, air conditioning, cellular phones all act to reduce the inconvenience cost of travel. In the policy realm, both U.S. gasoline taxation policy and transportation infrastructure policy reduce the cost of travel. Clearly the time cost of travel can be reduced by highway improvements to reduce traffic congestion and the distance between places. Indeed, it does not take a complicated analysis to predict that continually expanding our road and bridge capacity, extending it away from central places, supports separated land uses (Pauly 1992). However, the highway construction program is a political response to the belief that highways bring prosperity (a questionable assertion) and is a response to the demand for more driving. That demand, which begins with Downs's vision about the role of the automobile, is further encouraged by our national energy policy.

Consider how public policy unwittingly has influenced the price of traveling a mile. As a result of federal regulation, the fuel economy of automobiles on the highways has risen from 13.5 miles per gallon of gas in 1971 to about 21.7 miles per gallon in 1991; an increase of 60%. During the same time, the price for gasoline went from $0.43 per gallon in 1971 to $1.00 per gallon in 1991. However, adjusted for inflation, the 1991 gasoline price (in 1971 terms) fell 30% to $.30 per gallon.

A combination of 60% better gas mileage with a 30% drop in the inflation-adjusted gasoline price lowered the cost of driving and thus the price of separation. In the period from 1971 to 1991, the real fuel cost (1971 base) of driving an average car for 100 miles fell from $3.19 to $1.38, or by 57%. Recognizing how much the fuel price of separation has fallen partly explains why vehicle-miles traveled rose by over 60% between 1977 and 1990, an amount far greater than the rate of increase in driving age population. The falling cost all costs of travel helps to explain the increasing demand for separation and the political pressures for highway and bridge capacity expansion.

Housing Policy

The national vision for home ownership described by Downs has found its way into our national tax policy toward housing and has indirectly affected our coastal settlement patterns. Consider two illustrations. The federal tax code, and the state codes that follow it, permit deductions for all interest payments on all home mortgages. One purpose of that policy is to make home ownership possible for people who might otherwise not be able to make mortgage payments.

One possible side effect of the full deduction is that it increases the demand for land, in addition to the houses on the land, because interest costs for both the land and the dwelling unit are deductible from taxes. Another possible effect may arise because the home mortgage deduction also may be taken for second homes along the coast, increasing the demand for those kinds of properties.

The tax code provides a one-time exemption from capital gains tax liability for homeowners who sell a house after the age of 55. While there are many factors at work, the movement of retired people to the coast, and their subsequent purchase of large (perhaps waterfront) lots, has been at least supported by this tax exemption.

Finally an illustration particular to coastal areas is federal response to coastal storms. There is at least some evidence that the insurance rates charged for hurricane and flood damage are out of line with the likelihood and consequences of those kinds of storms. As a result, premiums for this insurance are too low (Daly 1993). In addition, when storms strike the nation has been generous with aid, to the point where coastal residents who locate in storm-prone areas may feel that the risks will be partly borne by the general taxpayer through disaster aid. This ability to shift costs may encourage some location along the waterfront.

Planning, Zoning and Rational Politics

A part of the ideal American vision is control by local communities over their land settlement. Local control has made zoning an instrument of exclusion in the service of the idealized vision of using land for separation. Zoning is not used to ensure compact and contiguous land settlement. This is, in Fischel's (1985) description, a rational community use of zoning. Consider just two examples of this rational community behavior. The first is the use of zoning for social exclusion. Racial, educational, or crime control policy failures in the cities and close-in suburbs have shifted the demand for separation from those places. In turn, residents who seek to escape these areas then use the zoning tool (or other types of land use control instruments) to exclude groups or types of development from communities where they have now relocated. Fischel concludes that "suburban exclusion of the poor is rooted in a larger social problem whose dimensions transcend the realm of land use control" (Fischel 1985, p. 336).

The forms of exclusion are especially interesting. There would be no legal basis to discriminate on income or racial factors, and there would be no basis for mandating that houses have a minimum prices. Instead, large lot zoning, or minimum building size requirements, are put in place. The justification often given is to protect the environment or to match service availability to the population, but the root cause of these zoning rules may be more suspicious.

The reasons for using zoning for exclusion may also be rooted in the reliance on the property tax as a primary revenue source for municipal government. First recognize that the cost of schools is the dominant item in local budgets. In many areas the perception (whether correct or not) is that property tax revenues from commercial and high-priced residential property, which usually is felt to be large homes on large lots, exceed the local cost of providing schooling services to those properties. Conversely, property tax revenues are expected to be less than the local cost of services for most other residential property, usually higher-density housing. In areas where this belief is strongly held, there is every reason to expect that the poor and higher-density residential development will be zoned out of communities (e.g., by large-lot requirements). Indeed, in the suburban setting, there is reason to believe that residential development in general will be discouraged and that residential settlement will be displaced to an outlying political jurisdiction, or to the inner suburbs, where extensive travel to work and to commercial locations will be required.

The land settlement consequence of rational zoning behavior can be significant. Consider 10,000 acres of land. If the land were urbanized a residential density of 10 persons per acre, as is the case in the planned community of Reston, Virginia, then 100,000 new people could be housed and serviced in that 10,000 acre space (Risse 1989).

Now consider a shift from the Reston density to large-lot zoning of 5 acres per house. Using an average household size of 2.5 people, the 100,000 people who might be accommodated on 10,000

acres in a Reston setting would instead need 200,000 acres of land. This is the minimum land use because it does not include supporting land for roads, public buildings, and commercial establishments, all of which are included in Reston's 10,000 acres.

Reston, which is auto oriented, not auto dependent, includes a mix of land uses and residential housing styles, and within the town boundaries, 40% of the land is open space. In fact, if Fairfax County, Virginia, where Reston is located, were settled in Reston-sized geographic units, and at Reston densities, two-thirds of the land area of that county would be vacant (Risse 1989). This would leave large open areas available for extra-urban, land-extensive economic activities, for ecologically healthy watersheds and for scattered small towns and farmsteads. Risse (1989) defends the Reston vision of land settlement by noting that, "Just about everyone who chooses to live in the suburbs would love Reston. The rest want to live in urbane downtown or on a farm." Unfortunately the Reston mixed-use model is not what many think of when they think of alternative development. We are now developing higher-density residential settlements, but they are still isolated from shopping and work opportunities. Perhaps the next logical move will be to add residential living opportunities to areas of commercial concentration (like Tysons Corner) and add commercial establishments to the singular residential areas.

Those who would choose the highest density/mixed-use urban model might look to the redevelopment of Arlington County near the Ballston Metro stop in Virginia. This settlement pattern is mass transit dependent and auto independent. Not everyone would want to live at Ballston, however the recent development at that site suggests that there is a strong preference for that living arrangement and that significant increases in regional population would choose to locate in very high densities near mass transit points, if the communities were willing and able to encourage such density. Instead, too often the outlying Metro rail stations are surrounded by parking lots not by desirable development.

What Are The Barriers to Economic Prosperity for Extra-Urban Areas?

An extra-urban economy supported by harvesting the water and the land is one part of the sustainable-development vision. How do land settlement patterns influence this economic activity? What are the influences beyond land settlement on these economic activities? Consider first water-related income opportunities.

Some argue that sprawling land settlement creates water quality degradation and spawning habitat loss, which may be partly responsible for the diminished productivity in many fisheries. Harvest pressures may also have been a problem for fish stocks, as seems to have been the case for the rockfish. Imagine that all these problems in the fishery were addressed. There will be many other limits on the economic potential of the Bay fisheries.

First, user conflicts will diminish the future income potential from the commercial harvest of finfish and blue crabs in response to pressure to allocate the stocks to recreational harvest for the urban population. Other types of urban pressures may confront the commercial fishery. Consider the menhaden for example. The fishery has been around for about 125 years. It is responsible for employment that is critical to some Northern Neck of Virginia counties, because there is nothing to replace that fishery employment if it were lost. Yet it is under attack, for reasons unrelated to the health of the menhaden stocks, by those who do not want the boats fishing off the shore of their summer cottages, by those who think (without merit) that there is by-catch of recreational fish (Virginia Sea Grant, 1994), by those who feel that the fishery is taking filter feeders that are more important for water quality improvement than for fish oil and meal, by those who want the menhaden left as a food fish for the recreationally valuable sport fisheries, and by those who have moved near the processing plants and now object to the plant's smell.

The oyster fishery is unlikely to be limited by demands for recreational harvest by "urban dwellers." In fact the limits on the income-producing potential of the blue crab and oyster fisheries are far more fundamental than user conflicts. Today, the blue crab dominates the commercial harvest. The income from this fishery is skewed to few larger firms, with most firms making low net incomes from crabbing. But this has always been the way!!!! The water was never a place to get rich. Still, the single activity of crab harvest can provide an adequate income for only a few watermen. Indeed, for most harvesters the profit margins are so thin that any declines in price or harvest levels (attributable to overfishing) will drive people off the water (Rhodes and Shabman in press).

Oyster populations have been diminished by disease and harvest pressure, but there are economic reasons for the decline as well, reasons that will not be overcome by disease-resistance break-

throughs, by water quality improvement, or by harvest management. The national demand for oysters has been in decline without interruption since the 1930s. Indeed, since that time, national oyster consumption per capita has fallen, while prices have held stable in real terms and incomes have risen. This can only happen if people have shifted their preferences away from oysters to other seafood and nonseafood substitutes (Kirkley and Lipton, 1993). This stagnant demand, as much as MSX, helps to explain the demise of the massive Virginia private grounds harvest which was the dominant production sector in the 1950s and early 1960s (Bosch and Shabman). It is a general consumer shift away from the oyster, and not the Gulf states competition, that will keep the industry from returning to its past glory.

Away from the water, concern has been expressed about landowners' willingness to continue farm production when offered high land prices in the shadow of the cities or for the waterfront of the farm. Land has been bid away from farming, often to remain in speculative holding and often vacant for decades.

The lure of high land prices may not be the only effect of sprawl that is driving farming from the watershed. Challenges of the new suburban neighbors to the perceived nuisances created by traditional farming practices have closed down some farm operations and denied the expansion of others, especially when high-value confined livestock operations were proposed. At times, the paperwork costs for compliance with environmental regulation have become so cumbersome that farm production has been discouraged. There is solid evidence that Virginia's loss of over one-half of it hog production in the last decade areas in large part from regulatory paperwork barriers, and that confined livestock growing is being blocked by local governments in rural areas that are seeking to become high-price "bedroom communities" (Thornsbury et al. 1991). Some point to the positive effect of the urban expansion that creates markets for alternative agricultural enterprises (Heimlich and Brooks, 1989). This may be the case, but "pick your own pumpkin" operations will not be land extensive.

Meanwhile, up and down the East Coast, a transition in the agricultural production sector is being driven by shifts in national farm policy that are letting the comparative advantage of Midwestern agriculture in row crop production take effect (Thornsbury et al. 1993). As a result, for example, Virginia has lost nearly one-half of it's acres planted to corn in the last decade (Thornsbury and Kenyon 1991).

A comment on forested land is also needed. At present, large wood products firms continue to hold significant amounts of land in forest cover in the watershed, and the forest products industry is a major employer and source of income. This land holding would not continue in the presence of high land prices for sprawling development and second homes. The experiences of the northern forests of Maine, New Hampshire, and Vermont, where forest products firms are selling off their historical land holdings may be repeated here (Wilderness Society, 1993). Still there, and here, forest cover will remain stable or maybe increase. What may change is the income-producing use of forest lands as both industrial and private nonindustrial forestland is converted to other types of ownership.

POLICY DIRCTIONS: A FEW SUGGESTIONS

Land settlement outcomes arise from the hidden connections between public policy, market price signals, and location preferences of the population. Understanding and then managing these complex and often difficult to analyze connections must be the basis of a land settlement policy. Some illustrative examples of how to approach these hidden connections are offered next.

Improve the Understanding of Land Markets and Policy

The models that must buttress any understanding of land settlement and policies to direct it are poorly developed (Feldman and Goldberg 1987). However, building such models will rival the complexity of any Chesapeake Bay modeling done to date.

To begin to understand the complexity of the market/policy interaction, consider an existing pattern of employment, commercial, and residential land uses within a region. A rise in transportation costs imposed by raising the gas tax by 50 cents may cause prices of parcels located farther from existing employment or commercial centers to fall and land prices closer in to rise. This relative price adjustment may result in fewer people (lower average density in the outlying areas) than would have been the case without the rise in transportation costs. Meanwhile, higher average density might be achieved nearer to commercial and employment centers. Of course, other adjustments may occur with time. The lower land prices and higher transportation costs might encourage the relocation of commercial and employment centers,

which could result in a new pattern of such centers in the region. Or, perhaps, people will switch employment or shopping locations. This is the dynamic that is leading to the emergence of edge cities.

The observation that the price of individual land parcels and land settlement may adjust to policy changes is as far as the economic model of land price formation leads. More realism about land settlement outcomes is gained by grafting a political component onto the economic, which gives rise to the need to address speculative behavior.

The policy example above was a fuel tax. But other types of policy actions are more obvious to owners of particular parcels. Decisions about highway location or zoning are expected to change directly the pattern and density of settlement and, therefore, the wealth of the owners of the parcels being affected. When wealth-creating possibilities are realized and can be directly attributed to a policy action, landowners who stand to gain or lose from changing land prices are motivated to political action to influence these obvious land settlement policy decisions. Many refer to "speculation in land"; "speculation in land policy" may be a more accurate description of speculative behavior, however. The economic return to speculation is realized more from policy decisions that favorably influence the price of particular parcels of land than from a good guess on the land "market." As a result, those policies whose potential for wealth creation is easily recognized will generate intense opposition from some landowners, and voters and intense support from others. This particular type of political activity over land settlement is most intense at the local level and will influence land settlement to some degree. Of course, when the possibility of "rational" community zoning is introduced, then the ability to understand and predict how land gets used is made even more difficult.

Understanding this complexity lends a perspective to the private property rights movement, which posits a sharp conflict between market-determined prices and uses for private property and public policies that limit use and diminish private property prices. That the price of a parcel of land may be reduced by regulation can not be denied there may be a "wipeout." But spending on a road or a school might increase the price of nearby land parcels – a "windfall." In fact, even as some property prices are diminished by a public decision (e.g. where to place a road), so other property prices will rise owing to that same public decision. The lesson is that private land prices are always a partial consequence of public action, as windfalls and wipeouts are always occurring.

Drawing connections between seemingly diverse policies and land settlement can only be done by identifying, studying, and then doing necessary economic and policy modeling of the determinants of the demand for separation and of the market pressures on the extra-urban economy. This is what should be accomplished in each state's department of planning. As a start, the states should begin to develop land settlement impact assessments of major state spending and tax policies.

This type of analytical effort can only be successful if a closer link is forged between the research and policy-making communities. Although we need to do a better job in researching and modeling land settlement behavior, the resources to support such work by policy economists and related disciplines has not been forthcoming in the Bay region. Think how much we would know if the resources and effort to model and study land settlement had been equal to the resources committed in the last decade to modeling water quality chemistry in minute detail. The efforts of the Population Growth and Development Committee of the Chesapeake Bay Program to expand the research program in the land settlement area will begin to address this need.

Use Market Information and Marketlike Tools For Policy Reform

A sophisticated understanding of land markets and land policymaking is critical, but we can move ahead if we develop an understanding that illuminates the sometimes hidden connections that are barriers to the sustainable-landscape vision. I offer only three examples to illustrate: waterfront settlement, tax policy, and the "extra-urban" economy.

Linear Waterfront Settlement

People will continue to locate permanent and seasonal residences in the Bay region. Often, the residential settlement pattern has been to subdivide a linear section of shoreline into individual lots, each with its own waterfront and boat dock. Residents of these houses, often at the edge of farm fields, then would travel significant distances to obtain commercial and public services, even securing a loaf of bread may be a journey.

A recent economic study of the residential preferences of home buyers in Maryland sheds

light on this purchase behavior and suggests policies to reduce parcelization of the waterfront (Feitelsen). The study found that most buyers wanted access to the water, not ownership of the waterfront. In fact, given the choice, the willingness to pay to own waterfront, if access to the water was available, was quite low.

Among the many initiatives of the Chesapeake Bay program has been the effort to improve Bay access, however this has been seen entirely as a recreational equity issue and a way to build support for water quality improvement efforts. Improved public access – in most of the Bay region today the only way to gain access to the water is to buy the waterfront – may be much more than a recreation and political support issue. It may take the pressure off the market to subdivide the shoreline.

At least one private entrepreneur has seen this demand structure as a market opportunity. The community of Haymont, a 1,600-acre mixed-use development, is now under construction (Bacon 1991). In the development plan, the 3 miles of frontage on the Rappahannock River includes only one boat ramp and a park. Of the total site, 50% is preserved and all houses will be over 1/4 mile from a shoreline buffered by marsh and forest. The Haymont plan will use the remaining land to house up to 12,000 residents in over 4,000 clustered housing units that maintain privacy and offer spacious living quarters. The alternative land use for the Haymont tract would have permitted houses as close as 50 feet to the water and dividing up the entire frontage into house lots. The Haymont model can accommodate a higher average density than is currently permitted for the site, while offering more environmental protection. Of equal significance, the site absorbs population growth that might have otherwise lined up along the waterfront far beyond the Haymont tract.

Tax Policy

Tax policy is about more than raising revenues. Tax policy changes choices people make. An obvious policy that would influence the "willingness to separate"would be a higher, gasoline tax. A higher gas tax has been advocated for air quality (ozone) improvement, but would not be cost effective if only air quality was the objective (Harrington and Walls 1994). Higher gasoline taxes have also been advocated as a revenue- raising device, and indeed that was the logic for the inclusion in the last federal budget.

However, the magnitude of a tax that might influence miles driven and land settlement is daunting. If the real cost of moving a mile in the average vehicle on the road in 1991 was just made equal to 1971 costs, a gasoline tax of $0.57 per gallon assuming $ 1.00/gallon be the current price) would be required. Although the prospects for such a tax may be brighter now than in the recent past, the possibility of having an increase of the magnitude that would raise the cost of driving above its level of 20 years ago is low. Perhaps if the gas tax increase were offset by reductions in income taxes, for example, the political feasibility of making such an increase would improve. But, the longer we wait, the more the settlement patterns get locked in and the more difficult the change will be to make. Indeed, the most persuasive argument against a gas tax is that it places a huge burden on people who have to make long commutes. It is ironic that the long commutes are partly the result of low gas prices of the recent past.

More immediate (and perhaps) realistic reforms to tax and public finance are possible. First, we might abolish the Highway Trust Fund and allow all gas tax receipts to flow into general revenues. Then highway projects would be forced to compete for funds directly against other spending possibilities. Second, we might change how we charge for the provision of municipal services. The basic idea is to ensure that the cost of any additional services allocated to new development are borne by that development. This is not the way services now are priced, except in the use of capital cost "impact fees." If the full life cycle cost to service sprawl development is more than for compact settlement, then setting fees in relation to costs may discourage sprawl. Setting fees in relation to costs is made difficult by the uncertainties about how to compute service costs as a function of development patterns. An excellent review of that issue has just been published by the Bay program (Chesapeake Bay Program 1993).

Third, we might reduce reliance on property taxes as a revenue source. Recall that in the presence of the property tax, rational local zoning may dictate the creation of sprawl development. This rational zoning behavior may be mitigated by reducing municipal governments' reliance on the property tax and changing the financial responsibility for provision of some local services. In Michigan a major tax reform has been put in place that will replace the local property tax and local funding for schools with a statewide sales and income tax alternative. Much of the interest in this change has been about how it will affect educational opportunity for the children of Michigan. The land settlement effects of this policy change may also bear watching.

Adjustments in the Extra-urban Economy

Policies to promote compact and contiguous settlement will reduce the demand for separation and could be expected to restrain land prices. To the extent that development price expectations are reduced and income opportunities from farmland and forestland increase, thus increasing the price of land dedicated to these uses, the pressure for sprawl settlement is relaxed. However, even if land prices do adjust, the sustainable-development vision of "living off the land" may not be economically attainable without additional actions.

First, policies responsive to the economics of extra urban land and water activities will be needed. For example, the oyster has shifted from having mass market appeal to a much smaller niche market. Assistance in the development of such markets, and/or vertical integration of growers with the distribution system, may be needed. Market penetration strategies may be needed for high-value farm crops, if that sector is to move beyond "pick your own" marketing. Traditional row crop agriculture may need a boost from research on alternative varieties and crops more suited to the weather patterns of this region (Thornsbury et al. 1993). Confined livestock raising may be the only alternative that yields a significant income for farm managers, but local govemment zoning may need to be more accommodating of that industry. Forest products firms may need to develop innovative contracting approaches with private landowners, rather than owning forestland in fee simple. Finally, inherent market limits on earning a full-time income from the land and water demands that extra-urban land-owners have nonresource income opportunities to supplement the income from agricultural, forestry, and fishing activity (Stallmann and Alwang, 1992). Therefore, employment retention and expansion strategies for so-called "rural areas" may be critical to keeping land in active farming and forestry. Indeed, some have suggested that new communication technologies make major relocation of employment centers to outlying areas feasible (Schmid 1991).

A second policy theme for Bay managers is to ensure that the efforts to achieve more benign farm and forest production do not drive people off the land with regulatory approaches that are insensitive to the economic structure of agriculture and forestry, both the farm and at the market level. To be sure, some of these activities can be and are detrimental to water quality and habitat. Also, there are agricultural activities that are less environmentally disruptive, but they do have lower returns per acre (cattle), and there are production practices (cover crops) that may raise production and management costs or lower per acre income. There is often no free lunch using less commercial fertilizer will typically mean lower farm income and greater risk, at least in the early years of adoption. Incentive payment programs to facilitate the transition to new production systems, going beyond physical BMP cost sharing for example, offering yield transition insurance for new production practices or providing market development loans for a new animal waste hauling and utilization industry—may be in order (Norris and Shabman 1992).

Under the best of economic and policy circumstances, in some areas the demand (and price) for development land will still exceed the price for land in alternative uses. This price signal should first be considered as evidence that the land should be developed—perhaps in patterns like Haymont or Reston. However, if there is still a case to be made for discouraging development, it may be necessary to acquire development rights to the land so that it will remain in open uses.
A development right is a legally sanctioned authority for a landowner to devote a land parcel to residential or commercial use. Absent specific zoning (other than agricultural zoning), land typically may be subdivided for residential or commercial purposes at some low density, such as one house per 5 acres. Therefore, a requirement for compact development is that low-density development not occur, despite existing rights to that development. Because rights for low-density development now exist and they might be acquired by public purchase or by other developers through a market in transferable development rights. Once development rights are acquired, the land could only remain in open space or very low-density (e.g. one house per 50 acres) uses.

The design of transfer and purchase of development rights systems must be carefully considered to ensure that, given limited revenue sources, there are rules for setting acquisition priorities to get the most cost effective acquisition. Also, transfer and purchase of development rights programs may be "buying back" property values created by other public polices, so care should be taken to ensure that rights acquisition programs are not being implemented in the same areas that public infrastructure or other such programs are supporting higher-density development.

CONCLUSION

Many believe that compact and mixed-use land settlement could accommodate expanding populations in the Bay region, while permitting the possibility of a vibrant extra-urban economy. Of course, providing compelling evidence of adverse fiscal, economic, and environmental consequences of separated land use will be critical to building public support for new land settlement patterns. Then achieving the desired land settlement pattern will require a long-term effort to reverse fundamental forces of public preferences and public policy. Reform can come only slowly, but to come at all will require two changes.

First, there needs to be a new vision of desirable land settlement, promoting "Restons," "Ballstons," "Haymont," and redeveloped, mixed-use, "Tysons Corners." It appears that the market demand for such altematives is present, but our public policies must begin to expand and accommodate that demand. Second, public policies must be based on understanding the causal connections from seemingly diverse and unrelated public policies to land settlement and its fiscal, economic, and environmental consequences. For example, only a land settlement perspective can forge a conceptual link between (1) crime control and enterprise zones in the central cities and inner suburbs, (2) depreciation and tax treatment of commercial shopping mall investment, (3) purchase of development rights, (4) assistance with niche market development for farm products, and much, much more. With this understanding, a conscious land settlement policy, not the accidental policy that now obtains can be the organizing principle for advancing the Year 2020 Panel's vision of sustainable development.

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GOVERNING THE CHESAPEAKE BAY- AN EVOLUTION OF ECOSYSTEM MANAGEMENT

Ann Pesiri Swanson
Chesapeake Bay Commission

RESTORING THE CHESAPEAKE

Chesapeake Bay is the nation's largest and most productive estuary. It is also the first to be targeted for restoration as a single ecosystem. Throughout our effort, sustainability has been a common theme, at least in terms of ecological sustainability. Many lessons have been learned as we have garnered our support, built our partnerships, and developed our programs. Still many more challenges lie ahead if we are to truly sustain the ecological integrity of the Chesapeake ecosystem.

The Chesapeake Bay Program – the cooperative compact forged to spearhead the restoration – has become a model for estuary cleanup efforts across the country. It is multi-jurisdictional in scope, involving federal, state, and local governments and all segments of the public.
Many of the Chesapeake Bay experiences of regional planning and management of ecosystems have taken place under the banner of "watershed management." Close examination, however, reveals that the Bay restoration effort is also one of this country's finest examples of ecosystem-based management and a very real attempt to achieve ecosystem sustainability.

What have we learned and where must we go now that we are roughly 20 years into building our program? What history must we build on as we proceed? And what pieces of our history do we need to change in order to ensure success in our future?

In my mind, for the past decade, governance of the Chesapeake Bay ecosystem has undergone a managerial evolution. What began as a water quality oriented program designed to address the Bay's living resource decline has become, over time, the integrated ecosystem management of land, air, water, and living resources.

Interactions among the decisionmakers of the region – the scientists, legislators, governors, federal state and local government officials, businesses, farmers, and citizens –have similarly evolved and are continuing to evolve as we define the practice of ecosystem management.

Over time, we have come to realize that management decisions employed by the program must factor in not only ecological needs but also socio-economic and cultural considerations. This evolution from watershed management to more comprehensive ecosystem management requires us to constantly assess how we manage the cleanup. As our concepts, knowledge, and constituencies evolve, so must our governance. We must constantly look for new and creative approaches to managing our resources, integrating and financing our programs, structuring our agencies, and meeting the needs of our citizens. Communication is essential. Political leadership is crucial.

So what have we learned from this decade of progress. What are the components that have made for a successful program – one whose governance is studied nationwide?

The conference coordinators have asked me to flesh out these questions. They have asked me to address the issue of sustainability and to focus on the lessons we have learned in our attempts to achieve it. They have asked me to review the often bewildering universe of issues and stakeholder that are responsible for providing workable solutions to the Bay's problems and to make some sense out of our complex program.

At this time, I hope to demonstrate the changes that have taken place since the Chesapeke Bay Program's inception, comparing the more regi-

mented management mechanisms of the past to today's highly interactive and interdisciplinary management structure. In addition, I hope to show that this evolution, while far from complete, represents the gradual transition from a compartmentalized management hierarchy to that of a multimedia management matrix.

As I analyzed the best and the worst of our effort, I couldn't help but identify a number of critical components to the success of our program almost intertwined with some of the greatest challenges, or obstacles, that lie ahead. Somehow, the best of the past must be merged with new and innovative programs to achieve a management system that is comprehensive, interactive, and responsive. After all, whatever we design must be as comprehensive, interactive and responsive as the ecosystem that we are trying to manage.

Managing an Ecosystem: Lessons Learned

Almost two decades have passed since the Environmental Protection Agency (EPA) began its research on Chesapeake Bay and the multijurisdictional management effort was launched. Much has been accomplished, yet many more challenges lie ahead.

A number of lessons gleaned from the Chesapeake Bay experience are now offering the basis for guidelines in structuring ecosystem management programs across the nation. In many ways, these lessons represent the best of what we have done and certainly the foundation for what must be retained in any programmatic changes that we plan for the Bay Program in its future. Lets take a look at these lessons. They essentially boil down to ten central themes.

We Began With a Comprehensive Study That Was Multidisciplinary in Scope, Combining Theory, Detailed Knowledge, and Interactive Modeling and Monitoring.

The EPA Bay program study presented the public and political leadership of the region with a solid, scientific foundation for decision-making. The report determined clear linkages between land, water, and living resources. Highly sophisticated modeling and monitoring efforts were put in place to test the recommendations and rethink them over time to determine the finest, scientifically based approaches to the cleanup. The information gave politicians a strong platform to stand on, and has thus continued to serve as the backbone for policy decisions in the region.

We Tested Scientific Theories and Management Approaches on a Small Scaleand Then Transferred the Results to the Whole Watershed.

In the late 1970s and early 1980s, a number of scientific investigations concerning ecological processes were comprehensively studied in smaller watersheds within the Bay ecosystem. The effectiveness of various point and nonpoint-source controls and approaches to public involvement were evaluated. In the Bay region, testing research methodologies and technologies on a small scale, using demonstration or pilot projects, has lead to increased success when those techniques have been applied more broadly.

The Highest Levels of Leadership Possible Have Embraced Clear, Strong, Specific, and Comprehensive Goals for the Management Effort, Based on the Best Science Available at the Time.

The Bay agreements, and the high-level leaders who have signed them and inherited those commitments, provide an outstanding and enduring commitment to the restoration of the Bay ecosystem. A set of highly specific goals have been adopted that are unmatched nationwide. These goals cover a comprehensive array of issues, including water quality, living resources, growth management, public information and education, research and monitoring and public access. They include such specific goals as achieving a 40% reduction in nitrogen and phosphorus reaching the Bay by the year 2000 and eliminating fish blockages throughout the Bay's tributaries. Goals that are quantifiable make progress measurable and leaders accountable. As public offices change, there is a publicly accountable commitment to continue.

The Success of our Endeavor Lies in the Diversity of the Participants.

The Bay ecosystem is extraordinarily complex - biologically, physically, and politically. A framework to manage it must, and does, involve a complex array of players representing all levels of government, the private sector, scientists, and citizens, These players are coupled with 3 governors, 40 members of Congress, hundreds of state legislators and local elected officials, 13 federal agencies, 4 interstate agencies, well over 1,000 local governments, and more than 700 citizen groups that all play a role in the restoration effort. Within the Bay program proper, there 50 subcommittees and workgroups. This, of course, does not even

include the numerous roundtables and study groups sponsored by the general assembly and others.

This diversity can be viewed by some to be a weakness of the program – contributing to the slow pace in the resolution of issues. Building consensus clearly takes time when so many players are involved. Yet, in the Bay Program this diversity has worked as a strong advantage, giving programs, once agreed to by all, a solid footing to stand on.

The Trick is to Bring Everyone to the Table.

There is a process within the Bay program that, while at times awfully frustrating, results in consensus that is often stronger than the lowest common denominator. Peer pressure of the states helps. The process involves true consensus – we don't settle on language until all can agree. This is largely true for the Chesapeake Bay Commission as well.

No voting occurs – I would characterize it instead as steady negotiation. To the EPA's credit, it is able to keep the process moving. The most important lesson is that anyone and I mean anyone – who wants to have input, who wants to feel a part of the negotiations, can join in.

Rather Than Being Hierachical, the Structure is More Like a Rubic's Cube.

While there is an executive council that leads the Bay program, in reality the restoration effort takes on many forms of leadership. The relationships are widely varied with different players taking the lead on different issues and at different times. Leadership is dictated not only by the subject matter, but also by available resources and is political as well.

The Federal Link Jump-Started the Program, but the States and Local Governments Will Keep it Going.

The Bay cleanup was absolutely jump-started with the congressional and EPA attention afforded to it in the late seventies and early eighties, and the Bay conference that was the result. But the vigilance to the program must now come from the states – and the array of legislative and executive branch actions that will ensure a strong mix of voluntary and mandatory cleanup actions. With state frameworks and guidelines in place, it will actually be up to the local governments to implement some of the most far-reaching goals.

An Informed Public is Key.

An appropriate note to conclude my list of lessons would involve the public. An informed public is key, as all of you know even better than I. An informed public can stand by you as you implement strong measures through general assembly actions. An informed public can support budget initiatives and take matters into their own hands, at the local level, within their businesses and in their homes.

In the Bay region, we have an extraordinarily enlightened public. In a recent survey of residents living within the watershed, the vast majority said they support the clean-up and think even more should be done to restore the Bay. Ninety percent of the people living throughout Pennsylvania, Maryland, Virginia, and Washington, D.C., are concerned about the health of the Bay and support the cleanup. Sixty percent believe more should be done, and two-thirds of the respondents believe the restoration effort should concentrate on making the Bay safe for fish, shellfish, and aquatic life – the current goals of the Bay program.

Interestingly, this support does not appear to vary with distance. Those living within 50 miles of the Bay, between 50 and 100 miles of the Bay, and over 100 miles from the Bay indicate similar high degrees of importance for the cleanup.

But the survey does not tell us that the public is fully enlightened or engaged. Clearly much more needs to be done in the way of two-way communication. For example, many still labor under the mistaken impression that the major problem for the Bay is pipes dumping chemicals from industry. Nutrient pollution was often chosen as the least serious to the Bay, even though the Bay program, the legislative community, and the Bay leadership has spent more than a decade working to reduce nutrients, considered to be the Bay's most serious problem.

Also troubling was the news of how citizens view themselves. Fewer than 10% of the respondents believe individual actions are serious causes of pollution. Clearly, people living in the Bay region do not understand how much their day-to-day lives contribute to the Bay's pollution problems.

Essential to our Ecosystem Management Approach is the Willingness of the Players to Constantly Reassess.

A cornerstone of the Chesapeake Bay Program has been the constant commitment to "pulse taking" and tracing of our progress. The health and vitality of the living resources serve as one important measure of our success. In addition,

routine water quality trends and assessments of pollution loading reductions track our progress in achieving our goals. These measures serve as our canaries in the mine shaft. Periodic research to assess progress toward goals provides new information that, in turn, leads to improved ways of controlling pollution, managing fisheries, and restoring habitat. Regardless of the commitments that have been made in the past, the leadership in the Bay community has repeatedly demonstrated an ability to alter course if new knowledge dictates a new approach is needed. This dynamic approach to management has contributed substantially to the integrity of the program.

Integration is the Ultimate Key to an Ecosystem Management Approach.

Despite the existence of theory, practice, and tools that support the implementation of ecosystem-based management, practical obstacles to implementing ecosystem-based management remain. Central to these obstacles are difficulties in defining management units, understanding the biological, physical, economic, and cultural factors at play, and structuring a management framework that properly integrates all the component parts.

But if there is one thing that we have learned, it is that it must be done. Therefore ,this final lesson serves as both a lesson and a challenge.

WHERE DO WE GO FROM HERE?

The 10 lessons that I just described collectively constitute a framework for governance that helps us to better manage the Chesapeake Bay for its ultimately sustainability. People are a part of the system and therefore must be as integral to any solution as the fish, birds, waters that we are trying to restore.

But in order to truly succeed, we must do more than simply continue to employ the practices contained in these lessons. The conference coordinator specifically asked me to touch on where we needed to go from here. If we have learned so much since the signing of the agreements, is there still more to do to ensure that we meet our goals?

I believe that the last lesson that of integration-provides the perfect transition into the first challenge for our future.

One of the most troubling aspects of ecosystem management—troubling at the national, state, and local level, concerns the compartmentalized management hierarchy that has emerged over time. Each of our states has a bureaucratic structure that separates the management of the ecosystem's component parts. Air is in one department, forests in another, fish in a third. Yet ecologically and managerially, they are all intertwined. The NPDES discharge permits that we issue in one department directly affect the fisheries managed in another. The provision of fish passage might change a section of a river from swimmable to fishable necessitating the need to change the NPDES permit. And so on.

Unfortunately, this compartmentalization can often lead to a piecemeal approach that falls short of the fully integrated ecosystem management that we are trying to achieve.

The compartmentalization of government also has a reverse side – too many individual agencies or departments having jurisdiction over one geographic area or environmental problem. Aspects of sediment control fall under the jurisdiction of multiple departments at multiple levels of government in each of the three states. This overlap is not necessarily a problem in itself, but rather becomes problematic when no mechanism exists to coordinate the different agencies.

Thus compartmentalization causes two distinct governance problems – gaps in ecosystem management where no agency has clear jurisdiction over an issue or environmental medium, and conflicts in governance where too many agencies have jurisdiction and have failed to coordinate their efforts. In the first case, this results in a lack of environmental performance. In the latter case, this results in duplication of effort and an inefficient use of precious financial resources, as well as frustration and perhaps noncompliance on the part of the regulated community.

The answer, however, is not necessarily a radical restructuring of government agencies. After all, many of the "compartments" are structured around the environmental expertise and the professional specialization that we need to solve many environmental problems. In addition, there is no clear best way to structure agencies some environmental problems are medium-specific, some are geographical in nature, and some are issue-oriented. The structure that works for one set of environmental problem may not work for others. The challenge for us as ecosystem managers is to introduce flexibility into how we administer environmental programs by improving communication between these discrete elements of government.

This means more crossing for managers and an

expansion of interagency team approaches to the delivery of environmental protection.

To the extent that any given agency structure is a square peg for a round hole, team approaches smooth the edges of the square. Although we should constantly revisit the idea of restructuring government agencies, introducing flexibility and adaptability into the delivery of public service, regardless of government structure, is critical. Agencies must be able to interact and communicate with one another. Teams representing different agencies and areas of specilization must be able to "spontaneously generate" and "rapidly deploy" in order to adapt to the problem at hand and the stakeholder involved.

It is beyond both my purpose and ability to dictate what the exact structure should be for any given state or region. If we provide the channels of communication and the mandate for cooperation, however, I believe that we can rely on the expertise and dedication of those in the various agencies, especially those who work "on the ground," to come up with solutions and dynamic structures that will succeed. This is what I mean when I say that we can and must make government as dynamic and adaptable as the ecosystems we are trying to manage.

Beyond continuing to develop integrated, flexible, highly responsive approaches to our governance at the state agency or even federal agency level, I believe that we must also rethink the relationship between state and local government. I ask you, Who is responsible for the protection of the rivers, the streams, the air, the land, and the water? Is it the federal government? Is it the state government? Is it local government? Or all three? I believe that it must be all three, and that this management must be in careful synchrony.

Prior to becoming legislators, many of the commission members were previously involved in local government. They remember a local government that did not necessarily see its role as one of protector of the environment. The state was viewed as having that responsibility while the local governments were in the business of "making land use decisions." The two were not seen as intertwined but rather virtually mutually exclusive. Now, of course, we have come a long way in our thinking, and most local governments have made great strides to protect the environment. But I submit to you that we have a much longer way to go.

In a corporation, the parent company sets the policy for the subsidiaries and ultimately the business units beneath. Each component of the company does its best to respect and implement the policies of the various structures of the company while at the same time retaining the flexibility and autonomy necessary to get the job done in the specific day-to-day circumstances it confronts.

Local government is in the same way an agent of the state, the state then being an agent of the federal government. Environmental protection and more specifically fully integrated ecosystem management (that carefully considers the interrelationship of land use decisions on water, land, and air) must become the dogma at every level. It must become the ingrained "business as usual" at every level if we are to achieve success in the Bay region.

The relationship between local governments and the state, in many ways, remains a critical barrier to ultimate success. Taken the other way, it poses the greatest single opportunity for success. If I had to point to one issue, I believe that an active, effective relationship that recognizes the direct interrelationship between air, water, and land use decisions is key to the Bay restoration's success.

In this same vein of thinking, we must begin to heed with greater attention , the public trust doctrine. This doctrine recognizes that the Commonwealth's authority to protect its natural resources is grounded in its interest in the protection of property it holds in the trust for all people. Clean water and clean air. At present, we recognize the police power of the state and local regulatory authority to protect the health, safety, and welfare of the citizenry. We also recognize that an individual has the right to use the waters that flow past his or her property. Finally, we recognize that if that individual does something that affects that water once it flows beyond his or her property, the government has the right to place reasonable restrictions upon him or her.

Regardless of the far-reaching nature of this concept, we are not always good at implementing it. We do not always recognize the cumulative nature of our decisions to the demise of our environment. A subdivision here. A drained wetland there. A denuded forest buffer over there. In isolation, none of these would challenge the resiliency of the environment. The environment is elastic and can take some degree of strain. But if we stretch that resiliency too many times, we will loose it forever.

As we degrade our environment, someone will pay. There is no free lunch. Someone will pay. If we grant a variance to a landowner to do something that we know is otherwise wrong, the cost of the degrada-

tion that variance will cause will be picked up by someone else.

Somehow, as we proceed with this great Bay cleanup, we must work from a cumulative scorecard. We must government the resources as public resources, and government must recognize the substantial responsibility it has to make sure that decisions made today do not become our children's burdens. The tragedy of the commons must not be played out in grand scale in Chesapeake Bay.

Let me close by saying that I have seen great promise in our progress thus far. I have seen, over the past 10 years, the participants in the Chesapeake Bay Program keep their noses to the grindstone and continue to negotiate until some movement forward has been reached. I have seen a remarkable ability and willingness to constantly reassess the situation, and re-group and change course if the most recent information dictates a necessary change.

This stamina and commitment, I believe, will keep us on the mark. I also believe that it will force us to consider some of the changes that I have outlined here today. I hope that you will take them to heart.

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The Significance Of Resoure Scale in Water Quality and Ecosystem Modeling and Decision Making

Robert V. Thomann
Manhattan College

INTRODUCTION

About 30 years ago, I had the occasion to review some work that had been done on the St. Lawrence River to assess the effects of sewage discharges from a large city. The sampling program extended some 5-10 miles below the city and it was indicated that little effect was observed from the municipal input over that distance. Although I had seen the St. Lawrence many times, I had never actually been out on the river. So I got on to the sampling boat and out to one of the main channels we went. It was a very interesting experience because the first thing the captain did was put the bow of the boat upstream and keep the engines going full blast just so we could stay in the same spot to take a water sample. A quick measurement of the water velocity indicated a speed of about 7 ft/sec or about 115 miles a day. Because we were dealing with organic carbon (BOD) inputs and resulting dissolved oxygen effects, with kinetic rates on the order of 0.1/day, it became obvious that the scale of interest was not 10 miles but more like hundreds of miles. Indeed, we estimated that the effect of the discharge was more than a hundred miles downstream, where a slower-moving portion of the river was encountered.

To be nearsighted is to see what is close up, but what lies on the horizon is pretty blurry. To be farsighted is to see the horizon but what's close up is hard to identify. Our task is to be clear-sighted across the spectrum of environmental problem contexts clear-sighted enough to see both near and far, and in addition to know what we are looking for. This paper is about avoiding myopia of the scale of environmental investigation and management, specifically in the context of water quality and ecosystem modeling. The paper also is about assessing our role as scientists and engineers and managers in providing clear directions on where we are to look when addressing environmental problems and to speculate about where we are going.

The paper first addresses the components of the scale of water quality problems. Then some relevant questions are raised about resource scale. The responses to these questions are then offered, followed by a brief justification for the responses in the light of the Chesapeake Bay experience. Finally, some summary conclusions and anticipated future directions are given.

THE COMPONENTS OF SCALE

Scale consists of three components:

1. The spatial extent of water quality responses to external inputs
2. The temporal extent of water quality responses to external inputs.
3. The state variables that are to be predicted.

For the spatial extent, one must decide on whether the problem scope is centered at the meter or kilometer or regional, state, or even international level. More than one problem context has been improperly analyzed or managed because it was discovered only later that the focus of sampling analysis was too limited in spatial scale. Conversely, the focus may be geographically too large and miss the important local effects to which the public may be most sensitive.

For the temporal questions, the scales include hours, seasons, years, and decades. Again, long- term behavior for large bodies of water such as the Chesapeake Bay or the Great Lakes indicate that

for some problem contexts, very long-time scales (e.g., tens of years) of modeling analysis and management issues may have to be considered. On the other hand, exclusive focus on the long term scale may overlook short-term events that may have significant ecological impacts.

The determination of the state variables to be included in assessing water quality and ecosystem problems requires a careful specification of the bounds of the problem. Incorporation of a full suite of nutrient forms and several phytoplankton functional groups together with a determination of the extent of upper trophic levels is an example. For toxic substances analyses, the inclusion of chemical species, dissolved and particulate forms, interactions with phytoplankton, and, organic carbon pools may need to be addressed.

Within these overarching components of scale, we can also identify three other scale-related issues:

1. The scale of computation the resolution of scale (spatial, temporal, state variable) at which model computations are to be made.
2. The scale of observation: the spatial and temporal scale at which field measurements will be conducted and what variables will be measured.
3. The scale of model/management domain: the temporal/spaial/variable scale that influences environmental control actions.

Relevant Questions

With the components of Scale at hand, we might then ask some relevant questions:

1. Who determines the relevant time, space and state variable scales?
2. How does one determine the relevant time, space, and variable scales that must be included in a given problem context?
3. What are the relevant water quality scales?
4. To what degree have the relevant scales changed in recent years?
5. What are the scientific and management consequences of such changes in spatial, temporal, and state variable extent?

ANSWERS /CONCLUSIONS

Based on personal experience, which is hardly reflective of the full scope of problem contexts, and based on a brief and quite unscientific review of the history of water quality analysis and management , I offer the following answers/conclusions to the proceeding questions.

1. Who? For many major water quality contexts, it is the scientific and engingeering community that identifies critical management and control issues related to the scale of the problem and as such "drives" important policy outcomes.
2. How? The determination of relevant scales is accomplished through a combination of field observations, laboratory process studies, and water quality and ecosystem modeling, such work being critical and essential to credible control policies.
3. What? The relevant water quality spatial scales ranges from mm to hundreds of kilometers the temporal scales from hours to decades and the number of state variables range up to about 30. Important multimedia interactions with atmospheric and terrestrial inputs are also now included.
4. Change? Modeling and decisionmaking scales have increased by about an order of magnitude every decade. Almost all of this increase has been in a finer level of spatial detail.
5. Consequences? Such increased scale requires new models of multi-media linking and coupling, much larger observational spatial and temporal scales and control policies that cross media and transcend watershed boundaries.

The Chesapeake Bay Water Quality Modeling Experence

Of course, the history of understanding and identifying relevant scales for the Chesapeake Bay system is very long and distinguished and includes the contributions of many outstanding scientists and managers. It is not my intention to review or specifically identify the heroes of the past work on Chesapeake Bay. Rather, the focus here is on the experience of the development of credible and defensible models of water quality of the Bay to be used for management and decision-making purposes. Because much of the predictive modeling efforts have been directed toward understanding the relationships between nutrient inputs and resulting responses in living resources and water quality, the discussion is further restricted toward that problem setting.

In the context of water quality/eutrophication modeling, three principal stages or time periods can be delineated:

Stage 1: 1970s - 1980s. Steady state modeling with user-specified external nonpoint and sediment nutrient inputs.

Stage 2: 1980s - 1990s. Extensive time variable modeling with associated watershed and coupled sediment modeling resulting in a considerable advance in internalizing previously user-specified inputs.

Stage 3: 1990s - 2000s. Projected further expansion of the modeling frameworks to finer detail in tributaries, expanded modeling of the coastal ocean boundary of the Bay, and linkage of atmospheric deposition models.

Figures 1 and 2 show the schematic progression of the water quality models and outcomes for these two phases. In the first stage, the scientific and engineering application of a steady state representation of the nutrient/phytoplankton processes in the Bay indicated that nonpoint and sediment nutrient inputs were important, if no determining factors in the Bay water quality response.

Figure 1. Schematic of the first stage of water quality modeling for Chesapeake Bay.

Figure 2. Schematic of the second stage of water quality modeling for Chesapeake Bay.

As a result, for the next stage of effort (stage 2), the basic modeling framework was expanded to include a fully time variable hydrodynamic and water quality model (Cerco and Cole 1994) with a coupled sediment nutrient flux model (Di Toro and Fitzpatrick 1993). In addition, the first phase of a Bay watershed model was constructed (Donigian et al. 1991) so that management questions could be addressed relative to the effectiveness of non-point and point source on loadings to the Bay and subsequent Bay water quality response. The significant outcomes of this second stage relative to issues of water quality modeling and decision making were threefold: (1) the significant potential effect of atmospheric deposition of nitrogen on the Bay basin, (2) the relative importance of the nutrient input load from the ocean (3) and the significance of the submersed aquatic vegetation (SAV) and the role of the upper trophic levels (see Funderburk et al. 1991, Batiuk et al. 1992, Dennison et al. 1993, and Thomann et al. 1994). In addition, it was apparent that further more detailed modeling of the tributaries of the Bay was necessary in order to support nutrient control strategies at that spatial and temporal scale.

Throughout these two stages spanning some 20 years, the size and complexity of the modeling frameworks has increased. Indeed, for water quality modeling in general, the size of water quality models has increased substantially. A "compartment" can be defined as the product of a state variable at a given grid location. Figure 3a shows the increase in the number of interactive compartments since 1950. (From the beginning of modeling in the 1920s to 1950, generally only analytical steady state models with a maximum of two variables were used.) As shown in this Figure, from early numerical models in the 1960s with fewer than 100 compartments to the current day with models approaching 106 compartments, there has been an approximate order of magnitude increase in size for every decade. Figure 3b shows that this increase in size is attributable almost exclusively to an increase in the number of spatial cells to meet the requirement of the models of the hydrodynamic transport.

The overall increase in the number of model compartments has been made possible by the increased availability of computing power as seen in figures 4a and 4b. Two points are particularly noticeable about these data: the substantial increase in computing speed within the last ten years,

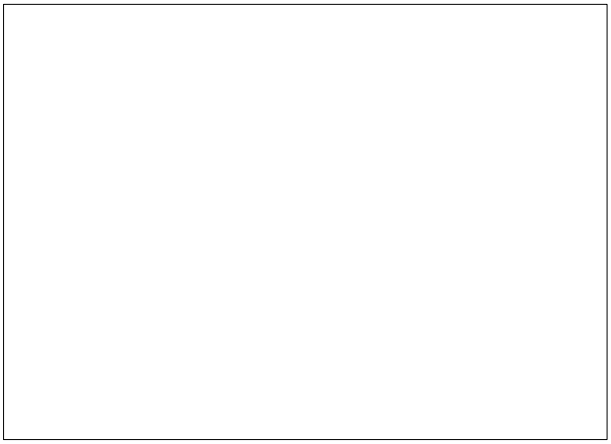

Figure 3a. The increase in size of water quality models where an interactive compartment is the product of the number of state variables and the number of grid cells.

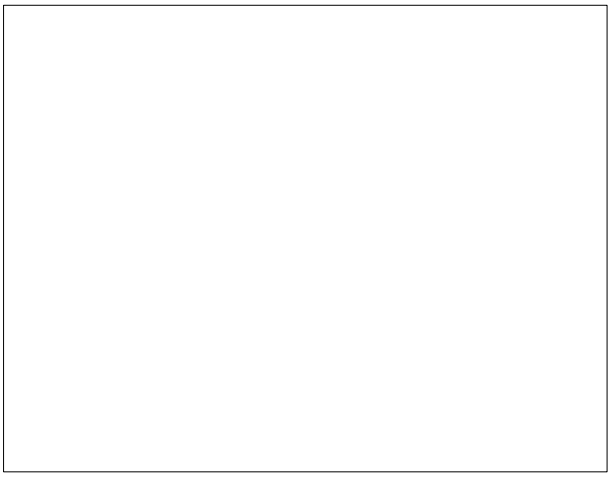

Figure 3b. The increase in model size is attributable primarily to an increase in the number of spatial cells required for the hydrodynamic model.

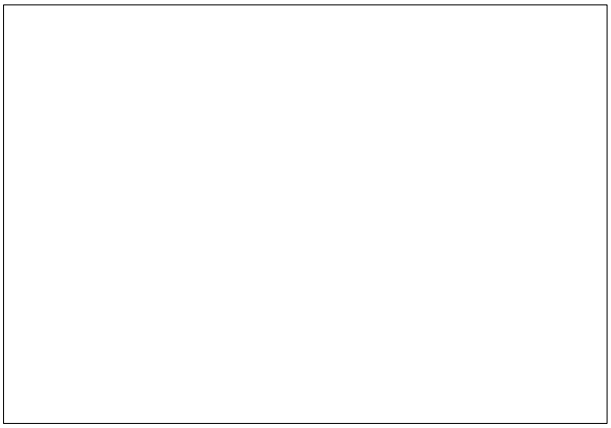

Figure 4a. The growth in computing speed. Data from Chapra and Canale 1994, and G Delic, EPA National Environmental Supercomputing Centers (press. Comm).

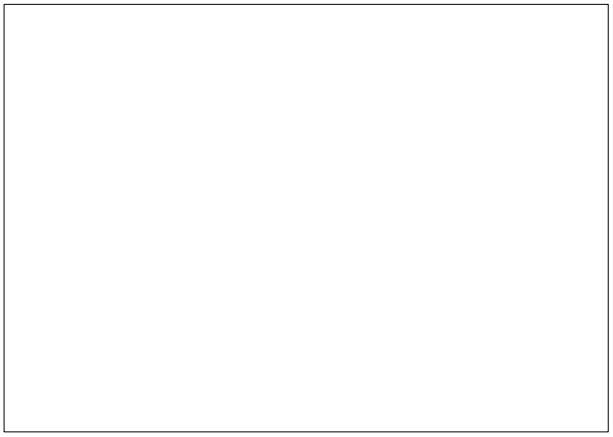

Figure 4b. The improvement in economic computing efficiency. Data from Chapra and Canale (1994), G. Delic, (press. Comm).

especially for small computers (e.g., Personal computers [PC's] and workstations) and the substantial improvement in economic computing efficiency, again for the smaller computers. Any reasonable projection of future trends would indicate that computing speed and economics would generally not be limiting the scope of future directions. This is not to say that computing is cheap or that we do not have the very real capability of filling up larger and larger machines with increasingly complex models. The point is that in order to obtain future increases in the predictive ability of environmental control actions, it is issues such as increased understanding of mechanisms and field observations that would appear to be more constraining than available computing power.

Figure 5 shows the expanding area of the domain of model/managment scale that has resulted from these 20 years of modeling activities. From an early focus exclusively on the Bay (and local regions of the Bay), the domain extended to its watershed, to inclusion of the coastal ocean, and finally the airshed that influences the Bay and its watershed. The resulting spatial scale and associated temporal and state variable scales have increased dramatically. Figure 6 shows the resulting current span of temporal and spatial scales that are operative in the Chesapeake Bay system. The spatial scales extend from millimeters in sediment processes to 1,000 km for atmospheric transport processes. Time scales extend from hour-to-hour processes in hydrodynamic transport to decades in sediment processes. Note that a spatial scale of centimeters affects response times on the order of years.

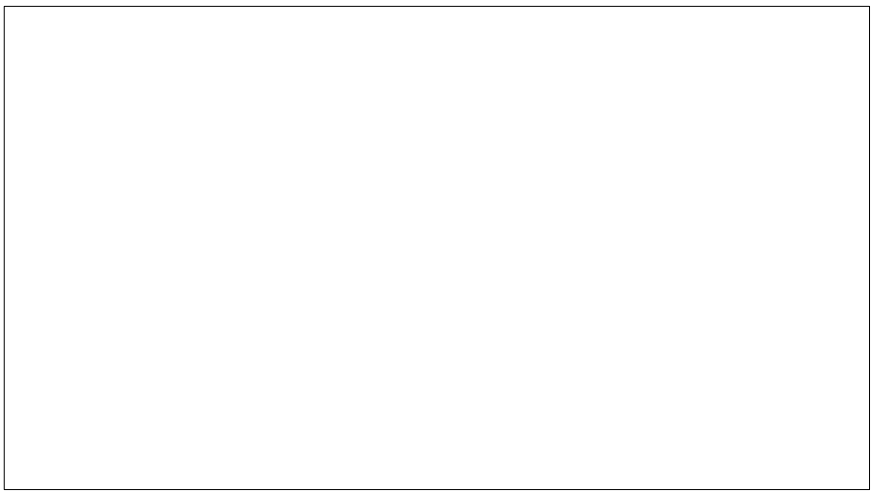

Figure 5. The expansion of the geographical scale of the modeling/management domain for the Chesapeake Bay.

Figure 6. The current relevant spatial and temporal scales of importance in modeling for the Chesapeake Bay.

THE FUTURE - STAGE 3: 1990s -2000s

One can now expect a substantial increase in scale for Chesapeake Bay, both in terms of temporal/spatial scale and in terms of the extent of state variables. Figure 7 shows the current schema and the expected outcome. At least four sub-models are to be coupled to the existing framework: benthic biomass, zooplankton, SAV, and finer-scale tributary models. These models will draw on the parallel development and existence of process models and regional and tributary water quality models (Wetzel and Meyers 1993, Kemp et al. 1994 University of Maryland and Virginia Institute of Marine Science 1994).

The ocean boundary will be expanded considerably to include a significant portion of the nearshore region at the mouth of the Bay. One can expect however, that ultimately the coastal ocean will be increasingly coupled to the Bay so that the fuller interactions of atmospheric deposition on the coastal waters as well as inputs from coastal estuaries can be directly modeled and incorporated. Increasingly, the framework will be expanded to include upper trophic level interactions in terms of a predictive capability for the living resources of the Bay. As noted above, the geographical area of interest is expected to increase substantially as well, with a linkage of the airshed model for estimation of atmospheric nitrogen inputs.

A further major expansion in the scale of the

modeling/mangement domain may be envisioned if one considers the example of coupling (rather than linking) air quality models with water quality models. Figure 8 illustrates such a coupling for the case of toxic chemical predictions, where the coupling of the models is through the air/water chemical exchange. Such a coupling of models will increase the size of model computations by at least an order of magnitude in spatial scale and in the number of state variables. Figure 9 shows the future domain for decision making where control of inputs for a large system such as the Great Lakes can be expected to influence chemical inputs to Chesapeake Bay and the coastal ocean. The latter region would, of course, influence the entire middle Atlantic coastal region's inputs of chemicals from atmospheric sources. The number of interactive compartments for such a calculation at a large geographical scale of the Chesapeake airshed and watershed would therefore probably increase another order of magnitude to about 107.

CONCLUSION

On the basis of the Chesapeake Bay experience which can easily be expanded by other experiences (e.g., the Great Lakes), it is clear that it is primarily the scientific and engineering community that ultimately determines the relevant spatial, temporal, and state variable scales. The management policies and decisions regarding control strategies are heavily influenced by the ability of modeling frameworks to successfully predict environmental responses. Historically, the scientific community continually points to new areas that must be included in such predictive support systems. The inclusion of (1) sediment flux models with thicknesses ranging from millimeters to centimeters, (2) the awareness of the significance of the coastal ocean, (3) the control of primary productivity by upper trophic levels, and (4) the need to assess the expected reduction in nutrient loads from sources in the watershed and airshed that are far distant from the Bay proper are all examples of increased scale that are recognized as increasingly necessary and indeed crucial to future success.

I believe we are at the doorstep of a greatly expanded scale of model development and support for environmental water quality decisions. The nature of the questions that are being asked continues to increase in complexity of geographical and mechanistic scope. Our ability to understand seems to be constrained more by understanding what we are observing than by our ability to compute. In any event, the following conclusions framed within two areas of management issues and scientific and engineering issues appear reasonable.

Management Issues

1. Source control policies to protect a given resource such as Chesapeake Bay will continue to increase in scale and will involve cross-media strategies.
2. The continually increasing domain of management control will require a greatly expanded and integrated multimedia monitoring program to ensure adequate determination of trends and compliance.
3. Future "surprises" in terms of unexpected responses or lack of response to environmental controls can be significantly reduced by continual and extensive expansion of research and development efforts on environmental processes and field observations.
4. Multiple basin, airshed, watershed, and coastal ocean programs efforts will have to be coordinated at a level heretofore not envisioned. Current programs that isolate estuaries and watersheds without recognition of the interactions of the larger scales on particular bodies of water can potentially result in a myopic strategy and hence "unsuccessful" responses.
5. The over-reliance on models of all types water quality, watershed, living resources, or air quality (e.g., "The model said...") can be disastrous and potentially defeating.
6. On the other hand, reliance on quantitatively vague or strictly observational ("Let's see what happens") approaches with little or no predictive power and the future neglect of expanded modeling frameworks courts potential cataclysmically wrong directions.

Scientific and Engineering Issues

1. Model development will include greatly expanded geographical scales and living resources interactions. Such models will demand increas ingly greater computational resources coupled to greatly expanded understanding of processes and mechanisms.
2. One can expect the equivalent of supercomputers to be "on the desk" with direct access to model ing frameworks and data bases where such resources will increase in power logarithmically for the foreseeable future.

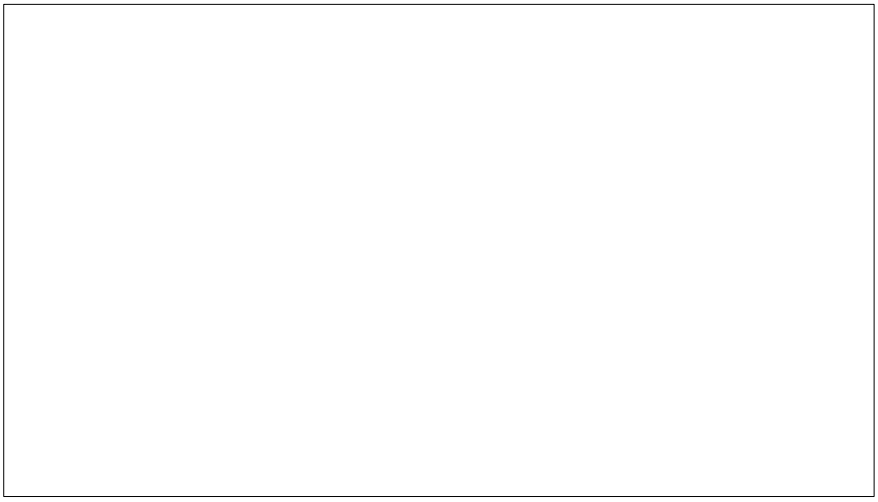

Figure 7. Current modeling framework under development for the Chesapeake Bay system.

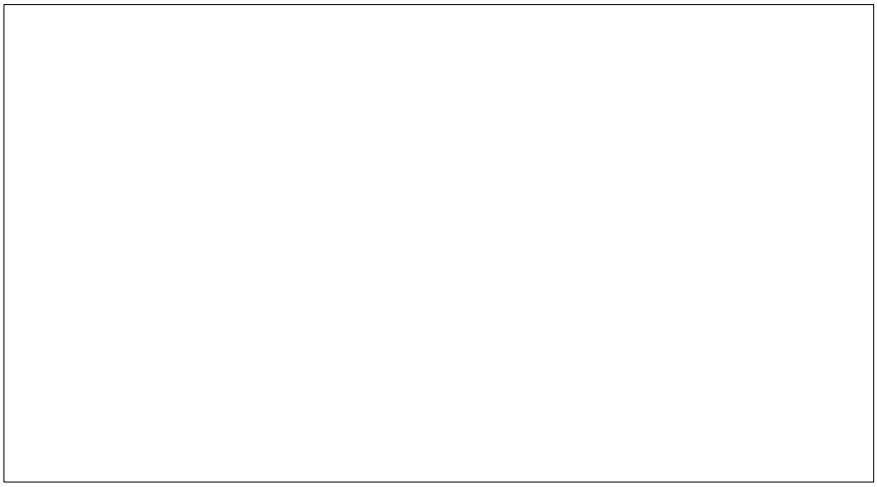

Figure 8. The coupling of air quality and water models for toxic chemical predictions.

Figur 9. Future modeling/management domain for large-scale interactions between the Great Lakes and Chesapeake Bay.

3. Cross-disciplinary cooperation is crucial to successful development of predictive modeling support for further scientific advances.
4. As model complexity increases, understanding what has been computed will also become more difficult. Resources will have to be expended to more fully understand and comprehend model results rather than simply relying on model output as "the truth."
5. Model "confirmation" with field observations will continue to be absolutely essential. Large complex models that are not "confirmed" in some sense and are offered as credible solely on the basis of the complexity of the framework will not be sustainable or defensible.
6. Field and process observations are central to the overall effort. Without data of the real world and without continual post auditing of system response, it will simply not be possible to develop predictive approaches that will withstand scrutiny.
7. Finally, the scientific and engineering community can take ownership, pride, and responsibility for "pointing the way" to management and the public for understanding the Chesapeake Bay resource and the directions that can be taken to restore and maintain that resource.

ACKNOWLEDGMENTS

It is important that I recognize discussions and input from two colleagues of the Chesapeake Bay community: Lewis Linker of the EPA Chesapeake Bay Program Office, Arthur Butt of the Virginia, Department of Environmental Quality. Also, Dominic Di Toro of Manhattan College and HydroQual provided a number of stimulating sessions in preparation for this paper. Finally, it is appropriate to recognize the many scientists, engineers, and managers who have contributed their talents to the understanding and appreciating Chesapeake Bay; it is because of their efforts over many years that these reflections are possible.

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A Question of Values: Religious Elements in Sustainability

Robert H. Nelson
University of Maryland

INTRODUCTION AND DISCUSSION

Verse 1 of Genesis, Chapter 6 in the King James version of the Bible, notes that "men began to multiply on the face of the earth, and daughters were born unto them." We learn shortly thereafter that God, looking down on the spread of mankind over the earth, was mightily displeased with this and other elements of his Creation –that "the wickedness of man was great in the earth." Indeed, God's displeasure was so great that he resolved to "destroy man whom I have created from the face of the earth; both man, and beast, and the creeping thing, and the fowls of the air."

It was, one might say, the first verdict on sustainability. And the judgment then, as is often said to be the case today, was negative.

In a recent translation of the Bible, the same verse is given a more contemporary sound. God is said to be displeased with the fact that "now a population explosion took place upon the earth." As a result of this and other signs that human beings are failing to fulfill his original intentions, he resolves to "cover the earth with a flood and destroy every living being." He recants later only to the extent of allowing Noah to save two of every species.

I mention these bibical passages partly to emphasize that the sustainability of current society is hardly a "value-neutral" question. Indeed, if using different words, the question of sustainability is a leading subject of the Bible.

Adam and Eve were created in happy harmony and bliss in the Garden of Eden but this condition proved not to be sustainable. Following theexplusion from the Garden, the Old Testament tells one story after another of the Jews falling into sinful ways and then, as a consequence, the wrath of God falling upon them. This punishment usually takes the form of an environmental disaster –if not a great flood, then famine, drought, pestilence, or other natural calamity. It is hard not to notice that our discussions today of issues of sustainability are often couched in similar terms. The greatest fears with respect to the spread of greenhouse gases and resulting global warming are said to be the onset of flooding, famine, drought, pestilence and other natural catastrophes familiar to readers of the Bible.

In our secular age, people are not likely to speak in mainstream discourse of the "sins of mankind." Yet, among some of the more radical members of the environmental movement, the sense of human depravity at the present time is strong. Dave Foreman, the founder of Earth First, states that human beings are the "cancer of the earth." Tom Watson, a founder of Greenpeace, uses a slightly different metaphor, that mankind is the "AIDs" of the earth. The appropriate remedy, if such statements were to be taken literally, would seem to be the same outcome decreed by God in Genesis – that human beings should be wiped from the face of the earth.

Foreman and Watson, of course, have extreme views. Yet, large numbers of people today do believe that the moral state of the world is bad and getting worse. In secular circles, while many people no longer believe in divine retribution, they often do have a sense that some form of punishment might be a consequence of the many transgressions of human beings against one another, against other species, and against the earth. These expectations of punishment seem, in many cases, to take the same forms as the expectations of God's justice in the Bible, the arrival of an environmental calamity.

How much of all this is coincidence? Or is perhaps part of what we are seeing in current discussions of "sustainability" an old biblical message of great power in the history of Western civilization, a message that is now being expressed

once again, but in a new form more suited to a less traditionally religious age.

The biblical messages were, of course, delivered by priests, ministers, and other clergy. Today, the discussions of sustainability are carried on mostly by physical and social scientists. But, as numerous commentators have noted, scientists in the modern age have in many respects taken the places of the priests of old.

Science for many people today offers the most valid explanation for the origins of the world, for the meaning of subsequent events in history, and for the future destiny of mankind. In our public arena, science is the most powerful source of social legitimacy for government actions. One might say that for many people today, science actually fills the role of religion.

And perhaps more surprising, science today may be less of a departure, religiously speaking, than many people have assumed. Indeed, as I have been discussing, our current physical and social scientists are now in secular language often delivering forecasts for the future and making judgments on the human condition that are remarkably similar to some of the great themes of the Bible.

Current biological and other scientists, for example, have been leading the effort for the preservation of species in the face of widespread habitat loss and other environmental threats. In a new secular rendering, their calls for species preservation are a reminder of God's instructions to Noah to build his ark.

Scientists as Theologians?

What are we to make of all this? One thing that is clear is that the question of the sustainability of the current condition of the earth is not a value-neutral subject. It forces us to consider the following questions. Are current predictions by scientists of unsustainability driven by a conviction that existing conditions should not continue, whether they actually will or not.

In other words, is an element of moral judgment on the current state of the world coloring predictions of the impacts of global warming, the threats to biodiversity, and other dire warnings about the future?

I would argue that at least sometimes this is the case. I believe we often hear moral judgments, in fact judgments that are remarkably biblical in quality, in the guise of scientific predictions about the future. Mankind is sinning against the earth, many of our prophets of unsustainability are telling us, and thus current behavior must be radically changed.

In truth, by most objective measures the prospects of being able to sustain the current economic system – while never offering absolute certainty – do in fact look fairly good. With the exception of timber, the long-run trend of prices of most natural resources continues to be downward. The *Washington Post* has just noted this week that the price of gasoline in real terms (adjusted for inflation) has hit its lowest level since World War II.

In the short run at least, the biggest agricultural problem for much of the world continues to be what to do about surpluses of food and their depressing effects on prices and farmer incomes. Over the history of the past 200 years, from Malthus onward, essentially all predictions of running out of food or other natural resources have been wrong. Recently, we have discovered that, even while wild salmon populations are dwindling, the price of salmon is staying low. Salmon aquaculture in Norway, Chile, and other places is more than making up for losses of wild populations.

All this, to be sure, does not mean that there is no possibility that the world is headed for an environmental disaster. But a healthy skepticism would seem to be in order.

Is the matter of sustainability therefore a false issue? I would suggest not. However, I think the moral aspect – really the biblical aspect – is the more important question. We should be asking, not whether the existing system of economic development can physically be sustained, but whether it should be sustained as a matter of its moral worth.

I can understand the reluctance of many scientists to enter into such a realm of debate. However, I also think scientists should be more cautious about giving us their own strong moral judgments in the guise of scientific truth. If scientists have strong moral convictions about current patterns of economic development and other matters, they should put their beliefs directly on the table. They should argue them honestly in the ethical terms that really get to the heart of the issue.

To be sure, doing so will require that everyone else agree to do the same. If assertions of scientific truth can be used as a rhetorical club, as a powerful devise in public persuasion, one side can not be expected to disarm unilaterally.

Indeed, I have written at some length of how the advocates of rapid economic growth have often offered a moral vision that has itself often been disguised as science. This subject is discussed in my 1991 book, *Reaching for Heaven on Earth: The Theological Meaning of Economics*.

Policy Debate as Good versus Evil

I decided to write this book after working a number of years at the Interior Department. My experiences there led me to the conclusion that probably the majority of policy debates are really about making moral judgments.

In a secular age, however, many people are uncertain how to argue moral questions, or even whether there is any way of resolution – perhaps morality is merely a matter of "emotion." At least partly for that reason, they obscure the moral elements under a layer of technocratic language and scientific methodology.

The wilderness debate, for example, is not really about "existence value," "methods of contingent valuation," and other economic and social science terms that often surround it. Wilderness is really about religion – a secular religion if you will. You can go back to the writings of John Muir, the founder of the Sierra Club and the inspiration for creating Yosemite National Park. Muir believed devoutly that wilderness was important because it offered spiritual inspiration. The wilderness was, as he wrote, his "temple," the place where it was possible to encounter directly the creation, and thus learn of God's handiwork most directly.

It is not only the Interior Department where questions of morality often seem to be driving environmental policymaking. I was just reading a new book about the Environmental Protection Agency. The authors comment that in many cases EPA policy issues are resolved not as a matter of simply cleaning up the environment or reducing pollution but "as life threatening contests between good and evil."

Getting back to Interior, besides a wilderness area, I always felt that the building of a dam by the Bureau of Reclamation was also a type of religious symbol, yet another secular cathedral if you will. A dam, however, represented a sacred place of an altogether different kind from a wilderness area. A dam inspired viewers with thoughts of the human conquest of nature and the march of science and progress in the world, which for many people in the modern age has been their true religion. Indeed, the clash between the values represented in the symbol of the dam and the values represented in the symbol of the wilderness may actually be the core religous issue in current sustainability controversies.

Economic Progress as the Route of Salvation

The idea of progress is at the heart of capitalism, socialism, Marxism, and virtually all the major systems of political and economic belief that have driven the history of the past 200 years in the Western world. These ideologies – or secular religions as I regard them – differed about the specific mechanics of how to achieve economic progress, but had no disagreement that progress would transform the world for the better. As I put it in my book, they all offered an economic path to heaven on earth.

To give a personal example, let me offer a statement from my old graduate thesis adviser, William Baumol, who is a leading American economist. Baumol was asked not long ago to contribute a short piece about why he decided to become an economist. He replied that "I believe deeply, with [George Bernard] Shaw, that there are few crimes more heinous than poverty. Shaw, as usual, exaggerated when he told us that money is the root of all evil. But he did not exaggerate by much."

Of course, the question of the origin of evil is certainly one of – if not the most – important subjects in Judeo-Christian religion. As the answer is given in the Bible, the explanation lies in the Garden of Eden. Baumol offers a more modern explanation. For him, the source of evil is poverty. Or, put another way, poverty is the true original sin in the religion of progress.

In his book *The Unheavenly City*, another distinguished social scientist, Edwin Banfield, observed a few years back that "the reformer wants to improve the situation of the poor, the black, the slum dweller, and so on, not so much to make them better off materially as to make himself and the society better off morally." Once again, we are reminded that curing poverty is not so much about providing material comforts as it is about making better people. Abolishing poverty, like sustainability, has at heart a religious content.

In "economic theology," the laws of economics take the place of the design of God. Economic laws for Marx controlled not only future material conditions but also all beliefs, cultural practices, governing forms, and other institutions of society. In Marxism and other economic faiths, the real explanation for evil in the world lies in material deprivation. Evil behavior is simply a matter of economic necessity; the requirements to survive – to obtain food, shelter, clothing and other necessities – drive human beings to fight, steal, lie, and do so many other bad things.

Then, if this diagnosis is correct, it also offers a route of salvation in this world – a path to heaven on earth. Sin can be abolished, mankind can be saved, if material scarcity can be abolished.

To do so will require heroic efforts to maintain and increase the rate of economic growth over the long run.

Abolishing scarcity for practical purposes may actually not even take very long. Marx saw the triumph of the proletariat not far in the future. John Maynard Keynes, the most influential economist of the 20th century, once predicted that for practical purposes the world would have all the material goods it needed within 100 years. It would mean a complete transformation of the human condition. People would no longer have to pursue their self interest, because self interest as an economic motive would no longer be useful. As Keynes wrote in 1930 in his essay "Economic Possibilities for our Grandchildren," the maintenance of rapid economic growth would fairly soon lead mankind "out of the tunnel of economic necessity into daylight."

Economic Religion under Challenge

To get back to the subject of sustainability, it is this vision of economic progress as secular salvation that, I believe, is at the heart of many of the current debates about sustainable development. There are at least two basic objections.

First, limits of physical resources, combined with growing population, might undermine efforts to maintain rapid economic growth. It may be that, materially at least, average human well-being cannot increase any further. The future escape from material scarcity posited in Marxism, socialism, the American progressive "gospel of efficiency," and other economic creeds may simply be a technical and physical impossibility.

This subject has been at the heart of the public debate thus far. However, even if high rates of economic growth can in fact be maintained over the long run for the whole world, the basic religious question remains – whether material advance is in fact the path to improvement of the moral and spiritual condition of mankind. Does material progress lead to heaven on earth?

The history of the 20th century suggests not. During this century there have been enormous economic advances. Yet, contrary to the supposition of all the various forms of economic faith, the record of the century is filled with world wars, genocide, nuclear bombs, and other dismal events. Instead of salvation, it has seemed at times that a new hell on earth might be more likely.

Thus, it may be that current rates of economic growth are in fact technically and physically sustainable, but that we no longer want to sustain them. Economic growth has been pursued not as a mere matter of obtaining some material comforts but with religious zeal. If the religious motive for growth is undermined, the policy goal to emphasize growth above all would seem to disappear.

The operative standard for much of our public policymaking has been whether a policy contributes to economic progress. The old standard of good and evil has been replaced in policy debates by a standard of "efficient" and "inefficient." If rapidly increasing economic output is in fact the path to heaven on earth, it follows logically that a criterion of efficiency should have such a powerful moral role and religious purpose.

However, if all this is now in question, perhaps other goals of public policy are more worthy. Perhaps the means of moral and spiritual improvement even involves a rejection of material advance. Perhaps the act of consumption is actually more corrupting than saving.

Calvinism minus God

The corrupting influence of material goods is a theme, like so many other supposedly "modern" ideas that is, as old as the Bible. Adam and Eve lived in happy harmony in the Garden of Eden. However, owing to their original sin, humanity has lived in a state of many evils ever since. Selfishness and greed, as many Christian theologians have written, took hold everywhere. The pursuit of material riches has been one of the main signs of the depraved condition of humanity.

In the theology of John Calvin, the extent of human wickedness is particularly great. Mankind is so infected with evil that the world can offer little but pain and suffering. Our current existence must simply be borne until God intervenes to save mankind.

There is found, at least in some segments of the environmental movement, a secular version of this old-style Calvinism. I mentioned above the references to mankind as the cancer or AIDs of the earth. One hears today in some quarters that the goal of public policy should be to remove human influence as much as possible from the earth. Dave Foreman is currently seeking not merely a modest increase in the size of the national wilderness system but an expansion of this system to perhaps 25 % of the land area of the United States.

Such forms of secular Calvinism assert a new standard of morality. Gone is the old standard that efficiency is the measure of moral value. That which is moral now is in harmony with true and original nature, that which has been least touched by human hand. The goal of policy becomes to

restore the condition of the world to the state that preceded the advance of civilization.

As I noted above, preventing air, water, and other pollution often becomes not a question of a cleaner environment but of fighting for the triumph of good over evil. Pollution represents the evil act of corrupting nature through human impacts.

In such a secular faith, economic growth is just as religiously charged a subject as it is in the creeds of economic progress. However, matters are now turned on their head. Economic growth is not the path to heaven on earth but the actual source of evil in the world, the path to hell on earth. If we persist in our current evil ways, it will mean the end of the earth as we know it — probably caused by flooding, famine, or other environmental (and biblical) catastrophes.

CONCLUSION

At the heart of the current debate over sustainable development is really a religious question of the very value of economic progress. It is not usually presented in these terms because most people in the mainstream of American life are not comfortable treating the formulation of public policy explicitly as a matter of resolving religious differences.

With some justification, Americans typically regard religious issues as matters of personal belief, hard to resolve and potentially socially divisive. Hence, it is better to keep them under the table. Policy debates in the public arena should be kept closely confined within the value-neutral framework of the social and physical sciences. The result, however, is often an intellectually impoverished discussion.

The times may be changing, however, as it is more and more recognized that policy issues ranging from health care, to welfare programs, to education, to the environment, and many others, are really about values in American life. For many years the scientific ideal was that the professional experts should address matters of "fact" and in other ways behave in a manner that is "value-free." Questions of values were in principle separable and should be addressed somewhere else. Thus, in the political world, theorists argued that governing could be divided into distinct domains of value-ladden "politics" and scientific "administration."

But all these assumptions of a tight division between facts and values, politics and administration, science and religion, have been falling into growing question. We need a public dialogue that is capable of addressing all these matters in the same arena. One important test will be the meaning of sustainable development.

Toward a Sustainable Coastal Watershed:
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WHAT ARE THE LIMITS TO GROWTH IN THE CHESAPEAKE?

W. Tayloe Murphy Jr.
Virginia House of Delegates

INTRODUCTION AND DISCUSSION

The Year 2020 Panel's 1988 report says this: "The use of land is a great environmental, social, and economic challenge. Society must create rational growth patterns, supported by adequate infrastructure and public transportation. Scattered unplanned development is wasteful and expensive and generates greater net pollution than more rational patterns of development."

To those of us, long familiar with the challenges we face in the efforts to restore Chesapeake Bay, those words ring true. Yet, as a society, as political leaders and as managers of a public resource, we have failed, in a comprehensive way, to heed them. I submit that while we have made progress, we have not done enough. Unless I can energize you and hundreds of others to become politically active, I must admit that I am deeply pessimistic. We must embark on aggressive strategies to manage our growth or the ability of the Bay to recover and survive will be diminished to the detriment of all of the United States.

In 1987, with the signing of the Chesapeake Bay Agreement, the issue of population growth and development took center stage. There was no particular magic in the words of the agreement. It simply stated that growth and development can have profound effects on the condition of Chesapeake Bay and unless those effects are minimized, our living resources and the quality of our lives will suffer.

If we continue to pursue the status quo, sprawling development will continue to consume the landscape, threaten sensitive lands, and make the automobile the only viable means of transportation.

There is little doubt now that the 1987 agreement and the subsequent study of the Year 2020 Panel were on the mark. If fact, it is arguable that the adverse impact of some land uses on water quality is greater than we had thought seven years ago. Now we have a better understanding of the impact of air on water quality. Greater amounts of nitrogen and toxics fall from the sky than previously thought. We are also discovering that nonpoint sources contribute greater amounts of toxics than originally estimated in addition to being the predominate source of nutrients. In a sense, our worst fears have been confirmed. The connections between land and water and air and their connection to the health of the Chesapeake Bay are obvious and strong.

In 1986, more than a year prior to the signing of the 1987 agreement, the Chesapeake Bay Land Use roundtable was convened inVirginia under the auspices of the Chesapeake Bay Commission. The roundtable found that the connections between land use and water quality were clear and that unmanaged development would impede our progress in restoring the Chesapeake Bay. The Roundtable rightly concluded that "If we do not deal with issues of land development and management as well as with specific point source discharges we will not be able to achieve our water quality and habitat protection goals for the Chesapeake Bay." The recommendations of the roundtable were transformed into the 1988 Chesapeake Bay Preservation Act, which, for the first time, established a state role in promulgating standards for development.

The land use roundtable was a study in consensus building. The members represented a range of interests and worked for the better part of two years to reach consensus on controversial issues.

The model of the land use roundtable, a consensus-based approach to difficult policy questions, was the basis for Virginia's next step in dealing

with the undesirable impacts of growth and development. As a result of the recommendations of the Year 2020 Panel, the general assembly created the Commission on Population Growth and Development, which I chair. As with the land use roundtable, its membership reflects a broad range of interests and includes citizens and members of the general assembly.

Since its first meeting in 1989, the commission has attempted to forge consensus among its members. It took seriously the challenge posed by the Year 2020 Panel and tried to take the principles of sound planning to state and local governments in order to create a future free of the calamities predicted by the panel. While the commission has advanced important initiatives, I must report that we have not fully advanced the Year 2020 Panel agenda. While a great deal of time and effort have been expended, we have not reached consensus with regard to modifying the relationship between state and local government with respect to land use planning. This, in my view, is a critical barrier to ultimate success.

Over time, the focus of the growth commission broadened beyond a resource-based view and embraced, as the recession took hold in Virginia, a view that strategic planning was a tool for economic recovery and development as well as resource protection. Despite near-universal agreement that population projections for the year 2020 were relatively accurate, the expectation of corresponding growth was dashed by economic reality. A casualty of the change in focus was the urgency of dealing with land use issues that was the foundation of the 1987 commitments and the year 2020 Panel report. As new land development ground to a halt in northern Virginia and the other heavily suburbanized areas of the Commonwealth, so did the urgency to change our ways of doing business.

In sum, while the Growth Commission has advanced solutions to important issues, such as regional approaches to problems of greater than local significance, coordinated state strategic planning, and the establishment of a statewide network for computer-based geographic information, we have not fundamentally changed traditional land use planning practices to achieve the 2020 visions.

But my remarks so far beg the following question. What must we do to achieve the visions of the year 2020 Panel and effectively cope with the impacts of millions of new people and acres of new development that will come to the watershed over the next three decades?

To begin, I have reluctantly come to the conclusion that consensus building is not the path to success. We must pursue more aggressive strategies, develop legislative initiatives, and marshall the political forces necessary to pass these proposals whether consensus is reached or not.

There is no doubt in my mind that, without aggressive political involvement by natural resource conservationists, the future of the Chesapeake is bleak. Although recent news is not all bad in terms of water quality, and some living resource indicators, the incremental destruction of the Bay's vital resources continues and without bold action will inexorably continue to 2020 and beyond.

My arguments for renewed action are founded in the context of the public trust doctrine. This ancient common law states that the beds of our bays, rivers, and creeks, the waters above them, and the resources in them belong to the state and are held in trust for the benefit of all people. Thus, the state's authority to protect these resources is grounded in its interest in protecting the property it holds in trust for its citizens. This is in contrast to the basis of much regulatory initiative, which is built upon the state's police power that is, the power to protect the health, safety and welfare of its people. Under the public trust doctrine, the riparian landowner, while possessing certain rights granted by the common law to use the waters that flow past his property, is prohibited from exercising those rights in a manner that is injurious to others. And those "others" include the state as trustee for the people. Unfettered rights to despoil a common property resource should not and do not exist. The public trust doctrine enables government to place reasonable restrictions on potentially damaging activities without having to defend its action against a claim of being arbitrary and capricious.

In order to fully understand the connection between the public good and private use, I suggest that there are three fundamental principles at work here. These principles apply in any situation where human activity affects the natural environment and in the context of these remarks, the resources held in trust for the people. Whether you like these principles or not, and no matter what your personal views or interests may be, they cannot be avoided.

The first, simply stated, is this: Every activity that impacts Chesapeake Bay imposes a cost and that cost must be paid by someone. For years, we cheerfully operated under the assumption that where the environment and natural resources were concerned we could operate outside the laws of

nature and economics. Cities disposed of their sewage for "free" by simply directing their outfalls to the nearest river. Factories poured wastes into the Bay and its tributaries at little or no cost to their owners. Unfortunately, even though the cost of such activities did not show up on any ledger book, they were being paid for, with heavy interest, by the downstream municipality forced to find another water supply, the waterman facing condemned oyster grounds, the seafood packer forced to look further and further afield for products to market all of them picked up the tab for this "free" activity.

As citizens and taxpayers, we have seen over the past few years just how big a bill must be paid to repair the damage. The vast sums we continue to spend to restore Chesapeake Bay and other water bodies are nothing more than the accumulated sum of many supposedly "free" lunches, with compound interest. I submit that environmental laws and regulations must, at their most basic level, ensure that persons who benefit from a particular activity pay the full cost of that activity. For example, if a manufacturer is required to install pollution control equipment to protect a body of water, that cost becomes part of the cost of doing business. The cost is borne by the consumer of his products rather than by those who happen to live and work downstream.

Then, as complaints about cost are voiced by this group or that group, legislators and regulators at times begin to backpedal and grant exemptions. But remember, each exemption simply transfers a cost from someone whose responsibility it should be to someone else, and in most cases, to the beneficiaries of the public trust. Each time this happens, we grant a subsidy to the favored group just as surely as if we took money from the public coffers and handed it over. For those whose livelihood depends on the health of the Chesapeake Bay and its tributaries, this type of subsidy is fatal. It is paid only at their direct expense, and ultimately at the price of their ruin.

The second principle is that of the commons. Simply stated, the law of the commons decrees that if each user of a finite resource follows his natural tendency to maximize his benefit from that resource, the cumulative effect of these individual and seemingly rational actions will destroy the resource. With this law at work, the public has no choice but to demand a rational system that regulates use to protect and perpetuate the commons.

The final principle, related to the commons, is that every individual and seemingly isolated action has consequences. Most activities that affect the Bay and other public resources are of little apparent consequence in themselves – a subdivision here, a road there, a filled wetland, a new field cleared from a forest– but as they are added together, they have the effect of an avalanche that starts with a few pebbles rolling down a hillside. We cannot make decisions by simply trying to determine the effects of individual acts. We have to look at an activity in the context of everything else. There are simply too many of us doing too many things in the Bay's vicinity to continue with the notion that our individual actions make no difference.

All of these principles that I have mentioned worked whether we like them or not. That they have been working all along is demonstrated by the all-too-obvious evidence of the Bay's decline. At a conference In 1993, my colleague, Senator Joe Gartlan of Fairfax, said that "the tragedy of the commons is, playing to an empty house." For our sake, I hope that ticket sales improve.

Let me give an example of how these principles can be put to work. A recent study conducted by the Virginia Division of Soil and Water Conservation concluded that serious deficiencies existed in local erosion and sediment control programs and that state oversight, owing to limitations in the statute, was uncertain. I chaired a legislative study charged with examining possible remedies. It became clear, from the research undertaken over the course of the study and through testimony, that the economic costs of individual actions were not being absorbed by the rightful parties. We heard testimony of serious violations which not only caused great damage to individual property owners, but also damaged streams and other water bodies held in trust. In effect, certain individuals were being served a free lunch and the commonwealth and certain private parties were picking up the check.

This issue also illustrated the inexorable law of the commons. The use, or in this case, the misuse of the commons was in the economic self-interest of the violator. It was an economically rational decision to use the commons to receive sediment rather than pay the bill for erosion control.

Finally, it was clear that the sum of individual actions was indeed significant. With each rain, hundreds of sites around the commonwealth deposited sediment and associated pollutants in Virginia's streams and rivers.

Our solution was grounded in a simple premise: Exert the state's responsibility to protect its interest in the public resources and ensure that the costs of protection are equitably

placed. Our solution called for the protection of the state's property interest in its streams and the grant to local governments of additional powers and responsibilities to safeguard the state's trust properties.

With respect to growth in this region, we must continue to forge new partnerships and responsibilities between the state and local governments. The state must exert its responsibility to protect the resources held in the public trust. While land use control is traditionally a local matter, it will not do to hide behind tradition if that prevents a solution to an obvious problem that transcends local boundary lines, or violates the public trust, or requires inordinate expenditures of public funds. Local governments, for their part, must accept the responsibility of paying for the cost of their activities and decisions that permit damage to public resources. If localities do not absorb the cost of their decisions, the Bay and the public will. Local governments, to the extent that they have the authority to do so, must look at the overall impact of their land use control authority and allow protection of the Bay equal time with local growth and development. To the extent that local powers to not allow such action, they must be granted the necessary authority by the general assembly.

In the public debate on these issues, advocates for advancements in resource protection are challenged by those who say that environmental protection usurps the right of the individual to use his property as he sees fit. My answer to that challenge is simple. The public also has property rights in the trustlands that the state owns, and the principle of nuisance, which says that one may only use his property to the extent that it does not damage another, applies here also. If the use of private property damages public property, then the state may enact reasonable limits on that private use. During the debate on the Chesapeake Bay Preservation Act regulations, it was argued that the act was a de facto taking of private property. To this day, however, there has been no successful challenge. Reasonable restrictions do not constitute a taking.

I realize that I have not answered the question posed by this plenary session, "What are the Limits to Growth in the Chesapeake?". I do not know what those limits are. But I do know that in order not to exceed them, we must do better than we are doing now. We do not have, in Virginia, and I daresay, in Maryland and Pennsylvania, the institutional mechanisms to improve local planning practices. We continue to plan in a piecemeal fashion that presumes that the effects of major land use decisions stop at municipal boundaries. We continue, to expend great sums of public money providing infrastructure and services to sprawling development. We continue to see the decline in our resource base and our quality of life. If this continues our legacy will be one of a paved landscape viewed from a closed, airtight car window. I hope that you will join me in redoubling our efforts to achieve a more desirable future.

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WHAT ARE LIMITS TO GROWTH IN THE CHESAPEAKE?

George B. Wolff
George B. Wolff Associates

CHESAPEAKE REGIONAL PERSPECTIVES

I am sure the subject of people growth in the Bay area and watershed will be addressed from many different positions by other people. Therefore, I would like to look at the stability, importance and growth of agricultural enterprises in the area.

I'm not going to give you pages of copy on the gross and net dollars that agriculture brings to the area nor the significant number of people who owe their paychecks to agriculture. We all know the tremendous importance of each. Rather, I'd like to suggest that the open space way of life and contribution to the overall environment is of such importance that we must first recognize agriculture's importance and then agree to support and encourage regulation, research, and assistance to encourage its expansion.

Most of my comments will be geared to Pennsylvania, since that is the area of which I have the greatest, though limited, understanding.

Few of our farms consist of enough acreage for our farm families to make a living from land units and therefore animal units are the backbone of Pennsylvania's agriculture. In order for the consumer to have a constant supply of fresh, inexpensive food available each day, the store required the processor to guarantee a certain supply be available each day. This almost requires the processor to enter into contracts with the producers for that production because they know very precisely just how long (number of days) it takes to produce meat or poultry. The processors carefully program the cycle.

This has been the end of the little backyard poultry flock and the mud-hole pigs. But this has also been the reason that each of these operations has become more efficient, benefiting us in many ways. If we now have an abundance of animal waste, just imagine the problem we would have if we were still taking 12 to 13 weeks to produce broilers instead of the present 6 weeks. Whereas it used to take 7 months to produce a 200-pound pig, it presently takes only 5 months and several days.

These changes in the growing cycles effectively came about as a result of better health, nutrition and housing for the species. The old reference that "that guy is as happy as a hog in mud" really meant that the person was comfortable. A hog, as you know, has no sweat glands and in the old days, he tried to stay cool by being in mud. Today he is kept in a temperature controlled building that maintains an optimum temperature of approximately 68°F. At higher temperatures, the hog burns off calories trying to keep cool and at lower temperatures, he burns calories trying to keep warm. It is cheaper and more efficient to buy kilowatt-hours than feed.

It's my contention that animal production must expand if agriculture is to remain viable in the region. As the units expand in number and size, the concentration of animal waste will be growing and could be the limiting factor. Yet there are many exciting possibilities and potentially very profitable opportunities. Remember, — a business without a profit is no more a business than a pickle is a candy bar. Any solution must allow the business to prosper and enhance its cash flow.

I told you that nutrition was one of the important factors to the increased efficiency. Yet we are only beginning to really understand its importance to the point that we are concentrating research and expertise toward that end. It's believed that by properly feeding the ruminant, we can secure greater meat and milk production and at the same time reduce the nitrogen and phosphorus in the manure by perhaps as much as 50%. We are learning that proteins are different. Soluble protein is digested in

the rumen and expelled as methane in the manure or in the belch as the cow regurgitates to chew her cud. Therefore, the addition of the bypass protein (not digested in the rumen but bypassed to the intestines) increases efficiency and decreases gas and waste.

The Lebanon and Berks County Conservation Districts have a joint project at the Bethany Home to administer a prescription feeding program—adding enzymes and bypass proteins. We started with weighing the feed that the cows were fed over a period of time. We also weighed the manure. After a 3-week period, we changed the ration incorporating the adjusted ration. We gave the cows 3-weeks to become acclimated to the new ration and then started weighing the feed and manure again. We didn't observe some of the changes in the manure that we expected even though we kept adjusting the ration. This led us to believe that the scale on the mixer was not accurate. The Department of Agriculture checked the scale and confirmed that this scale was indeed not accurate and was off as much as 5 or 10 pounds at different weights. The manufacturer's only comment was that the feed was not for sale—only for feeding cows, so what's the difference?!

Even so, we reduced the manure production by 18 pounds per day and has an increase of 2 pounds in milk production. The cows were eating an extra pound of dry matter per day. A full report will be out in the near future along with the analysis of the manure before and during the feeding program. I believe that reducing the cow manure from 164.6 pounds per day to 146.3 pounds per day is worthy of attention.

This knowledge has gotten the attention of the feed formulators who want their feeds to be as efficient and cost-effective for their consumers as possible. A large portion of a ration is grain. The grain breeders who have in the past concentrated their genetic information on production and agricultural yield per acre are now also looking at genetic involvement in making the grain more useful and palatable to the end user (the person or animal who eats it).

The Pennsylvania delegation of the Chesapeake Bay Commission was aware of the nutritional aspects and therefore visited the Netherlands to view firsthand the work that they are doing to reduce nutrient output through nutrition. During the first week of December 1994, the Pennsylvania delegation will sponsor a symposium in Harrisburg, Pennsylvania, at which any of the researchers interested in the subject can present papers. We will be setting up the formal protocols to collaborate with the Dutch on this subject.

With the advent of fuel cells that can convert methane gas to electricity, many new opportunities are opening to us. Different types of fuel cells seem to be able to handle different types of gas. There is a German group that licensed Royal Resources Corporation of Fairmount, West Virginia, to promote the concept of electro-farming. They are currently working with Auburn University and other researchers here in this country to grow C4 grasses. These grasses photosensitize an extra molecule of carbon and when pyrolized, give off a fairly high grade of clean hydrogen. They believe that 360 acres of C4 grass can fuel a 2-megawatt fuel cell.

Additionally, the C4 grasses, because they regenerate off the root stock, could be used as the filter in streambank filter strips. I have personally never been too excited by filter strips—not that they didn't work but they generally use a lot of a farmer's land with little or no dollar return. However, if the German process works as they think, then that C4 grass acreage could return $120 per acre net return to the farmer. That is more than a farmer can make in a year growing corn or soybeans on that same acreage, and the soil would not have to be tilled. This would be a positive tool for conservation.

Therefore, if we could run the manure into the methane digester, we could then convert the methane to electricity, spray irrigate the nutrient rich water on the land, grow C4 grass, gasify the grass, and convert the hydrogen to electricity. We could use the ash that this process generates, which has most of the nutrients that were in the grass as soil amendments, as fertilizer. Through these processes, we could generate three cash streams, reduce the methane released into the atmosphere, concentrate the nutrients and, more importantly, put them in dry form so that they could be shipped back west to be put on the land that the grain originally came from to feed the animals that generated the manure.

Yes, there is a need for research funds, but I can hardly think of an expenditure of dollars, knowledge, and effort that could generate as much in the way of return for agriculture, the environment, and humanity in general as this process would generate.

Ladies and gentlemen, if necessity is the mother of invention, then I can assure you that she is alive and well. Let's not encumber this mother of invention by our own negative thoughts that agriculture must be limited and controlled too extensively. Rather, let's join hands and make it grow, become more environmentally effective, and productive for you and me who have developed the expensive and often overindulged habit of eating.

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CHESAPEAKE BAY: POPULATION, CARRYING CAPACITY, AND LIMITS TO GROWTH

Robert McConnell
Mary Washington College

INTRODUCTION AND DISCUSSION

Population Growth and Sustainability

Any attempt to determine "limits to growth" aims at a moving target. We should foremost be clear on terminology. Needlessly compounding the problem is the often-synonymous use of two separate concepts: "growth," meaning increase, which I will show to be unsustainable, and "development," meaning change, which is not inherently unsustainable.

Population growth can be shown to be unsustainable with simple arithmetic, as growth can be approximated using the compound interest equation future value = present value x $(1 + i)^n$, where i equals the rate of increase and n is the number of years over which the growth is to be measured.

For example, the population of Prince William County, Virginia, is increasing at a rate of 4% per year, based on 1990 census figures. At this rate the population will double in 17.5 years, and will double again in each succeeding 17.5 -year interval.

Furthermore, it is possible to project a time in years when the human population density of Prince William County will reach one person per square meter, a logical absurdity: 216 years from 1990. The formula is $t = (1/k)\ln(N/N_0)$ where t is in years, k is the growth rate (in this case 0.04), ln is natural log, N_0 is the 1990 population (215,000), and N is the population needed to occupy the county to a density of one per square meter (10^9 m^2 of land area in the county).

Therefore, it is appropriate to restate a first principle of sustainability: Population growth is inherently unsustainable. It then becomes a question not of whether population growth will end, but how, and at what level.

While it has been shown that a continually increasing human population is physically unsustainable for the earth or any part of it, some continue to argue that population growth is essential, or at least, on balance, positive (e.g., Simon 1981). This position holds that unquantifiable values such as "ingenuity" and "creativity" increase for a population with each additional person; thus ever-increasing numbers of people invariably means ever-increasing ability to solve problems.

Such cornucopian views are logically incongruous, and founded on the fact that human beings are not pure minds, but have bodies in need of sustenance, and individually generate substantial ecosystem demands in terms of waste disposal, energy consumption, space, water use, and raw material demand.

Population Growth in the Chesapeake Bay Watershed

Projections of Chesapeake Bay's future population based on revised 1990 census data have recently become available, and they are even more "startling and compelling" than projections noted by the Commission on Population Growth in 1988 (Year 2020 Panel 1988). For example, Virginia's estimated 1993 population of 6.468 million will grow to 7.048 million by 2000, and is projected to reach 8.388 million by 2020, a 29% increase. Moreover, the rate of increase of the state's over-65 residents will grow one-third faster than population up to 2020. And it is important to note that by 2020, 1.087 million of Virginia's growth will be from migration. Nearly *48%* of these new

arrivals (over 519,000) are projected to be international migrants (U.S. Bureau of the Census cited *in* Cohn [1994]).

Thus the State's demographic makeup will be significantly altered, which could materially impact public support for Bay remediation efforts. Such demographic shifts have been shown to alter public support for local school funding in California, for example. For further discussion see McConnell (1992).

Maryland's population increased over the period 1982-93 to 4.97 million, or by 16%("Prince George's County Indicators" 1994): at that rate, that state's population would reach 7.1 million by 2020.

Such projections have grave implications for the region's transport network and already seriously stressed environment, in that from 1982-93 vehicle-kilometers traveled in the watershed increased more than twice as rapidly as population, and from 1952 to 1986 vehicular pollution rose five times as fast as population (World Resources Institute 1994).

Economic Growth and Environmental Impact

Economic growth, like population growth, can be shown arithmetically to be fundamentally unsustainable (Daly 1994; ,Hardin 1993). Even over the near term, however, it is axiomatic that both economic growth and development adversely impact quality of life, if measured by such essential criteria as access to quiet, solitude, space, and natural beauty. For example, according to conventional wisdom "efficient" roadways are essential if Americans are to exercise one of their most prized freedoms, the freedom of unhindered travel. Yet the very increases in population, motor vehicles, and per capita kilometers driven by the Bay's inhabitants (see above) renders even the most ambitious road construction plans self-defeating. All roads fill up eventually, constituting as they do a "free public good." Thus, attempts to mitigate motor vehicle-related environmental degradation may prove to be frustrating, intolerably expensive, and ultimately futile: moreover, the conventional approach of building new roads to address transportation needs or to promote development inevitably depletes the region of all other high-quality items listed above.

Carrying Capacity and the Limits to Growth

Carrying capacity (Carrying Capacity Network 1994, p. 2) has been defined as: "The number of individuals who can be supported without degrading the natural, cultural and social environment; i.e., without reducing the ability of the environment to sustain the desired quality of life over the long term. " Or as stated by Plato in *Laws* (cited in Carrying Capacity, Network [1994], p. 4), "A suitable total for the number of citizens cannot be fixed without considering the land and the neighboring states. The land must be extensive enough to support a given number of people in modest comfort."

Clearly, to determine human population carrying capacity for an area like the Chesapeake Bay watershed, one must specify a level of consumption and waste production for a population of any given size. One way to begin this process is to determine the historical onset of population-related pressures that have adversely affected specific aspects of the Bay's ecosystem.

Based on census data coupled with analysis of Bay sediment, severe degradation of the Bay began during the decade of the 1950s (McConnell in press), when the population was approximately one-half its present 16 million. This suggests that a population of 8 million could be supported by the Bay ecosystem, but more research is clearly needed.

Associated with this doubling of the watershed's population has been a relentless alteration of the natural environment that has had severe and quantifiable impact on environmental quality. Resulting from these land use changes, at least 10 percent of the entire state of Maryland is now turf (World Resources Institute 1994). Additionally, 1.7 million square meters of office space was added in Prince George's County alone during 1982-91 ("Prince George's County indicators" 1994), and over 7 million square meters of land in Prince William County, Virginia, is presently slated for development (Forgey 1994).

Turf (lawns, golf courses, etc.) is a major source of nutrients and pesticides causing groundwater contamination, and commercial construction is an important contributor to the growing problem of urban runoff: as an example, stormwater runoff from urban and suburban areas constitutes the "second largest single source of 'Toxics of Concern' metals" namely (cadmium, chromium, copper, lead and mercury (Chesapeake Bay Program 1994b, p. 2).

That the limits to growth and the carrying capacity of the Bay's watershed have already been reached, and that additional growth can only be accommodated at the expense of the environment and of what remains of the region's quality of life seems to many to be

intuitively obvious. The following will illustrate:

- Road congestion is chronic and is becoming untreatable: the very measures traditionally employed to ease congestion (i.e., road construction projects) at best buy only a few years time and usually generate significant, and often bitter, public opposition (e.g. Kyriakos 1993). Moreover, massive new development projects like the proposed Disney "theme park" for western Prince William County, Virginia, promise to derail even the most carefully planned and engineered road "improvements."
- Restoring the Chesapeake is proving to be elusive, barring significant lifestyle changes, in the face of relentlessly increasing economic activity and population growth. The following five points will illustrate:
  1. After a striking reduction in mean annual phosphorus input to the Bay in 1989 resulting from a ban on phosphate detergents, phosphorus levels have stubbornly stabilized (Chesapeake Bay Commission 1993). Nitrogen levels have actually increased slightly since 1985 (Chesapeake Bay Commission 1993, 1992).
  2 Though reports quantifying toxic emissions in the watershed suggest substantial improvement since 1989 some of that reduction may be accounting gimmickry, and much of the rest is attributable solely to the 1989 closure of Avtex Fibers in Front Royal, Virginia. (For example, toxic air emissions from Avtex Fibers for 1987 equalled *50.9* million pounds, and constituted the State's greatest single source of air pollution [Valentine 1993]). The elimination of this one source contributed 89% of the toxic air emissions reduction from 1987 to 1989 (data from VERC 1994: calculations done by this author). Given an 11% increase in point sources since 1989 (Chesapeake Bay Program 1994b), future improvement will require major changes in industrial processes, at significant cost, even if the 1990 Clean Air Act Amendments [CAAA] are strictly enforced (by no means a certainty; see below).
  3. Reducing air pollution from power plants, motor vehicles, and other mobile sources will depend likewise, at the very least, on strict CAAA enforcement. Yet the Amendments permit extensive delays in compliance, and an internal report produced by a Virginia Power task force recommended seeking a 2-year delay in installation of a scrubber at the Mount Storm coal-fired power station, one of the region's major sources of SO_x, solely as a cost-saving strategy (Virginia Power 1991). At the same time, Virginia's immense potential for energy conservation (Virginia Energy Coalition 1992) remains largely unrealized owing to institutional barriers, intransigence on the part of utility management, and lack of leadership from the State Corporation Commission. The annual report of Dominion Resources, Inc. Virginia's largest electric utility, offers a partial explanation. The company lists 21 senior vice-presidents and vice-presidents, only two of whom are women (Dominion Resources 1994). One is a recent hire in the largely cosmetic post of VP for public affairs. Eliminating the latter, the company's 20 senior managers average 24 years of service. Thus the average decisionmaker was trained nearly 30 years ago, before awareness of global warming, before significant awareness of acid rain, and before passage of any significant piece of environmental legislation. Clearly, improvement in the state's electricity efficiency, among the lowest in the mid-Atlantic region (McConnell 1994, Virginia Energy Coalition 1992), would result in significant reduction in airborne toxics, yet this may ultimately require public interest representation on the board of directors of Dominion Resources.
  4. Clean Air Act-mandated reduction in air pollution from motor vehicles will be extremely difficult to implementowing to l lifestyle preferences and demographic changes in the nation generally, and specifically within the Bay's watershed as described above. Moreover, the actual transport mix is changing, owing to saturation advertising for light trucks and "sport-utility" vehicles, which now accout for 45% of vehicle sales ("Production indicators" 1994). Because these vehicles are covered by less-strict fleet mileage requirements than are cars, average fleet fuel mileage will level out or actually decline unless fuel economy regulations are substantially strengthened.
  5. Health and diversity of the Bay bottom-grass community is a key to Bay remediation. Since 1984, areas covered by bottom grasses reportedly have increased from 10% of their former range to 15% (Chesapeake Bay Commission 1993). Yet the initial floral species diversity of revegetated areas, critical to biodiversity maintenance, is typically down 50% to 80% (Blankenship 1993).

Population Control in the Chesapeake Bay Watershed

Most residents of the watershed are woefully misinformed about the nature and sources of Bay degradation, and about the impact of population growth and personal consumption on the Bay. In a recent survey commissioned by the Chesapeake Bay Program, only 9% of respondents considered population growth to be among the most serious factors in Bay degradation, while 11% considered it to be the least significant factor (Chesapeake Bay Program 1994a). The survey also indicated that only 7% of residents believe individual actions to be a significant factor in Bay pollution, while twice as many feel it is the least significant factor. And only 1% of respondents feel that the Bay's pollution level should be reduced enough so as to be safe for swimming.

Yet population growth in the United States, with the world's highest level of fossil fuel use, resource consumption, and waste generation, is widely recognized as a major factor in global and regional environmental degradation (World Resources Institute, 1994, Mazur 1994, Pimentel et al. 1994). Clearly, one of the major objectives for the next decade of Chesapeake Bay remediation should be education of residents on the impact of individual consumption and population growth on the Bay.

However, controlling (or even rationally discussing) the Bay watershed's population growth may prove politically impossible to address over the near term; thus, reduction of per capita environmental impact becomes even more critical with each passing year.

One aspect of the population growth problem in the region that may be amenable to redress is the continuing large influx of extranational migrants, both legal and illegal. As noted above, over 519,000 extranationals are projected to be added legally to Virginia's population alone by 2020.

Several recent studies have begun to quantify the cost of extranational migrants to the nation's states and localities (Simcox 1993, Subcommittee on Criminal Aliens, County of Los Angeles 1992) and at least two state governors have filed suit against the federal government to pay for "unfunded mandates" related to the cost of undocumented extranationals (Wilson 1994).

Given the adverse environmental impact of such a massive influx into the Bay areas, it may be possible to reach consensus on the advisability of reducing this component of population growth within the Bay's watershed, at least to the extent of strict interdiction of illegal immigration. Such a policy, however, can best be successfully implemented with the advice and cooperation of all member groups of the Bay community, which means that all members of the community must feel a stake in Bay preservation and restoration.

Reducing per capita Environmental Impact on the Bay

Reducing per capita impact of human activity on the Bay will require, among other things, quantification of pollution cost, with a view toward incorporating external environmental costs into the pricing of economic goods. For example, a Minnesota survey of 17 cities identified actual cost of contaminated groundwater at over $24 million ("Survey examines full range of groundwater pollution costs 1991"). Incorporating external environmental costs may be most critical in the prices of fossil fuels, items destined for disposal, and water. For the latter items, such pricing is beginning to be implemented in Virginia. Between 1990 and 1992, average water and sewer rates charged by Virginia municipalities rose 13% ("State water and sewer rates steadily rising, survey finds"1992).

Costs associated with fossil fuel consumption are beginning to be accurately quantified. For example, a 1985 study concluded that acid rain caused $39 million damage annually to buildings in seven Virginia cities (Kahn 1985). More significant, but more difficult to quantify using traditional economics techniques, is the impact of fossil fuel consumption on soil fertility, water quality, biodiversity, and human health (World Resources 1994, Pimentel 1994).

Nevertheless, a growing consensus is emerging that advocates significantly higher prices for fossil fuels in order to send rational signals to consumers. Moreover (and ironically) low fuels taxes can adversely impact economic viability in the United States (McConnell 1993) by subsidizing job losses to Mexico.

Yet any significantly higher prices must be phased in over a number of years, to allow consumers to adjust their behavioral patterns, avoid severe economic dislocation, and provide maximum incentive to the development of renewable energy and energy-efficiency strategies and technologies.

Other industrialized countries, notably those of Western Europe and Japan, have been successful at inhibiting consumption of transport fuels with high prices. For example, gas taxes in a survey of

Western European countries ranged from $1.00 to $2.50, compared with the present U.S. federal tax of approximately $0.18 (Brown et al. 1994). Yet even this level of taxation is insufficient to cover total transport costs. A 1993 study for Germany identified external cost of driving (that is, the environmental costs not included in the price of fuel: air pollution, carbon dioxide impact, noise and accidents) at an additional $ 40 per thousand passenger-kilometers, equivalent to approximately $ 0.065 per mile (Brown et al. 1994).
Applying these calculations to U.S. fuel prices suggests that they should rise at least $3.50 per gallon solely to cover external environmental and health costs of personal motor vehicle use.

Thus, a federal tax on motor fuel that approaches $4 per gallon, indexed to rise with inflation, phased in over a decade and coupled with enhanced mass transit and targeted reductions in income tax rates, could be among the most effective strategies for significantly reducing the impact of fossil fuels on critical ecosystems like Chesapeake Bay, especially in the face of rising population. It could also reduce the need for complex and costly additional regulations mandating increased fleet fuel efficiencies for the American automobile industry. And it could help take financial pressure off the critically stressed health care industry.

Indeed, the motor vehicle itself, with its insatiable demand for paved surfaces, is a major impediment to real progress in environmental remediation. Moreover, some are beginning to question whether the $4-5 billion spent annually on motor vehicle advertising is truly in the nation's economic and environmental interest. (Total annual spending on advertising in the United States is around $125 billion [Brown et al 1994].)

Other strategies for reducing per capita impact include the following:

- To address urban and suburban nonpoint source pollution, a "no net loss of permeable surfaces" policy patterned on present attempts to maintain wetlands should be given careful consideration. This would involve offsets for construction, resulting in no net increase of impermeable surface area in the watershed's urban and suburban areas. It would also apply to roads in rural areas.
- A major ongoing project to educate Bay residents on the impact and environmental cost of personal consumption on the Bay ecosystem is essential.
- A major ongoing energy efficiency plan for all states in the Bay watershed, involving implementation of the 1991 Virginia Energy Plan, the recommendations in the, Virginia Energy Coalition's 2000 report, and comprehensive demand-side management programs.
- An education effort to empower local and state government employees to assume responsibility for (and benefit from) minimizing energy consumption at work.
- Strict enforcement of the provisions of the 1990 CAAA, with revision of the Amendments to further reduce SO_x and NO_x emissions after 2000.
- A major effort to humanely reduce extranational migration into the region to the extent practicable, consistent with constitutional mandates.
- A basinwide effort to reduce turf area by encouraging alternative plantings, especially in the commercial and government sectors, and an ongoing effort to educate residents on the impact of turf on the Bay.
- A study to determine the environmental and economic impacts of converting the interstate highway system to toll roads over a decade, necessary to reduce the 40-50% taxpayer-funded subsidy for road travel (Brown et al. 1993).

CONCLUSION: INCLUSIVENESS, COMMUNITY AND ENVIRONMENTAL STEWARDSHIP

Strict enforcement of present legislation is essential to address degradation, and ultimately restore the Bay. But just as clearly, present legislation may prove ineffectual, given increasing population, energy consumption, motor vehicle use and waste production.

Yet legislation and education may themselves be insufficient without an ongoing initiative to involve all members of the Bay community in this monumental task. Groups without whose participation Bay restoration efforts will likely be futile, and which should be especially targeted for inclusion, should include evangelical and fundamentalist Christians, whose anti-environment beliefs may arise out of an Augustinian-Lutheran-Calvinist vision of Christianity as opposed to the vision of St. Francis or Thomas Aquinas: see Tarnas (1991) for details. It is also critically important to include members of the immigrant community, as well as African-Americans, providing economic incentives for disadvantaged groups where appropriate. Those who feel alienated and betrayed by society are unlikely to be motivated to make further sacrifices to protect the environment.

Ultimately, however, efforts to restore the Bay and indeed the global biosphere may depend not upon science and technology, but upon recapturing a cast-off vision of reality, sadly lost as a byproduct of the Enlightenment and the scientific revolution of the 17th and 18th centuries. This reality, championed by Rousseau, enhanced by Goethe and Nietzsche, involves a rekindling of the spiritual ties that bind humans to nature.

Restoring the lost tension between science and philosophy, could, following Hegel, generate a new dialectic, to be resolved into a new paradigm, a clearer vision of humanity's role as stewards of the planet.

In the words of Richard Tarnas (1991), our imperative to restructure the human relation to nature is driven by "the growing recognition that modern science's mechanistic and objectivist conception of nature [is] not only limited but fundamentally flawed. . . The original project of Romanticism– the reconciliation of human and nature, spirit and matter, conscious and unconscious, intellect and soul–has reemerged with new vigor. . . The twentieth century's massive and radical breakdown of so many structures– cultural, scientific, philosophical, religious, moral, artistic, ecological–all this suggests the necessary deconstruction prior to a new birth. . . The collective psyche seems to be in the grip of a powerful dynamic in which the long-alienated modern mind is breaking through. . . to rediscover its intimate relationship with nature. . ."

"For the evolution of the Western mind has been driven by a heroic impulse to forge an autonomous rational human self by separating it from the primordial unity with nature, [and] the fundamental perspectives of Western culture have all been affected by this decisive masculinity. [Thus] the crisis of modern man is an essentially masculine crisis.

"Yet perhaps an epochal shift is taking place in the contemporary psyche, a reconciliation between the two great polarities, a union of opposites. . . between the long-dominant but now alienated masculine and the long-suppressed but now ascending feminine."

"And this is the great challenge of our time, the evolutionary imperative for the masculine to overcome its hubris and one-sidedness, to choose to enter into a fundamentally new relationship of mutuality with the feminine in all its forms. Nature (the feminine) then becomes not that which must be controlled and exploited, but rather fully acknowledged."

"Thus, if the planet's ecosystem can survive the transition, a rebirth of humanity, incorporating material and spiritual, individual and collective, masculine and feminine, may arise out of the ashes of the old order, and a new human paradigm may be forged."

This indeed may be the ultimate salvation of the Chesapeake, and of ourselves.

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