Examining Property Values and Green Infrastructure in Omaha, NE

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Presentation Outline

Introduction
• Defining GI and Hedonic Analysis
• Property Sales and GI
• Research Objective

Working in Omaha
• Study Site
• Repeat Sales Model and Analysis
• Results

Discussion & Conclusion
• Comparison Studies
• Future Planning
Green Infrastructure (GI) uses natural hydrologic properties of soil and vegetation to help manage stormwater. We focus on distributed vegetated technologies, e.g.,

- Rain gardens
- Tree trenches
- Bioswales
- Retention ponds etc.
The Hedonic Method

• A property's price is determined by the
  – Structural,
  – Neighborhood and,
  – Surrounding environmental characteristics

• Estimate the extent to which each factor affects the price of the home

• Uses transactions in the housing market to identify the value homeowners place on each factor
Property Values and GI

• Greenspace, property values and Hedonic studies
  – Parks, lakes, and trails vs cemeteries

• Literature is limited
  – Green streets, LIDs, green roofs, stream restoration
  – Hedonic, difference-in-difference, other willingness-to-pay models
  – Distance to project, project phase, etc.

• Need for research that values relationship between property values and GI

Credit: USEPA Flickr.com account
Examine how residential property prices are affected by the installation of GI in public parks

- Are property values increasing?
- Use a repeat sales model
Working in Omaha

2009

• Reduce occurrences of combined sewer overflows
• GI demonstration and best-management practices

2014

• Revised 15-year stormwater management plan

Today

• 70+ privately funded/constructed BMP projects
• 10+ city GI demonstration projects
  – 8 sites of GI in parks

Credit: Omahastormwater.org/greeninfrastructure
Site Selection Motivation

**Why parks?**
- Consistency
  - Locations
  - Funding
- No new construction (e.g., housing, parking lots)
- GI installed 2009-2018
  - Mix of sewer systems
Methods: Repeat Sales Model

- Evaluates the change in a property’s value between sales
- Controls for unobserved constant factors
- Properties must have sold more than once

\[ \ln \left( \frac{P_i}{P_i'} \right) = \beta_A \ln(A_i) + \beta_R \ln(R_i) + \sum_{h=1}^{H} \beta_{C_{ih}} C_{ih} + \beta_{D_i} D_i + \sum_{j=1}^{J} \sum_{k=1}^{K} \beta_{N_{ijk}} N_{ijk} \]

\[ + \sum_{l=1}^{L} \beta_{S_{il}} S_{il} + \beta_{W_i} W_i + \sum_{m=1}^{M} \beta_{G_{im}} G_{im} + (\varepsilon_i - \tilde{\varepsilon}_i) \]

\[ A_i = (\text{Age}_i - \tilde{\text{Age}}_i)/\tilde{\text{Age}}_i \]

\[ R_i = \frac{\text{Area}_i}{\tilde{\text{Area}}_i} \]

\[ C_{ih} = \text{Condition}_{ih} - \tilde{\text{Condition}}_{ih} \]

\[ D_i = (\text{Trend}_i - \tilde{\text{Trend}}_i) \times \text{Downtown}_i \]

\[ N_{ijk} = (\text{Year}_{ik} - \tilde{\text{Year}}_{ik}) \times \text{Neighborhood}_{ij} \]

\[ S_{il} = \text{Season}_{il} - \tilde{\text{Season}}_{il} \]

\[ W_i = \text{ConstPrd}_i - \tilde{\text{ConstPrd}}_i \]

\[ G_{im} = \text{Gl}_{im} - \tilde{\text{Gl}}_{im} \]

- \( i \) – sales pair
- \( j \) – neighborhood
- \( k \) – sales year
- \( l \) – season
- \( m \) – GI distance buffer

N=25,472 pairs
Repeat Sales Models

- Controlled for changes in age, condition, square footage
- Interactions: neighborhood, year of sale, distance to downtown, season of sale

#### Defined GI Buffers

<table>
<thead>
<tr>
<th>Model</th>
<th>GI Buffer (treatment)</th>
<th>Properties included</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;= 0.5km</td>
<td>All Properties</td>
</tr>
<tr>
<td>2</td>
<td>Adjacent, 0-0.25km, 0.25-0.5km</td>
<td>All Properties</td>
</tr>
<tr>
<td>3</td>
<td>&lt;=0.5km</td>
<td>Properties &lt;= 1km</td>
</tr>
<tr>
<td>4</td>
<td>Adjacent, 0-0.25km, 0.25-0.5km</td>
<td>Properties &lt;= 1km</td>
</tr>
<tr>
<td>5</td>
<td><em>GI installed before 2017 only</em> Adjacent, 0-0.25km, 0.25-0.5km</td>
<td>Properties &lt;= 1km</td>
</tr>
</tbody>
</table>
Property Sales Data

Sales records from Jan. 2000 through August 2018
- Single-family homes
- <1 acre
- Sales > $20,000 (arms-lengths sales)
- Properties with < +/- 20% change in square footage

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales price (first transaction, 2018 USD)</td>
<td>192,992</td>
<td>(139,105)</td>
</tr>
<tr>
<td>Sales price (second transaction, 2018 USD)</td>
<td>196,872</td>
<td>(135,120)</td>
</tr>
<tr>
<td>Area of home (first transaction, square feet)</td>
<td>1,719</td>
<td>(885)</td>
</tr>
<tr>
<td>Area of home (second transaction, square feet)</td>
<td>1,730</td>
<td>(894)</td>
</tr>
<tr>
<td>Age of home (first transaction, years)</td>
<td>51</td>
<td>(29)</td>
</tr>
<tr>
<td>Age of home (second transaction, years)</td>
<td>57</td>
<td>(29)</td>
</tr>
<tr>
<td>Condition of home (first transaction, scale: excellent (1) to poor (5))</td>
<td>2.638</td>
<td>(0.687)</td>
</tr>
<tr>
<td>Condition of home (second transaction, scale: excellent (1) to poor (5))</td>
<td>2.645</td>
<td>(0.688)</td>
</tr>
</tbody>
</table>
Results: Home Sales (2000-2018)

• Correlations
  + Increase in sq footage
  + Improved conditions
  + Distance to downtown
    – Increases in age
    – Decline in condition

• GI had no affect on property sales prices
Making sense of the results

1. Time between our analysis and completion of the GI is too limited (e.g., the effects of construction are still present)
2. Insufficient GI sample size
3. GI practices are collectively too small or in low-visibility spaces
4. Residents are unaware of benefits outside of aesthetic value
5. Parks already account for any possible effects on property values
6. GI does not affect sale prices

Studies with similar findings

- Livy and Klaiber (2016) and Hofe et al. (2017)
- All found high heterogeneity in how local park renovations are capitalized in property values
Implications for GI in Omaha

- **Increase Understanding of Ecosystem Services**
  - Education/outreach on benefits of GI
  - Other services (e.g. no more basement flooding)

- **Incorporate park and GI size (current work)**

- **Motivations for implementing GI**

- **Future Studies**
  - Major renovations or new construction
  - Unit/coding distinctions (e.g., Multi-unit apartments vs commercial properties)
  - What do the people say?
Contact Us

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<table>
<thead>
<tr>
<th>Park Name</th>
<th>Install Date</th>
<th>GI Type</th>
<th>GI Size (sewer)</th>
<th>Park Size</th>
<th>% GI Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard Park</td>
<td>2009</td>
<td>Bioretention</td>
<td>0.073 (CSS)</td>
<td>8</td>
<td>0.91</td>
</tr>
<tr>
<td>Saddle Hills</td>
<td>2014</td>
<td>Rain garden</td>
<td>0.053 (MS4)</td>
<td>3.5</td>
<td>1.51</td>
</tr>
<tr>
<td>Adams</td>
<td>2016</td>
<td>Detention pond</td>
<td>14 (CSS)</td>
<td>60</td>
<td>23.33</td>
</tr>
<tr>
<td>Elmwood</td>
<td>2012</td>
<td>Bioretention</td>
<td>0.034 (CSS)</td>
<td>216.4</td>
<td>0.02</td>
</tr>
<tr>
<td>Fontenelle</td>
<td>2018</td>
<td>Detention pond</td>
<td>6.69 (CSS)</td>
<td>108</td>
<td>6.19</td>
</tr>
<tr>
<td>Miller</td>
<td>2014</td>
<td>Detention pond</td>
<td>3.30 (MS4)</td>
<td>80</td>
<td>4.12</td>
</tr>
<tr>
<td>Prairie Lane</td>
<td>2014</td>
<td>Bioretention</td>
<td>0.1226 (MS4)</td>
<td>5</td>
<td>2.45</td>
</tr>
<tr>
<td>Spring Lake</td>
<td>2016</td>
<td>Detention pond</td>
<td>1.87 (CSS)</td>
<td>96</td>
<td>1.95</td>
</tr>
</tbody>
</table>
### Results

* p<0.1, ** p<0.05, *** p<0.01

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(A) Age of the home</td>
<td>-0.034***</td>
<td>-0.034***</td>
<td>-0.041***</td>
<td>-0.041***</td>
<td>-0.036***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>ln(R) Home sq ft</td>
<td>0.145***</td>
<td>0.145***</td>
<td>0.316***</td>
<td>0.315***</td>
<td>0.304***</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td>(0.033)</td>
<td>(0.098)</td>
<td>(0.098)</td>
<td>(0.101)</td>
</tr>
<tr>
<td>C: Excellent</td>
<td>0.106***</td>
<td>0.106***</td>
<td>0.095***</td>
<td>0.095***</td>
<td>0.085***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>C: Good</td>
<td>0.058***</td>
<td>0.058***</td>
<td>0.073***</td>
<td>0.073***</td>
<td>0.056***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>C: Fair</td>
<td>-0.170***</td>
<td>-0.170***</td>
<td>-0.158***</td>
<td>-0.158***</td>
<td>-0.174***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>C: Poor</td>
<td>-0.418***</td>
<td>-0.418***</td>
<td>-0.404***</td>
<td>-0.404***</td>
<td>-0.398***</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.032)</td>
<td>(0.070)</td>
<td>(0.070)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>D Dist to downtown</td>
<td>0.0003***</td>
<td>0.0003***</td>
<td>0.001*</td>
<td>0.001*</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>W if sale occurred during construction</td>
<td>0.0004</td>
<td>0.0002</td>
<td>0.005</td>
<td>0.005</td>
<td>-0.020</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.019)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>GI: 0-0.5km</td>
<td>-0.012</td>
<td>-0.008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.011)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GI: Adjacent</td>
<td>0.044</td>
<td></td>
<td>0.049</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.047)</td>
<td>(0.047)</td>
<td>(0.045)</td>
<td></td>
</tr>
<tr>
<td>GI: 0-0.25km</td>
<td>-0.017</td>
<td>-0.010</td>
<td>-0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.016)</td>
<td></td>
</tr>
<tr>
<td>GI: 0.25-0.5km</td>
<td>-0.015</td>
<td>-0.012</td>
<td>-0.012</td>
<td>-0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.015)</td>
<td></td>
</tr>
<tr>
<td>Neighborhood Price Index</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Season of Sale</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Obs.</td>
<td>25,472</td>
<td>25,472</td>
<td>4,476</td>
<td>4,476</td>
<td>3,914</td>
</tr>
<tr>
<td>R²</td>
<td>0.211</td>
<td>0.211</td>
<td>0.255</td>
<td>0.256</td>
<td>0.267</td>
</tr>
</tbody>
</table>