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# Estimating the Ecological Economic Impact of Stormwater Runoff

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# 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.
- Abatment = 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*. $\alpha$, $\beta_1$, $\beta_2$, and $\beta_3$ 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.

## 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 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<br>* P<0.001<br>**P<0.05 | | | | |

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 |

- 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.

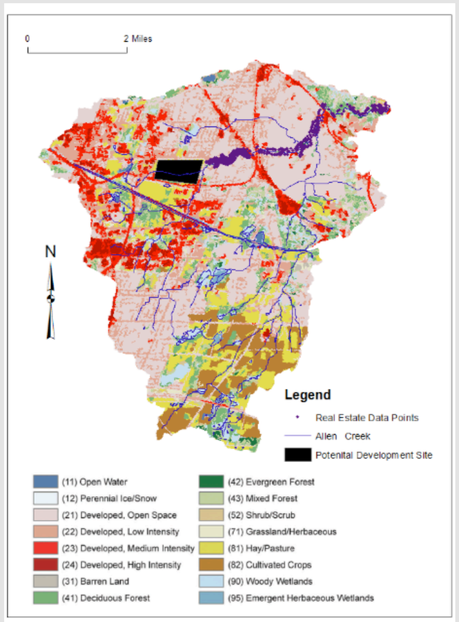


Figure 2. Location of potential development site in the watershed.

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