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Urbanization, Stream Buffers, and Stewardship in Maryland

by Dr. Glenn E. Moglen, Department of Civil and Engineering, University of Maryland

The stream buffer is the region immediately beyond the banks of a stream that serves to limit the entrance of sediment, pollutants, and nutrients to the stream itself. When forested, a stream buffer promotes bank stability and serves as a major control of water temperature (Leopold, 1997). From a biological perspective, the importance of a healthy, intact riparian zone has only been understood for the last 20 years (Rapp, 1997).

Most counties in Maryland have some kind of regulations in place to keep development away from perennial streams and tidal waters, whether through local stream buffer, steep slope, flood plain or critical area ordinances. However, the quality and extent of the buffer varies markedly across the state.

This note documents recent trends in land conversion in urban, suburban and rural counties in Maryland, with a strong emphasis on how these changes have affected land cover within the stream buffer zone. The study examines how the composition of land cover in the buffer zone changes in response to development, with respect to forest, agricultural and urban cover within 100 feet of each streambank.

Methods and Data Sources

This study was based on analyses performed with a Geographic Information System (GIS). The key data source for land use was the Generalized Land Use coverages produced by the Maryland Office of Planning (MOP) for 1990, 1994, and 1997. These data were derived and interpreted from high altitude aerial photography and satellite imagery (SPOT 1994 and 1997) with a 10 acre minimum mapping unit. Land use was classified by 24 different descriptors, but was more broadly reclassified as urban, agricultural, or forest for purposes of this study.

Stream locations within Maryland were determined from U.S. Environmental Protection Agency River Reach files (Dewald & Olsen, 1994). The modified GIS produced a digitized version of the Maryland

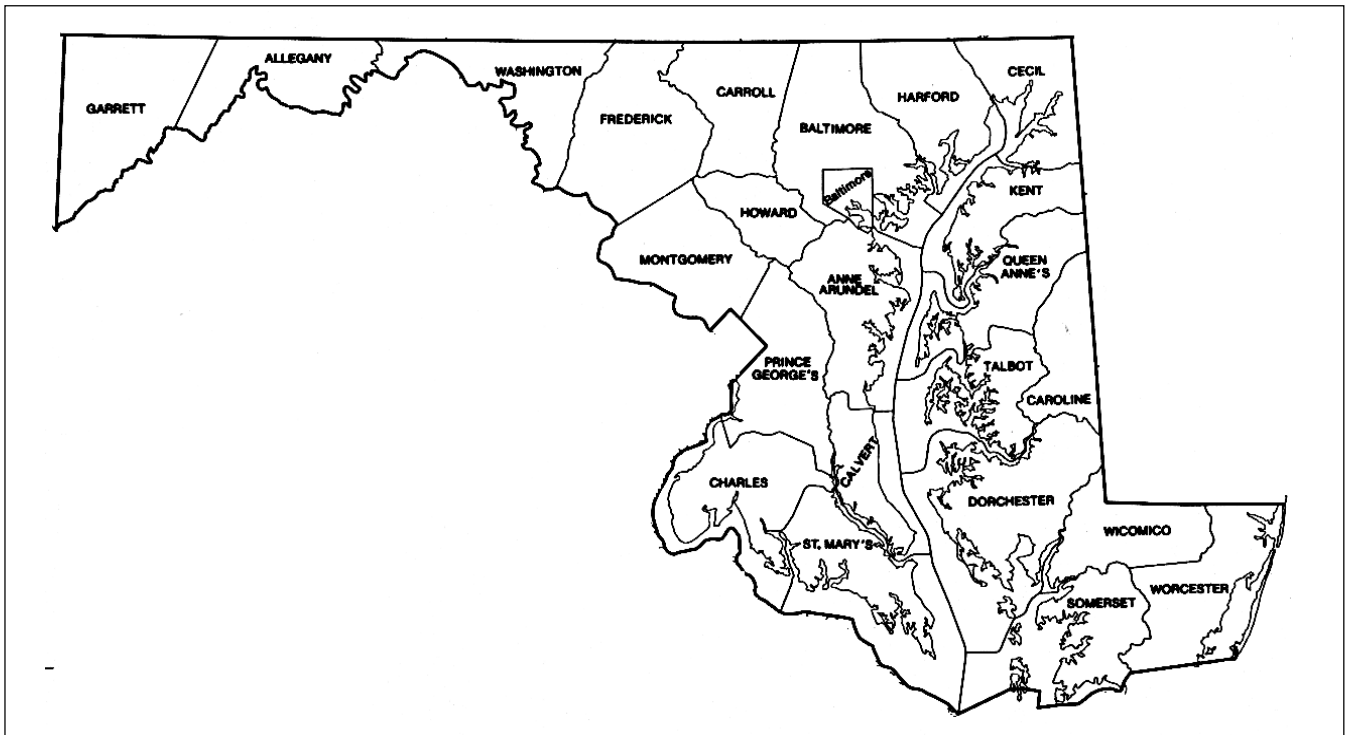

Figure 1: Map of Maryland Counties Analyzed in the Article

stream network at 1:100,000 scale. Past studies have shown that the extent of the drainage network is sensitively dependent on the map scale (Moglen and Beighley, in press). This same analysis undertaken at a finer 1:24,000 scale would have shown a greater number of first order streams. The 1:100,000 scale files used in this study were selected because of their general availability across the state of Maryland.

Although Schueler (1995) emphasizes that the stream buffer is not simply a "line on a map," this study characterizes buffers as precisely that. Polygons were generated for stream buffers extending exactly 100 and 200 feet to each side of the digitized tester streams. Figure 2 presents a typical segment of stream channel, illustrating the stream and a 200-foot buffer zone. The "buffered" area was compared to the land use coverages for 1990, 1994, and 1997. Statistics were compiled to document overall changes in land use distributions within each county, as well as changes in land cover within the stream buffer zone.

Trends in Land Conversion by County

Urban land use cover across the state of Maryland increased by 3.9% between 1990 to 1997, cumulatively representing the conversion of 390 square miles of land (see Table 1). Urban land conversion came at the expense of agricultural land (2.2% loss) and forest land (1.5% loss). The remaining 0.2% loss was spread across the "water," "wetland," and "other"categories.

Patterns of Urbanization by County

While some trends were evident at the statewide scale, land use changes at the county scale were much more variable. Land and buffer conversion was even more striking when viewed on a county basis (see Figure 1).

For purposes of analysis, each county was classified as urban, suburban or rural, based on the fraction of urban land present in 1997. Five counties were considered "urban," as more than 35% of their land area was classified as urban. Urban counties grew at the fastest pace over the eight year period, with an average rate of growth of 6.5%. Nine counties were classified as suburban, with 12% to 25% of their land area in the urban category. These suburban counties experienced a moderate rate of growth (4.4%) in urban area during the study period. Finally, nine counties were considered rural, as urban land comprised less than 12% of their total area. These rural counties experienced the slowest rate of growth (2.5%) over the study period.

As might be expected, the urban growth occurred by converting forest and agricultural lands. The loss of forests for rural, suburban and urban counties was 0.8%, 2.1% and 2.5%, respectively, during this eight

Table 1: Overall Land Use Distribution and Change in Land Use Distribution by County (Negative changes indicate loss of land cover in indicated category.)

	1997				Changes: 1990 to 1997		
*County	Urban (%)	Agriculture (%)	Forest (%)	Other (%)	Urban (%)	Agriculture (%)	Forest (%)
Anne Arundel (U)	37.8	17.7	41.1	3.5	5.2	-1.1	-3.6
Baltimore (U)	35.0	27.2	33.7	4.1	3.6	-1.8	-1.6
Howard (U)	35.3	31.4	32.2	1.1	9.8	-3.8	-4.8
Montgomery (U)	41.7	26.3	29.4	2.6	6.1	-7.1	1.8
Prince Georges (U)	38.5	16.2	40.9	4.4	8.0	-2.4	-4.5
Calvert (S)	24.2	20.5	49.4	6.0	8.4	-1.7	-6.6
Carroll (S)	17.8	57.7	23.4	1.0	5.0	-4.6	-0.2
Cecil (S)	13.5	44.3	37.8	4.4	2.8	-1.8	-1.0
Charles (S)	16.0	20.3	58.8	5.0	3.4	-0.3	-3.0
Frederick (S)	12.2	57.5	29.7	0.6	3.6	-2.4	-1.0
Harford (S)	22.9	38.3	33.5	5.3	3.2	-2.0	-1.2
St. Marys (S)	15.6	27.2	53.3	3.8	4.2	-2.2	-1.8
Washington (S)	14.1	47.9	35.9	2.1	4.2	-2.4	-1.8
Wicomico (S)	12.4	35.7	43.5	8.4	4.9	-2.6	-2.1
Allegany (R)	10.5	12.3	76.1	1.2	2.5	-0.4	-2.1
Caroline (R)	7.5	57.5	31.4	3.6	2.3	-2.0	-0.3
Dorchester (R)	4.4	31.8	34.1	29.8	2.2	-1.3	-0.7
Garrett (R)	6.9	22.5	68.6	2.1	1.7	-1.5	-0.3
Kent (R)	5.5	61.6	24.6	8.3	1.8	-1.8	0.1
Queen Annes (R)	7.6	62.6	26.4	3.4	2.2	-0.4	-1.5
Somerset (R)	5.8	25.7	43.3	25.1	2.6	-1.6	-0.8
Talbot (R)	11.1	57.5	23.2	8.2	5.3	-3.0	-2.0
Worcester (R)	6.7	30.3	54.7	8.3	2.2	-2.5	0.6

* U = Urban, S = Suburban, R = Rural

year period. Conversion of agricultural lands was even greater, with losses of 1.6%, 2.2% and 3.2% respectively in the rural, suburban and urban counties, respectively. Individual statistics on the county-wide loss of forest and agricultural cover are provided in Table 1

Urban land conversion has uniformly come at the expense of agricultural land for every county in the state. In general, forest land was also lost across the state — as much as 6.6% was lost in Calvert County. A few counties reported gains in forest cover, most notably Montgomery County, which gained 1.8%, and Worcester, which gained 0.6% over this period.

Trends in Stream Buffer Cover

The stream buffer zone was considered to be in a desirable condition if it was in a forested or wetland land use as indicated by the "Total Buffered" columns in Table 2. The trends in land conversion within the 100-foot stream buffers are somewhat different. While urban land use increased by 1.9% in the buffer zone (about 8.3 square miles) between 1990 to 1997, forest cover actually increased by a modest 0.6%. Once again, the loser in this exchange was agriculture, which lost 2.1% of its share of the stream buffer zone over this period. Since tidal and non-tidal wetlands are protected and preserved by both state and federal law, it was not surprising that changes in overall wetland land cover were found to be small, if not negligible. Taken together, the 100-foot stream buffer zone occupies approximately 5.2% of the total land area in Maryland.

On a county basis, the amount of forest cover in buffer zones was as low as 24.1% in Dorchester County, and as great as 76.6% in Charles County. In several Eastern Shore counties, tidal and non-tidal wetland comprise more than 10% of land within the stream buffer zone. Indeed, more than 50% of the buffer areas are designated as wetlands, so the low forestation value for Dorchester county should be taken with the understanding that "buffering" still exists, but in the form of a wetland rather than forest (again, see Table 2). Although one might expect the rural counties to have relatively high forestation in the buffer zones, this was not always the case. In counties with less than 50% forestation in the buffer zones, a large fraction of the buffer zone was generally designated as agricultural land use, presenting the opportunity for significant buffer zone reforestation in coming years.

Table 2: 100-Foot Stream Buffer Land Use Distribution and Change in Land Use Distribution by County (Negative changes indicate loss of land cover in indicated category.)

	1997					Changes: 1990 to 1997				
*County	Urban (%)	Agri-culture (%)	Forest (%)	Wet-land (%)	Total Buffered (%)	Urban (%)	Agri-culture (%)	Forest (%)	Wet-land (%)	Total Buffered (%)
Anne Arundel (U)	21.4	7.9	67.6	3.1	70.7	1.7	-0.3	-1.0	0.0	-1.0
Baltimore (U)	21.8	18.0	58.6	1.4	60.0	0.2	-0.8	0.8	0.0	0.8
Howard (U)	18.2	19.8	61.6	0.3	61.9	3.3	-2.4	-0.2	-0.0	-0.2
Montgomery (U)	17.0	12.3	70.3	0.4	70.6	-0.3	-12.5	13.5	0.0	13.5
Prince Georges (U)	20.1	7.2	69.8	2.7	72.5	2.5	-0.4	-1.1	-0.4	-1.5
Calvert (S)	13.9	7.9	67.7	10.5	78.1	4.8	-0.2	-3.4	-0.8	-4.2
Carroll (S)	7.2	46.9	45.8	0.0	45.9	2.0	-4.0	2.1	-0.1	2.0
Cecil (S)	9.2	17.7	68.5	3.8	72.4	1.6	-0.6	-0.8	-0.2	-1.0
Charles (S)	7.4	9.7	76.6	6.2	82.8	1.4	-0.2	-1.2	-0.1	-1.3
Frederick (S)	6.9	53.7	39.3	0.0	39.3	1.2	-0.9	-0.2	0.0	-0.2
Harford (S)	12.3	28.2	54.7	4.9	59.5	0.9	-0.2	-0.9	0.3	-0.6
St. Marys (S)	11.1	16.0	68.0	4.7	72.6	2.2	-1.8	-0.3	-0.0	-0.3
Washington (S)	9.4	47.8	42.8	0.0	42.8	2.5	-1.7	-0.8	-0.0	-0.8
Wicomico (S)	10.0	17.5	50.7	21.7	72.4	3.4	-0.6	-1.4	-1.2	-2.6
Allegany (R)	11.8	13.5	74.6	0.0	74.7	3.4	-1.2	-2.2	0.0	-2.2
Caroline (R)	7.2	32.3	53.6	6.8	60.4	3.1	-0.7	-2.0	-0.4	-2.4
Dorchester (R)	3.6	17.9	24.1	54.3	78.3	2.0	-1.6	-0.3	-0.2	-0.5
Garrett (R)	7.7	16.8	73.8	1.7	75.4	1.3	-1.2	-0.1	-0.0	-0.1
Kent (R)	6.0	28.8	56.6	8.5	65.1	2.2	-6.5	5.0	-0.7	4.4
Queen Annes (R)	6.1	34.0	54.5	5.4	59.8	1.1	0.2	-1.0	-0.3	-1.3
Somerset (R)	3.8	11.9	31.6	52.6	84.3	1.9	-0.8	-0.6	-0.6	-1.2
Talbot (R)	15.8	40.5	35.7	8.0	43.7	7.8	-10.0	2.4	-0.3	2.1
Worcester (R)	4.1	13.3	65.1	17.1	82.2	1.4	-3.2	2.1	-0.5	1.6

* U = Urban, S = Suburban, R = Rural

Although one might expect that urban counties would have relatively low forest cover in the buffer zone compared to the less densely developed counties, this was not the case. The five most urban counties averaged about 66% forest and wetland cover in the buffer zone, compared to 63% for suburban counties and 69% for rural counties. The key differences was in the composition of the non-forest cover in the buffer. In urban counties, only 13% of the buffer zone was agricultural cover, whereas this figure was about 25% in the rural and suburban counties.

Disturbing trends were noted in suburban counties that continued to lose forest cover within the buffer zone. It appears that developing counties, not the urban counties, are experiencing the greatest loss of forest cover. For example, Calvert County, which exhibited the greatest rate of urban growth, also showed the greatest loss of forest cover within the buffer zone (about 1.1% per year).

The analysis did have some heartening news. There was strong evidence that many counties have recently begun to slow, stop and even reverse the loss of forest cover in the buffer zone. In the first four years of the study, 75% of the counties recorded forest loss in the buffer zone, and 25% indicated no change in forest cover. In the last four years of the study, however, only 48% of counties recorded a loss of forest cover, and 52% actually gained forest cover in the buffer zone. Seven counties added more than 3% forest cover to their existing buffer zones during the 1994 to 1997 period.

The gains in forest cover appeared to be due to several factors: gradual succession of agricultural lands into forest, riparian reforestation efforts, and stronger enforcement of stream buffer and flood plain regulations. Of these factors, it appears that succession was probably the greatest factor, since agricultural cover was lost at a rate of 2.5% in the buffer zone during the study period. Clearly, croplands are reverting to forest either because they are now protected by a stream buffer or because they have been abandoned as suburban growth advances into the countryside.

The nature of existing adjacent land use appears to play a role in the ability to reforest the buffer zone. Typical residential and commercial developments, for example, do not offer much flexibility for reforestation after development. And indeed, only 13.3% of the reclaimed 100-foot buffer zones in Montgomery County came from formerly urban sources, with the remainder coming from agricultural use. Agricultural land provides much greater flexibility for buffer re-conversion, and contributed a disproportionately larger share of reclaimed buffers relative to overall land use distributions within all counties. Figure 3 illustrates the spatial location of reforested 100-foot stream buffers in Montgomery county. Forested buffers are most sparse in the southeastern part of the county, where the most dense development has historically occurred and thereby constrains buffer reclamation.

Implications: Buffer Zones at Risk

Efforts to reforest the buffer zone can be successful, even in urban counties. This is illustrated by the strides made by Baltimore City and Montgomery County, among others. Furthermore, the goal to protect and reserve the stream buffer zone from development is not necessarily at odds with future development. Twelve Maryland counties all managed to undergo further urbanization while actually enhancing the amount of forest cover in their buffer zones in the last four years of the study.

Several counties that had low forest cover in the buffer zone and a large agricultural land use component — Talbot, Frederick, Washington, and Carroll counties — have potential to reclaim significant percentages of forest cover within the buffer zone in future years. Should the buffer zone become reforested in these formerly agricultural settings, the reclaimed stream buffers would likely lead to significant enhancement of stream water quality.

Urban development in Calvert County is illustrative of the most discouraging activities going on in the state. From 1994-1997, Calvert County underwent the greatest percentage change in urban land use (7.6%) within the state, while simultaneously undergoing the greatest loss in forested buffer zones within the state (3.4%). Lost wetlands totaled another 0.8%, also the greatest in the state. Ten other counties across the state followed a similar urbanization/deforestation pattern in the buffer.

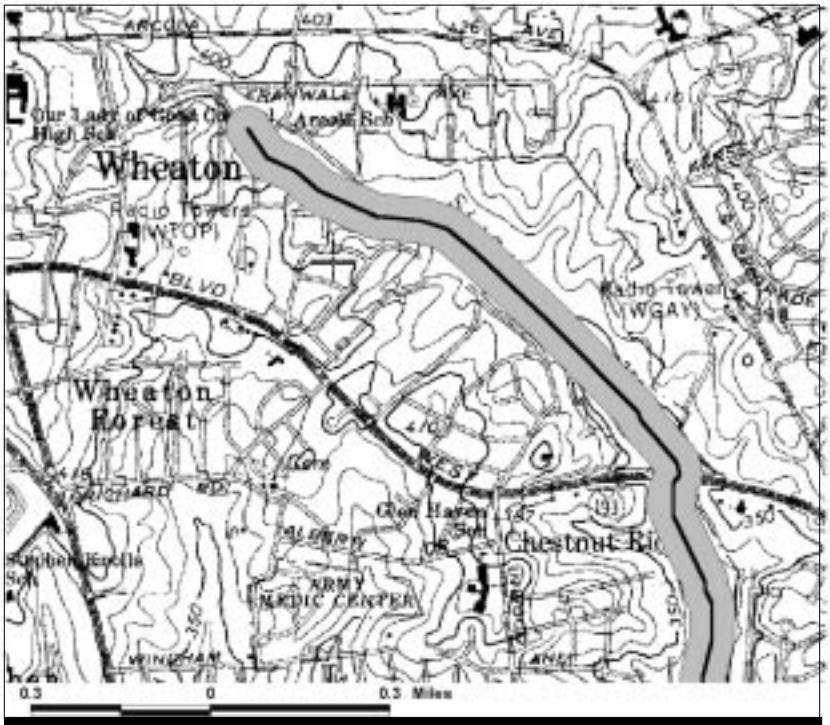

Figure 2: Sample Stream With 200-foot Buffer Identified (Background is U.S.G.S. 1:24,000 quadrangle map.)

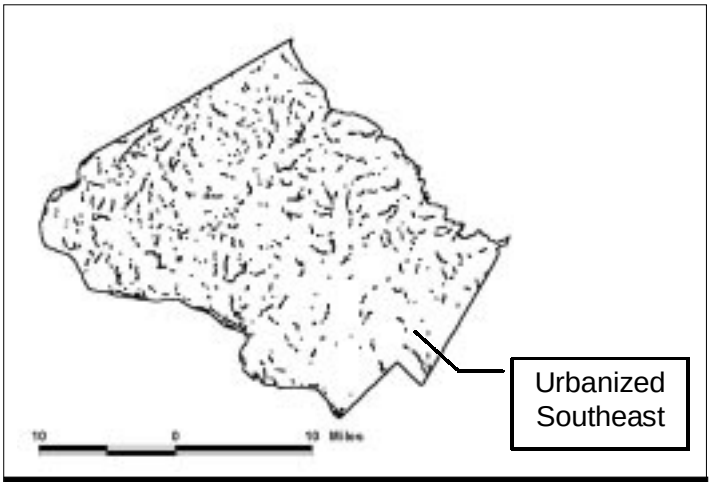

Figure 3: Location of Reforested 100-foot Stream Buffers in Montgomery County, MD for 1994-1997 (Note absence of buffers in the more highly urbanized southeastern corner of county.)

These trends are unsettling not only because of their immediate negative impact on the stream buffer zone, but also because of the difficulty of reforestation after development. Better enforcement and more stringent stream buffer programs are most needed in these rural areas, but growing counties have the most to lose in terms of loss of potential development.

While the story told here is specific to Maryland, the general themes of the need for land use planning, conversion from agriculture to residential land, and reclamation of the stream buffer by forests in urban and agricultural settings surely extend to many other states. The data needed to perform similar studies in other states remains the same: digital land use coverage throughout the state for at least two different points in time, and a digitized stream network covering the same area. The existence and quality of the former (land use) may vary considerably depending on the state, while the availability of the latter (stream network) exists from the EPA (USEPA, 1999) if not from elsewhere.

The author has developed a sample ArcView program to facilitate the comparative analysis in other states. A planner possessing these two digital products may readily perform the same analyses presented here.

Summary

While continued urbanization has been a constant across the state, more than half of Maryland's counties have posted increases in forest cover in the stream buffer zone. Based on land use distributions in 1997, a number of counties were identified that have the potential to significantly enhance the amount of forest cover within their buffer zones. These counties have a large percentage of agricultural land use currently in this zone. It was observed that reforestation of the buffer zone after urban development has taken place is more difficult, and the available width of the buffer zone is more limited. This highlights the need for sound environmental stewardship of the watershed as well as the necessity of crafting development plans that set aside stream buffers prior to development. Such planning is especially important in rural but rapidly growing counties that can quickly lose forest buffer zones over as short a span as a single decade.

Acknowledgments

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