Willingness to pay for environmental improvements generated by stormwater projects: Literature review and benefit transfer

Authors
Lisa Wainger
Elizabeth Price
Taylor Hollady

University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory
Solomons, MD, USA

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Executive Summary

The purpose of this report is to review the potential value to Maryland residents of environmental improvements resulting from the implementation of stormwater projects. We conducted a literature review and economic valuation to estimate annual willingness to pay (WTP) values for Maryland households for a variety of *direct benefits* that accrue per project and *indirect benefits* that could be expected to result from widespread stormwater implementation. The benefits captured in the economic literature were the direct benefits of 1) open space, as capitalized in home values; 2) flood control; and 3) wildlife habitat and aesthetics (combined). The indirect benefits were valued as a bundle of improved water clarity, aquatic habitat, commercial fishing, and recreational fishing. Other benefits were omitted due to a lack of appropriate economic studies or an inability to quantify the environmental changes with available information and resources.

We used economic benefit transfer, in which values for the Maryland stormwater program were derived from the published economic valuation literature by selecting relevant values and transforming them to represent Maryland using local data. Values transferred from the literature for direct and indirect benefits ranged from $13 - $1,121 per household per year (Table ES-1), although the largest value is only applicable if people perceive stormwater projects as offering substantial flood control benefits. Perhaps the value that best reflects the WTP to achieve a mix of environmental benefits, as would be expected from stormwater implementation, is the $162/household/year value estimated for achieving the Chesapeake Bay Total Maximum Daily Load (TMDL). Although this value was not strictly measuring outcomes of stormwater projects, it reflects the value of a bundle of environmental outcomes that could arise from widespread stormwater implementation.

Table ES-1. Summary of annual WTP per household in Maryland for stormwater projects

Ecosystem Service	**Annual WTP per Household (2017$)** (unless otherwise noted)	Notes	Source
Increase in open space near residences	$39 in 250 m zone $13 in 250-500 m zone	Based on an Ohio scenario of 30% low impact development required for new housing construction and transferred to Maryland by applying ratios to state median home value. Values only apply to households in proximity to open space.	Mazzotta et al. (2014), Table 2
Flood control	< $1,121	Study showed value of hardened defenses for flood control. Value only applies to stormwater projects to the degree that people perceive flood control from those projects comparable to hardened defenses.	Beltrán et al. (2018)
Habitat and aesthetics of stream restoration	$0.26-$12.51 / mile	A study for Maryland provided the high value.	Bergstrom & Loomis (2017), Table 3
A bundle of water clarity, aquatic habitat and fishery benefits	$162	Average value per Chesapeake Bay watershed resident. (Includes users and nonusers of the bay).	Moore et al. (2017), Table 4

Introduction

The purpose of this report is to review the potential value to Maryland residents of environmental improvements resulting from the implementation of stormwater projects. Although stormwater projects include both green and gray types, we emphasize the green types here since they have been the subject of greater economic study than the gray types. The types of environmental improvements covered here include any biophysical change that affects human well-being, including a change in property flood risk, health outcome or ecosystem health.

To estimate the value of additional stormwater projects and green infrastructure, we conducted a literature review to identify and summarize relevant values. If studies were not conducted recently in Maryland, we used the common valuation method of economic benefit transfer to estimate Maryland-specific values, as described in methods. Results are summarized in a table in the Conclusions section.

This report complements a prior analysis of stormwater remediation fees paid by homeowners, reported in absolute values and as a percentage of median household income, in Maryland counties and Baltimore City (MDE, 2018). Both types of values are useful for informing decisions about public willingness to accept costs associated with stormwater improvement programs (e.g., utility fees, taxes). The public would need to understand the benefits that are generated by stormwater improvements to align WTP for environmental improvements found via economic analysis with acceptance of cost increases.

Types of economic values included in analysis

Economic values cover any category of change that make people better off and are not limited to direct financial gains. Benefits from environmental improvements include those benefits that people derive from using natural systems for recreation or visual amenities. Benefits are also derived from natural systems that people do not use, if they gain value from the satisfaction of being good stewards of such systems and providing opportunities for others or future generations to use the system. Such values are referred to as nonuse or passive use values and they have been demonstrated with many types of evidence (Wainger et al., 2018).

In the case of projects that are implemented to manage stormwater, people may have a measurable WTP for benefits that result from being proximal to or visiting areas (direct benefits) or for regional benefits that result from the cumulative effects of many projects being installed, such as improvements in Chesapeake Bay water quality (indirect benefits). The potential list of benefits spans outdoor recreation, health, and nonuse benefits, which represent the satisfaction people receive from being stewards of natural systems for current and future generations. Specific examples of benefit types are shown in Figure 1.

Benefit delivery pathways may not be simple relationships between stormwater project installation and improvements in peoples' well-being. Instead, such analyses frequently require sophisticated modeling to determine the magnitude of the environmental change that was generated by stormwater projects. Understanding the degree of change is a necessary step to establishing the value of that change and can be challenging. For example, urban vegetation is thought to trap air pollution (especially particulate matter) that would otherwise contribute to health problems, such as asthma, in sensitive populations. To value this air quality benefit would require models to establish 1) the effectiveness of the specific vegetation used in projects at trapping particles; 2) the proportion of the population exposed to harmful levels of air pollution; and 3) that population's WTP to avoid health problems in sensitive groups. Because such modeling has not been done for all benefits in Figure 1, not all types of benefits shown in Figure 1 have been quantified in the literature and are thus omitted from the literature review.

Scope of study

This study summarizes available *primary* economic valuation studies with potential relevance to Maryland. Primary economic studies include specialized economic surveys and statistical models that are used to measure values for a specific change, over a geographically defined population, for the social, political and economic conditions at the time of the study. A subset of direct and indirect benefits is included, reflecting the availability of benefits that have been valued as part of robust economic studies.

To use these literature values to estimate value for Maryland residents requires conducting economic *benefit transfer*. Benefit transfer uses published case studies to estimate values for unstudied sites. The most common type of benefit transfer is to average values for a specific type of environmental change across many relevant case studies. It is expected that averaging many values will smooth out the variability among sites and values are considered most robust when study sites are similar to the unstudied site or sites. However, such averages can only provide a rough indication of WTP (or willingness to accept) in an unstudied situation, since the specific environmental conditions, socio-demographics and other variables will not necessarily be captured.

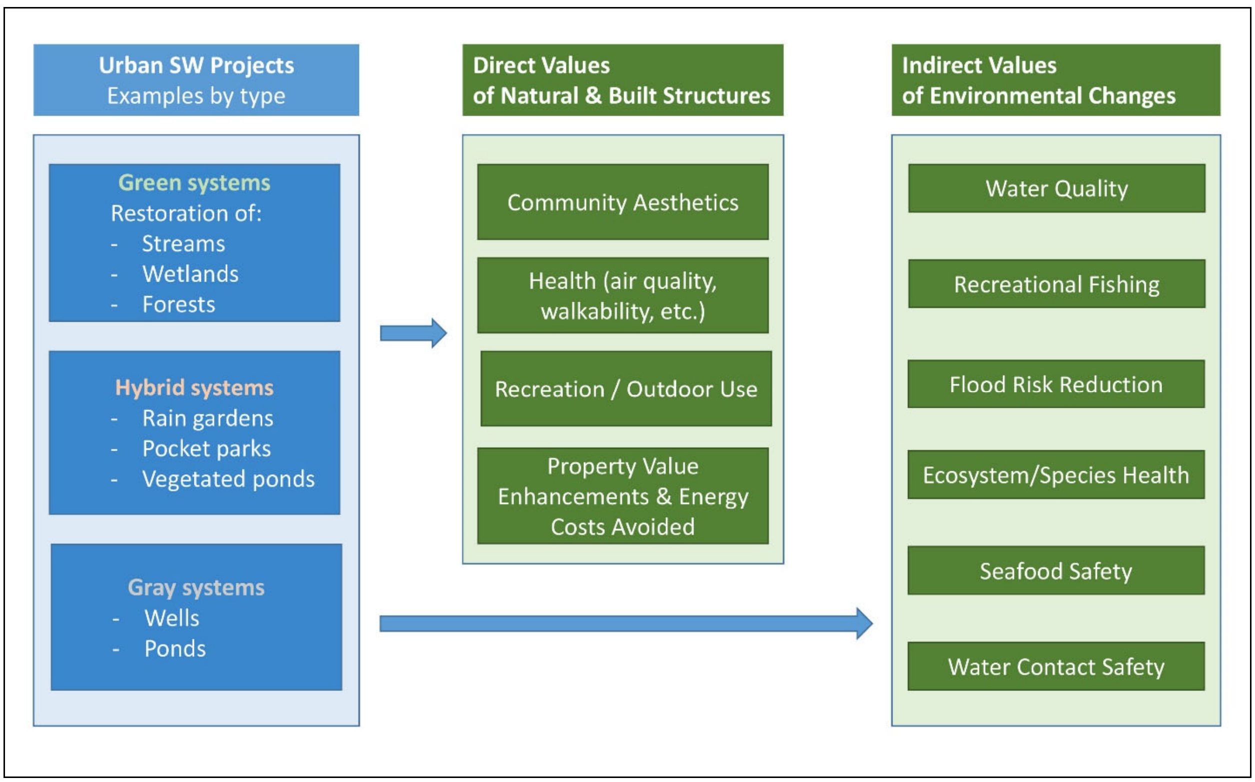

Figure 1. Examples of direct and indirect benefits generated by stormwater projects.
Urban stormwater projects generate a variety of direct and indirect benefits that vary by project type. Direct values generally accrue per project to people living/working near project sites or those with access to sites. Indirect values accrue to people (regardless of site proximity) when multiple stormwater projects generate cumulative effects in watersheds and downstream water bodies.

Methods

We conducted a review of recent economic valuation literature (1990-present) to compile values for individual direct and indirect benefits and for bundles of benefits generated by water quality improvements. Although the full suite of benefits that may be realized from stormwater management are broad (as shown in Figure 1), economic studies are concentrated in only a few of these categories. Therefore, many benefits could not be captured through a literature review.

To conduct benefit transfer of literature values to present day Maryland, we used three methods. First, because Maryland has been well-studied, we were able to select recent individual studies to suggest WTP for some types of environmental improvements. Second, when values were capitalized in home values, we translated average WTP to a percentage of median home price for the study area and then apply that percentage to current Maryland median home prices. Third, we used average value per household across multiple studies when either Maryland studies were not available or were not considered to be sufficiently representative of modern stormwater projects.

Many valuation studies did not specifically study changes due to stormwater projects or environmental restoration but still captured the value of environmental differences. We aimed to include studies that were most representative of interventions used to change existing conditions, but substituted studies that compared people with and without an environmental amenity, as needed, to include a broad suite of environmental outcomes. In general, we judged that a recent local study would be superior to an average of many literature values. We found through our literature review that many recent studies on stormwater projects were conducted in other countries or that studies in the US were not specifically for restored environment, but rather retained natural areas.

Results & Discussion

The benefits captured in the economic literature were the direct benefits of 1) open space, as capitalized in home values, 2) flood control, 3) wildlife habitat and aesthetics. The indirect benefits were valued as a bundle of improved water clarity, aquatic habitat, commercial fishing, and recreational fishing. Other benefits were omitted due to a lack of appropriate economic studies or a lack of a quantification of the environmental changes. For example, the benefits of sequestering carbon in living matter and the associated reduced risk of climate change damage was not included because we did not have estimates of how much net carbon would be sequestered through stormwater projects.

Direct Benefits

Open space benefits

Many projects to reduce impervious surfaces or capture runoff create small open space areas that increase vegetated or open water areas in urban and suburban settings. These practices improve aesthetics and air quality, microclimate regulation, wildlife habitat, water purification, flood risk reduction, and carbon sequestration, among other benefits. Since most projects being implemented in Maryland are small, they do not often provide on-site recreation. When projects are large or connected via walking trails (including accessible ponds or lakes) they are more likely to provide recreation benefits.

All of these benefits of stormwater projects are potentially capitalized in home values, meaning that homeowners pay a premium to be near them or to be in neighborhoods with low impact design. A recent study conducted a thorough review of the literature of the value of open space to homeowners where open space included small to large areas in permanent vegetation, including wetlands, trees, and landscaped lawn and shrub areas. Using 35 studies they generated a statistical (meta-analysis) model to estimate the percentage change in a home's value for an observed percentage change in open space within a specific radius of a parcel (Mazzotta et al., 2014).

The authors found that, holding all else constant, the addition of open space in a 250 m buffer around a house would increase the home rental value by 0.17% for an average of 1.99% increase in open space, which is equivalent to roughly a 0.085% increase in annual value for a 1% increase in open space. If the open space was added within a ring of 250-500 m, annual home rental rate increased 0.1%[1] for an average of 2.17% increase in open space, which is roughly equivalent to 0.046% increase in annual value for a 1% increase in open space.

This result is consistent with other reviews that have found that all open space types have positive effects on adjacent property values, even when open space consists of small acreage (Lutzenhiser and Netusil, 2001). Although, the capitalized value of additional natural areas depends on the landscape context and is affected by the availability of all types of open space and proximity of parks and refuges (Neumann et al. 2009). Three of the studies used in the Mazzotta et al. (2014) meta-analysis were conducted in Maryland (Table 1). None of these values can be directly compared to the full model due to transformations made to standardize the data for the meta-analysis. But two of the studies show a 0.01% or 0.4% increase in home selling price (not the annualized increase used in the meta-analysis) for a 1% increase in open space. The third study shows an average increase for the state in home selling price of 2.2% from being 1% closer to a park. However, the authors note that being adjacent to parks can decrease home value in high crime neighborhoods (Troy and Grove, 2008).

Table 1. Studies examining the value of open space in Maryland

Type of Environmental Change	% Change in environment	% Change in House Price	Data Year	County of Study	Current County Median House Price (2017$)	Value per Household (2017$)	Reference
Open space in subdivision	1%	0.01%	2000	Calvert	$ 347,200	$ 35	Kopits et al. (2007)
Preserved farmland adjacent to subdivision	1%	~0.43%	2000	Howard	$ 439,900	$ 1,892	Towe (2009)
Distance to park	1%	2.2%	2004	Baltimore City	$ 153,200	$ 337	Troy and Grove (2008)

These increases in home values vary by characteristics such as existing amount of open space, urban or rural setting, type of vegetation and spatial arrangement of open space. Therefore, it is also revealing to

[1] Using a rental value increase is an analytic technique for roughly estimating the annual increment in the future selling price of a home.

examine results of scenario in Mazzotta et al. (2014) for Ohio in which they found that use of LID in 30% of the area of new development created mean increases in perceived open space of 1.3%-3.7%, which provided an average annual increase of 0.44% and 0.12% per property for houses in the 250 m and 250–500 m buffers, respectively.

If we assume the same home price premiums (as percentage of median rental value) would hold for Maryland, the values calculated for Ohio in 2013 would be equivalent to $39 and $13 per household (2017 dollars) for houses in the 250 m and 250–500 m buffers, respectively. These values represent 0.44% and 0.12% of Maryland's median rental rate of $8,895 (3% of median value of $296,500 following methods in Mazzotta et al. 2014) (Table 2). These scenario results for Ohio are useful since that state is similar to Maryland in many respects. However, the calculations are still approximate values since effects of open space on value depends on many site-specific factors.

In the Mazzotta et al. (2014) study, they found that value per percentage change in open space increased when open spaces were permanently protected and were non-recreational. Values also increased when the open space took the form of trees or permanent vegetation in riparian areas, compared to general open space. Finally, a percentage increase in open space is worth less in rural and exurban areas, compared to suburban and urban density areas, and worth less when homes have larger lots, all else equal.

Table 2. Median home values and estimated price premiums per house by Maryland county

County	Median Home Value	Median Rental Value (3% discount rate)	Average Annual Price Premium per Affected House by Zone (per 1% increase in open space)*		Average Annual Price Premium per Affected House by Zone (for scenario of 30% LID)†	
			250 m	500 m	250 m	500 m
	2017 dollars	2017 dollars	0.085%	0.046%	0.44%	0.15%
Allegany	119,900	3,597	$3	$2	$16	$5
Anne Arundel	346,000	10,380	$9	$5	$46	$16
Baltimore	249,600	7,488	$6	$3	$33	$11
Baltimore City	153,200	4,596	$4	$2	$20	$7
Calvert	347,200	10,416	$9	$5	$46	$16
Caroline	296,500	8,895	$8	$4	$39	$13
Carroll	328,100	9,843	$8	$5	$43	$15
Cecil	238,000	7,140	$6	$3	$31	$11
Charles	294,000	8,820	$7	$4	$39	$13
Dorchester	179,300	5,379	$5	$2	$24	$8
Frederick	315,400	9,462	$8	$4	$42	$14
Garrett	167,100	5,013	$4	$2	$22	$8
Harford	281,400	8,442	$7	$4	$37	$13
Howard	439,900	13,197	$11	$6	$58	$20
Kent	237,400	7,122	$6	$3	$31	$11
Montgomery	467,500	14,025	$12	$6	$62	$21
Prince George's	272,900	8,187	$7	$4	$36	$12
Queen Anne's	343,200	10,296	$9	$5	$45	$15
St. Mary's	291,500	8,745	$7	$4	$38	$13
Somerset	131,000	3,930	$3	$2	$17	$6
Talbot	326,300	9,789	$8	$5	$43	$15
Washington	205,300	6,159	$5	$3	$27	$9
Wicomico	171,700	5,151	$4	$2	$23	$8
Worchester	252,100	7,563	$6	$3	$33	$11
Maryland State	296,500	8,895	$8	$4	$39	$13

*Estimated annual increase in rental rate (or buyer WTP) for homes near open space, based on meta-analysis of Mazzotta et al. (2014), per 1% increase in open space.

†Estimated annual average increase in rental rate (or buyer WTP) for homes near open space, based on a projected growth scenario in Ohio in which 30% of new growth was in low impact development (LID). Average open space increase was 3.1% in 250 m buffer and 1.5% 250-500 m buffer around houses. (percentage increase derived from non-recreational open space in Mazzotta et al. (2014), Table 8).

Source of Median Home Value: US Census Bureau (2017)

Flood control benefits

Stormwater projects can provide the rainwater interception, storage, and infiltration functions that are lost when impervious surface is created. Therefore, they would be expected to reduce some flooding (particularly in low to moderate intensity storms) and associated harms from flooded basements, icy sidewalks and streets, and other transportation inconveniences and risks. Studies have generally concluded that green infrastructure can be an effective complement to traditional stormwater infrastructure for reducing nuisance flood risk, but that effectiveness varies by storm characteristics and landscape factors (Gonzalez-Meler et al., 2013; Zellner et al., 2016).

People are willing to pay for flood risk reduction and the strongest evidence is that homes outside of flood zones are worth more than homes in flood zones, all else equal (Bin and Landry, 2013). However, the household WTP for nuisance flood risk reduction has not been thoroughly studied. The most relevant economic study we found showed a substantial increase in home value of 12.6-16.7% for hardened defenses such as sea walls and flood gates (Beltrán et al., 2018). Taking 12.6% of the Maryland median rental rate, yields and estimate of WTP of $1,121 annually for flood control projects. This value can only be applied to stormwater management if people perceive comparable flood control benefits compared to the hardened defenses used in the study.

A recent study is indicative of the type of work that has been done to evaluate the flood risk reduction of stormwater projects that is based on many assumptions about performance rather than observational data. Zhang et al. (2012) used models to estimate the effectiveness of stormwater projects and then used a replacement cost approach (cost of installing a reservoir for the same amount of water storage) to assess the risk reduction value. The average value for flood risk reduction was about $3,800/ha (2017$)[2] of installed projects, although benefits varied widely across the study area. Using a reservoir replacement value to represent the value of flood control may be relevant for some areas of Maryland, but could inflate the value of WTP in Maryland for areas that are not considering using reservoirs. In general, replacement value is only robust if the method has a high likelihood of being used. This value reflects a case study in China and was not adjusted for Maryland.

Habitat and aesthetic values of stream restoration

Most green infrastructure also provides wildlife habitat, potentially including pollinator habitat, that people value (Gonzalez-Meler et al., 2013). However, as with other benefits of stormwater, we did not find studies that specifically isolated values of urban habitat. Some of the WTP for terrestrial habitat value has already been captured in the open space values reported above. In addition, habitat values have been evaluated by looking at multiple benefits of stream restoration, which was not included in the open space meta-analysis.

Stream and river restoration has been given special attention in the economic literature and a recent review summarized the household WTP for various river restoration projects (Table 3). The values represent benefits perceived by people for changes in a variety of ecosystem services encompassing fish and other wildlife habitat, recreational fishing, boating, swimming, drinking water, aesthetics, climate regulation, flood regulation, and habitat for rare and endangered species. The results value a mix of direct and indirect benefits. The direct benefits are from some types of habitat, aesthetics and climate regulation since they can accrue for small isolated projects. The indirect benefits are those that require many projects to be implemented to achieve the indirect benefits (e.g., fish habitat is likely to require many projects).

Since projects varied greatly in size, benefits are reported per mile, although it is not necessarily true that WTP would accrue per mile. Rather, people may only be willing to pay for the large completed

[2] Based on an exchange rate of 6.3027 RMB / dollar in 2011 and using the BLS CPI to adjust 2011 values to 2017 dollars.

project, not small projects, although in a study conducted in Maryland (bolded line in Table 3) authors measured a WTP for a small project. The benefits measured were stated to be for two ecosystem services of aesthetic and recreational benefits among Baltimore City residents and, since respondents did not have access to the site, the benefits were nonuse values (Kenney et al., 2012).

Table 3. Summary of Economic Valuation Studies of River Restoration (Bergstrom & Loomis, 2017)

State	Annual WTP/HH (2017$)*	Restored River miles	Annual WTP/mile (2017$)*	# ecosystem goods and services valued
AZ	$45	170	$0.26	2
AZ	$53	40	$1.33	1
NM	$65	80	$0.81	1
WV	$198	24	$8.25	3
NC	$35	6	$5.91	5
MD	**$3**	**0.25**	**$12.51**	**2**
WA	$114	70	$1.63	2
CO	$30	45	$0.67	3
OR	$229	120	$1.91	3
NM	$57	17	$3.38	2
NM	$180	17	$10.61	2
AZ	$176	300	$0.58	5

*Values converted from 2015 to 2017 dollars using the Bureau of Labor Statistics CPI inflation calculator. Excerpted from larger table presented in Bergstrom and Loomis (2017)

Indirect Benefits

Indirect benefits are the cumulative benefits arising from many stormwater projects. Those benefits include systemic aquatic system restoration, as might be expected by achieving the Chesapeake Bay TMDL. The TMDL benefits are the primary results shown in this section due to the availability of relevant and high quality studies for Maryland. However, indirect benefits could also include systemic improvements that were not captured in the set of studies presented. Examples include regional recreational opportunities (e.g., aesthetics of long-distance hiking or boating trails) or migratory opportunities for rare species.

Economic values measured for the Chesapeake Bay TMDL

The U.S. Environmental Protection Agency (EPA) recently conducted several extensive economic studies measuring values that people hold for a range of environmental outcomes generated by water quality improvements in the Chesapeake Bay watershed. The values measured include those for improvements in Bay water clarity, striped bass populations, submerged aquatic vegetation, and crab populations. They also included reduced eutrophication (measured qualitatively as levels of eutrophication) in freshwater lakes throughout the Bay watershed.

The most comprehensive of the TMDL benefit assessments showed a total household WTP of $154/year for a bundle of projected improvements due to fully implementing the Chesapeake Bay TMDL (Table 4). Stormwater projects are only a part of the set of actions being undertaken to achieve the TMDL and the outcomes of improved aquatic habitat and water quality. Therefore, this value cannot be said to represent a WTP for the municipal separate storm sewer system (MS4) permit projects being used to advance the TMDL. Yet, the economic study demonstrates that people are willing to pay for outcomes that can be generated by stormwater implementation or impervious surface reduction.

An important outcome of this study was the demonstration that watershed residents (and state residents outside the Bay watershed) have WTP to achieve improvements in lake water clarity and Bay habitat quality, even if they don't fish, boat or directly use the Chesapeake Bay (Moore et al., 2017). The use and nonuse values were comparable for all TMDL outcomes measured, except water clarity (Table 4, See columns labeled 'Model 2').

Table 4. Marginal and total willingness to pay (WTP) for Chesapeake Bay TMDL improvements ($2014 dollars) from Moore et al. (2017)

Benefit type	Marginal* WTP (Users & Nonusers) (Model 1) ($/person/year)	Marginal* WTP Users (Model 2) ($/person/year)	Marginal* WTP Nonusers (Model 2) ($/person/year)	Projected improvement due to TMDL
1-inch increase in Bay water clarity (average for entire Bay & tributaries)	$3.51	$8.62	$1.45	+4.33 inches (+12.0%)
1 million additional striped bass	$6.62	$6.14	$7.00	+1.03 M fish (+4.3%)
1 million additional blue crabs	$1.21	$0.95	$1.24	+41 M crabs (+16.4%)
~1 ton increase in oysters	$0.02	$0.03	$0.01	+541 tons (+16.4%)
1 hyper-eutrophic lake moves to lower eutrophication level	$0.18	$0.20	$0.18	+455 lakes (+15.7%)
Total annual WTP for projected improvements				**$154/ household/year**

*Marginal WTP is the value reported for the last increment of environmental change rather than the total value for the change due to the TMDL.

Other Chesapeake Bay restoration benefit studies estimated values for single benefits rather than the bundle of benefits measured by Moore et al. (2017). All of the values for individual benefits are lower per person than the total bundle, as expected, and range from $0.02 - $6.62 per expected environmental change and per household (Table 5). Values represent either annual payments or total home value increase. These individual values have substantial overlap in beneficiaries and benefits and therefore, cannot be summed (Table 5).

In two of the studies from (Table 5), economists analyzed price premiums on home values resulting from improvements in water clarity or submerged aquatic vegetation (SAV). For water clarity, they found an average value increase of $5,571 for waterfront homes and $366 for non-waterfront homes within 500 m of tidal water, when water clarity increased by 11% (~0.33-0.5 % of home value) (Klemick et al., 2018; Walsh et al., 2017). For submerged aquatic vegetation, authors estimated a value increase of $36,317 per waterfront home and $17,289 per non-waterfront home within 200 m of water when SAV was present (~6% of home value) compared to when not present (Guignet et al., 2016). These statistical models separate out the additional value (price premium) paid for an environmental improvement after holding many other price factors constant. The full statistical models include a large set of property and location characteristics (bedrooms, water depth, school district, etc.) to remove the effect of these factors on price.

The remaining studies looked at commercial and recreational fishing benefits and improvements in outdoor recreation (Massey et al., 2017). Recreational fishers were willing to pay just under $2/trip for the increases in fish. Other outdoor recreators were willing to pay between $2.50 - $6.67 per person per year, based on an estimate of 42 million total trips/year to outdoor recreation sites.

The estimated values per household are consistent with values measured for other large water body restorations. A value of $379/household/year (2017 dollars, converted from 1998$) was estimated for a 45-mile restoration of the South Platte River near Denver, Colorado (Loomis et al., 2000). A large review reported a range of values for restoring fisheries, aquatic habitat and/or water quality in large water bodies of $20 - $512 per household (2017$ converted from 2002$) (Johnston and Thomassin, 2010).

The U.S. EPA studies described above encompass residents of all states that make up the Chesapeake Bay watershed (inside and outside the watershed), and therefore will have some error for representing Maryland residents. In particular, because users of the bay were willing to pay more for water clarity than non-users (Table 4), it is possible that the WTP for achieving the TMDL is higher for Maryland that has proportionally more Bay users than other states. However, because values for other types of outcomes were similar for users and nonusers, this error is not compounded across the bundle of services.

Table 5. Recent values for water quality improvements due to the Chesapeake Bay TMDL

Ecosystem service increases	*Spatial extent of beneficiaries*	*Monetary values for TMDL*	*WTP per HH (dollar years as marked)*	*Authors*
Striped bass, crabs, and oysters; bay water clarity; and lake water clarity (use & nonuse)	Full watershed; ~80% of total benefits accrue to nonusers of Bay	$1.20 to $6.49 billion / year	$154 / yr (2014$)	Moore et al. (2017)
Water clarity (11% increase in clarity or roughly 11 cm increase in secchi depth, as capitalized in home values)	14 water-adjacent counties in Maryland	$213-$427 million (present value)	0.33-0.5 % increase ($5571 for waterfront, $366 non-waterfront in 500 m buffer, 2010$), Klemick 2018, p. 282)	Walsh (2017); Klemick et al. (2018) Klemick 2018 does a 11% increase in clarity as projected for TMDL
SAV extent **(capitalized in home values)**	Waterfront & near-waterfront homes (CB)	$300-$400 million	$36,317 (per waterfront) and $17,289 (per non-waterfront) home within 200 m of water (2009$)	Guignet et al. (2016)
Commercial fishing	Chesapeake Bay	$3 - $26 million / year	(2014$)	Massey et al. (2017)
Recreational fishing	Chesapeake Bay & salt water sites	$5 - $59 million / year; $10.4 million avg across all models	$1.91 avg WTP (2014$) per person per trip for projected increases in fish catches in CB	Massey et al. (2017)
Outdoor recreation (excluding fishing)	Chesapeake Bay, DE Bay & coastal sites with water access	$105 - $280 million / year	$2.50 - $6.67 / person / year (2014$) (using 42 million trips)	Massey et al. (2017)

Summary & Conclusions

In summary, we found diverse evidence to suggest that Maryland residents would be willing to pay substantial amounts for the benefits of stormwater projects. The benefits we reviewed included WTP for open space, flood control, wildlife habitat and aesthetics. Values transferred from the literature for these benefits ranged from $13 - $1,121 per household per year (Table 6), although the high end value is only applicable if people perceive stormwater projects as offering substantial flood control benefits. Perhaps the value that is most likely to reflect the WTP, in terms of allocating government funds to stormwater projects, is the $162/household/year value estimated for achieving the TMDL and associated environmental benefits. Although this value was not strictly measuring stormwater project outcomes, it does reflect the value of a bundle of environmental outcomes that could arise from widespread stormwater implementation.

Table 6. Summary of annual WTP per household in Maryland for stormwater projects

Ecosystem Service	**Annual WTP per Household (2017$)** (unless otherwise noted)	Notes	Source
Increase in open space near residences	$39 in 250 m zone $13 in 250-500 mzone	Based on an Ohio scenario of 30% low impact development required for new housing construction and using Maryland state median home value. Values only apply to households in proximity to open space.	Table 2, Benefit transfer of Mazzotta et al. (2014)
Flood control	< $1,121	Study showed value of hardened defenses for flood control. Value only applies to stormwater projects to the degree that people perceive the same level of flood control from those projects.	Beltrán et al. (2018)
Habitat and aesthetics of stream restoration	$0.26-$12.51 / mile	A study for Maryland provided the high end value.	Table 3, Bergstrom & Loomis (2017)
A bundle of water clarity, aquatic habitat and fishery benefits (Water clarity in Chesapeake Bay and freshwater lakes; recreational and commercial fisheries (striped bass, blue crabs, oysters)	$162	Average value per Chesapeake Bay watershed resident. (Includes users and nonusers of the Chesapeake Bay).	Table 4, Moore et al. (2017)

We noted in the introduction that the benefits of stormwater projects encompass a wide range of benefits, not all of which are well captured in the economic literature. Some notable omissions are the value of carbon sequestration (or climate change damages avoided), terrestrial recreation that could be created through linked networks of project (e.g., walking trails along streams), and economic revitalization that could occur as a result of street greening. Also, the WTP that is capitalized in home values is clearly not a comprehensive representation of value but it is a dominant valuation technique in the economic literature. The study by Moore et al. (2017) that looked at a bundle of ecosystem service benefits suggested that the stated values for environmental improvements are likely to exceed the values capitalized in home values, as reflected in the maximum of $39/household for home value increases vs $162/household for the bundle of water quality and fishing benefits.

Some important caveats regarding these numbers are that the values for specific programs can vary greatly depending on how value of government services is perceived and depending on local economic and social conditions. As a result, benefit transfer, as was conducted here, will not provide precise estimates of WTP. We provided the most relevant studies found, yet some conditions in the studies used do not exactly match the context of the question of WTP for stormwater projects. In particular, most of the review papers that we included used a mix of restoration projects and pre-existing natural areas to assess values for ecosystem services. This could be a problem since studies suggest that some kinds of restoration projects, particularly wetlands, can be worth less to people than existing natural areas (Lupi et al., 2002). As a result, some values for open space that we present could be inflated. Further, WTP varies by ability to pay. Using average WTP (including using state average median home value) to conduct benefit transfer will not fully reflect heterogeneity in WTP across the diverse areas of Maryland. Table 2 shows the variability in median home price to demonstrate some of this variability.

Overall, the literature provides a strong sense of WTP among Maryland residents for the direct and indirect benefits of environmental improvements expected from stormwater implementation. To fully transfer these economic literature values to a specific stormwater program would require quantifying the environmental changes that could be expected with program implementation. The quantities of environmental change ultimately determine their value to Maryland residents.

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