

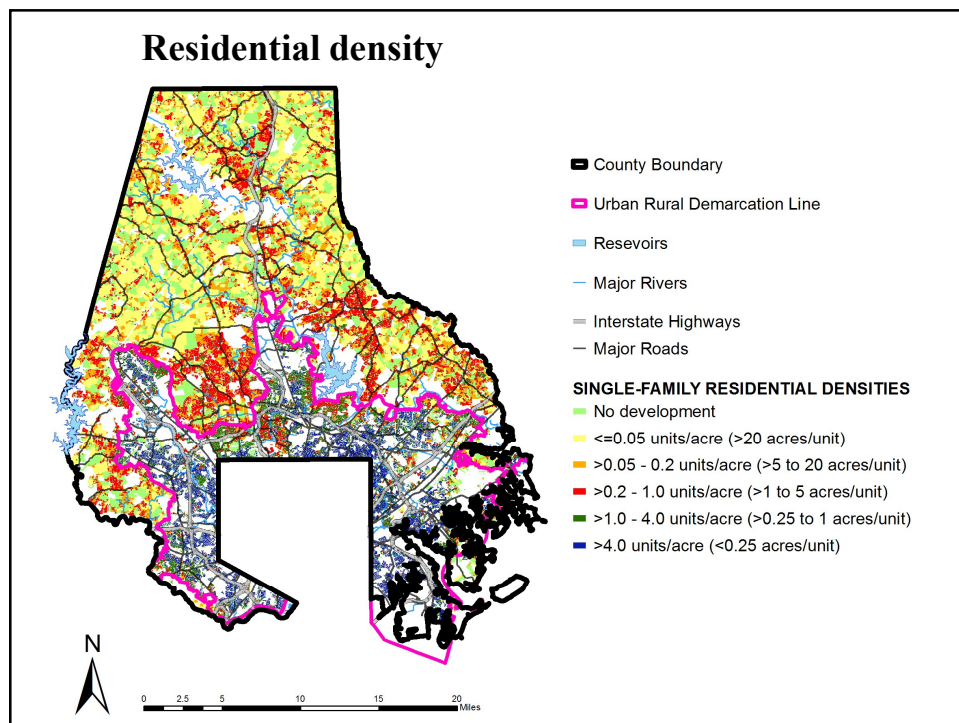
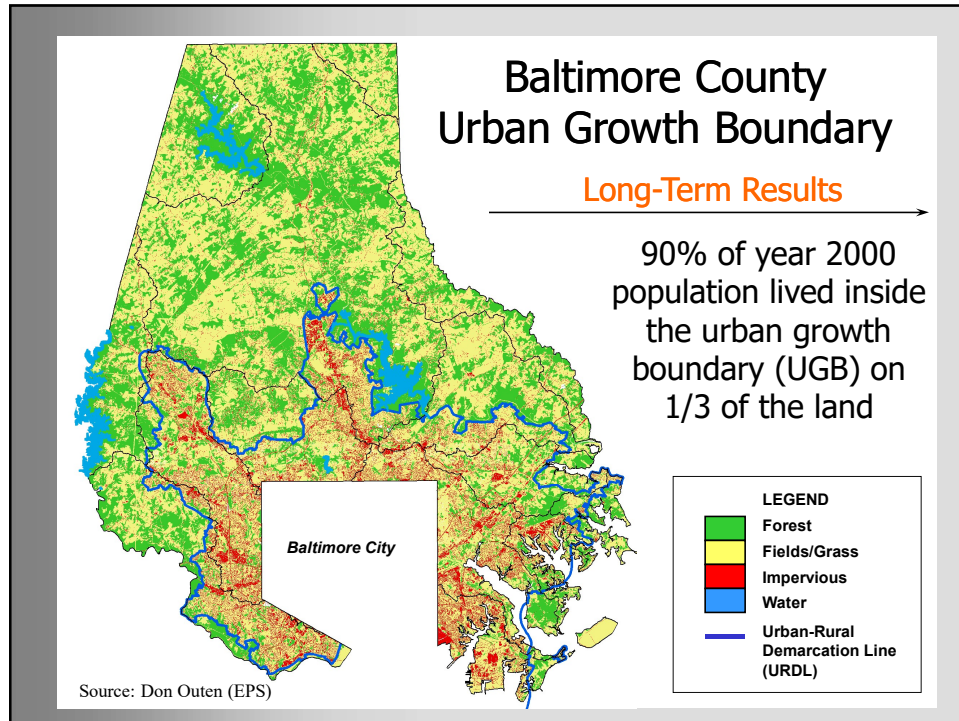
Maryland's Forest Conservation Act and the Impact on Residential Development and Forest Cover in Baltimore County

David Newburn

Department of Agricultural and Resource Economics
University of Maryland

Forest Conservation Act (FCA) and development

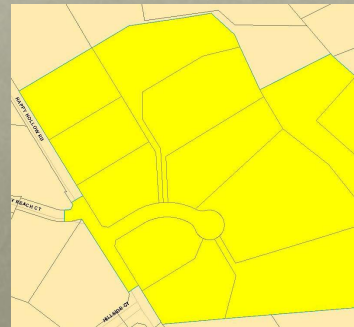
- **Research question**
 - How did the 1993 Forest Conservation Act (FCA) in Maryland affect residential development and forest cover change decisions?
- **Study area and data**
 - Rural area in Baltimore County (Outside UGB)
 - Parcel-level residential development from tax assessment records
 - Forest 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



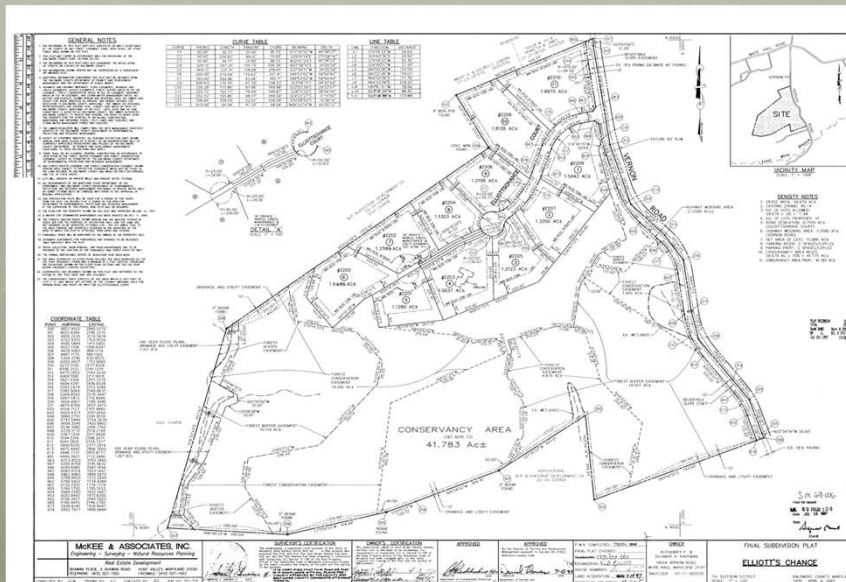
Subdivisions

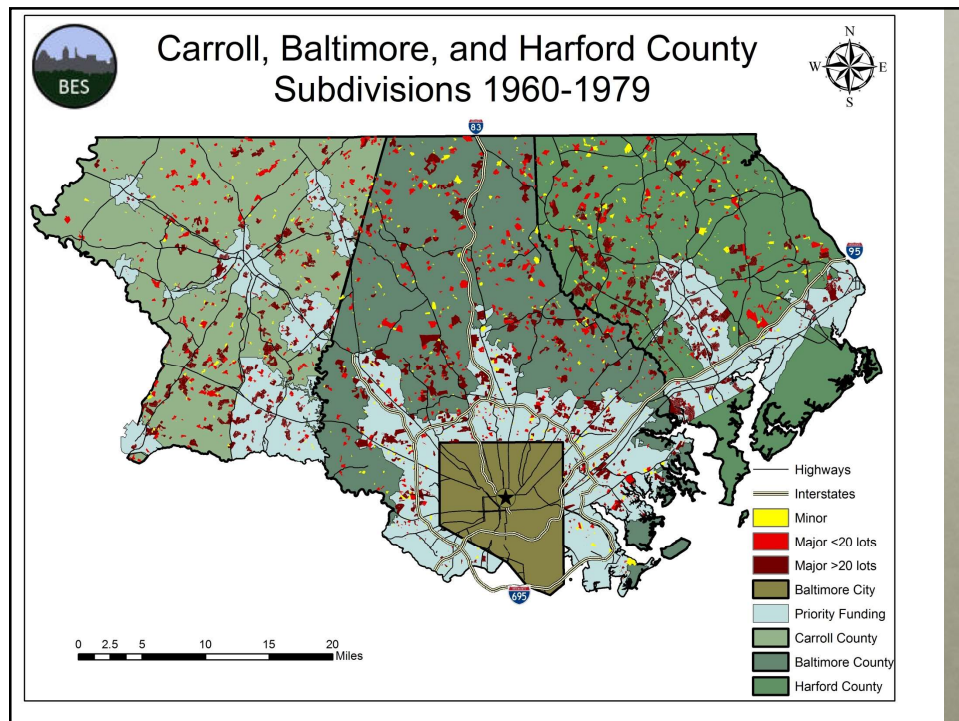
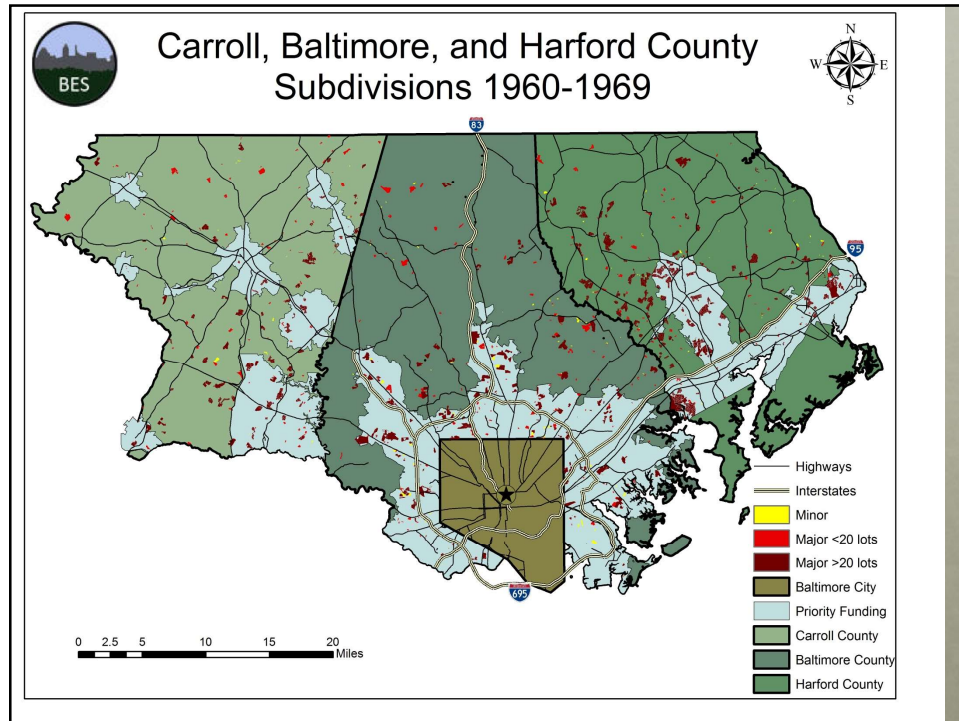
MD Property View parcel data to reconstruct historic subdivisions:

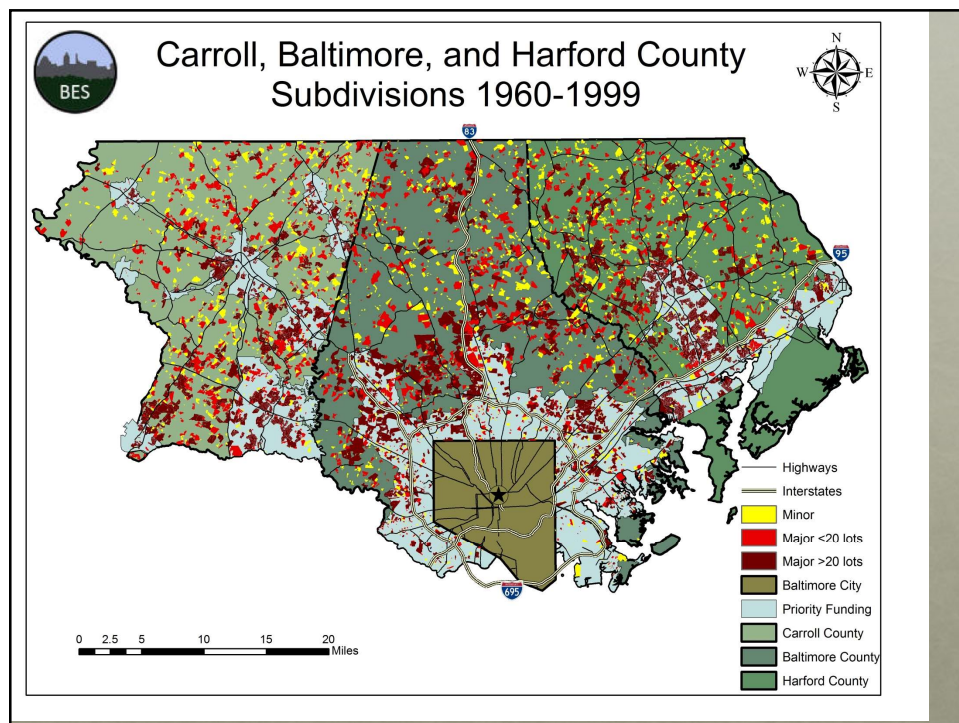
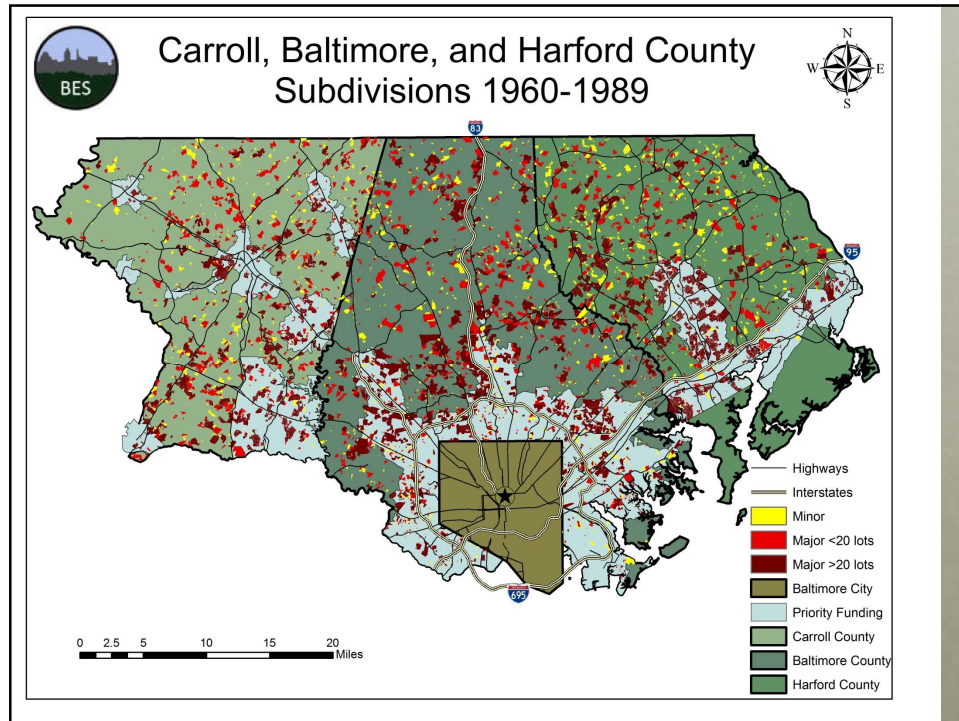
- Identify polygons in MDPV parcel layer within same subdivision
- Dissolve individual parcels into original parent parcel
- Record year start and number of lots in subdivision

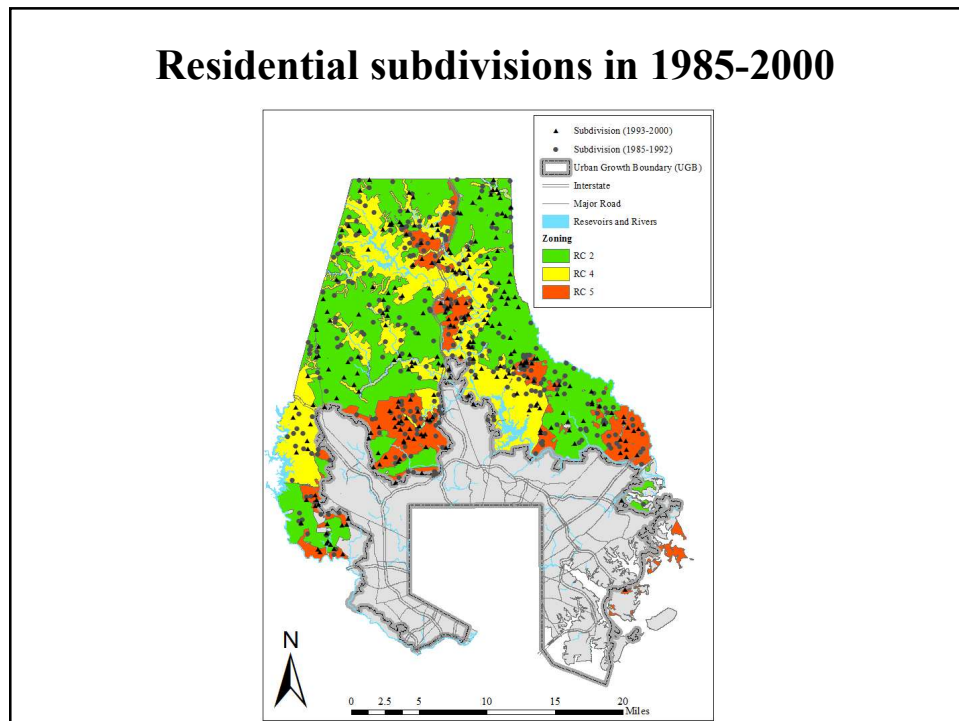
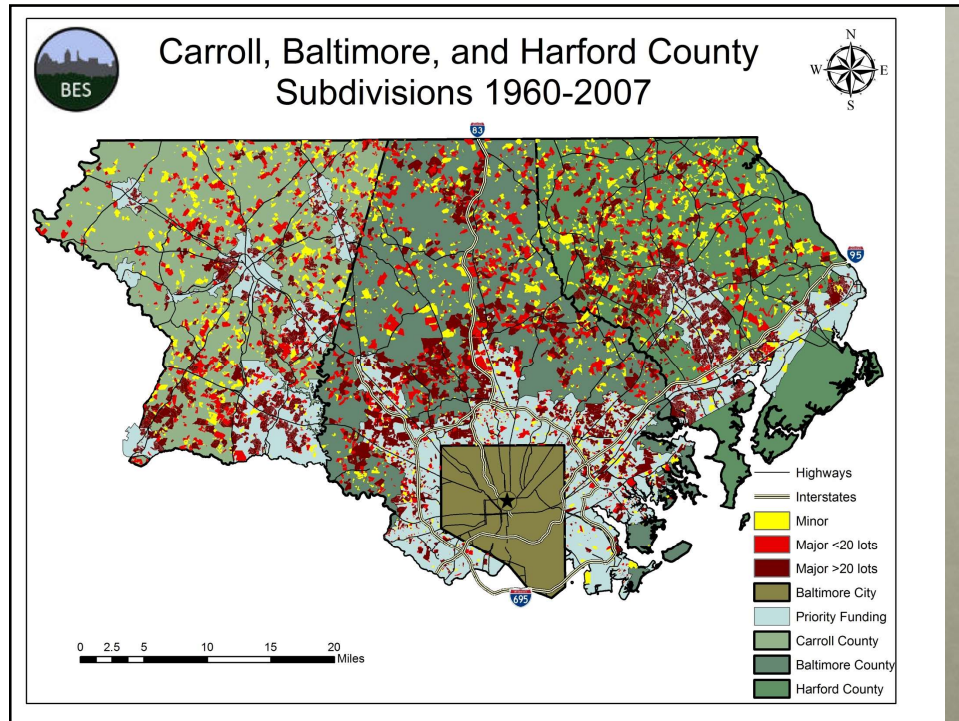


Subdivision in RC4 zoning









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)

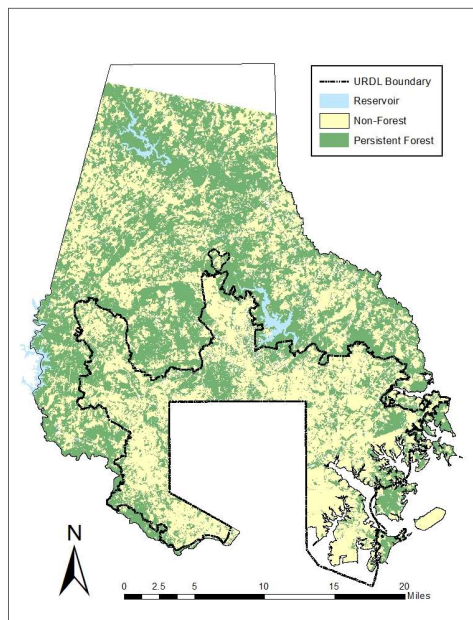
Forest Cover Data

- 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

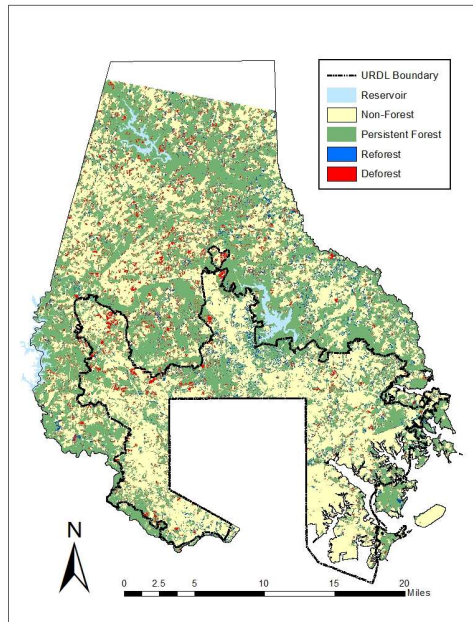
Forest Cover Change

- 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

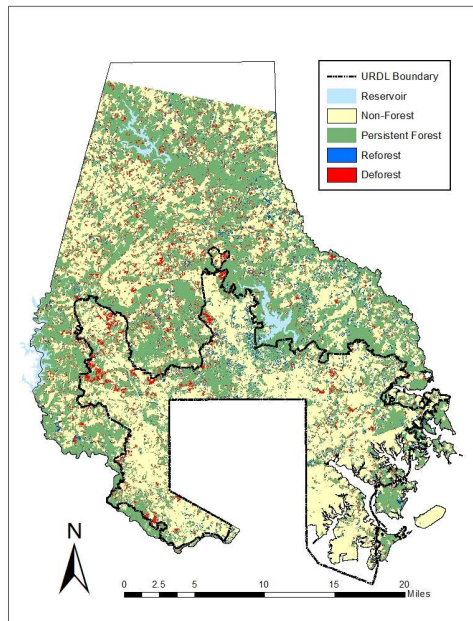
Forest Cover in 1984



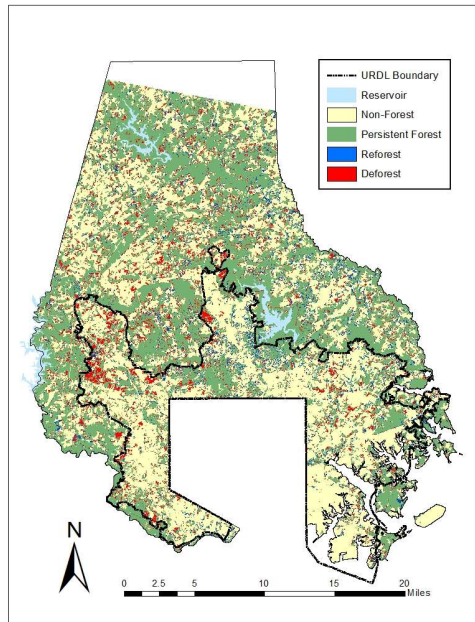
Forest Cover in 1990



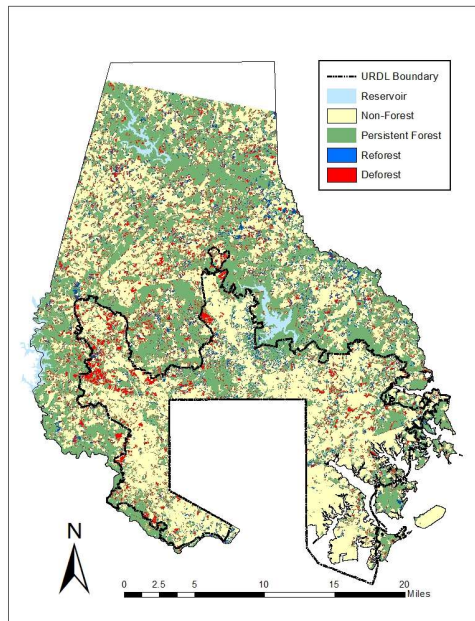
Forest Cover in 1995



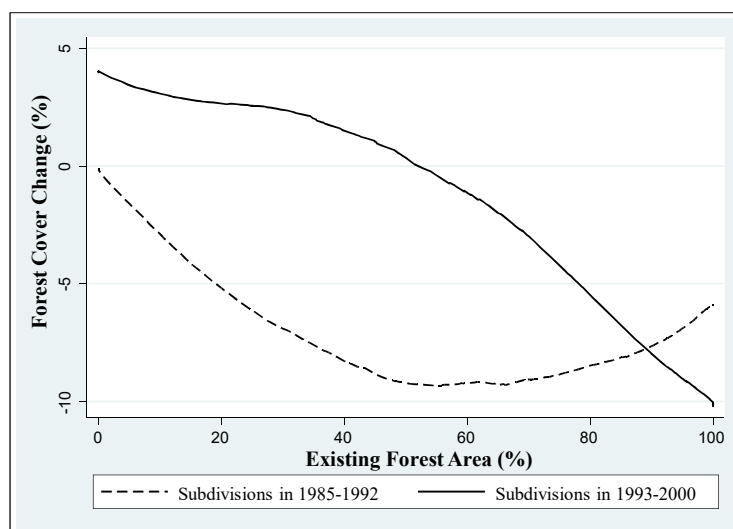
Forest Cover in 2000



Forest Cover in 2004



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



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)

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

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

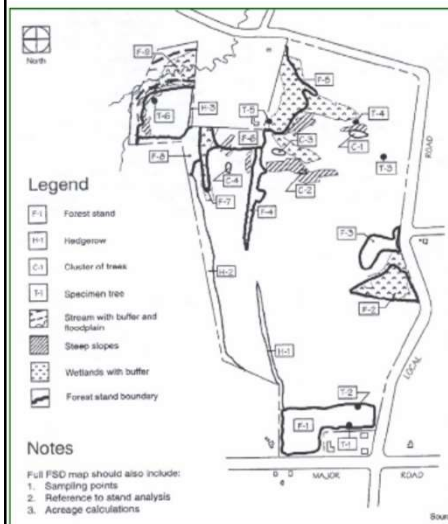
Thank you!

David Newburn

Email: dnewburn@umd.edu

Ph: 510-517-5862 (cell)

Forest Conservation Act



Forest stand delineation



Forest conservation plan

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

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

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

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

FIML Heckman Selection Model Results for Select Coefficients

Variables	Probability of Development		Forest Cover Change	
	Coefficient	Standard Error	Coefficient	Standard Error
Forest Cover Quintiles				
Forest cover 20-40%	-0.10964	0.09999	-6.67854**	1.87897
Forest cover 40-60%	0.08965	0.09094	-5.86740**	1.94954
Forest cover 60-80%	0.09250	-0.09232	-7.20691**	-2.35234
Forest cover 80-100%	0.01915	-0.08483	-4.10248**	-1.58868
Post-1993 Forest Cover Quintiles				
Post-1993* Forest cover 20-40%	0.21267	-0.13557	5.75130	-2.97732
Post-1993* Forest cover 40-60%	0.01350	-0.1306	7.17126*	-2.84029
Post-1993* Forest cover 60-80%	0.02220	-0.13054	-0.88349	-2.70729
Post-1993* Forest cover 80-100%	-0.03651	-0.11784	-10.29618**	-2.60728
Post-1993	0.02061	-0.13628	8.44116***	-2.97329
	0.74614**	-0.16393	--	--
Time Fixed Effects	Yes		Yes	
Observations	47,309		427	

**p<0.01, *p<0.05

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

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* [443, 2253]	140* [43, 256]	-80* [-191, -11]	1311* [618, 2081]	147* [61, 250]	25 [-16, 70]
Forest cover 20-40%	1280* [444, 2335]	378* [129, 698]	-155* [-332, -41]	2173* [1171, 3293]	643* [352, 981]	3 [-90, 92]
Forest cover 40-60%	1865* [859, 3119]	906* [419, 1527]	-228* [-449, -80]	2020* [1097, 3091]	980* [524, 1506]	62 [-15, 152]
Forest cover 60-80%	1326* [538, 2349]	903* [366, 1591]	-162* [-356, -44]	1470* [698, 2336]	1002* [480, 1583]	-69* [-138, -22]
Forest cover 80-100%	1654* [742, 2880]	1234* [553, 2075]	-107* [-231, -28]	1592* [919, 2421]	1194* [646, 1811]	-124* [-213, -52]
Total	7380* [4148, 11376]	3561* [2071, 5517]	-733* [-1314, -321]	8567* [6620, 10743]	3965* [2998, 4978]	-103 [-272, 61]

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