Estimating the Ecological Economic Impact of Stormwater Runoff

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Background

- Stormwater runoff occurs as a natural result of snowmelts and precipitation events.
- Conversion of natural landscapes to urbanized areas, can significantly increase stormwater flow.
- Changes to the natural system can have impacts on water quality & quantity in a watershed such as:
  - Increased flooding.
  - Physical stream degradation.
  - Increased pollutants delivered to water bodies.
- Damage from uncontrolled stormwater runoff implies that the privately optimal rate of runoff exceeds the socially efficient rate.
- We develop a theoretical model to determine the economically efficient rate of runoff & estimate empirically the marginal damage.

Data Description

- The empirical model considers homes in Town of Brighton, NY located in the Allen Creek watershed (Figure 1).
- We estimate the marginal damage and marginal abatement cost curves for households located downstream from an area in Brighton that currently exists as an open field but is being considered for development (Figure 2).
- We include single-family residential downstream properties that are within 100 meters of either side of Allen creek (Figure 2).
- These properties were mapped using ArcGIS 10 and data from Monroe Country, NY for the years 2005-2010. The characteristics of these properties are publicly accessible through the Monroe County Real Property Database.
- Our analysis includes 260 residences with an average assessed value of $200,000 in a town where the median income is $66,093.

Theoretical Model

- Stormwater volume = S.
- Abatement = A(S) with A'< 0 & A" > 0.
- Damage = D(S) with D' < 0 & D" > 0.
- The planner solves:

$$\text{Min } L = A(S) + D(S)$$

First order condition:

$$-A' = D'$$

This implies that the optimal volume of runoff is such that the marginal damage cost equals the marginal abatement cost.

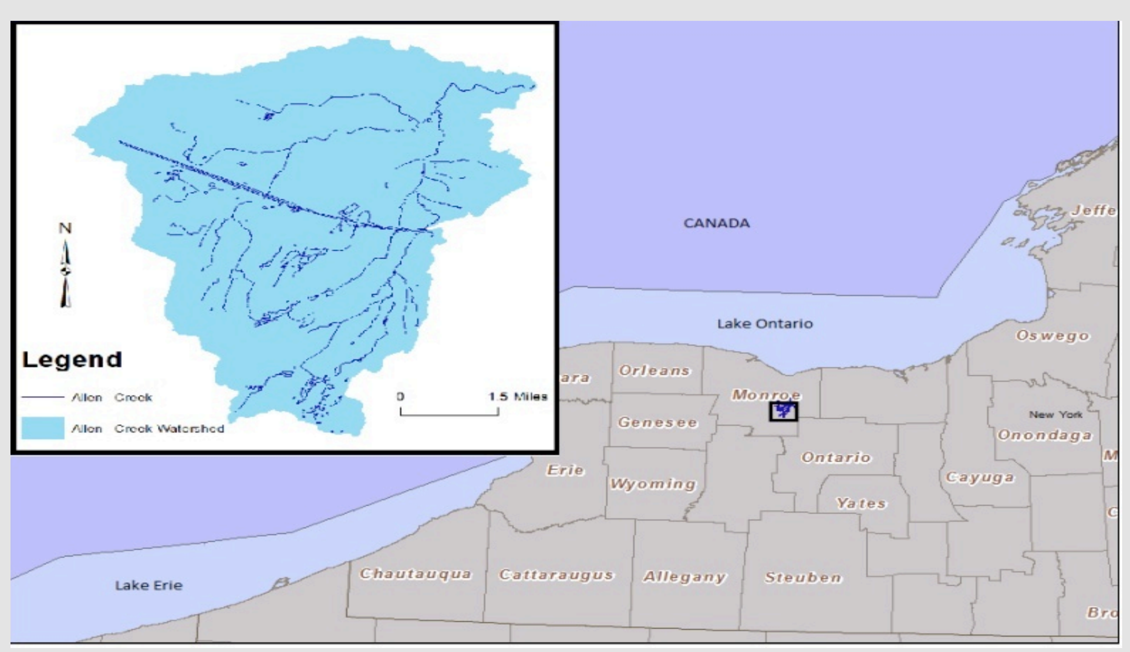

Figure 1. Reference map showing the location of the Allen Creek watershed.

Empirical Model

- The marginal damage curve is derived from an estimated total community damage curve for urban stormwater runoff.
- For simplification we assume the marginal damage curve is linear and that 0 volume of runoff generates 0 damage (which gives one point on the curve).
- A second point is determined using a hedonic model examining the change in assessed property values resulting from changes in water quantity (average annual volume of runoff).
- The hedonic model is estimated as follows:

$$LNREALAV_{it} = \alpha + \beta_1 S_{it} + \beta_2 N_{it} + \beta_3 E_{i,t-1} + e_{it}$$

where $LNREALAV_{it}$ is the log of real assessed value (2010 constant dollars) for home *i* at time *t*. α, β_1, β_2, and β_3 are regression coefficients to be estimated; S_{it} are structural characteristics for home *i* at time *t*; N_{it} are neighborhood characteristics for home *i* at time *t*; $E_{i,t-1}$ is the annual volume of runoff for home *i* at time *t*-1; and e_{it} are random error terms.

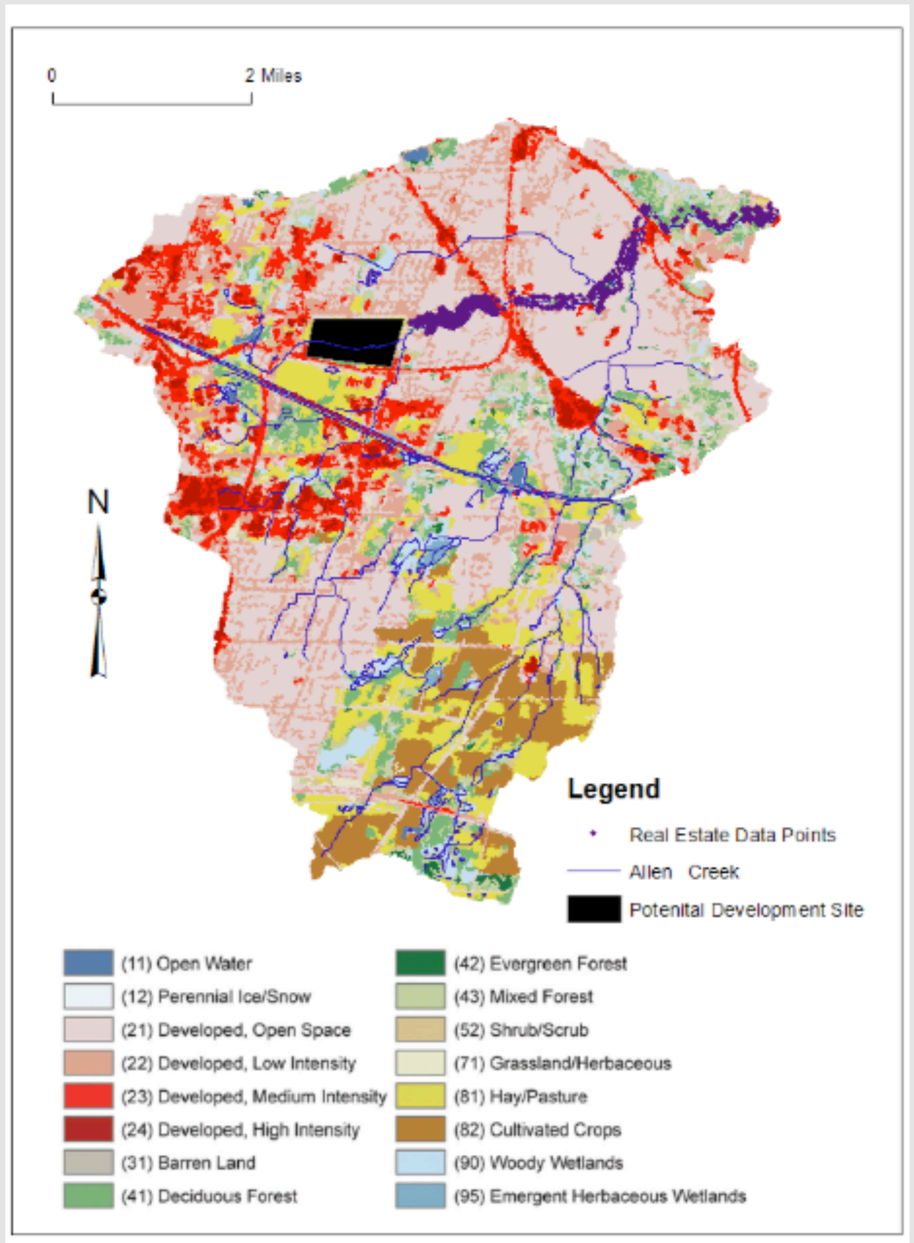

Figure 2. Location of potential development site in the watershed.

Results & Conclusions

- Holding all else constant, a one percent increase in the average annual volume of runoff would result in an average decrease in the assessed value of a home by about $2000.00 (Table 1).
- With the potential develop site in its natural state, the estimated annual volume of runoff is19,043 ft^3. Given this, we assume that the total cost to the community of 19,234 cubic feet of runoff is $2000*260 downstream properties, which equals $520,000.
- Assuming that the total cost of zero cubic feet of runoff to the community is $0, the equation for the total community damage curve for urban stormwater runoff is y=27.036S, where is S is runoff volume in cubic feet and y is 2010 constant dollars.

Table 2. Volumes of runoff that can be practically abated.

Yard Space Used per Household (%)	Abatement Area Required per Household (sqft)	Total Community Abatement Area (sqft)	Total Community Abatement Volume (cubic feet)	Maximum Development Scenario (CN)	Reasonable per Household Abatement Volume?
0.1	23	5,980	5,980	41	YES
0.5	115	29,900	29,900	53	YES
1	230	59,800	59,800	58	YES
5	1,150	299,000	299,000	73	MAYBE
10	2,300	598,000	598,000	79	MAYBE
60	13,800	3,588,000	3,588,000	94	NO
100	23,000	5,980,000	5,980,000	97	NO

Table 1. Regression results.

Variable	Coefficient	S.E.[a]	t-value	P-value
Intercept	7.475659*	0.418	17.88	<.0001
PITTS	0.228854*	0.0225	10.18	<.0001
YRBUILT	0.001712*	0.000213	8.04	<.0001
BDROOMS	0.004795	0.00755	0.64	0.5252
GARAGE	0.115017*	0.0112	10.30	<.0001
BATH	0.015697	0.012	1.31	0.1911
FIRE	0.028274*	0.00857	3.30	0.0010
HALF	0.026509**	0.0118	2.25	0.0248
LIVING	0.000621*	0.000026	23.66	<.0001
LIVING2	-4.06E-08*	2.895E-09	-14.02	<.0001
LRO52FT3	-0.01461*	0.00141	-10.34	<.0001
TIME	0.003046	0.00414	0.74	0.4618
NETLOT	0.000004315*	7.736E-07	5.58	<.0001
NETLOT2	-1.82E-11**	8.91E-12	-2.04	0.0416
NETLOT3	1.46E-17	2.59E-17	0.56	0.5730
N	1557			
F-statistic	969.93			<.0001
Adj R^2	0.90			
[a] Heteroskedasticity-consistent standard errors * P<0.001 **P<0.05				

- Using previously estimated cost functions for household level abatement measures, we compare the marginal cost of runoff to marginal damage under various development scenarios (Table 2).
- The empirical model suggests that all runoff should be abated in the downstream community regardless of the development state of the potential development site.

References

Dunn T., Leopold, L.B., 1978. Water in Environmental Planning. W.H. Freeman. San Francisco.

Monroe County New York Real Property Portal. http://www.monroecounty.gov/ apps/propertyapp.php

Ohio Environmental Education Fund (OEEF), 1997. Assessing the Impact of Land Use Change on Runoff, Recharge and Wetland Hydrology: A Practical Approach. Manual supported by the Ohio Environmental Educational Protection Agency.

Poor, P.J., Pessagno, K.L., Paul, R.W., 2007. Exploring the hedonic value of ambient water quality: a local watershed-based study. Ecological Economics 60, 797-806.

Purdue. 2011. "L-THIA Detailed Input." Accessed Oct. 17. https://engineering.purdue.edu/mapserve/LTHIA7/lthia/detailed_input.htm.

Schueler, T.R., 1987. Controlling urban runoff: a practical manual for planning and designing urban BMPs. Washington Metropolitan Water Resources Planning Board Rep., Washington, DC.

Thurston, H.W., Goddard, H.C., Szlag, D., Lemberg, B., 2003. Controlling stormwater runoff with tradable allowances for impervious surfaces. Journal of Water Resources Planning & Management 129, 409-418.

United States Department of Agriculture (USDA), 1986. Technical Release 55: Urban hydrology for small watersheds, Engineering Division, Soil and Conservation Service, Washington, DC.

United States Census Bureau, 2000. http://www.census.gov.