Tidewater Ecosystem Assessment

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Patuxent River
Water Quality and Habitat Assessment
Overall Condition 2012-2014

The Patuxent River basin includes areas in Howard, Montgomery, Prince George's, Anne Arundel, Charles, Calvert and St. Mary's counties (Figure 1). The basin can be divided into an upper (including Western Branch watershed), middle and lower river.

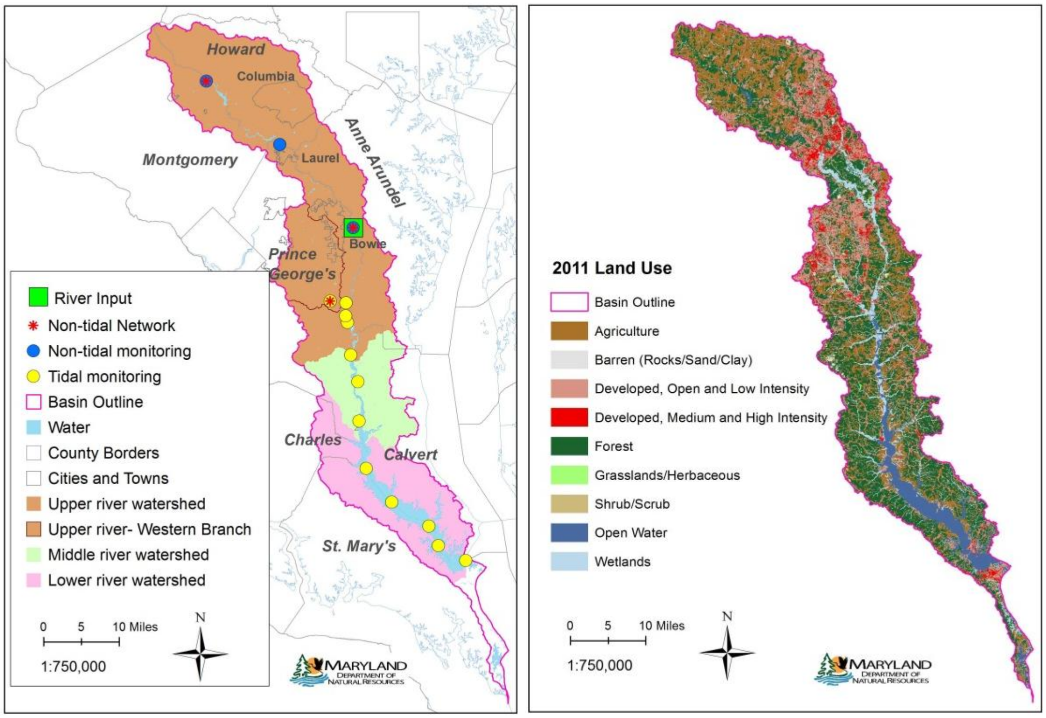

Figure 1 Patuxent River basin. Left-side panel shows the individual watersheds and MD DNR sampling stations (non-tidal and tidal) and the Non-tidal Network stations in the basin where trends were determined for 2014. The River Input station for loadings trends is also shown. White areas of the basin drain to the mainstem Bay. Right-side panel shows the land use throughout the basin for 2011.[1]

Land use in the upper Patuxent River watershed was estimated to be 34% forest, 32% developed, and 23% agriculture.[1] Impervious surfaces cover 11% of the upper basin.[2] Stormwater is the largest source of nitrogen and sediment loadings in the upper river, and a large source of phosphorus loadings.[3] Wastewater is the largest source of phosphorus loadings, and also a large source of nitrogen and sediment loadings. Agriculture is also a large source of sediment loadings. Stormwater is the largest source of nitrogen, phosphorus and sediment loadings in the Western Branch section of the upper river.

Land use in the middle Patuxent River watershed was estimated to be 49% forest, 23% agriculture and 15% developed. Impervious surfaces cover 5% of the middle basin. Agriculture is the largest source of nitrogen, phosphorus, and sediment loadings to the middle river. Septic and forested lands are also large sources of nitrogen loadings, and urban lands are a large source of phosphorus loadings.

Land use in the lower Patuxent River watershed was estimated to be 57% forest, 16% developed and 16% agriculture. Impervious surfaces cover 3% of the lower basin. Septic is the largest source of nitrogen loadings to the lower river; agriculture is also a large source of nitrogen loadings. Agriculture is the largest source of phosphorus loadings, and urban lands are also a large source of phosphorus loadings. Agriculture is the largest source of sediment loadings.

How healthy is the Patuxent River?

Maryland Department of Natural Resources (MDDNR) measures water and habitat quality at three non-tidal long-term monitoring stations and at 13 tidal long-term monitoring stations in the Patuxent River (Figure 1). Current conditions are determined from the most recent three years of data; trends are determined from the 1999-2014 data.

MDDNR also participates in the Non-tidal Network, a partnership with the United States Geologic Survey (USGS), the Chesapeake Bay Program, and the other states in the basin, to measure non-tidal water quality using the same sampling and analysis methods. Two of Maryland's long-term non-tidal stations are also part of the Non-tidal Network (Figure 1, Table 2); a third station on Western Branch is part of the Non-tidal Network and sampled just upstream of a tidal long-term monitoring station. USGS completes the trends analysis for all Non-tidal Network stations. USGS combines river flow data and the nutrient and sediment data for the most recent 10-year period. The USGS method accounts for changes in river flow so that underlying changes in nutrient and sediment levels can be determined.[4]

USGS and MDDNR also measure the nutrient and sediment loadings at the fall-line station (River Input station on Figure 1) to determine trends in loadings at this station.[4]

Upper River: Non-tidal areas: Nitrogen and phosphorus loadings have decreased at the fall-line station at Bowie, but sediment loadings have increased.[4] Nitrogen and phosphorus levels in the water also decreased at this station, both with and without accounting for the effects of river flow (Table 1). Nitrogen levels also decreased in the non-tidal portion of Western Branch when changes in river flow are accounted for.

At the upstream non-tidal station, nitrogen levels in the water increased but phosphorus levels decreased.

Tidal areas: In the tidal portion of the upper river, water quality is fair to poor, but nitrogen and phosphorus levels are improving (Table 2). Sediment levels are also improving at Jackson Landing. However, nutrient and sediment levels are still too high. Habitat quality for underwater grasses is fair due to low water clarity and algal densities are too high at Nottingham.

Underwater grasses covered larger areas in the early 2000s, meeting restoration goals, but have not been as widespread in more recent years. Grass beds only covered approximately 15% (in 2012) and 7% (in 2013) of the area needed to meet the restoration goal, but covered more than 56% of the area needed to meet the restoration goal in 2014.[5] Bottom dwelling animal populations are healthy in the areas sampled during this period.

Middle River: In the middle river, tidal water quality is poor at the two upstream stations due to high nitrogen, phosphorus and sediment levels. Nitrogen and phosphorus levels improved at the Lower Marlboro station. Water quality was fair at the Long Point station. Habitat quality for underwater grasses is poor due to moderate algal densities and low water clarity; habitat quality has degraded at the Jack's Creek station. Summer bottom dissolved oxygen levels are unhealthy at the Long Point station.

During the last ten years, underwater grasses covered more than 90% of the area needed to meet restoration goals for several years, but only covered approximately 15% of the goal during 2012 and 2013. In 2014, grass beds covered 37% of the area needed to meet the restoration goal. Bottom dwelling animal populations are healthy in areas sampled in the lower section of the middle river, but were degraded in other areas sampled in the upper section of the middle river. The health of bottom dwelling animal populations has also degraded over the longer term period.

Table 1. Summary of non-tidal water quality trends.
Trends for nitrogen (N), phosphorus (P) and sediment (Sed). Trends at MDDNR long-term non-tidal monitoring stations (columns labeled 'MDDNR') are determined for 1999-2014; analysis does not include use of flow data. Trends at Non-tidal Network stations (columns labeled 'USGS') are determined by USGS for 2005-2014 (at some stations there is no 2005 data); analysis includes use of flow data.[4] Non-tidal Network stations include the corresponding USGS gage number. Stations in bold typeface are MDDNR long-term non-tidal monitoring stations that are also part of the Non-tidal Network. The River Input Station (fall-line station) is highlighted in yellow. Decreasing trends ('Dec') are improving trends and shown with green typeface. Increasing trends ('Inc') are degrading trends and shown with red typeface. Blanks indicate no significant trend. Grey shading indicates that the station does not have data for that parameter. Stations are ordered roughly from upstream to downstream.

			MDDNR 1999-2014 (without flow)			USGS 2005*-2014 (with flow)		
Watershed	USGS Gage #	MD DNR Station	N	P	Sed	N	P	Sed
Upper Patuxent	01591000	PXT0972	Inc	Dec				
		PXT0809						
	01594440	TF1.0	Dec	Dec		Dec	Dec	
Western Branch	01594526	TF1.2				Dec		

Table 2. Summary of tidal water quality and habitat quality indicators.
Annual trends for 1999-2014 for nitrogen (total nitrogen), phosphorus (total phosphorus), sediment (total suspended solids), algal densities (chlorophyll *a*), and water clarity (Secchi depth). Summer bottom dissolved oxygen (DO) trends are for June through September data only. Trends are either 'Increasing' or 'Decreasing' if significant at $p \leq 0.01$; blanks indicate no significant trend. Improving trends are in green, degrading trends are in red. Nitrogen (dissolved inorganic nitrogen) levels below the level for nitrogen limitation 'Meet' criteria, otherwise 'Fail' criteria for 2012-2014 data. Phosphorus (dissolved inorganic phosphorus), sediment (total suspended solids), algal densities (chlorophyll *a*) and water clarity (Secchi depth) either 'Meet' or 'Fail' submerged aquatic vegetation (SAV) habitat requirements for 2012-2014 data. Summer (June through September) bottom dissolved oxygen levels either 'Meet' or 'Fail' EPA open-water 30-day dissolved oxygen criteria.

		Water Quality			Habitat Quality		
River portion	Station	Nitrogen	Phosporus	Sediments	Algal Densities	Water Clarity	Summer Bottom DO
Western Branch	Wayson's Branch	Decreasing Fail	Meet	Meet	Meet		
	Mouth of Western Branch	Decreasing Fail	Decreasing Meet	Fail	Meet	Fail	
Upper River	Wayson's Corner	Decreasing Fail	Decreasing Fail	Meet	Meet	Fail	
	Jackson Landing	Decreasing Fail	Decreasing Meet	Decreasing Fail	Meet	Fail	
	Nottingham	Decreasing Meet	Decreasing Meet	Fail	Fail	Fail	Meet
Middle River	Lower Marlboro	Decreasing Fail	Decreasing Fail	Fail	Fail	Fail	Meet
	Jack's Creek	Fail	Fail	Fail	Increasing Fail	Decreasing Fail	Meet
	Long Pt.	Meet	Fail	Meet	Fail	Fail	Fail
Lower River	Jack Bay	Meet	Meet	Meet	Increasing Fail	Decreasing Fail	Fail
	Petersons Pt.	Meet	Meet	Meet	Increasing Fail	Meet	Fail
	Pt. Patience	Meet	Meet	Meet	Meet	Meet	Fail
	Drum Pt.	Fail	Meet	Meet	Increasing Fail	Meet	Decreasing Fail

Lower River: In the lower river, tidal water quality is good at the upper three stations and fair at the Drum Point station. Habitat quality for underwater grasses is good at Point Patience but is fair to poor at the other stations due to poor water clarity and high algal abundances; habitat quality has degraded in the lower river overall. Summer bottom dissolved oxygen levels are unhealthy throughout the lower river and have gotten worse at Drum Point.

Very limited areas of underwater grass beds are present in this section of the river, with grass beds covering only 1% or less of the area needed to meet restoration goals during this period. Bottom dwelling animal populations are degraded or severely degraded in most areas sampled during this period and have degraded over the longer term period.

How does the Patuxent River compare to other Maryland rivers?

The Patuxent River is in the 'Low Agriculture/High Developed' land use category. Compared to other similar systems, the Patuxent has lower nitrogen levels, moderate sediment levels and high phosphorus levels (Figure 2). Algal densities are relatively low. Water clarity is moderate for similar systems and summer bottom dissolved oxygen levels are moderate compared to similar systems but are below the 5 mg/l threshold for healthy systems.

What has been done to improve water and habitat quality in the Patuxent River?

Wastewater, Stormwater and Septic Loads

Wastewater treatment plant nitrogen loadings to the upper Patuxent River have been reduced by 63% and phosphorus loadings have been reduced by more than 74%.[6] Upgrades to the six major wastewater treatment plants that discharge to the upper Patuxent were complete by 2015 (but loadings data is only available through 2012). Wastewater treatment plant nitrogen loadings to the Western Branch have been reduced by 72% and phosphorus loadings have been reduced by 58%. Upgrades to the major wastewater treatment plant that discharges to Western Branch are under construction and will be completed by the end of 2015.

Managing stormwater runoff has reduced nitrogen loadings and prevented 20,550 pounds of nitrogen from entering the river since 2003, and 450 septic systems retrofits were completed between 2008 and 2013.[7]

Agricultural Loads[7]

In 2014, cover crops were planted on 12,585 acres in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on 9,371 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. Stream buffers were in place on 3,185 acres, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands. A total of 277 containment structures have been built to store animal wastes and allow these nutrients to be applied to the land in the most effective manner at the appropriate time.

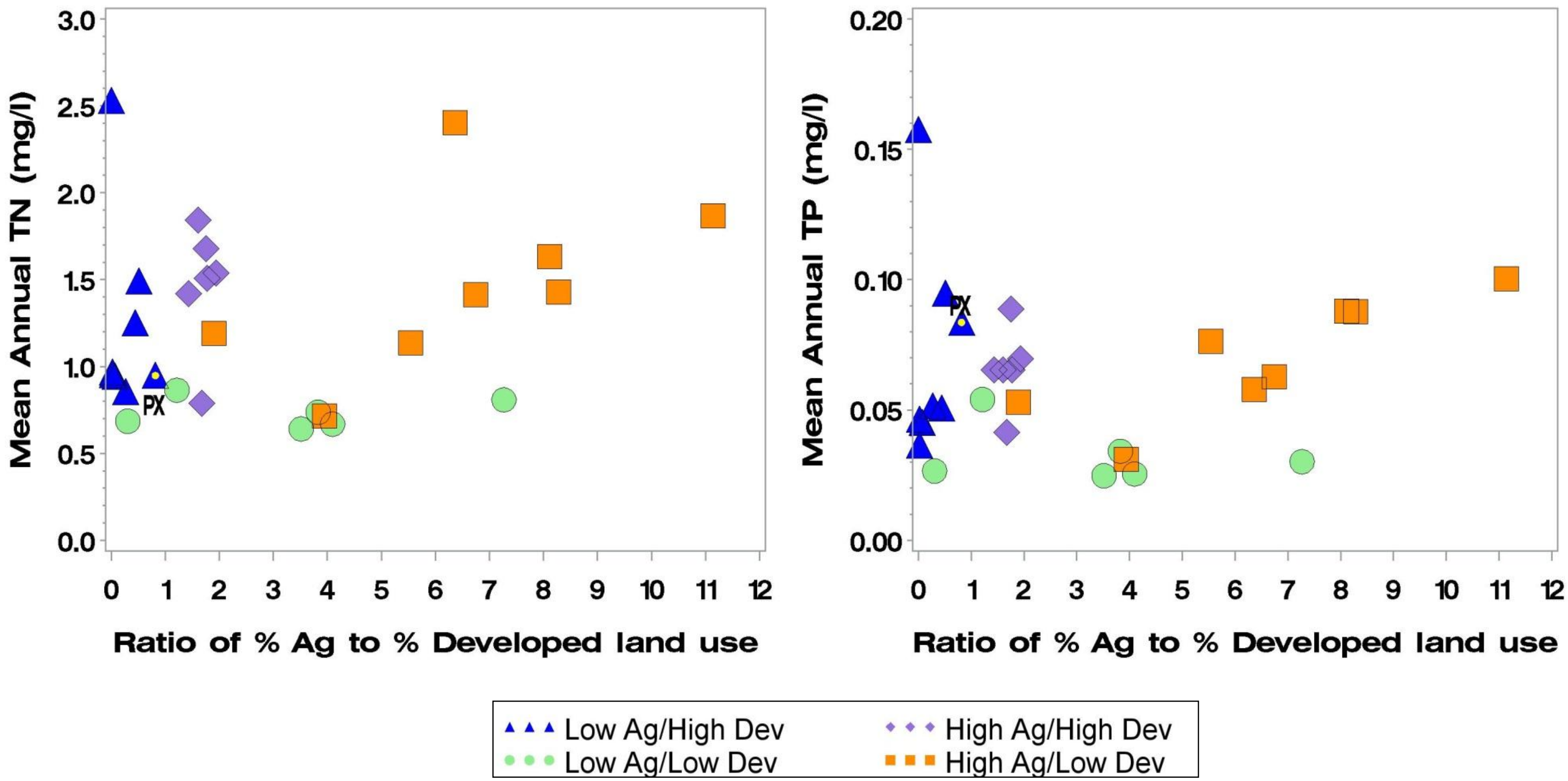

Figure 2. Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as mean annual concentration (in mg/L) for total nitrogen (TN) and total phosphorus (TP). Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Patuxent (PX) river data.

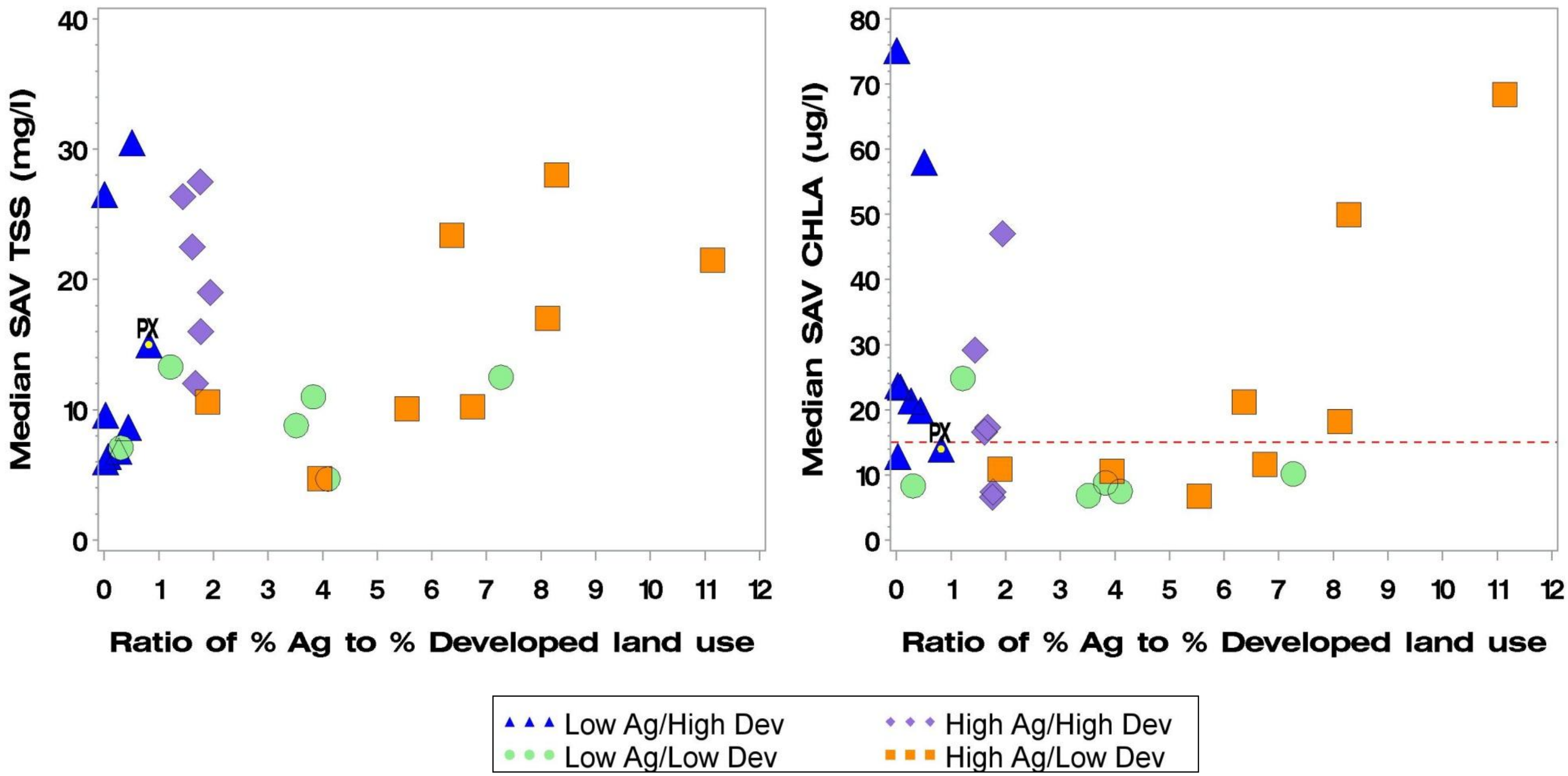

Figure 2 (cont.). Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as submerged aquatic vegetation (SAV) growing season (April-October) median for total suspended solids (TSS, in mg/L), chlorophyll *a* (CHLA, in µg/L). Reference lines are included on the CHLA graph. Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Patuxent (PX) river data.

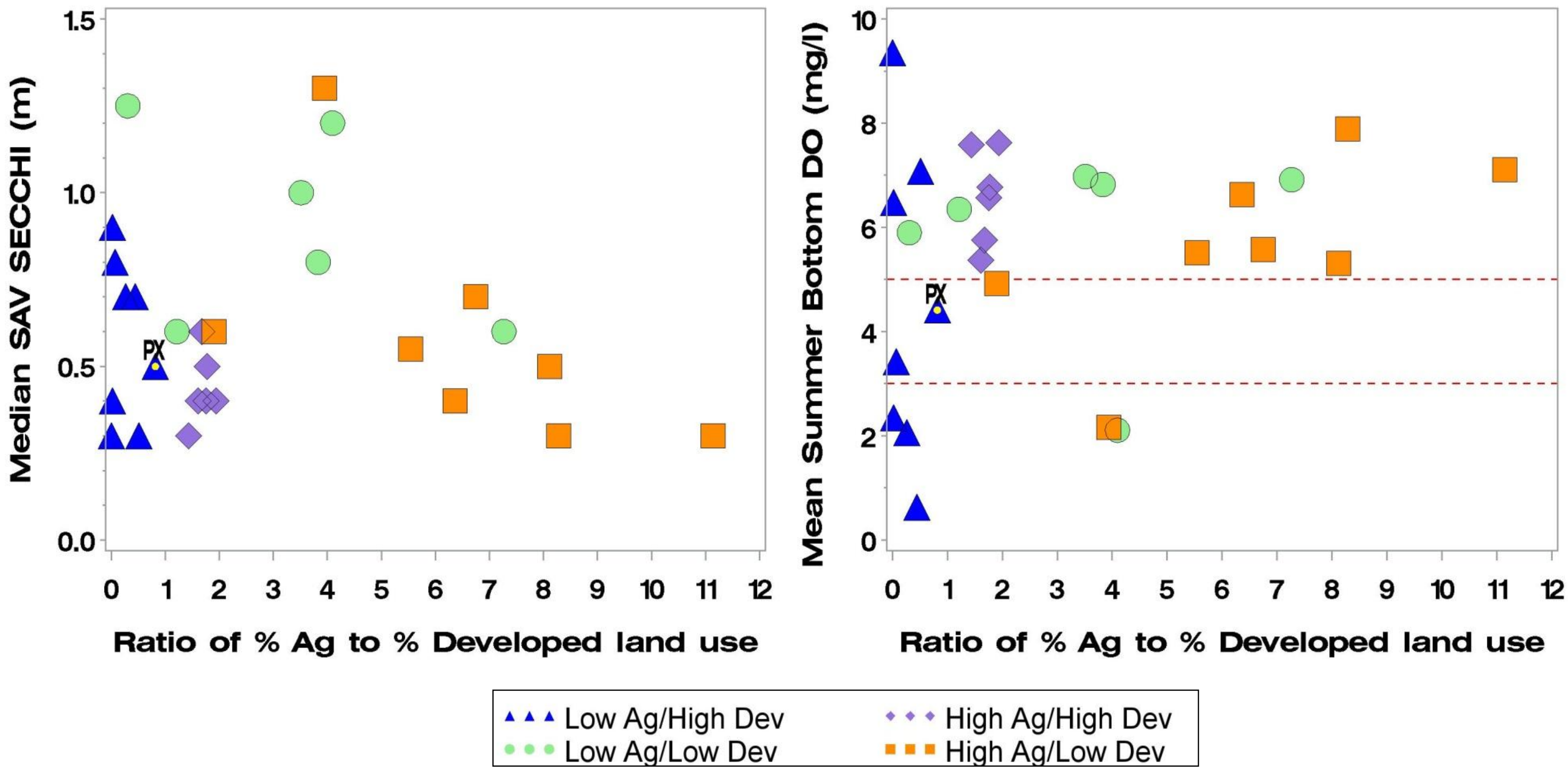

Figure 2 (cont.). Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as submerged aquatic vegetation (SAV) growing season (April through October) median for Secchi depth (in m) and as mean for summer (June through September) bottom dissolved oxygen (DO, in mg/L). Reference lines are included on the DO graph. Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Patuxent (PX) river data.

For more information

An integrative assessment of the water and habitat quality of the Patuxent River for 1985-2012 is available online at http://eyesonthebay.dnr.maryland.gov/eyesonthebay/tribsums.cfm. Current water and habitat quality information is also available from Maryland DNR's Eyes on the Bay website www.eyesonthebay.net.

References and data sources

Data not collected and/or analyzed by the Maryland Department of Natural Resources include:

[1] Land use by basin determined from 2011 National Land Cover Database (NLCD). Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354. GIS layer downloaded on 11/24/2015 from http://www.mrlc.gov/nlcd11_data.php

[2] Impervious surfaces data downloaded from Maryland Department of the Environment (MDE) website on 12/1/2015 http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Pages/phase6_development.aspx

[3] Nutrient and sediment loads data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite.

[4] Nutrient and Sediment non-tidal loadings trends results are through WY2014 from USGS website http://cbrim.er.usgs.gov/summary.html for Short-term period (WY2005-WY2014) accessed February 4, 2016. Nutrient and sediment non-tidal concentrations trends results are through WY2014 from USGS website http://cbrim.er.usgs.gov/trends_query.html file dated 2/02/2016, downloaded 2/4/2016. Trends are determined using the Weighted Regressions on Time, Discharge, and Season (WRTDS) model, Hirsch and others, Environmental Modelling & Software 2015, http://www.sciencedirect.com/science/article/pii/S1364815215300220. Results are reported in the text if the trend was 'Extremely Likely' (Likelihood values ≥ 0.95) or 'Very Likely' (Likelihood values $0.95 > p \geq 0.90$).

[5] Underwater grasses (submerged aquatic vegetation, or SAV) data are available from the Virginia Institute of Marine Sciences SAV in Chesapeake Bay and Coastal Bays webpage, Tables tab http://web.vims.edu/bio/sav/SegmentAreaTable.htm#.

[6] WWTP loadings data were downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 10/14/2015 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Data for calendar year available for 1985-2012. Changes in loadings determined from the difference of the average of the first three and last three years of data.

[7] Data are from Maryland's 2014 - 2015 Milestone Goals and Progress Report website http://baystat.maryland.gov/solutions-map/.

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Chesapeake Bay Program
A Watershed Partnership

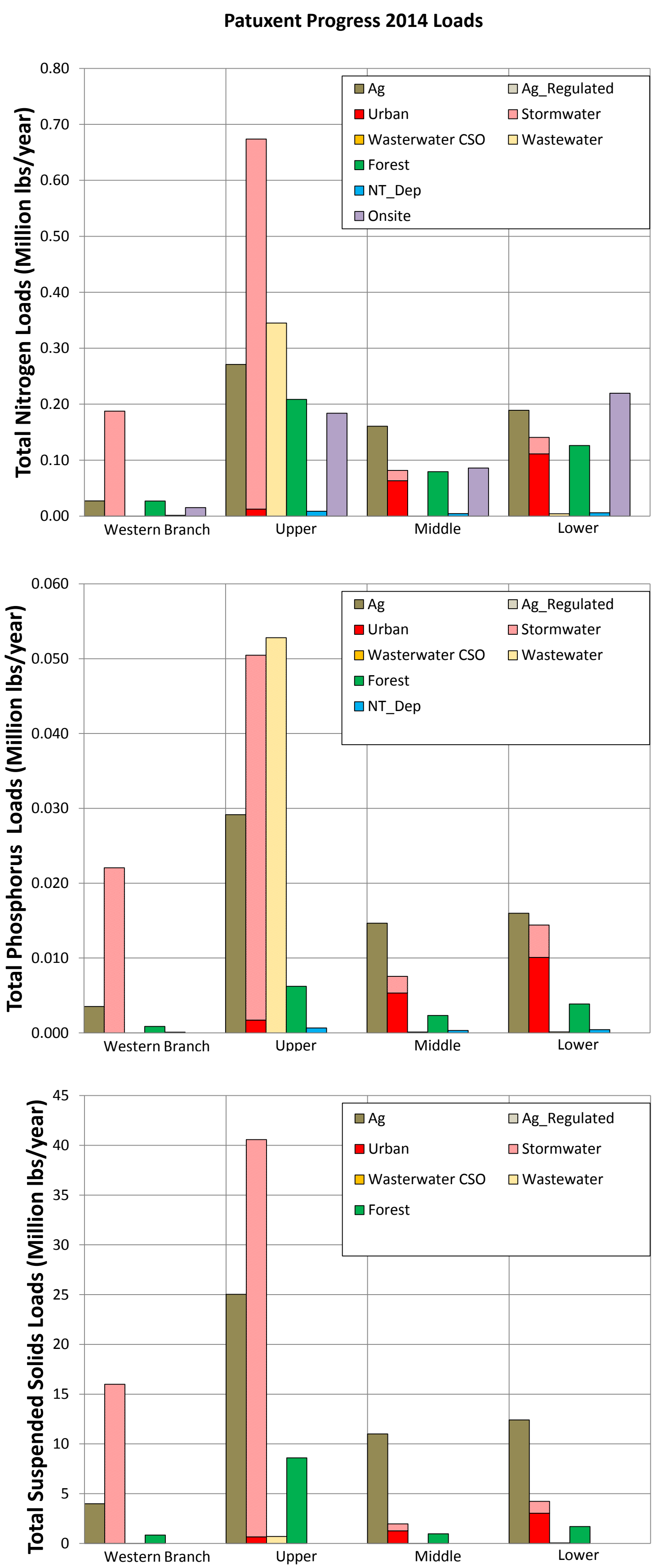

Figure 3. Nitrogen, phosphorus and sediment loads to Patuxent River. Loads (in million lbs/year) are summarized by Chesapeake Bay Program model segment and by source category. Data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite.

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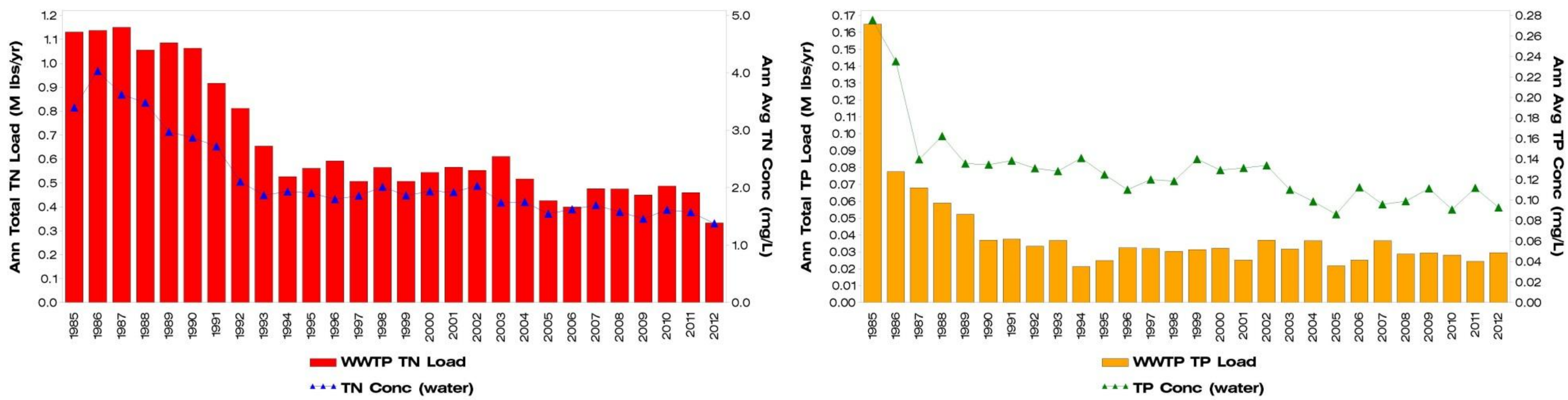
River	Segment	State	Source	TN Load (delivered)	% TN load	TP Load (delivered)	% TP load	Sed. Load (delivered)	% Sed. Load
Western Branch	WBRTF	MD	Ag	0.027	10.5%	0.0035	13.2%	3.99	19.2%
			Ag_Reg		0.0%		0.0%		0.0%
			Urban		0.0%		0.0%		0.0%
			Stormwater	0.188	**72.6%**	0.0220	**83.2%**	15.99	**76.8%**
			CSO		0.0%		0.0%		0.0%
			Wastewater	0.000	0.0%	0.0000	0.0%	0.00	0.0%
			Forest	0.027	10.5%	0.0009	3.2%	0.84	4.0%
			NT_Dep	0.001	0.5%	0.0001	0.3%		0.0%
			Onsite	0.015	5.9%		0.0%		0.0%
			Total Load	**0.258**		**0.0265**		**20.82**	
Upper River	PAXTF	MD	Ag	0.271	16.0%	0.0291	**20.9%**	25.02	**33.4%**
			Ag_Reg		0.0%		0.0%		0.0%
			Urban	0.012	0.7%	0.0017	1.2%	0.66	0.9%
			Stormwater	0.662	**39.1%**	0.0488	**35.0%**	39.92	**53.3%**
			CSO		0.0%		0.0%		0.0%
			Wastewater	0.345	**20.4%**	0.0528	**37.9%**	0.70	0.9%
			Forest	0.208	12.3%	0.0062	4.5%	8.60	11.5%
			NT_Dep	0.009	0.5%	0.0006	0.5%		0.0%
			Onsite	0.184	10.9%		0.0%		0.0%
			Total Load	**1.691**		**0.1393**		**74.90**	
Middle River	PAXOH	MD	Ag	0.160	**38.9%**	0.0146	**58.7%**	11.00	**78.9%**
			Ag_Reg		0.0%		0.0%		0.0%
			Urban	0.063	15.3%	0.0053	**21.3%**	1.26	9.0%
			Stormwater	0.018	4.5%	0.0022	9.0%	0.71	5.1%
			CSO		0.0%		0.0%		0.0%
			Wastewater	0.000	0.1%	0.0001	0.4%	0.00	0.0%
			Forest	0.079	19.3%	0.0023	9.3%	0.97	6.9%
			NT_Dep	0.004	1.1%	0.0003	1.2%		0.0%
			Onsite	0.086	**20.8%**		0.0%		0.0%
			Total Load	**0.412**		**0.0249**		**13.94**	
Lower River	PAXMH	MD	Ag	0.189	**27.6%**	0.0160	**45.9%**	12.41	**67.5%**
			Ag_Reg		0.0%		0.0%		0.0%
			Urban	0.111	16.2%	0.0101	**28.9%**	3.03	16.5%
			Stormwater	0.030	4.3%	0.0043	12.5%	1.20	6.5%
			CSO		0.0%		0.0%		0.0%
			Wastewater	0.004	0.6%	0.0001	0.4%	0.05	0.2%
			Forest	0.126	18.4%	0.0038	11.1%	1.69	9.2%
			NT_Dep	0.006	0.9%	0.0004	1.2%		0.0%
			Onsite	0.220	**32.0%**		0.0%		0.0%
			Total Load	**0.685**		**0.0348**		**18.38**	

Upper Patuxent



Western Branch

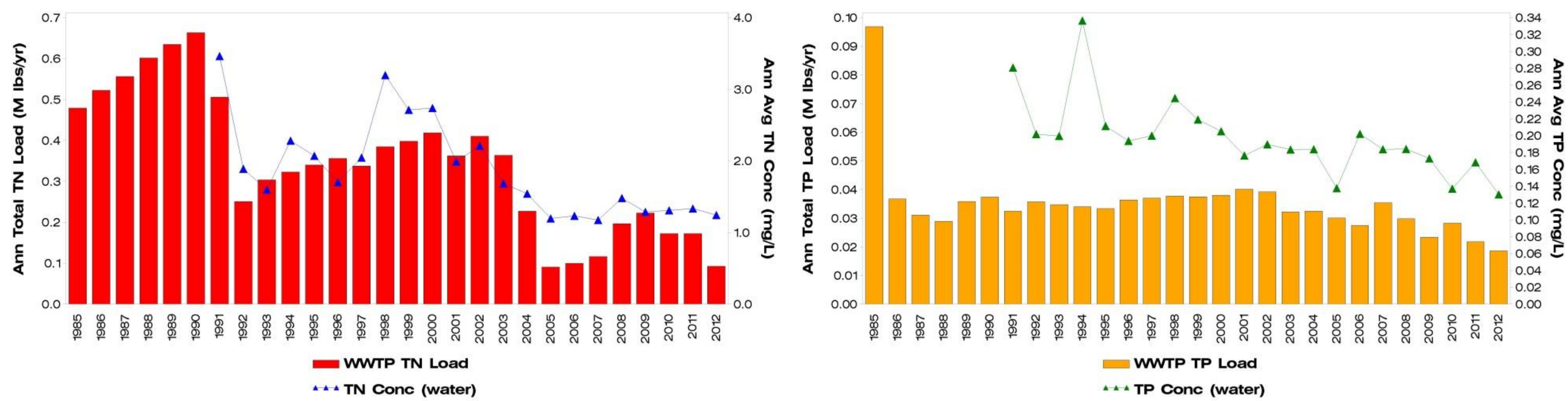


Figure 4. Total Wastewater Treatment Plant loads versus water quality. Summed total of loads from five major wastewater treatment plants (in million pounds per year, M lbs/yr) that discharge into the Upper Patuxent (top graphs) and the single facility that discharges to Western Branch (bottom graphs) compared to annual mean nutrient concentrations (in mg/L) at the long-term monitoring site in each section of the river. Total nitrogen loads (red bars) compared to total nitrogen concentrations (blue triangles) are shown in the left side graphs; total phosphorus (orange bars) compared to total phosphorus concentrations (green triangles) are shown in the right side graphs. Full calendar year loadings data are only available through 2012, and was downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 10/14/2015 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Water quality sampling at the Western Branch long-term monitoring station began in 1991.