

**Maryland's Forest Conservation Act and
the Impact on Residential Development and
Forest Cover in Baltimore County**

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Forest Conservation Act (FCA) and development

- **Research question**
 - How did the 1993 Forest Conservation Act (FCA) in Maryland affect residential development and forest cover change decisions?
- **Study area and data**
 - Rural area in Baltimore County (Outside UGB)
 - Parcel-level residential development from tax assessment records
 - Forest cover data in 1984-2004 from North American Forest Dynamics Project
- **Panel Heckman selection model**
 - **First stage:** Panel probit model on residential development
 - Develop or remain developable in 1985-2000
 - Subdivisions before FCA (1985-1992) and after FCA (1993-2000)
 - **Second stage:** Forest cover change, conditional on development
 - **Explanatory variables**
 - Existing forest cover, zoning, accessibility, land quality, surrounding land uses

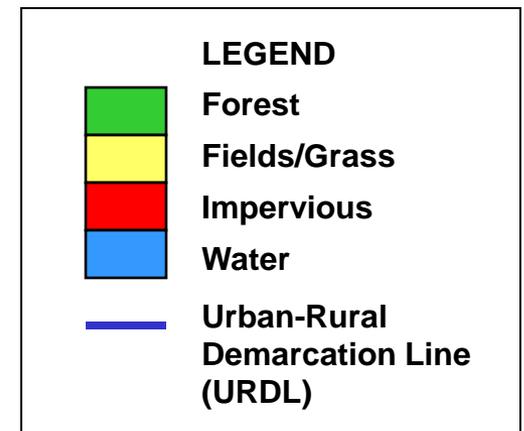
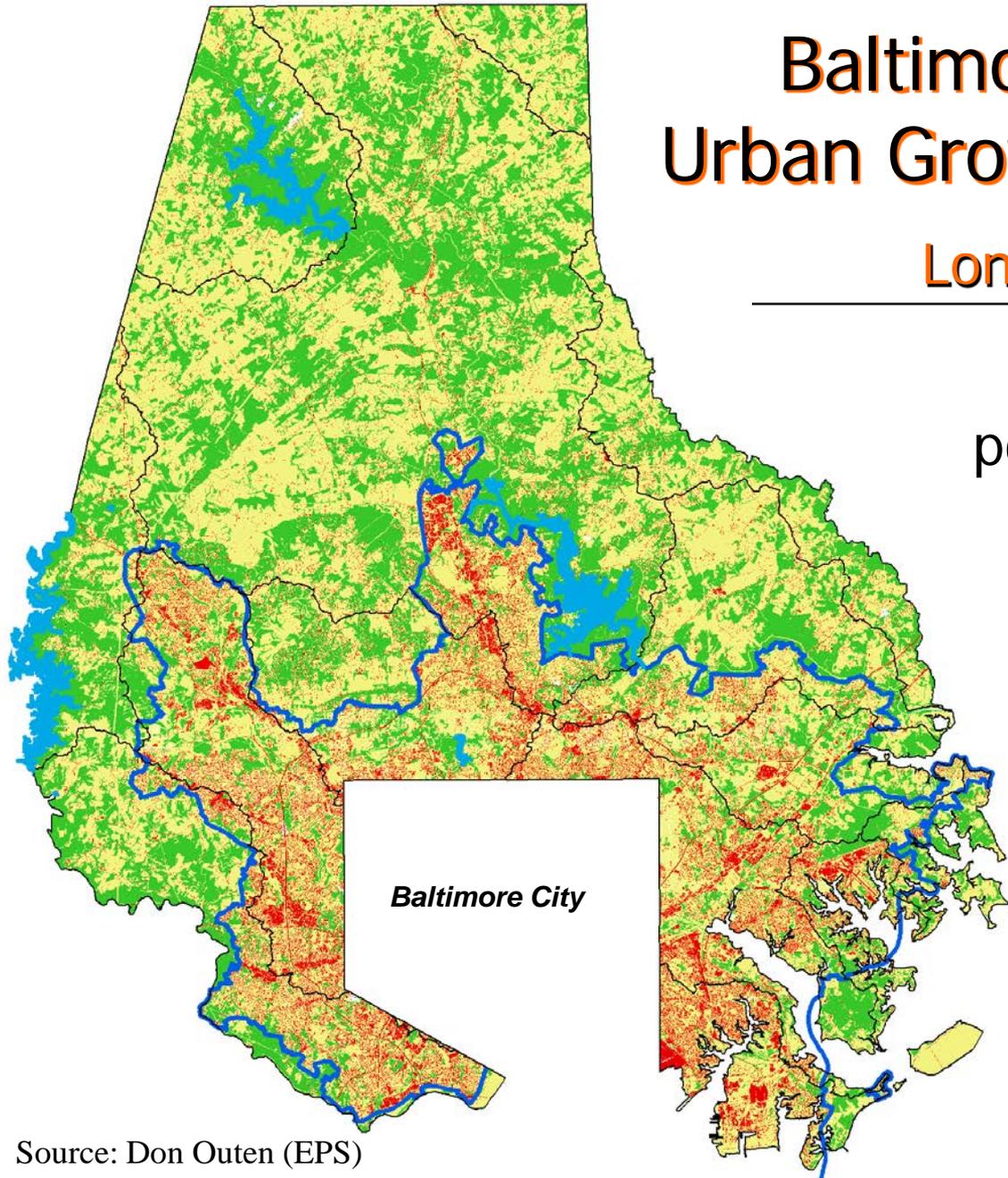
Literature on forest cover and development

- **Voluntary incentive payments for forest cover and ecosystem services**
 - Nelson et al. (2008); Lewis, Plantinga and Wu (2009)
- **Land use regulation and residential development**
 - Irwin and Bockstael (2004); Newburn and Berck (2006); McConnell, Walls, and Kopits (2006); Lewis (2010); Butsic, Lewis and Ludwig (2011)
- **Forest conservation regulations within residential subdivisions**
 - Lichtenberg, Tra and Hardie (2007)

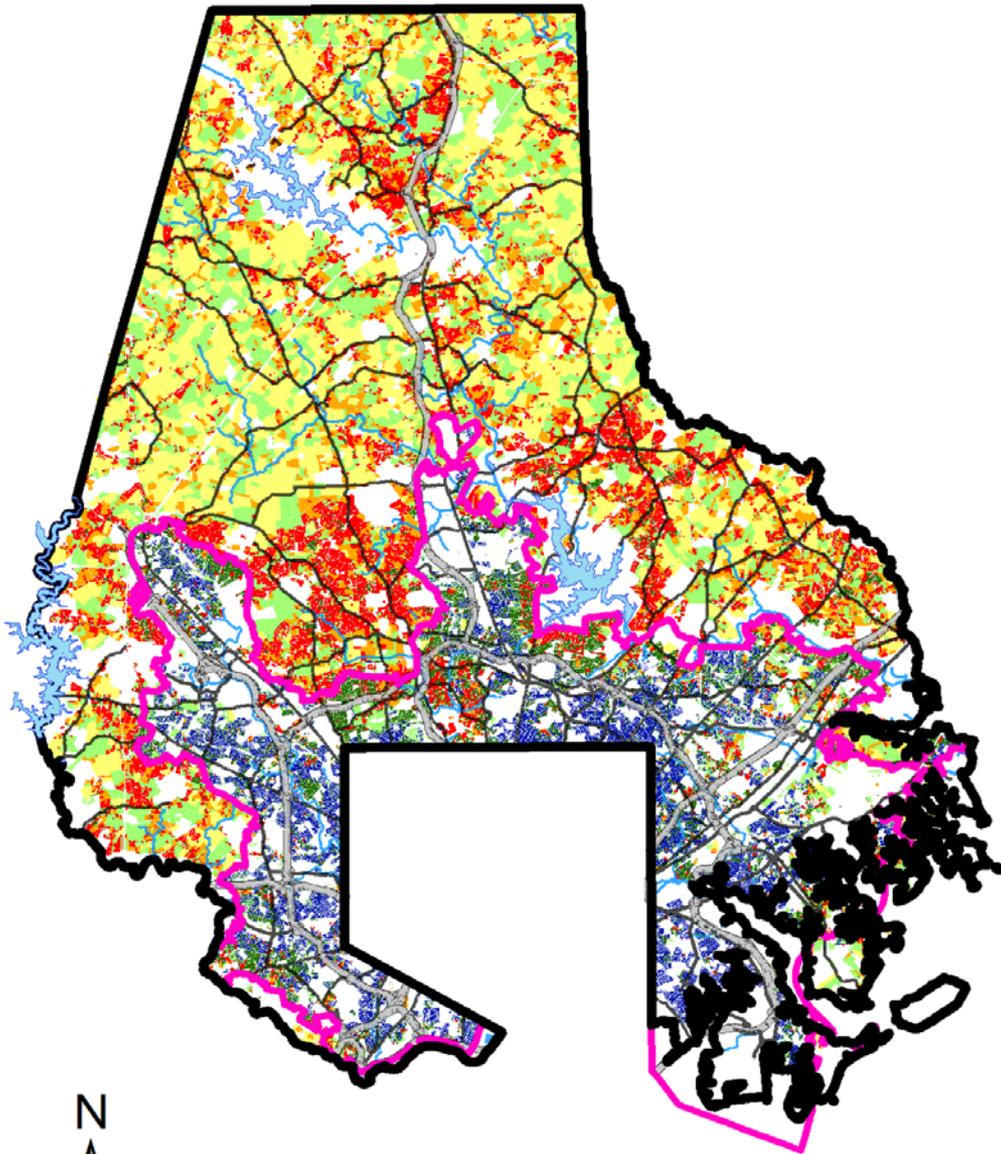
Baltimore County Urban Growth Boundary

Long-Term Results

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



Residential density



▣ County Boundary

▭ Urban Rural Demarcation Line

▭ Reservoirs

— Major Rivers

— Interstate Highways

— Major Roads

SINGLE-FAMILY RESIDENTIAL DENSITIES

▭ No development

▭ ≤ 0.05 units/acre (>20 acres/unit)

▭ $>0.05 - 0.2$ units/acre (>5 to 20 acres/unit)

▭ $>0.2 - 1.0$ units/acre (>1 to 5 acres/unit)

▭ $>1.0 - 4.0$ units/acre (>0.25 to 1 acres/unit)

▭ >4.0 units/acre (<0.25 acres/unit)

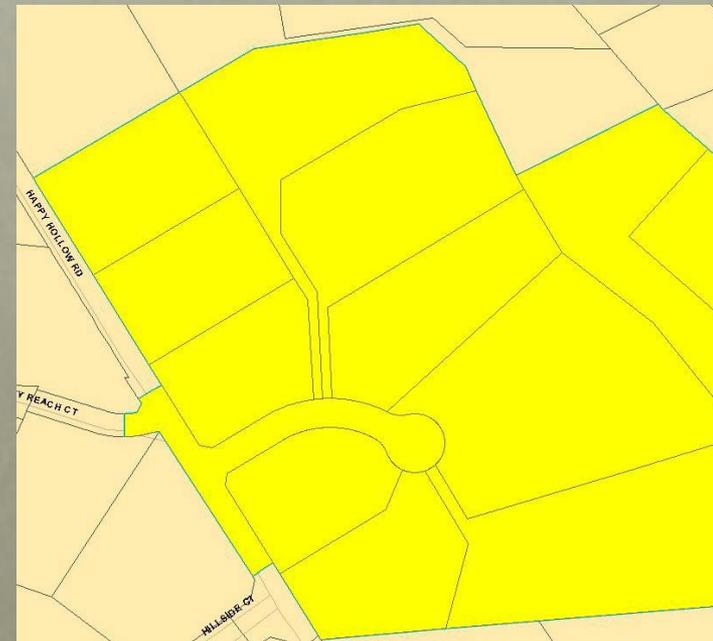


0 2.5 5 10 15 20 Miles

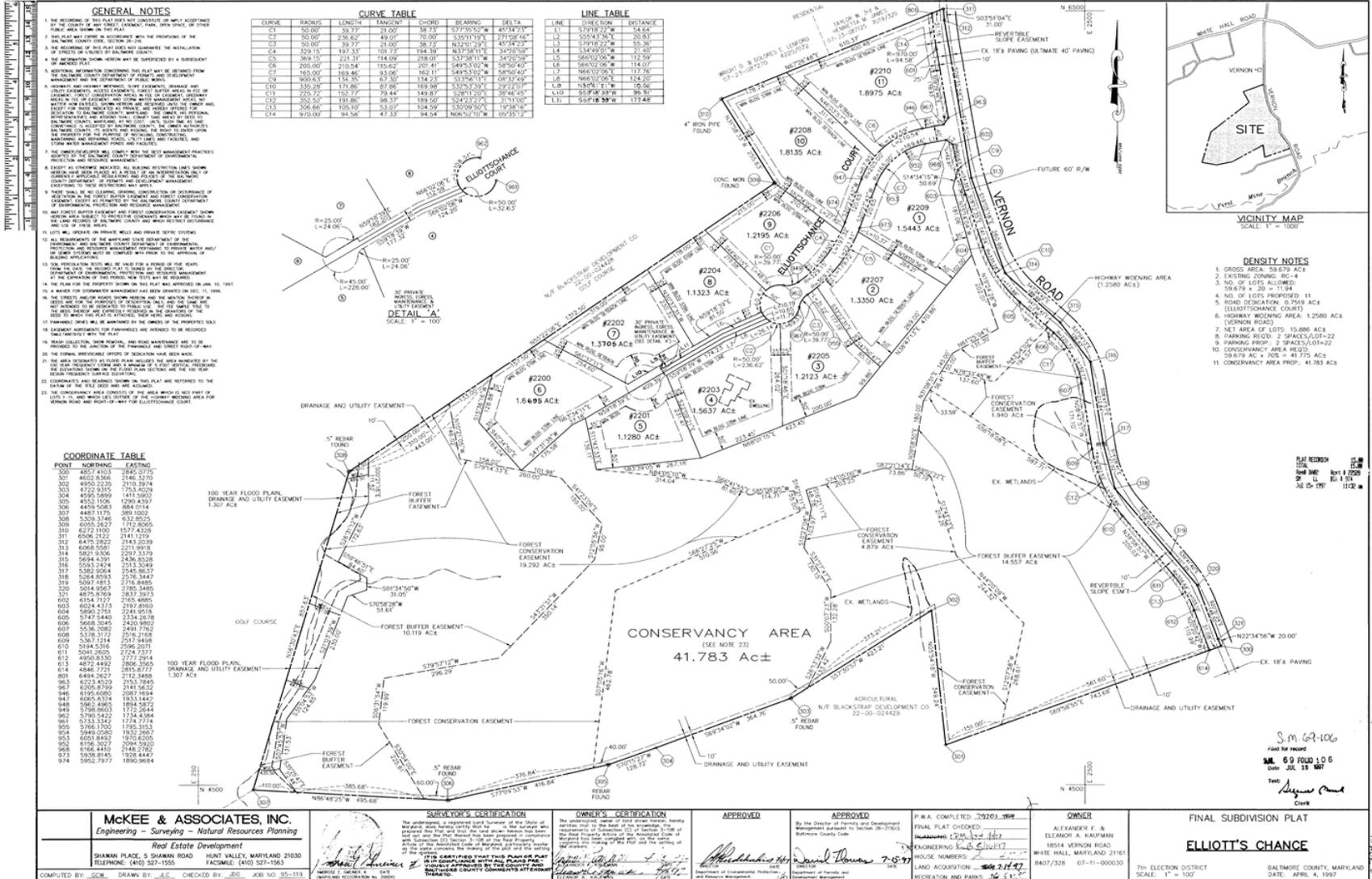
Subdivisions

MD Property View parcel data to reconstruct historic subdivisions:

- 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



Subdivision in RC4 zoning



GENERAL NOTES

1. THE RECORDS OF THIS PLAT SHOW THE CONSTRUCTION OF THE PLAT TO BE IN ACCORDANCE WITH THE PROVISIONS OF THE SUBDIVISION ACT AND THE PROVISIONS OF THE SUBDIVISION ACT.
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CURVE TABLE

CURVE	RADIUS	LENGTH	TANGENT	CHORD	DELTA
C1	50.00	39.27	24.00	38.73	57.74
C2	50.00	25.62	16.00	25.00	36.87
C3	50.00	39.27	24.00	38.73	57.74
C4	250.15	191.33	109.73	194.39	93.97
C5	369.15	221.31	114.09	218.01	107.31
C6	205.00	155.84	95.62	151.41	69.51
C7	163.00	124.46	75.00	119.11	54.90
C8	400.00	314.16	196.25	308.11	143.93
C9	335.28	271.86	165.98	265.33	122.23
C10	225.72	175.77	110.44	171.87	84.44
C11	250.25	191.86	119.57	187.12	93.97
C12	358.86	275.07	170.31	268.59	134.50
C13	212.00	161.56	101.32	156.24	76.25

LINE TABLE

LINE	DIRECTION	DISTANCE
L1	S79°15'27\"/>	
L2	S79°15'27\"/>	
L3	S79°15'27\"/>	
L4	S48°00'00\"/>	
L5	S88°00'00\"/>	
L6	N89°00'00\"/>	
L7	N89°00'00\"/>	
L8	N89°00'00\"/>	
L9	N89°00'00\"/>	
L10	N89°00'00\"/>	
L11	S107°05'58\"/>	

COORDINATE TABLE

POINT	NORTHING	EASTING
100	4507.4103	2141.2718
101	4507.4103	2141.2718
102	4507.2235	2110.3974
103	4507.2235	2110.3974
104	4505.2899	1411.5627
105	4505.2899	1411.5627
106	4495.5085	884.0114
107	4495.5085	884.0114
108	5309.3746	632.8025
109	6025.2827	192.8025
110	6272.1100	1577.4328
111	6272.1100	1577.4328
112	6268.2522	2141.2718
113	6268.2522	2141.2718
114	6068.2522	2110.3974
115	6068.2522	2110.3974
116	5884.4391	2436.8239
117	5884.4391	2436.8239
118	5582.9584	2545.8637
119	5582.9584	2545.8637
120	5097.4913	2716.8485
121	5097.4913	2716.8485
122	4875.8769	2837.5973
123	4875.8769	2837.5973
124	4514.1174	405.8865
125	4514.1174	405.8865
126	5890.2768	2041.9519
127	5890.2768	2041.9519
128	5717.4481	1986.5597
129	5717.4481	1986.5597
130	5668.3048	2430.9802
131	5668.3048	2430.9802
132	5378.3172	2576.2168
133	5378.3172	2576.2168
134	5367.1214	2147.8485
135	5367.1214	2147.8485
136	5097.4913	2716.8485
137	5097.4913	2716.8485
138	4900.8330	2777.2994
139	4900.8330	2777.2994
140	4872.4892	2806.5065
141	4872.4892	2806.5065
142	4846.7271	2724.3377
143	4846.7271	2724.3377
144	6494.2627	2112.3488
145	6494.2627	2112.3488
146	6205.8739	2141.5632
147	6205.8739	2141.5632
148	6065.8134	1933.1442
149	6065.8134	1933.1442
150	5788.9053	1772.2644
151	5788.9053	1772.2644
152	5703.8422	1744.8384
153	5703.8422	1744.8384
154	5786.1300	1798.3153
155	5786.1300	1798.3153
156	6001.8482	1870.6205
157	6001.8482	1870.6205
158	6166.4410	2148.7782
159	6166.4410	2148.7782
160	5952.7977	1890.9684
161	5952.7977	1890.9684

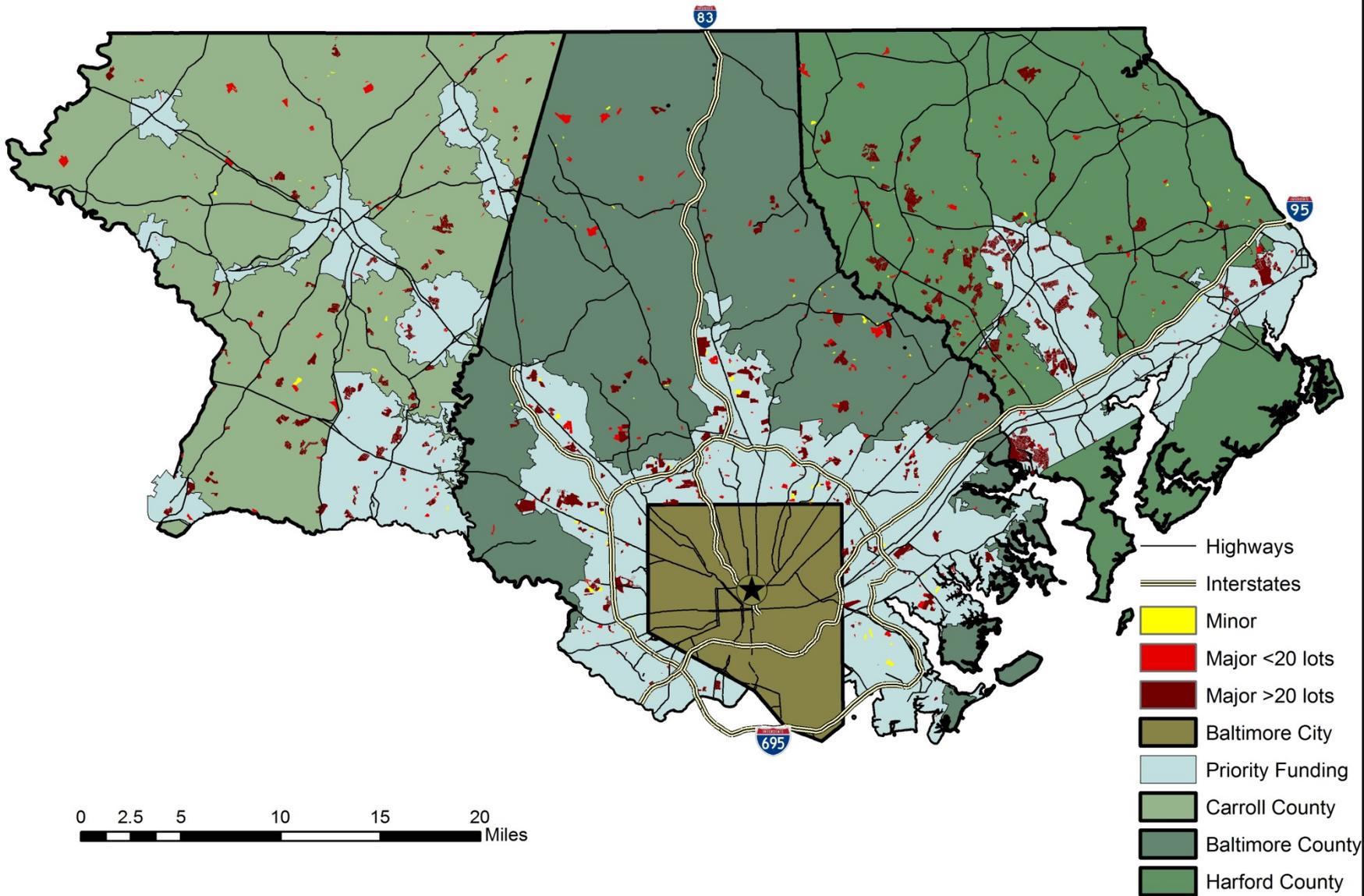
DENSITY NOTES

1. GROSS AREA: 18,879 AC±
2. EXISTING ZONING: RC-4
3. NO. OF LOTS: 10,806
4. ROAD DEDICATION: 0.7919 AC± (EXISTING/NEW ROAD)
5. HIGHWAY WIDENING AREA: 1,2580 AC± (EXISTING/NEW)
6. NET AREA OF LOTS: 15,886 AC±
7. PARKING SPACES: 2 SPACES/LOT-22
8. PARKING PROP.: 2 SPACES/LOT-22
9. CONSERVANCY AREA: 41.783 AC±
10. CONSERVANCY AREA PROP.: 41.783 AC±

McKee & Associates, Inc. Engineering - Surveying - Natural Resources Planning Real Estate Development SHAWAN PLACE, 5 SHAWAN ROAD HUNT VALLEY, MARYLAND 21030 TELEPHONE: (410) 527-1555 FACSIMILE: (410) 527-1563		SURVEYOR'S CERTIFICATION I, the undersigned, being a duly licensed Surveyor for the State of Maryland, do hereby certify that this is a true and correct copy of the original survey as the same was filed in my office. In testimony whereof, I have hereunto set my hand and seal of office at Baltimore, Maryland, this 7th day of July, 1997.	OWNER'S CERTIFICATION We, the undersigned, being the owners and legal representatives of the property herein described, do hereby certify that this is a true and correct copy of the original survey as the same was filed in my office. In testimony whereof, I have hereunto set my hand and seal of office at Baltimore, Maryland, this 7th day of July, 1997.	APPROVED By the Director of Planning and Management pursuant to Section 28-2105, Baltimore County Code.	OWNER AL KANER F. & ELIZABETH K. KAUFMAN 1834 VERNON ROAD WHITE HALL, MARYLAND 21161 8407/328 07-11-00030	FINAL SUBDIVISION PLAT ELLIOTT'S CHANGE 7th ELECTION DISTRICT BALTIMORE COUNTY, MARYLAND DATE: APRIL 4, 1997
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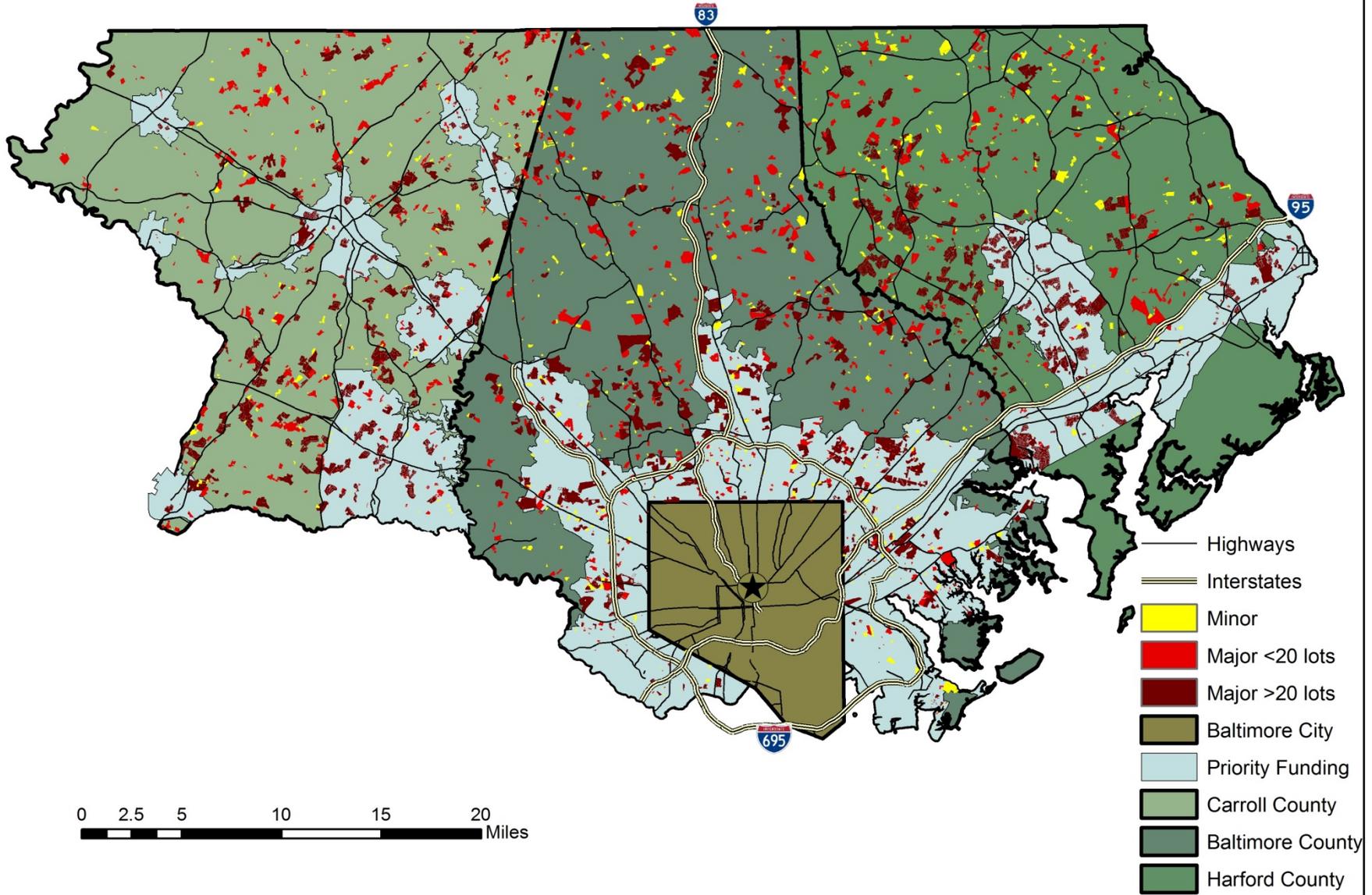


Carroll, Baltimore, and Harford County Subdivisions 1960-1969



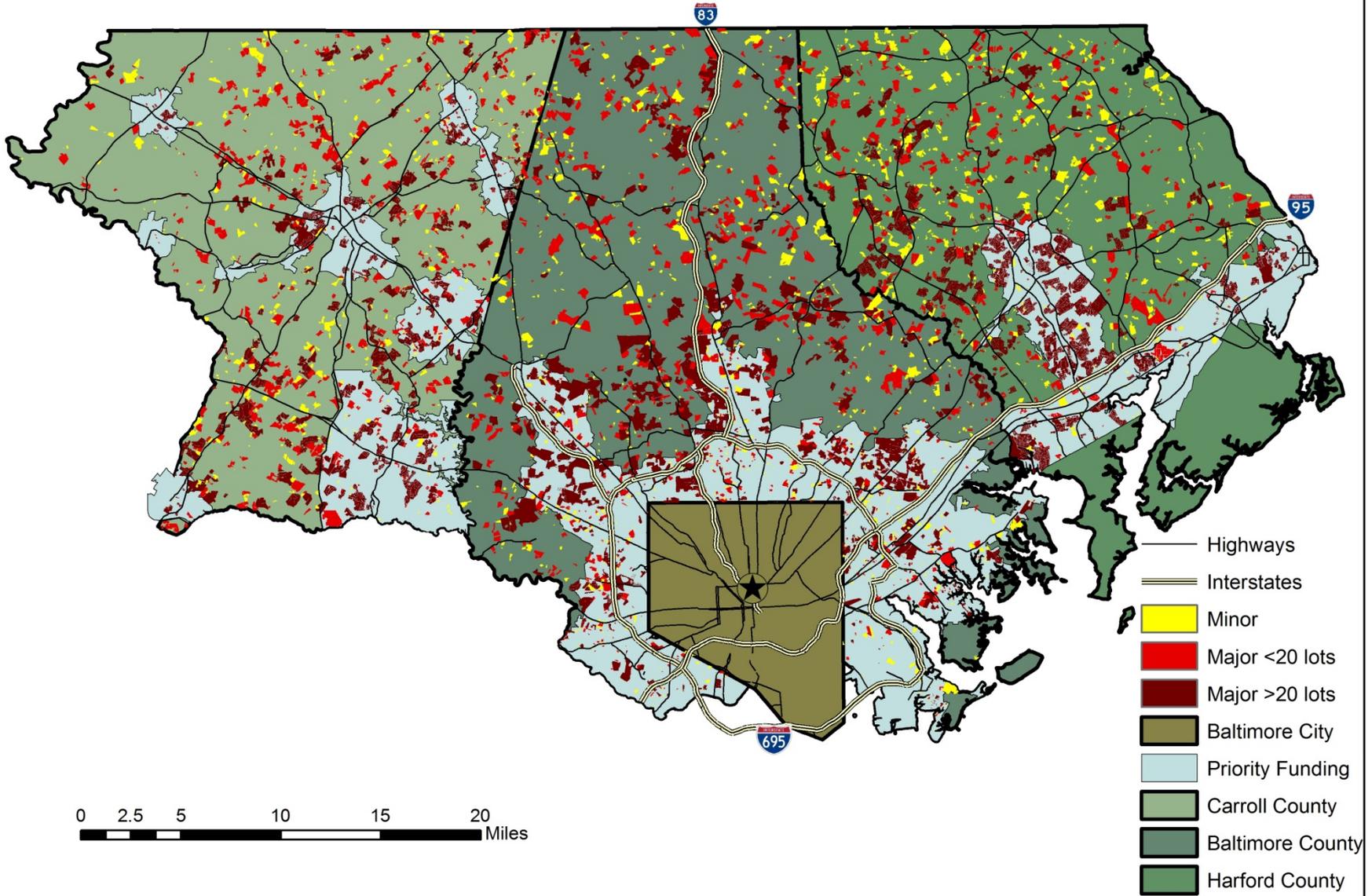


Carroll, Baltimore, and Harford County Subdivisions 1960-1979



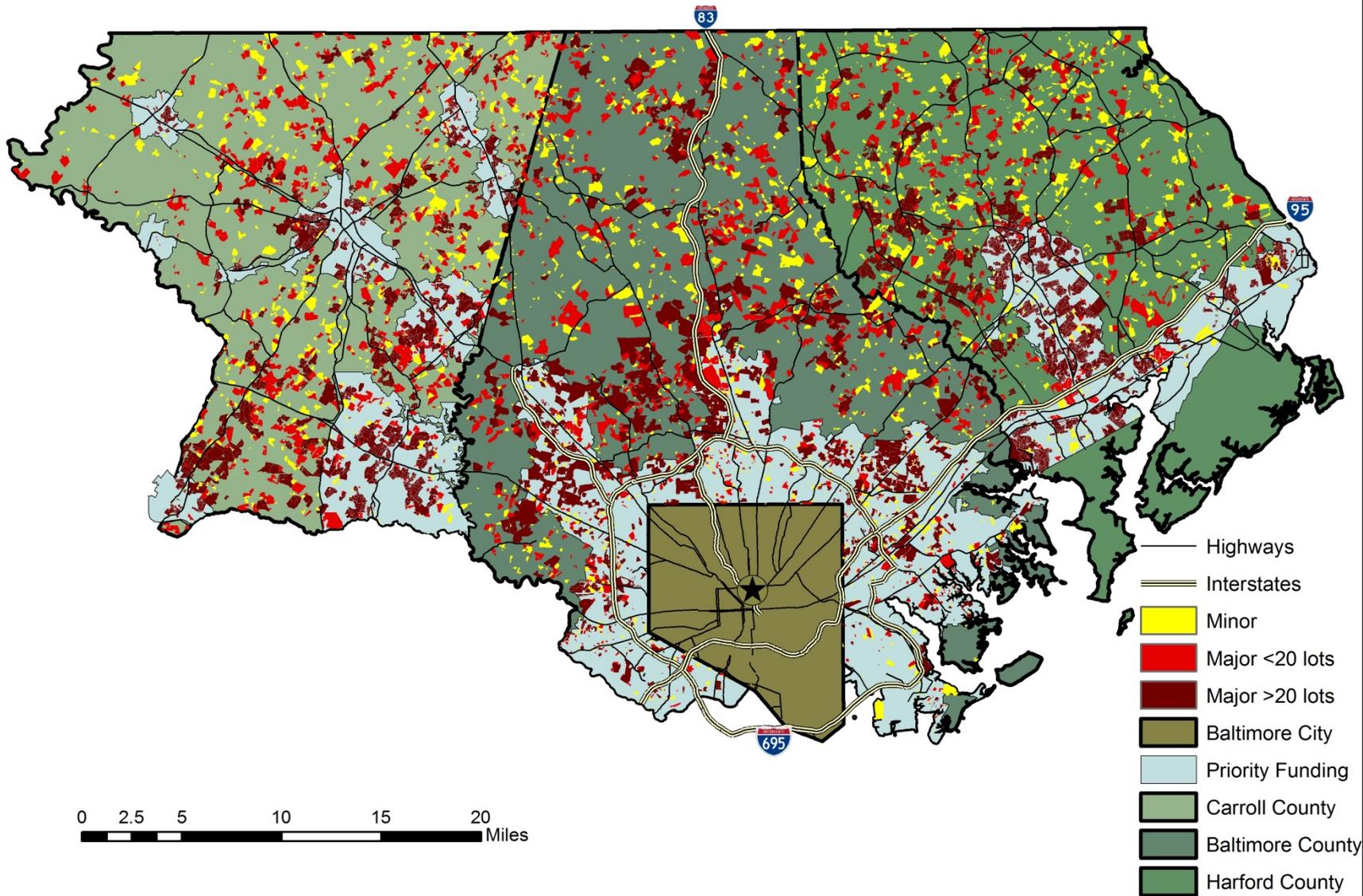


Carroll, Baltimore, and Harford County Subdivisions 1960-1989



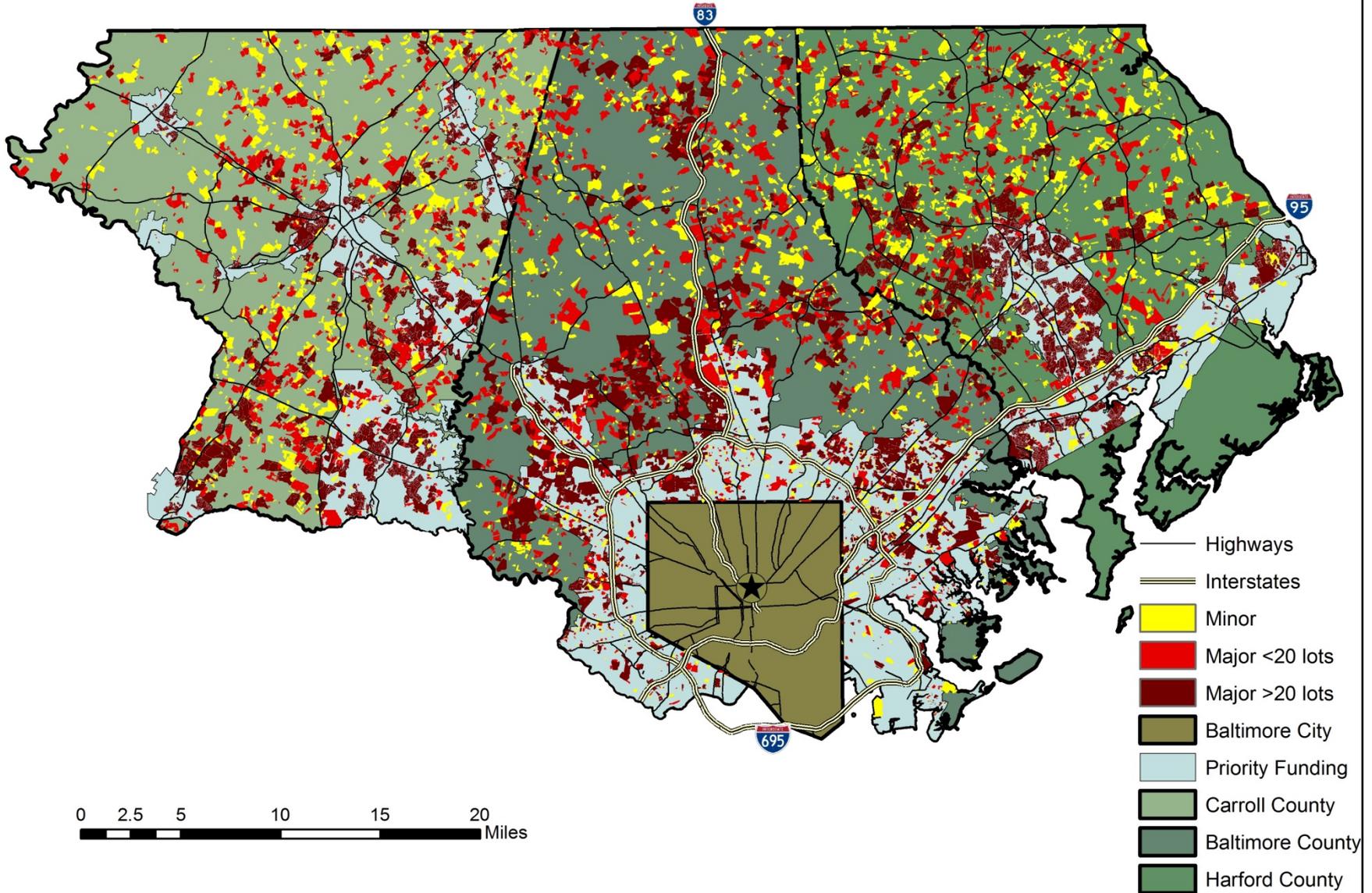


Carroll, Baltimore, and Harford County Subdivisions 1960-1999

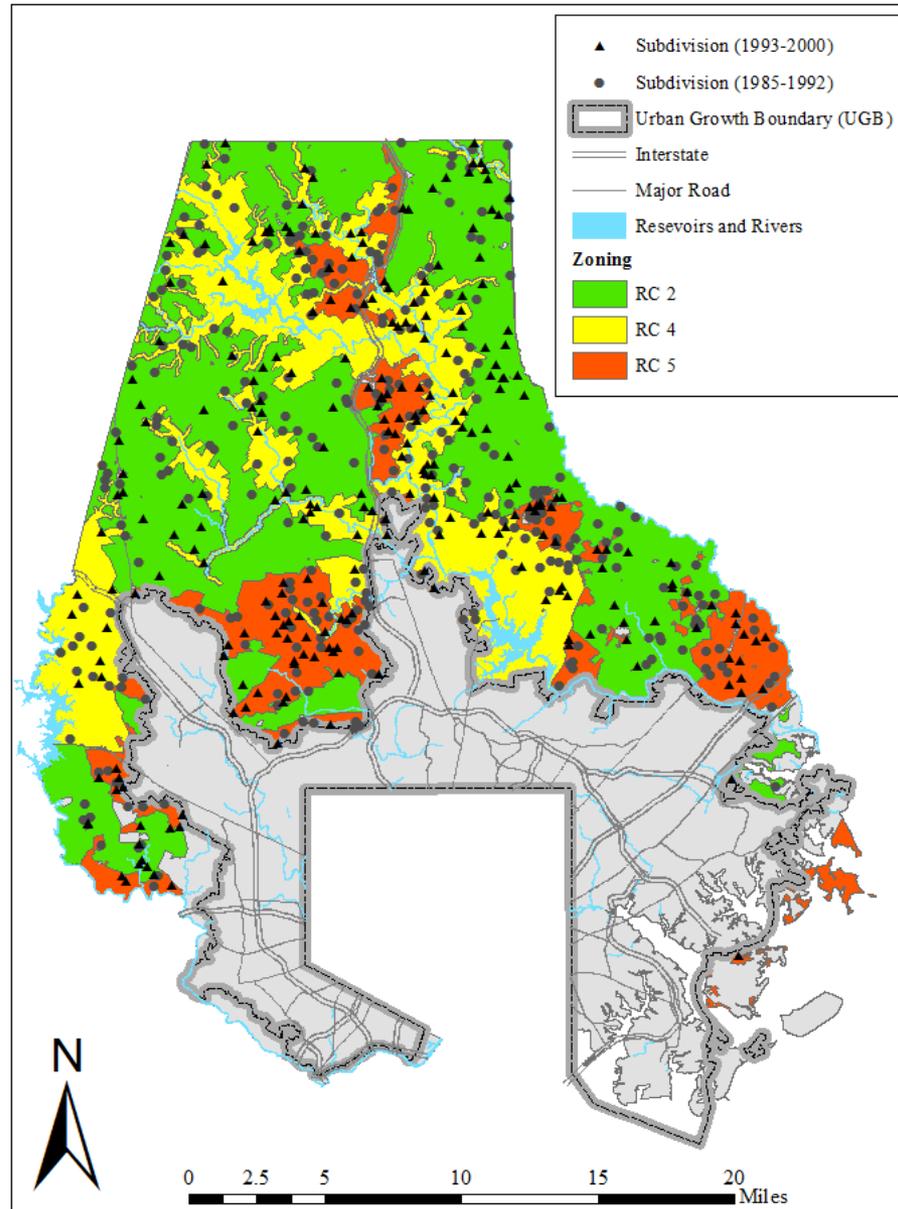




Carroll, Baltimore, and Harford County Subdivisions 1960-2007



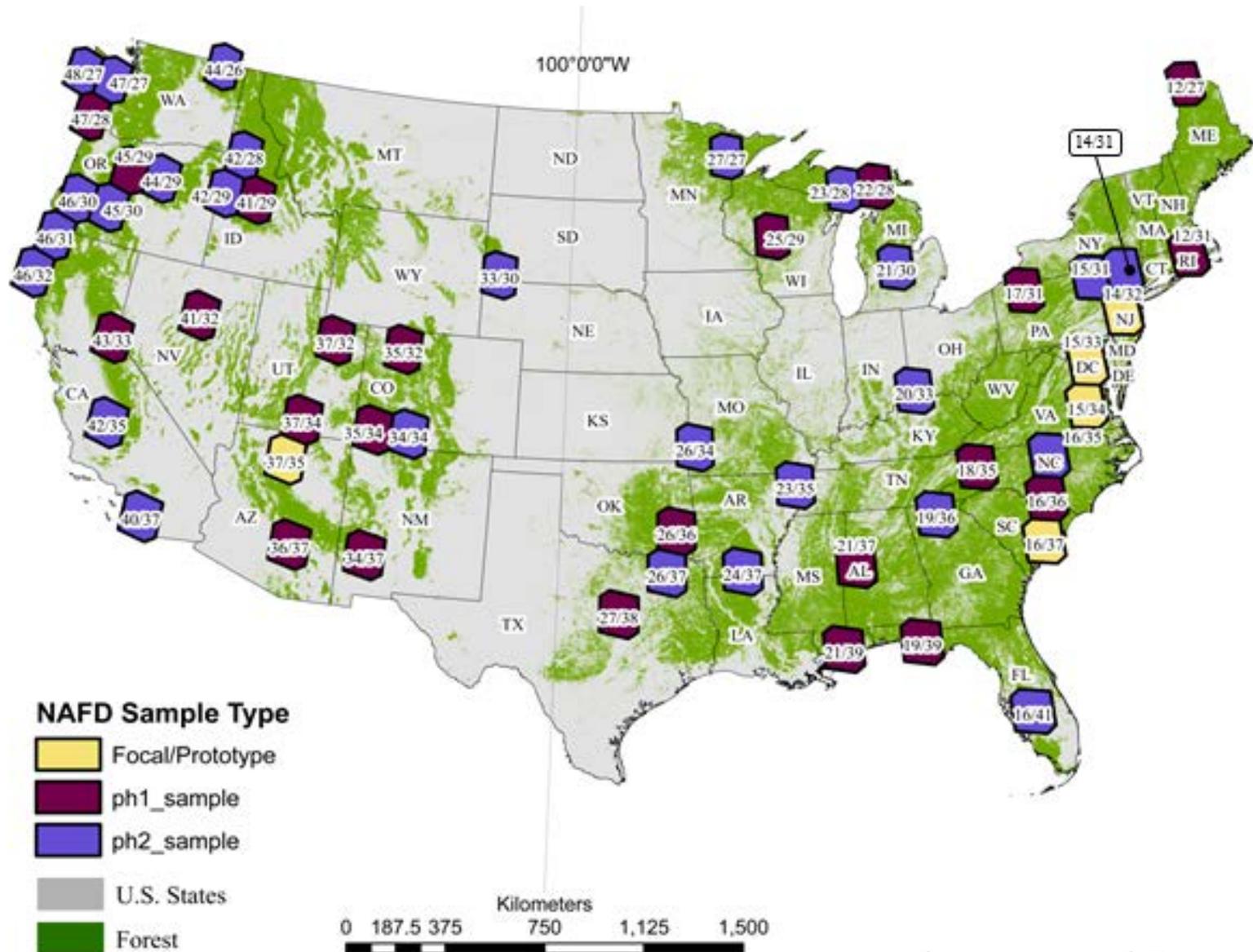
Residential subdivisions in 1985-2000



Forest Conservation Act (FCA) in Maryland

- FCA is a statewide law in Maryland and implemented by county and local governments starting in 1993
- **Afforestation threshold**
 - Afforestation threshold at 20% forest cover for parcels in agricultural and resource areas (RC2 & RC4 zoning) and for medium residential areas (RC5 zoning)
- **Conservation threshold**
 - Conservation threshold at 50% forest cover for agricultural and resource areas (RC2 & RC4 zoning) and 25% forest cover for medium residential areas (RC5 zoning)

North American Forest Dynamics Project (55 Sites) under of the North American Carbon Program



Source: NACP

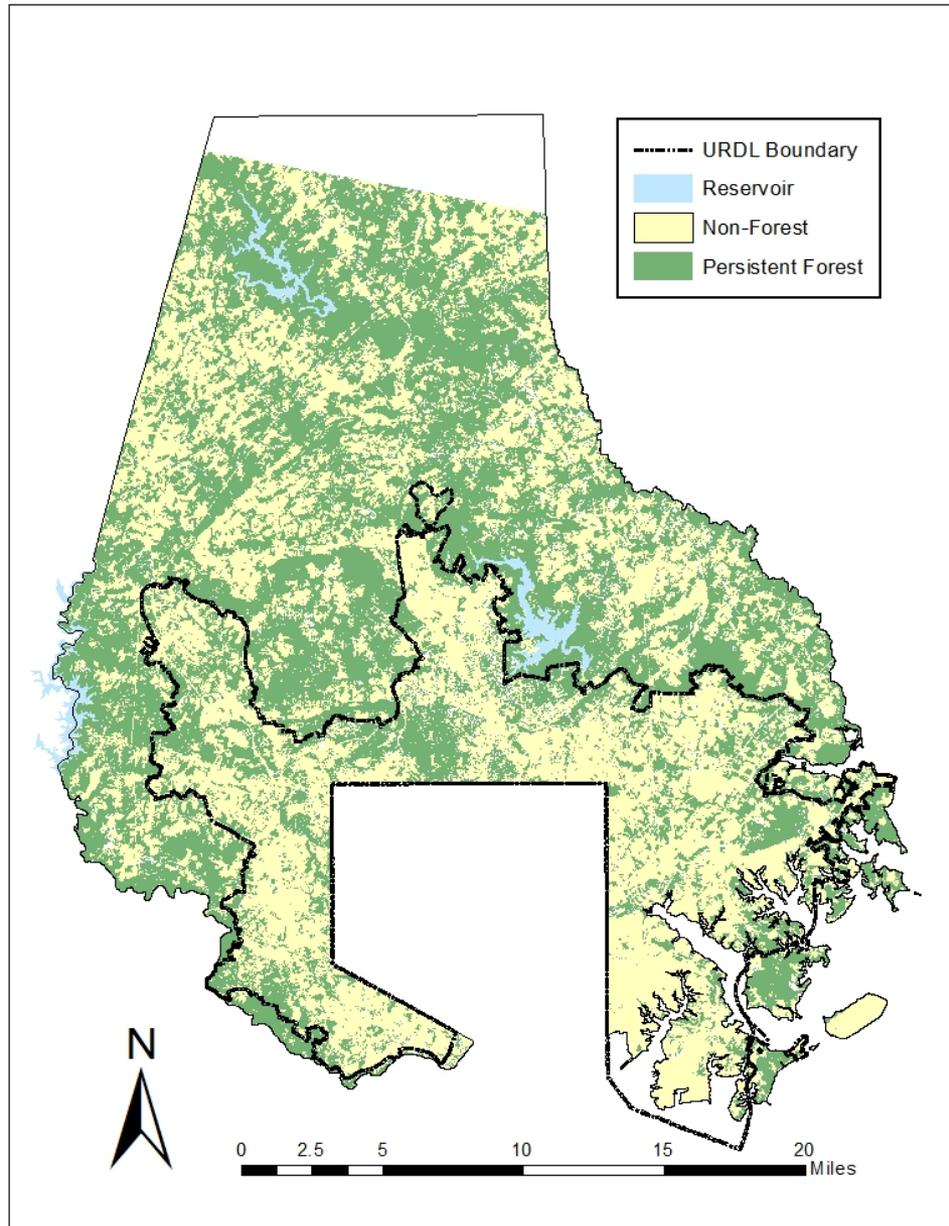
Forest Cover Data

- Forest cover data in 1984-2004 for Baltimore-DC corridor
 - NASA funded North American Forest Dynamics Project (Goward et al. 2012)
 - Forest classification based on Landsat imagery at 30 meter grid cells
 - Snapshot on forest cover for 12 time periods: 1984, 1986, 1987, 1988, 1990, 1991, 1994, 1996, 1998, 2000, 2002, 2004
 - Accounts for deforestation, reforestation and afforestation
- Existing forest cover
 - % existing forest cover calculated as forest area divided by total parcel area

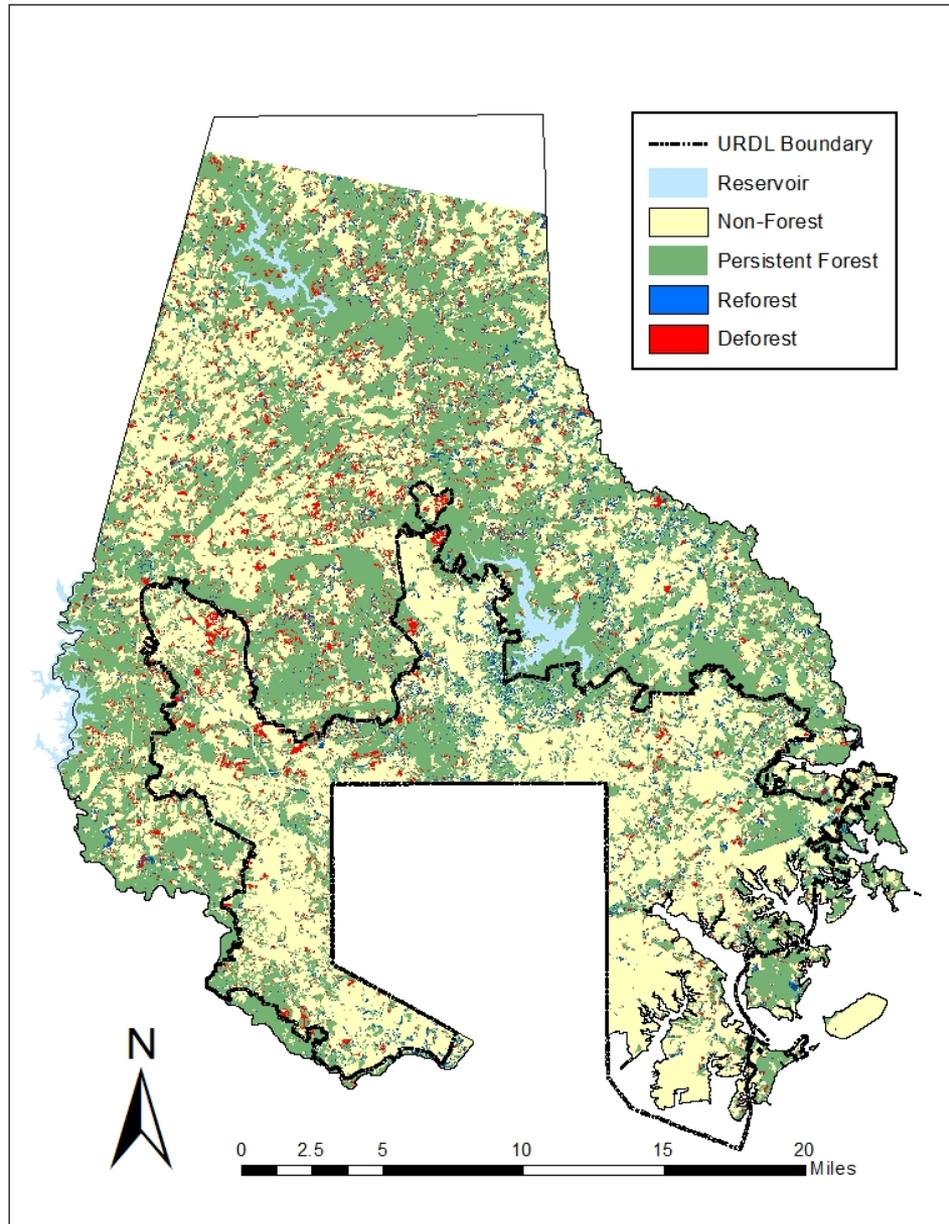
Forest Cover Change

- Forest cover change (dependent variable in second stage)
 - Difference in % forest cover after development and prior to development
 - Difference in % forest cover in 1996 and prior to development for subdivisions in 1985-1992
 - Difference in % forest cover in 2004 and prior to development for subdivisions in 1993-2000
 - Example: Subdivision event in 1989 would calculate difference for % forest cover in 1996 and % forest cover in 1988 prior to development

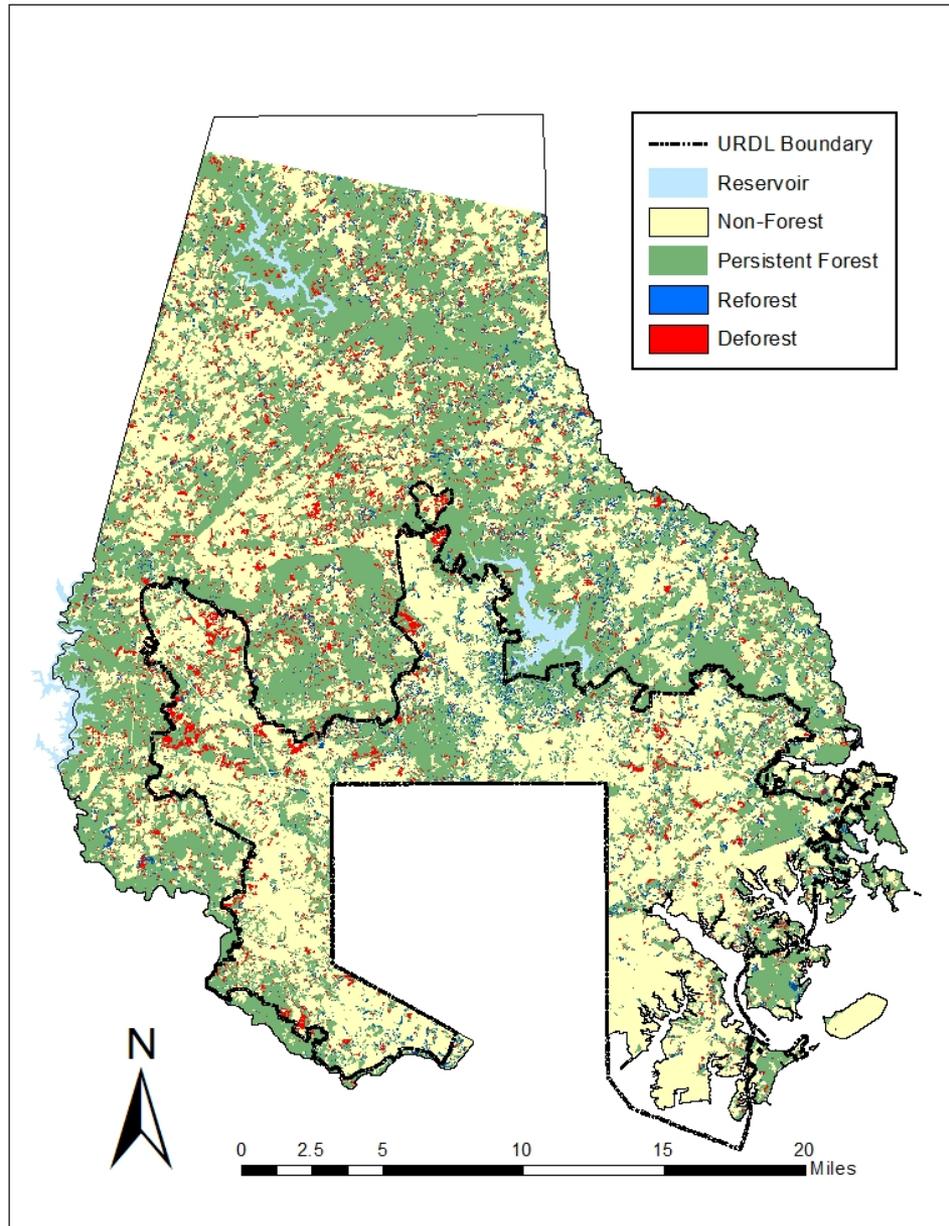
Forest Cover in 1984



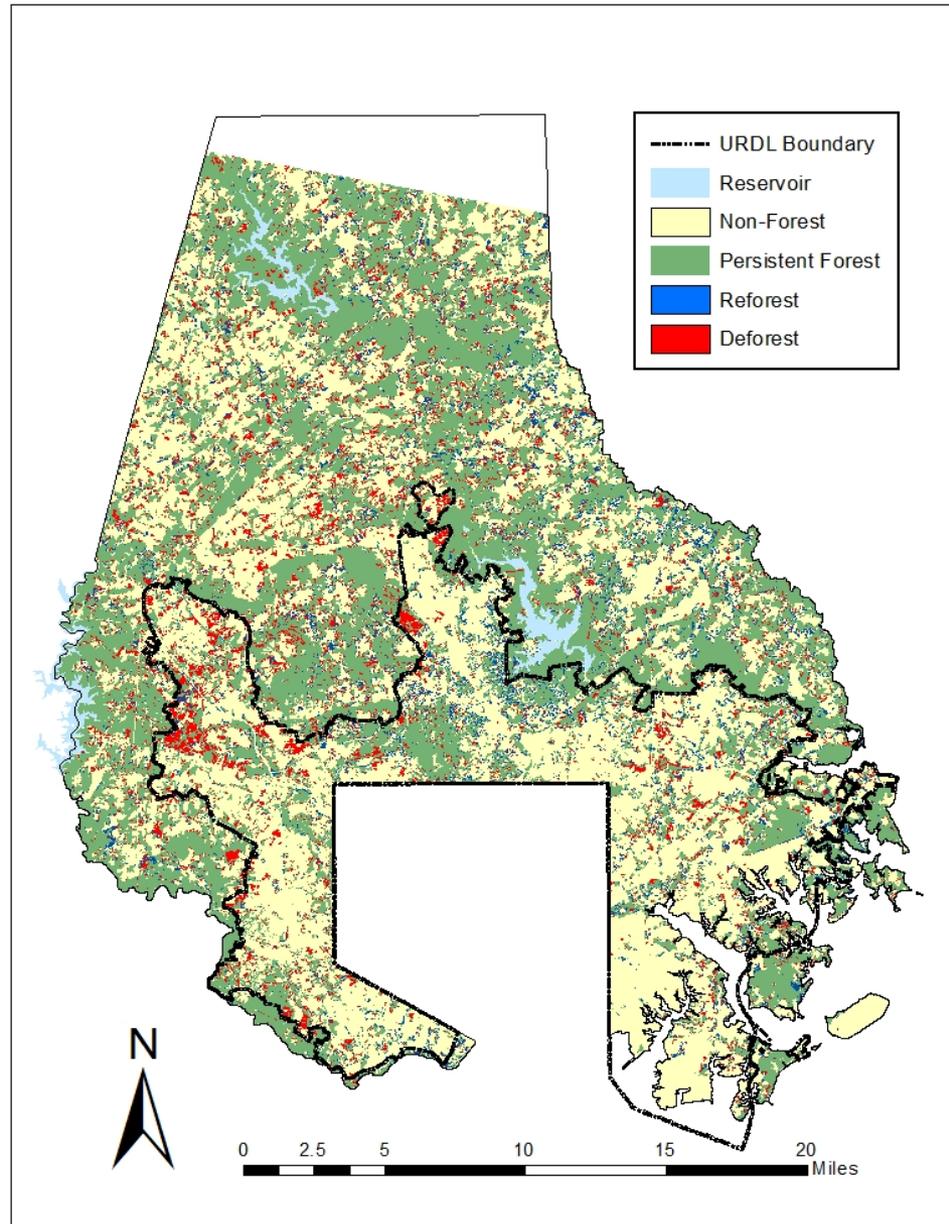
Forest Cover in 1990



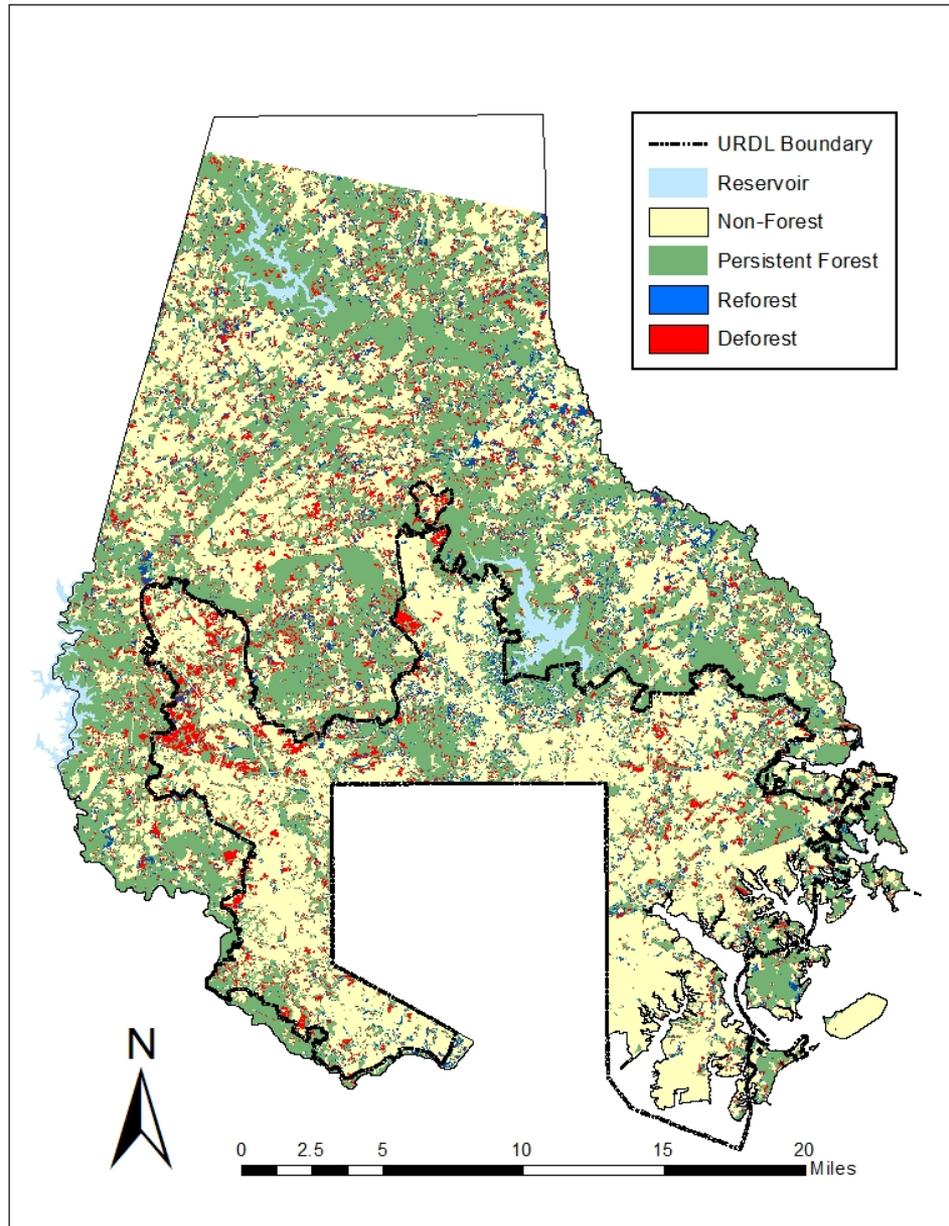
Forest Cover in 1995



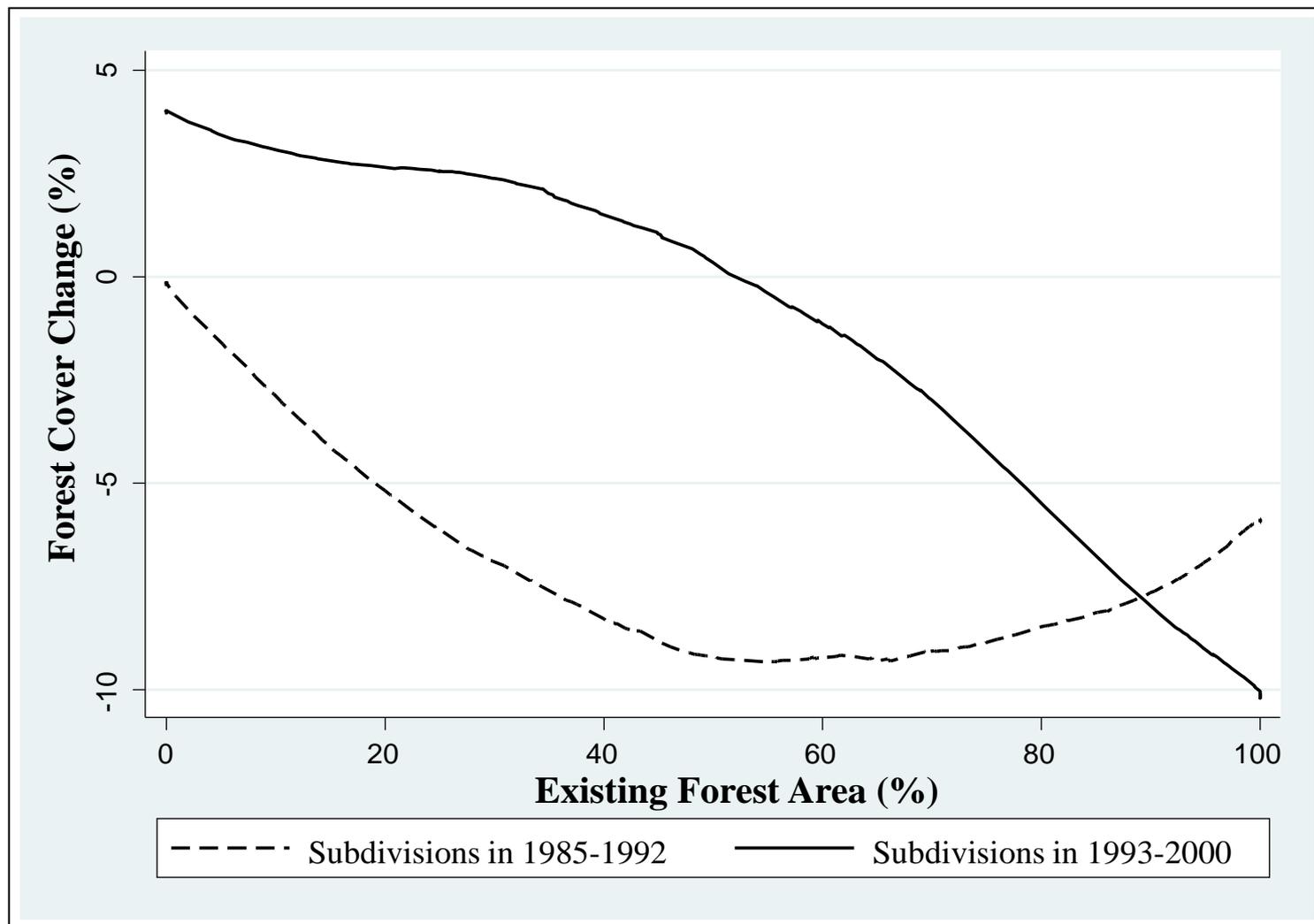
Forest Cover in 2000



Forest Cover in 2004



Forest cover change on subdivisions before (1985-1992) and after (1993-2000) FCA policy



FIML Panel Heckman selection model

First stage: Panel probit model develop or remain developable in 1985-2000

$$Y_{it}^* = F_{it}\beta_1 + \tau\beta_2 + \tau F_{it}\beta_3 + X_{it}\beta_4 + Z_{it}\beta_5 + T_t\beta_6 + \varepsilon_{it}$$

$$Y_{it} = 1 \quad \text{if } Y_{it}^* > 0, \quad Y_{it} = 0 \quad \text{if } Y_{it}^* \leq 0$$

Second stage: Forest cover change, conditional on development in 1985-2000

$$\Delta F_{it}^* = F_{it}\gamma_1 + \tau\gamma_2 + \tau F_{it}\gamma_3 + X_{it}\gamma_4 + T_t\gamma_5 + \mu_{it}$$

$$\begin{bmatrix} \varepsilon_{it} \\ \mu_{it} \end{bmatrix} = N \left(0, \begin{bmatrix} 1 & \rho \\ 0 & \sigma^2 \end{bmatrix} \right)$$

F_{it} = Existing forest cover quintile
(baseline = 0-20% forest cover)

τ = Post-1993 dummy

X_{it} = Other parcel attributes
(land quality, distance, etc.)

Z_{it} = Exclusion restriction

T_t = Annual time fixed effects

Explanatory variables

Existing forest cover

Forest cover quintile categories (baseline = 0-20% forest cover)

Zoning attributes

Zoning type (baseline = RC5 zoning)

Accessibility attributes

Distance to Baltimore City

Distance to major road

Physical land attributes

Parcel area

Slope

Elevation

Riparian buffer area

Existing house

Surrounding % land use (within 500 meter buffer)

Protected areas

Existing residential

Existing non-residential (commercial, industrial)

Marginal Effects

Variable	Annual Probability of Development		Forest Cover Change	
	Coefficient	Standard Error	Coefficient	Standard Error
Forest Cover Quintiles				
Forest cover 20-40%	-0.0019	0.00172	-5.7755**	1.74596
Forest cover 40-60%	0.0019	0.00192	-6.6025**	1.82222
Forest cover 60-80%	0.00197	0.00196	-7.9653**	2.2224
Forest cover 80-100%	0.00038	0.00165	-4.2598**	1.41691
Post-1993 Forest Cover Quintiles				
Post-1993* Forest cover 20-40%	0.00233	0.00212	-1.7709	2.14031
Post-1993* Forest cover 40-60%	0.00233	0.00222	0.45921	2.20977
Post-1993* Forest cover 60-80%	0.00262	0.00225	-9.0293**	1.73404
Post-1993* Forest cover 80-100%	-0.0003	0.00178	-14.256**	2.31952
Zoning Type				
RC 4	-0.0007	0.00138	3.98198**	1.2302
RC 2	-0.0021	0.00171	0.30985	1.39832
Parcel Characteristics				
Distance to Baltimore	-0.00020**	0.00006	0.0222	0.07435
Distance to Major Road	-0.00020	0.00071	-0.6382	0.98663
Slope	0.00005	0.00009	0.25817*	0.1213
Elevation	-0.00010	0.00012	0.00778	0.1148
Riparian Buffer Area (%)	-0.00010**	0.00003	0.09392**	0.03207
Existing House	-0.0019*	0.00087	-0.0238	0.85597
Ln(Parcel Area)	0.00317**	0.00056	--	--
Authorized Minor	-0.00661**	0.00138	--	--
Surrounding Land Use within 500 meter buffer				
Non-residential (%)	-0.00007	0.00008	-0.0086	0.08554
Parks (%)	0.00001	0.00004	0.03218	0.03888
Residential (%)	0.00021**	0.00003	0.03517	0.02735

**p<0.01. *p<0.05

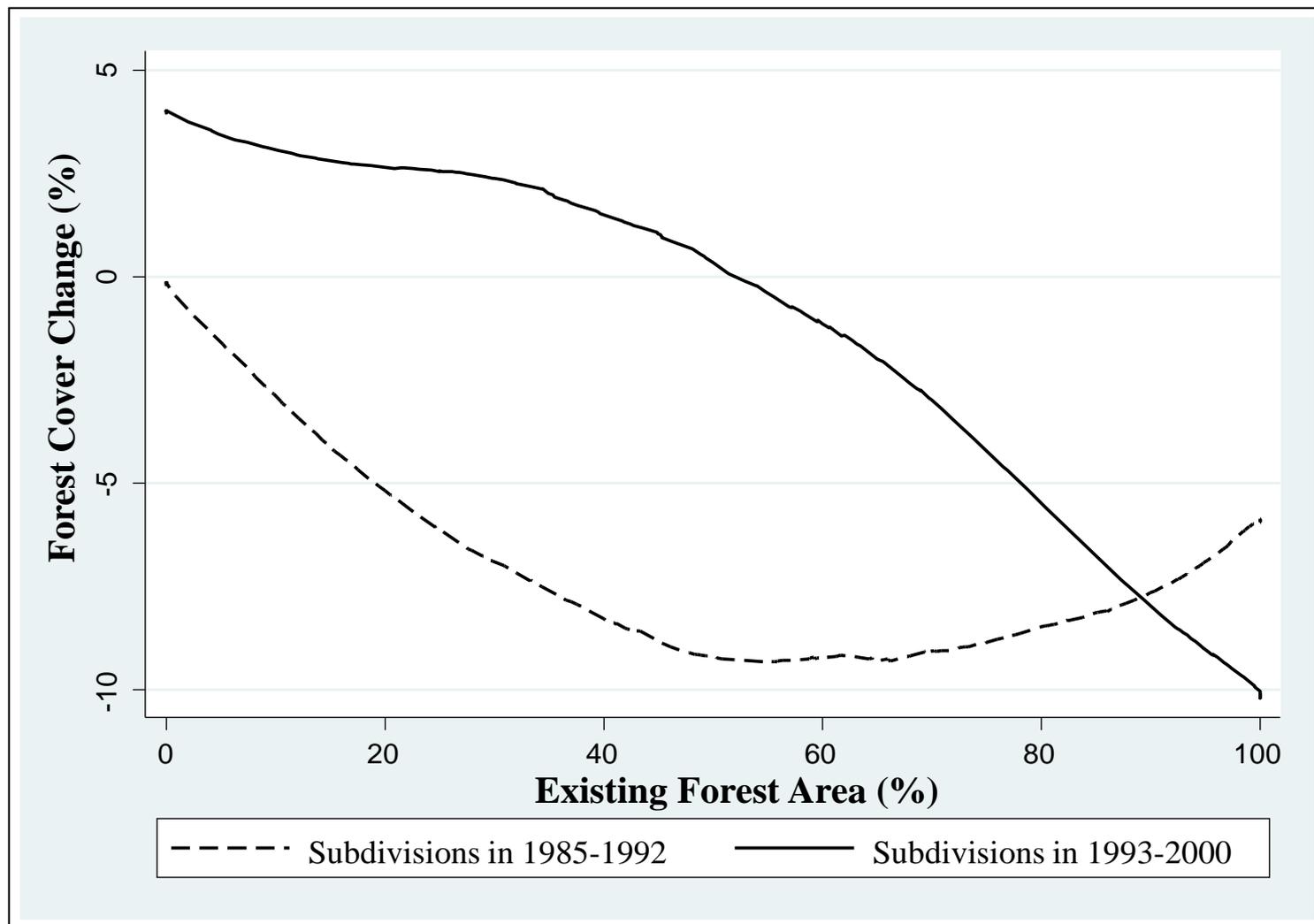
Forest Cover Change Conditional on Development in 1985-1992 and 1993-2000

Forest Cover Quintile	Forest Cover Change in 1985-1992	Forest Cover Change in 1993-2000	Difference
Forest cover 0-20%	-3.6142 (2.5552)	4.9490** (1.2769)	8.5632** (2.6788)
Forest cover 20-40%	-9.0944** (3.037)	3.1678 (1.6712)	12.2621** (3.3536)
Forest cover 40-60%	-9.959** (3.0127)	5.7351** (1.9013)	15.6941** (3.3403)
Forest cover 60-80%	-11.204** (3.8725)	-4.0878** (1.227)	7.1158* (3.5958)
Forest cover 80-100%	-7.6628** (2.7323)	-9.2863** (1.8637)	-1.6235 (3.0799)

Robust standard errors in parentheses calculated using delta method.

** p<0.01, * p<0.05

Forest cover change on subdivisions before (1985-1992) and after (1993-2000) FCA policy



Policy Simulation of Landscape-Level Forest Cover Change

- **Purpose:** Predict developed land area and forest cover change with versus without FCA policy
 - Use 1,000 bootstrapped samples of the original data set followed by model estimation
 - Predictions on undeveloped parcels as of 1993
- **First stage:** developed land area
 - Predict parcel-level expected annual probability of development in each year during 1993-2000
 - Parcel is developed in first year that probability of development exceeds a randomly drawn uniform number (Lewis et al. 2009)
- **Second stage:** forest cover change conditional on development
 - If parcel develops, expected forest cover change conditional on development in that year is calculated

Difference with versus without FCA policy

Forest Cover Quintile	Difference with versus without FCA policy		
	Land area	Existing forest area	Forest cover change
Forest cover 0-20%	57 [-938, 963]	7 [-104, 110]	105* [26, 219]
Forest cover 20-40%	893 [-81, 2128]	265 [-22, 613]	161* [21, 350]
Forest cover 40-60%	155 [-1093, 1246]	74 [-534, 612]	291* [123, 522]
Forest cover 60-80%	144 [-796, 1001]	98 [-540, 697]	93 [-23, 258]
Forest cover 80-100%	-62 [-1246, 804]	-41 [-905, 616]	-16 [-125, 97]
Total	1187 [-2973, 4688]	404 [-1524, 1964]	633* [193, 1222]

* Statistical significance of the bootstrapped 95% confidence interval displayed in brackets

Landscape-Level Simulations With and Without FCA Policy (1993-2000)

Forest Cover Quintile	Subdivisions without FCA Policy			Subdivisions with FCA Policy		
	Land area	Existing forest area	Forest cover change	Land area	Existing forest area	Forest cover change
Forest cover 0-20%	1255*	140*	-80*	1311*	147*	25
	[443, 2253]	[43, 256]	[-191, -11]	[618, 2081]	[61, 250]	[-16, 70]
Forest cover 20-40%	1280*	378*	-155*	2173*	643*	3
	[444, 2335]	[129, 698]	[-332, -41]	[1171, 3293]	[352, 981]	[-90, 92]
Forest cover 40-60%	1865*	906*	-228*	2020*	980*	62
	[859, 3119]	[419, 1527]	[-449, -80]	[1097, 3091]	[524, 1506]	[-15, 152]
Forest cover 60-80%	1326*	903*	-162*	1470*	1002*	-69*
	[538, 2349]	[366, 1591]	[-356, -44]	[698, 2336]	[480, 1583]	[-138, -22]
Forest cover 80-100%	1654*	1234*	-107*	1592*	1194*	-124*
	[742, 2880]	[553, 2075]	[-231, -28]	[919, 2421]	[646, 1811]	[-213, -52]
Total	7380*	3561*	-733*	8567*	3965*	-103
	[4148, 11376]	[2071, 5517]	[-1314, -321]	[6620, 10743]	[2998, 4978]	[-272, 61]

* Statistical significance of the bootstrapped 95% confidence interval displayed in brackets

Conclusions

- **Before FCA policy**

- Loss in forest cover across the range of existing forest cover
- Prior studies often implicitly assume residential development creates a complete loss in forest cover

- **After FCA policy**

- Overall 22% increase in forest cover on residential subdivisions relative to the amount without the FCA policy
- Parcels with 0-60% existing forest cover have increase in forest cover
- Most intact habitat have continued forest fragmentation (parcels with 80-100% not affected by FCA policy)

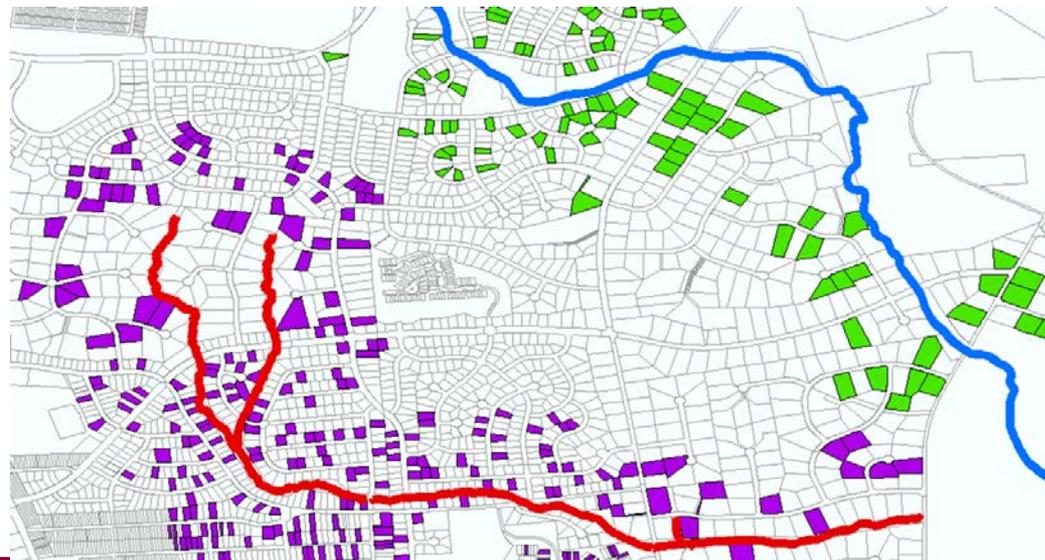
- **Opportunities for synergy between FCA and land preservation programs**

- Target funds from easement programs (or in lieu fees) to protect high priority forested areas with intact habitat

Stream restoration and housing values

Charles Towe, Allen Klaiber, and Joe Maher

- **Research questions**
 - Does stream restoration increase nearby housing values? Is the value heterogeneous depending on the location/type of restoration activity?
- **Study approach**
 - Stream restoration sites in Baltimore, Montgomery, Howard and Anne Arundel Counties (~60 sites)
 - Repeated sales of single-family homes (before and after restoration)
 - Treatment: House sales within 1000 feet of stream with restoration (purple lots)
 - Control: House sales within 1000 feet of stream without restoration (green lots)



Stream restoration and housing values

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- **Results**

- Private land: No significant effect on home values near restoration on private lands
- Public lands: Significant 3-5% increase in home values near restoration on public land (e.g., parks)

<u>Coefficients</u>	<u>Distance to Stream (ft)</u>		<u>Falsification (shift 8 yrs)</u>
	<u>Under 1K</u>	<u>1K - 2K</u>	
AT=Private	-0.028	-0.027	0.013
AT=Public Park	0.036***	0.023	0.004
AT=Public Other	0.052***	-0.020	-0.014
<i>Fixed Effects</i>			
Property	YES	YES	YES
Year-of-Sale	YES	YES	YES
Census Tract	YES	YES	YES
<hr/>			
N Observations	40,686	9,184	50,609
N Treated	496	205	487
By:			
Private	156	68	149
Public Park	307	108	245
Public Other	81	22	122

Thank you!

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