Modeling Residential Development in the Baltimore Metro Region

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Residential development in Baltimore County

Subdivision data in 1960-2008

Land use trends and zoning policies

Residential land-use change models in 1996-2007

Excess zoned capacity and septic law in Maryland
  • Business as usual (before septic law)
  • After septic growth tiers adopted

Ongoing research in Baltimore Metro Region
Groundwater wells and septic

Source: Josh Cole (UMBC)
Protecting Drinking Water Sources

Baltimore County

- 63% of the region’s 294 sq. mi. of reservoir watersheds
- 48% of the County

Source: Don Outen (EPS)
Baltimore County:
Land use trends and zoning
Baltimore City

90% of year 2000 population lived inside the urban growth boundary (UGB) on 1/3 of the land

Source: Don Outen (EPS)
Residential Development by Year Built

LEGEND
- County Boundary
- Urban Rural Demarcation Line
- Interstate Highways
- Major County Roads
- State Secondary Highways
- Reservoirs
- Major Rivers
SINGLE-FAMILY RESIDENTIAL YEAR BUILT
- Pre 1900s
- 1900 - 1939
- 1940 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2008
Resource Conservation Zoning - 2008

- low-density zoning protects forests and water resources
- first adopted in 1975
- applies to about 2/3 of the County
- quadrennial Comprehensive Zoning Map Process

Source: Don Outen (EPS)
Residential subdivisions in 1960-2008
Subdivision in RC4 zoning
MD Property View parcel data to reconstruct historic subdivisions 1960-2008:

- Identify polygons in MDPV parcel layer within same subdivision
- Dissolve individual parcels into original parent parcel
- Record year start and number of lots in subdivision
Internal subdivision characteristics

Multiple phases of development (subevents)

Land code on each parcel within subdivision
- Buildable lot
- Open space
- Remain developable
- Internal road
- Commercial, Industrial, Multifamily

Open space types
- Storm water management; Floodplain; Wetlands; Forest conservation; Forest buffer; Local open space; HOA
Residential Subdivisions in 1960-2008

LEGEND
- County Boundary
- Urban-Rural Demarcation Line
- Interstate Highways
- Major County Roads
- State Secondary Highways
- Reservoirs
- Major Rivers
- Protected Area
- Subdivisions
  - Other
  - Minor (2 or 3 lots)
  - Major (>=4 lots)
Major versus minor subdivisions

Major subdivisions (4+ lots)
- Formal public hearing for subdivision approval
- Longer permit review process

Minor subdivisions (2 or 3 lots)
- No formal public hearing (only planning board approval needed)
- Shorter permit review process
- Minor exemption rules in RC2 and RC4 zoning
  - RC2 zoning (50-acre min lot size): Allows 2 lots for parcels between 2 and 100 acres
  - RC4 zoning (5-acre min lot size): Allows 2 lots for parcels between 6 and 10 acres
Subdivision size by buildable lots
Residential land-use change model

Binary model specification

Baseline data
- Developable parcels in 1996 (zoning allows 2 or more lots)

Residential development model (first-stage)
- Binary probit model for land-use transitions in 1996-2007
  Categories: Develop or remain developable

Truncated count model (second-stage)
- Number of buildable lots in subdivision, conditional on development in 1996-2007
- Truncated negative binomial model
  Subdivision must have 2 or more lots (truncated at zero or one)


Explanatory variables

Zoning attributes
- Zoning type
- Authorized lots minor

Accessibility attributes
- Distance to Baltimore City
- Distance to major road

Physical land attributes
- Parcel area
- Slope
- Elevation
- Soil quality (good/fair, poor, very poor)
- Water table depth
- 100-year floodplain
- Existing house
- Rural Legacy area
## Residential land-use change model

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RC2 (0.02 du/ac)</td>
<td>-0.795**</td>
<td>(0.136)</td>
<td>-4.574**</td>
<td>(0.247)</td>
</tr>
<tr>
<td>RC8 (0.02 du/ac)</td>
<td>-0.908**</td>
<td>(0.242)</td>
<td>-4.421**</td>
<td>(0.836)</td>
</tr>
<tr>
<td>RC7 (0.04 du/ac)</td>
<td>-0.617**</td>
<td>(0.235)</td>
<td>-2.683**</td>
<td>(0.438)</td>
</tr>
<tr>
<td>RC6 (0.2 du/ac)</td>
<td>-0.566*</td>
<td>(0.242)</td>
<td>-1.928**</td>
<td>(0.316)</td>
</tr>
<tr>
<td>RC4 (0.2 du/ac)</td>
<td>-0.516**</td>
<td>(0.109)</td>
<td>-3.014**</td>
<td>(0.188)</td>
</tr>
<tr>
<td>RC5 (0.5 du/ac)</td>
<td>-0.420**</td>
<td>(0.083)</td>
<td>-2.292**</td>
<td>(0.134)</td>
</tr>
<tr>
<td>DR1 (1 du/ac)</td>
<td>-0.266**</td>
<td>(0.093)</td>
<td>-1.497**</td>
<td>(0.174)</td>
</tr>
<tr>
<td>DR2 (2 du/ac)</td>
<td>-0.278**</td>
<td>(0.071)</td>
<td>-0.767**</td>
<td>(0.129)</td>
</tr>
<tr>
<td>DR3.5 (3.5 du/ac)</td>
<td>-0.044</td>
<td>(0.050)</td>
<td>-0.350**</td>
<td>(0.093)</td>
</tr>
<tr>
<td>Auth lots_2</td>
<td>-0.293**</td>
<td>(0.080)</td>
<td>-0.518*</td>
<td>(0.236)</td>
</tr>
<tr>
<td>Auth lots_3</td>
<td>-0.131*</td>
<td>(0.057)</td>
<td>-0.457*</td>
<td>(0.183)</td>
</tr>
</tbody>
</table>

Baseline zoning = DR5.5 (5.5 du/ac)
Significance at the 1 %, and 5% level are represented by ** and * respectively
### Residential land-use change model (cont’d)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Binary Probit Model</th>
<th>Truncated Negative Binomial Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to Baltimore City</td>
<td>-0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Distance to major road</td>
<td>-0.045</td>
<td>0.029</td>
</tr>
<tr>
<td>Ln(parcel area)</td>
<td>0.336**</td>
<td>0.021</td>
</tr>
<tr>
<td>Slope</td>
<td>-0.014**</td>
<td>0.004</td>
</tr>
<tr>
<td>Elevation</td>
<td>0.024**</td>
<td>0.004</td>
</tr>
<tr>
<td>Poor soil</td>
<td>0.066</td>
<td>0.046</td>
</tr>
<tr>
<td>Very poor soil</td>
<td>-0.071</td>
<td>0.109</td>
</tr>
<tr>
<td>Water table depth</td>
<td>-0.011</td>
<td>0.018</td>
</tr>
<tr>
<td>Floodplain_100yr</td>
<td>-0.637**</td>
<td>0.159</td>
</tr>
<tr>
<td>Existing house</td>
<td>-0.302**</td>
<td>0.039</td>
</tr>
<tr>
<td>Rural Legacy</td>
<td>0.263**</td>
<td>0.061</td>
</tr>
<tr>
<td>Alpha</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.580**</td>
<td>0.102</td>
</tr>
<tr>
<td>Number of observations</td>
<td>68,531</td>
<td></td>
</tr>
</tbody>
</table>

Time fixed effects for 1996-2006 are estimated but not shown here.
Significance at the 1 %, and 5% level are represented by ** and * respectively.
Predicted probability of development in 1996-2007

Legend
- County Boundary
- Urban Rural Demarcation Line
- Interstate Highways
- Major County Roads
- State Secondary Highways
- Reservoirs
- Protected Area

Development Probability
- 0.000365 - 0.001000
- 0.001001 - 0.050000
- 0.050001 - 0.100000
- 0.100001 - 0.200000
- 0.200001 - 0.500000
- 0.500001 - 1.000000

Scale: 0 - 16 Miles
Simulations on predicted development

- Predictions on development and subdivision size
  - Binary probit model (first stage)
    - Estimate site-specific probability of development for each developable parcel
    - Compare to random uniform number to determine conversion events
  - Truncated count model (second stage)
    - Conditional on development, estimate probability for each subdivision size for buildable lots $y = 2, 3, 4, 5, \ldots, 1000$
    - Compare to random uniform number to determine number of buildable lots in subdivision

- Policy scenarios
  - Current zoning (business as usual)
  - Septic bill regulations
### Predicted development in 1996-2007

<table>
<thead>
<tr>
<th>Subdivisions</th>
<th>Inside URDL</th>
<th>Outside URDL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor (2-3 lots)</td>
<td>116</td>
<td>112</td>
<td>228</td>
</tr>
<tr>
<td>Major small (4-19 lots)</td>
<td>141</td>
<td>112</td>
<td>254</td>
</tr>
<tr>
<td>Major large (20+ lots)</td>
<td>47</td>
<td>35</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>259</td>
<td>564</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Buildable lots</th>
<th>Inside URDL</th>
<th>Outside URDL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor (2-3 lots)</td>
<td>277</td>
<td>256</td>
<td>534</td>
</tr>
<tr>
<td>Major small (4-19 lots)</td>
<td>1116</td>
<td>966</td>
<td>2084</td>
</tr>
<tr>
<td>Major large (20+ lots)</td>
<td>3739</td>
<td>1467</td>
<td>5209</td>
</tr>
<tr>
<td>Total</td>
<td>5133</td>
<td>2689</td>
<td>7827</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acreage developed</th>
<th>Inside URDL</th>
<th>Outside URDL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor (2-3 lots)</td>
<td>193</td>
<td>2429</td>
<td>2622</td>
</tr>
<tr>
<td>Major small (4-19 lots)</td>
<td>671</td>
<td>5303</td>
<td>5976</td>
</tr>
<tr>
<td>Major large (20+ lots)</td>
<td>1507</td>
<td>4025</td>
<td>5533</td>
</tr>
<tr>
<td>Total</td>
<td>2370</td>
<td>11757</td>
<td>14131</td>
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</tbody>
</table>
Excess zone capacity and septic law in Maryland
Sustainability Growth and Agricultural Preservation Act ("septic bill") passed by State of Maryland in 2012

**Purpose:** Restrict major subdivisions on septic systems in resource areas dominated by agricultural and forest lands (Tier 4)

**Four tier system:**
- Tier 1 = Existing sewer service areas
- Tier 2 = Planned sewer areas (future growth areas)
- Tier 3 = Major subdivisions on septic allowed (Large-lot residential development and rural villages)
- Tier 4 = No major subdivisions on septic (Agricultural and forest dominated areas)
  - Only minor subdivision are allowed
Baltimore County Growth Tiers

- **Tier 1 and Tier 2** = Inside URDL (existing and planned sewer)
- **Tier 3** = RC5 zoning mainly
- **Tier 4** = All other RC zoning types and portion of RC5 zoning
  - Only minor subdivision with 3 lots are allowed
Excess zoned capacity (EZC)

\[
EZC = \frac{\text{Parcel area}}{\text{Minimum lot zoning}} - \text{Number of existing houses}
\]

**Example #1:** 75-acre vacant parcel in RC4 zoning (5-acre min lot zoning).

\[
EZC = \frac{75}{5} - 0 = 15 \text{ lots remaining}
\]

**Septic bill impact on EZC** = 15 – 3 = 12 lot reduction

Assumes minor subdivision with 3 lots built in Baltimore County. In contrast, Carroll County has redefined minors to 7 lots.
Excess zoned capacity (EZC)

\[
EZC = \frac{\text{Parcel area}}{\text{Minimum lot zoning}} - \text{Number of existing houses}
\]

Example #2: 200-acre vacant parcel in RC2 zoning (50-acre min lot zoning).

\[
EZC = \frac{200}{50} - 0 = 4 \text{ lots remaining}
\]

Septic bill impact on EZC = \(4 - 3 = 1\) lot reduction

Example #3: 12-acre vacant parcel in RC2 zoning

Still allows subdivision into 2 lots (EZC=2) due to minor exemptions
Excess Zoned Capacity Reduction

LEGEND
- County Boundary
- Interstate Highways
- Major County Roads
- State Secondary Highways
- Urban Rural Demarcation Line
- Reservoirs
- Major Rivers
- Protected Area
- Excess Zoned Capacity Reduction
  - >=1 lot
Baltimore County

- 63% of the region’s 294 sq. mi. of reservoir watersheds
- 48% of the County

Source: Don Outen (EPS)
# Septic bill impacts in Tier 4 (Baltimore County)

<table>
<thead>
<tr>
<th>Subdivision potential</th>
<th>RC2</th>
<th>RC4</th>
<th>RC5</th>
<th>RC6</th>
<th>RC7</th>
<th>RC8</th>
<th>RC20/50</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed already</td>
<td>9,058</td>
<td>3,704</td>
<td>2,807</td>
<td>3,373</td>
<td>1,499</td>
<td>1,490</td>
<td>372</td>
<td>22,356</td>
</tr>
<tr>
<td>Potential minor (2 lots)</td>
<td>4,476</td>
<td>175</td>
<td>160</td>
<td>58</td>
<td>7</td>
<td>78</td>
<td>10</td>
<td>4,965</td>
</tr>
<tr>
<td>Potential minor (3 lots)</td>
<td>9</td>
<td>35</td>
<td>76</td>
<td>24</td>
<td>7</td>
<td>17</td>
<td>3</td>
<td>171</td>
</tr>
<tr>
<td>Potential major (4+ lots)</td>
<td>10</td>
<td>81</td>
<td>226</td>
<td>61</td>
<td>22</td>
<td>0</td>
<td>7</td>
<td>408</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Buildable lots</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing house</td>
<td>5,899</td>
<td>2,738</td>
<td>1,868</td>
<td>2,828</td>
<td>987</td>
<td>1,032</td>
<td>127</td>
<td>15,528</td>
</tr>
<tr>
<td>Potential minor (2 lots)</td>
<td>8,952</td>
<td>350</td>
<td>320</td>
<td>116</td>
<td>14</td>
<td>156</td>
<td>20</td>
<td>9,930</td>
</tr>
<tr>
<td>Potential minor (3 lots)</td>
<td>27</td>
<td>105</td>
<td>228</td>
<td>72</td>
<td>21</td>
<td>51</td>
<td>9</td>
<td>513</td>
</tr>
<tr>
<td>Potential major (4+ lots) (BEFORE)</td>
<td>57</td>
<td>659</td>
<td>2,156</td>
<td>558</td>
<td>407</td>
<td>0</td>
<td>41</td>
<td>3,912</td>
</tr>
<tr>
<td>Potential major (4+ lots) (AFTER)</td>
<td>30</td>
<td>243</td>
<td>678</td>
<td>183</td>
<td>66</td>
<td>0</td>
<td>21</td>
<td>1,224</td>
</tr>
<tr>
<td>Septic bill impact (CHANGE in Lots)</td>
<td>27</td>
<td>416</td>
<td>1,478</td>
<td>375</td>
<td>341</td>
<td>0</td>
<td>20</td>
<td>2,688</td>
</tr>
</tbody>
</table>

| % Septic impact/Potential major  | 47%  | 63%  | 69%  | 67%  | 84%  | NA   | 49%     | 69%   |
| % Septic impact/Potential major + minor | 0%   | 37%  | 55%  | 50%  | 77%  | 0%   | 29%     | 19%   |
| % Septic impact/Existing + potential | 0%   | 11%  | 32%  | 10%  | 24%  | 0%   | 10%     | 9%    |

Lot reduction in major subdivisions in Tier 4 are mainly in RC5 and RC4/RC6.

RC2 has 8,952 potential buildable lots in minor subdivisions, due to minor exemption rule (i.e. parcels with 2-100 acres allowed 2 lots).
Main findings in Baltimore County

Zoning impacts
Minimum lot size zoning regulations strongly affect both the probability of development and density

Urban vs. Rural impacts
Majority of new buildable lots occur within urban area
(5,133 lots inside URDL vs. 2,689 outside URDL)

But majority of acreage developed still occurs within rural area
(2,370 acres inside URDL vs. 11,757 outside URDL)

Septic bill regulations
Septic bill results in 69% reduction on major subdivisions in Tier 4 areas.

But there is still a significant number of potential minor subdivisions on septic systems in Tier 4.
Zoning in Carroll County
Carroll vs. Baltimore County

Designation on Tier 3 versus Tier 4 areas
Carroll County has not publicly released growth tier map
Baltimore County designated about 90% of rural area in Tier 4 (most preservation-oriented in State of MD)

Redefinition of minor subdivision (Increased to 7 lots)
Carroll County redefined minors to include 2 to 7 lots
Baltimore County continued to define minors as 2 or 3 lots

Minor exemptions
Agricultural zoning in Carroll County has 20-acre min lot size, with minor exemption for 2 lots on parcels between 6 to 40 acres

Existing development
Existing development is much greater than potential minor and majors in both Baltimore and Carroll Counties (septic retrofits with BAT)
Main issues on septic law

Designation on Tier 3 versus Tier 4 areas
MD Dept of Planning proposed Tier 4 as Rural Legacy areas, priority preservation areas, and forest/agricultural dominated areas.

Tier 3 adopted in majority of rural area in some counties

Redefinition of minor subdivision (Increased to 7 lots)
Will there be clustered development?

Example: 140 acre parcel with 7 lots allowed in minor subdivision
   Without clustering: 7 lots at 20 acre each (increase farmland loss)
   With clustering: 6 lots at 1 acre each + 134 acre farm