NEGATIVE POPULATION GROWTH

THE NPG FORUM

The Plight of The Chesapeake

by Stephen Tennenbaum & Robert Costanza

This is the thirteenth in a series of NPG FORUM papers exploring the idea of optimum population — what would be a desirable population size for the United States? Without any consensus even as to whether the population should be larger or smaller, the country presently creates its demographic future by inadvertence as it makes decisions on other issues that influence population change.

The approach we have adopted is the "foresight" process. We have asked specialists in various fields to examine the connection between alternative population futures and national or social objectives. In this issue of the FORUM, the authors graphically document the impact of population growth, urbanization and increasing economic activity in the Chesapeake Bay watershed upon the quality and productivity of the Bay.

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Lindsey Grant, Editor

Summary

The Chesapeake Bay is the largest estuary in North America, and it has been the subject of more scientific study and political wrangling than any other body of coastal water in the world. It has become clear that what happens in the Bay is in large part a function of activities in the drainage basin, but the focus of most past studies has been rather narrow. We are only now beginning to develop a comprehensive picture of the Bay and its connections to its drainage basin.

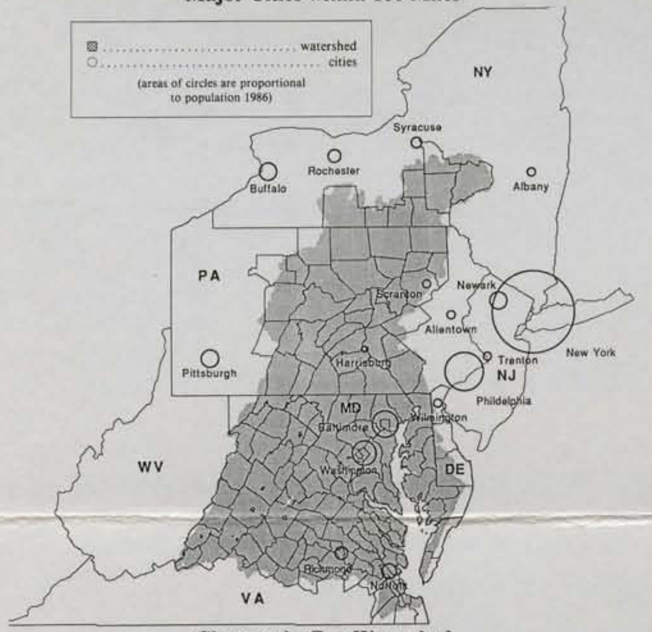
Population increases in the Chesapeake Bay watershed have led to changes in land use and agricultural practices resulting in increasing volumes of wastes which impact natural terrestrial and aquatic systems, and ultimately lead to the deterioration of the Bay itself. Regulation of human activities may slow these effects but the only long term cure is a stable or declining population ensconced in a healthy and likewise stable economy.

We develop an historical and spatial perspective of human activities in the Chesapeake Bay drainage basin. Fundamental in gaining this perspective is conceptualizing the Chesapeake Bay system as the combination of the drainage basin and the Bay itself. We have assembled and mapped past and present human activities in the Chesapeake Bay drainage basin in order to gain this perspective.

Background

The Chesapeake Bay is an ecological system whose beauty and vitality have led to high human population growth rates. These high population growth rates have directly and indirectly caused its infirmity, including declining fisheries, receding wetlands, vanishing seagrasses and a devastated oyster industry. The larger scale terrestrial trends within the entire Chesapeake Bay watershed which have produced these impacts are the subject of this essay. These trends have also led to a decline in the quality of human life. Traffic congestion, disappearing natural and agricultural areas, swelling landfills, and overtaxed water treatment facilities are some of the effects.

Figure 1 — Location of Watershed and some Major Cities within 100 Miles



Chesapeake Bay Watershed
Maps compiled by S. Tennenbaum and R. Costanza
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The Chesapeake Bay is a mosaic of estuaries which taken together comprise the largest single estuary in the United States. It was formed from Atlantic waters eroding and drowning the mouths of the rivers which feed it. It is 193 miles long, 3 to 25 miles wide, and with its tidal tributaries covers an area of 4,400 square miles and has 8,100 miles of shoreline[1]. The drainage basins which feed it comprise 64,000 square miles in six states, and three major cities lie on the banks of its tidal system (Figure 1).

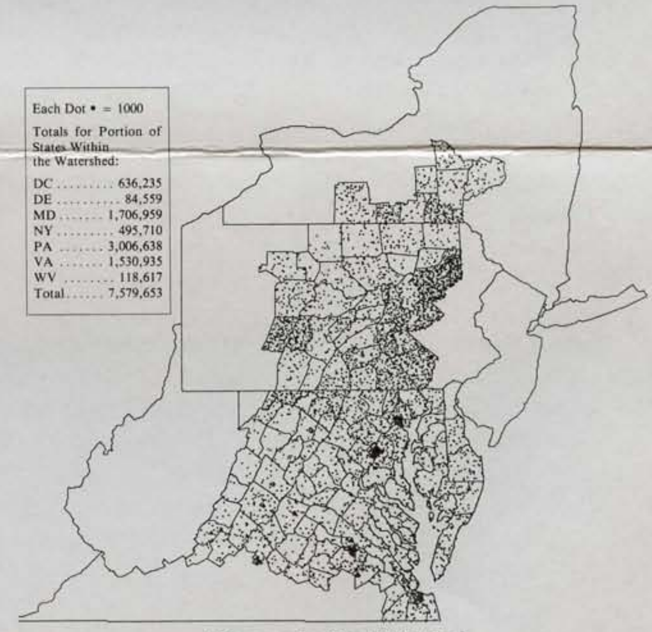
There are complex factors affecting the Bay which have manifested themselves as substantial changes in water quality and structure of the biological communities. Many of these changes have been observed for some time due to the importance of the Chesapeake Bay as a commercial fishery. The Chesapeake Bay Program has documented some of these trends[2,3]. For example, increased levels of nutrients in the upper reaches of the Bay and its tributaries have contributed to eutrophication and increasing blue-green algae and dinoflagellate blooms. Concentrations have increased as much as 250 times in the past thirty years. Areas of the Bay that have experienced oxygen depletion have increased 15 fold times in the same period. There are high concentrations of toxic organic compounds and metals in the water column and sediments near industrial facilities and river mouths such as the Patapsco and Elizabeth rivers. Submerged aquatic vegetation (SAV) is rapidly disappearing in all but a few areas. Commercially important fish such as alewife and shad which spawn in freshwater and whose young use SAV for refuge and as feeding areas have decreased substantially as well, replaced in part by marine breeding species such as bluefish and menhaden. Oyster harvests have declined from over 100 million pounds annually in the late 1800's to only around 20 million pounds in the latter part of this century. And there are increasing worries about the sustainability of the blue crab population because of these problems along with the ever increasing crabbing pressures. In spite of all this, the Chesapeake fishery has for over thirty years provided an average of 10% of the total U.S. fishery catch and employment for 14% of the nation's fishermen[4].

Watershed Demographics

Population changes in the watershed are shown in Figures 2a-b. The number of dots is proportional to population in each county and distributed randomly within each county. Between 1940 and 1986 the population of the watershed increased 87%. About 20% of this increase was due to net migration into the watershed, the majority of it to the areas surrounding Baltimore and Washington in Maryland and Virginia. The population of the watershed grew at an average annual rate of 1.6% between 1952 and 1972, almost the same as the US average of 1.5% for the same period. But the growth was concentrated in the Maryland and Virginia portions of the watershed, which averaged 2.6% growth compared to the remainder of the watershed which grew more slowly at only 0.4%.

The most striking changes were in three areas: Richmond, the Norfolk-Virginia Beach area, and the

Figure 2a. — Population 1940



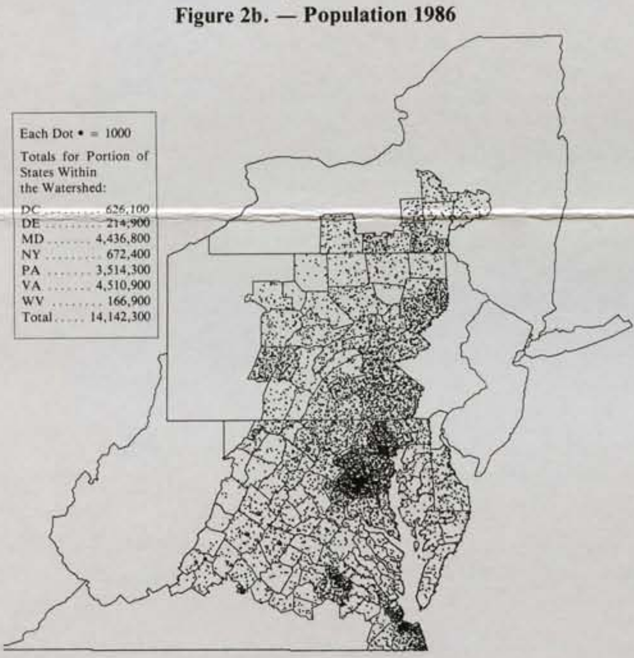
Chesapeake Bay Watershed

Baltimore-Washington corridor. Growth can, in part, be attributed to increases in industry related directly and indirectly to the expanding US Government as well as the increasing fashionableness of the Chesapeake Bay as a recreation area. The latter forces are amplified by the high immigration rates to the area.

These areas also illustrate the 'urban flight-suburban sprawl' phenomena that has at once undermined the more natural and rural atmosphere that many originally left the city for, while at the same time removing businesses and middle and upper income residents which served as a revenue base for the cities. The resulting deterioration of services and infrastructure worsens as people move further and further out. Increasing travel times required to reach work with the concurrent degeneration of traffic conditions, and soaring property values are some of the resistive forces that quell the further spread of suburban development.

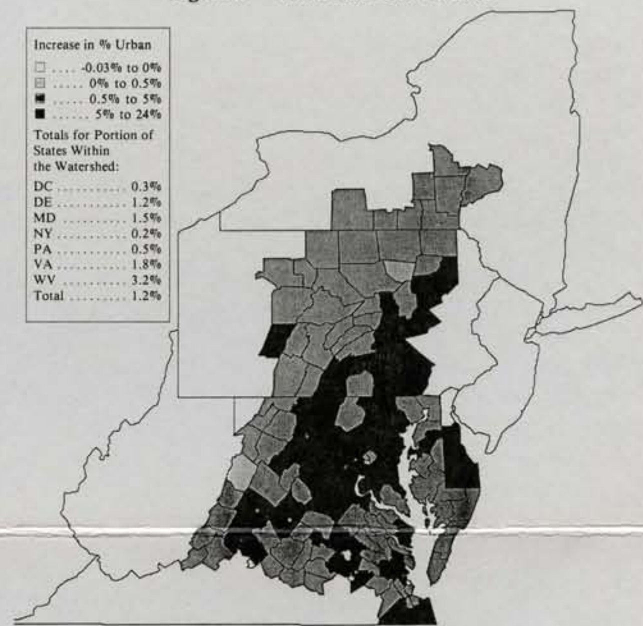
It appears that these forces may be approaching an equilibrium at least for the time being. Between 1972 and 1986 the growth rate of the Maryland watershed population slowed to an annual rate of 0.9%, and in Virginia to 1.8%, and emigration rates from the cities have slowed. For example, Washington D.C.'s emigration rate decreased from an annual average of 1.3% in the 1960's to less than 0.8% in the early 1980's. In addition, the spatial extent of the sprawl appears to be presently limited to the counties immediately surrounding the cities in question (Figure 2b). However, the information contained in these maps is only suggestive. Demographic trends can be the result of any number of factors. Variation in birth rates, cultural heritage, local versus long distance moves, political climate, and zoning laws all muddy the waters. In addition, as sprawl and growth occur simultaneously, secondary economic centers inevitably spring up, initiating their own cycles.

Figure 2b. — Population 1986



Chesapeake Bay Watershed

Figure 3 — Land Use 1978 to 1985



Chesapeake Bay Watershed

Patterns of settlement and resettlement broadly affect land use in other ways as well. For example, there has recently been a slight but noticeable increase in woodland in the New York portion of the watershed. The fact that there was a concurrent loss of cropland and pasture only indicates that there were net changes from one type to another but no indication as to why. In fact, the marked differences in changes in agricultural and forested acreage from one state to another strongly suggest these are due to differences in state agricultural policies and tax laws. On the other hand, the pattern of urbanization is more straightforward in light of the population changes discussed above (Figure 3).

Increases in evidence of human activity accompany the increases in population in both magnitude and distribution. Maps of manufacturers, energy consumption, housing units, water use, solid waste production, and air pollutants all closely resemble the maps of population. However, changes in lifestyle have caused accelerated increases in consumption and waste production. From 1952 to 1986 we have seen the following increases in the watershed: per capita energy consumption has gone from 567,000 BTU/day to 744,000 BTU/day; NO_x emissions by vehicles have gone from 1.0 lb/week per person to 1.7 lb/week per person; and per capita solid waste production has risen from 2.2 lb/day to 3.7 lbs/day. In contrast, public and industrial per capita water use has decreased in the same period for the watershed as a whole from 334 gal/day to 278 gal/day. This is due in large part to the decline in total use in Pennsylvania during this period from 1.46 billion gallons per day in 1952 to only 1.18 billion gallons per day in 1986. In the Maryland and Virginia portions of the watershed, the per capita use rate held nearly constant at about 237 gal/day. This suggests that the former change may be due to changes in heavy industry in Pennsylvania while the latter lack of change may be due to a relatively constant per capita public demand for water in a region which is primarily residential and light industry.

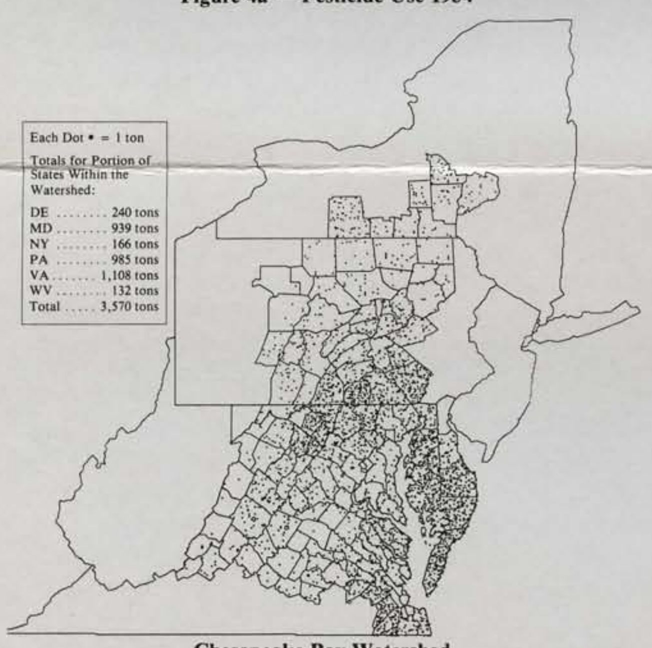
Agriculture

Changes associated with agriculture are tied to increases in population in their overall magnitude, and to cultural and historical practices in their distribution and local magnitude. Heavily populated areas necessarily exclude agriculture. Some of the best agricultural land in the country, which was the basis for the initial local growth, is rapidly being converted to residential developments, industrial parks, and shopping malls as rising property values make farming unprofitable. It is not clear, however, whether agriculture itself is more benign to an ecosystem such as the Chesapeake Bay than urban and surburban development. Both load the system with wastes and nutrients while consuming "natural" areas that could have absorbed some of that load.

While total farm acreage has decreased from 23.2 million acres in 1954 to 14.4 million acres in 1987 in the watershed, cropland has only decreased from 10.5 million acres to 9.0 million. Meanwhile from 1954 to 1987 the average farm size increased from 126 acres to 190 acres. This means larger percentages of farms are devoted to crops (64% versus 45%) while less lies fallow, pastured, and wooded. Operations are larger and more intensive. Irrigation has increased from 40 thousand acres to 180 thousand acres. Fertilization rates have increased from about 210 lbs per cultivated acre to 250 lbs per cultivated acre, and the nitrogen content has more than doubled. Figures 4a-b show that pesticide use, which was almost non-existent in the early 1950's, peaked in the 1970's, and subsequently decreased from 15 thousand tons in 1974 to 13 thousand tons in 1986. This reflects the greater specificity of the pesticides used in 1986.

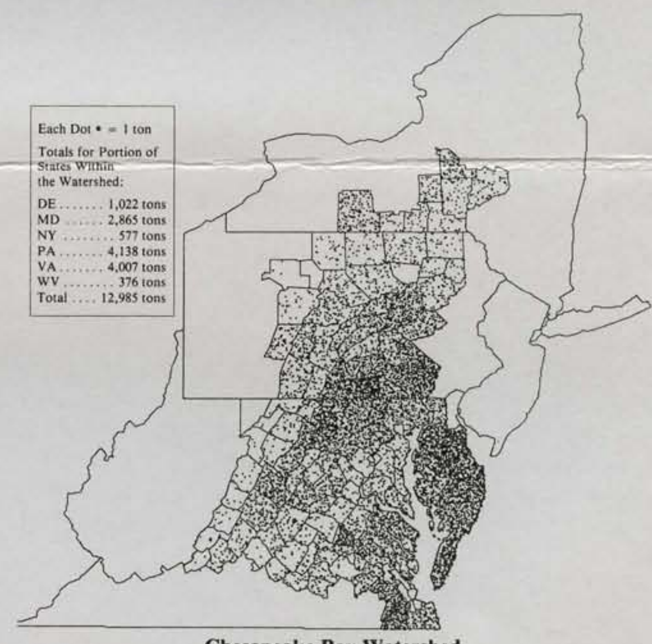
If we examine the application of fertilizer nitrogen (Figures 5a-b) we see a pattern which follows the general distribution of farmland, but with an overall increase in the intensity of use. The nutrient loading rates for the mainstream Chesapeake Bay are 78.7 thousand tons per year nitrogen and 3.6 thousand tons per year phosphorus[5]. If one assumes that the loading rate is proportional to the amount of nutrients applied within the watershed, then this implies that phosphorus loading has

Figure 4a — Pesticide Use 1954



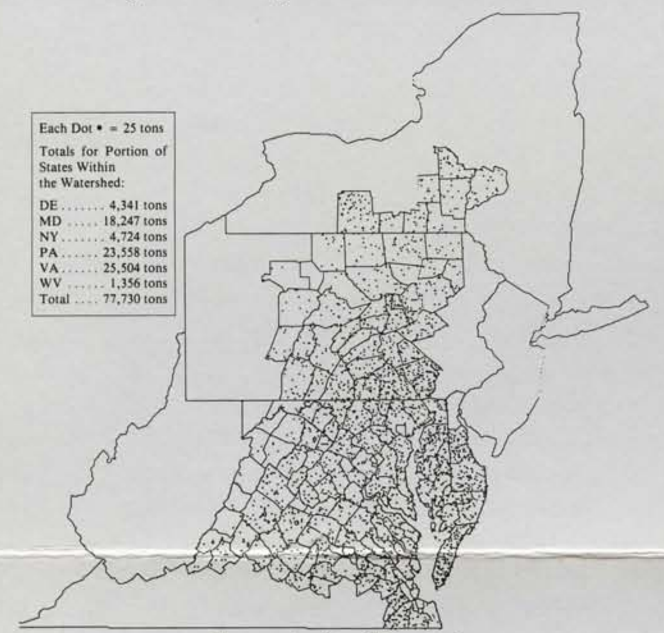
Chesapeake Bay Watershed

Figure 4b — Pesticide Use 1987



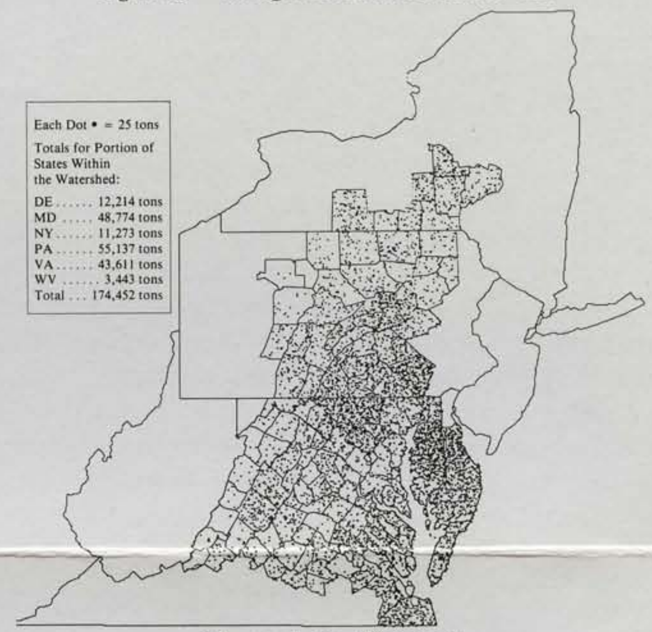
Chesapeake Bay Watershed

Figure 5a — Nitrogen Contents of Fertilizer 1954



Chesapeake Bay Watershed

Figure 5b — Nitrogen Contents of Fertilizer 1987



Chesapeake Bay Watershed

increased around 4 to 10% and nitrogen loading has increased somewhere between 34 to 125% since 1954 (depending an one's estimate of the run off from manure). This would not only be a great change in amount of nutrients but (and this may be even more crucial) a great change in the relative proportion of nutrients. The increased concentrations of nutrients in specific localities such as Lancaster County, Pennsylvania may intensity this problem.

Conclusions

The Chesapeake Bay has undergone very rapid population growth with its associated environmental impacts. We have mapped some of these changes as they are reflected in the characteristics of the Bay's watershed. The impacts of these activities in the watershed on the Bay itself are known to be large, but their specific interconnections are only now being investigated. The Chesapeake Bay has 200,000 people living in its drainage basin for every km³, of water in the Bay (the Baltic sea has 4000 people/km³, and the Mediterranean has 85 people/km³ by way of comparison). Even if all of these people were minimizing their environmental impacts (which they are not) their sheer numbers are daunting to a system as sensitive as the Chesapeake. If these numbers continue to increase as they have been in the past, the prospects for America's largest estuary seem bleak.

FOOTNOTES

1. V.K. Tippie, 1984. "An environmental characterization of Chesapeake Bay and a framework for action." In: *The Estuary as a Filter*. pgs. 467-488. V. S. Kennedy editor. Academic Press. Orlando, Florida.
2. *Chesapeake Bay Program*. 1983. *Chesapeake Bay Program: Findings and Recommendations.* Environmental Protection Agency, Washington, D.C.
3. Chesapeake Bay Program. 1989. *The State of the Chesapeake Bay: Third Biennial Monitoring Report — 1989.* Environmental Protection Agency, Washington, D.C.
4. U.S. Department of Commerce. *U.S. Statistical Abstract 1977 and 1986.* U.S. Government Printing Office, Washington, D.C.
5. W. Boynton, J. Garber, and M. Kemp. 1990. "Patterns of Nitrogen and Phosphorus input, storage, recycling, and fate in the Chesapeake Bay and selected tributary rivers." In preparation.

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