



Chesapeake Bay Program
A Watershed Partnership

The Chesapeake Bay Land Change Model

General Overview
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Policy question driving analysis of future conditions



Chesapeake Bay Program
A Watershed Partnership

How to maintain progress in restoring the Chesapeake Bay?

**... with continued population and urban
growth.**

Relevance of future conditions to restoring the Chesapeake Bay



Identify areas where:

- **Current restoration strategies may fail to accommodate expected land use trends.**

E.g., lack of emphasis on urban BMP's despite high rates of urban growth and continued farmland loss.

Relevance of future conditions to restoring the Chesapeake Bay



Identify areas where:

- **Policy conflicts challenge the long-term success of Bay-restoration efforts.**

E.g., Incentives to preserve forests and farmland and encourage urban infill development; caps on loads from wastewater treatment plants; more stringent stormwater management regulations.

Relevance of future conditions to restoring the Chesapeake Bay



Inform decisions about the appropriate scale of water quality trades*.

Broad-scale = most flexibility but least protective of local waters

Fine-scale = least flexible but most protective of local waters

***Off-setting increased nutrient and sediment loads in one area based on nutrient and sediment load reductions in another area.**

Chesapeake Bay Decision Support System

Chesapeake Bay Living Resources



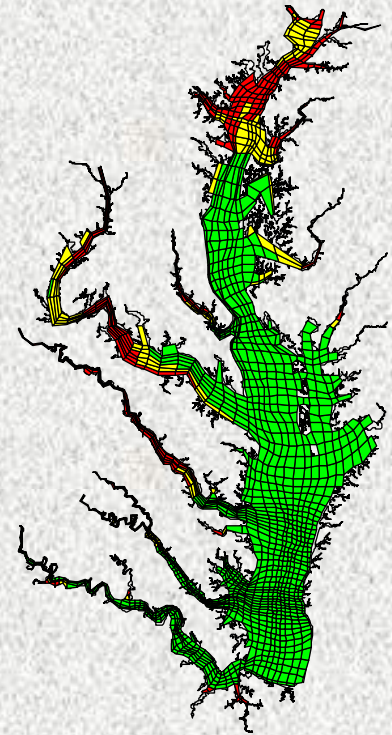
Water Quality Criteria

Dissolved
Oxygen

Water
Clarity

Chlorophyl- a

Water Quality Model

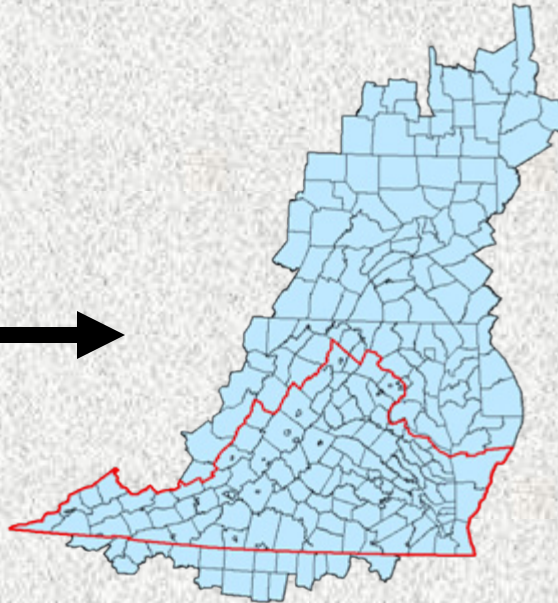


Chesapeake Bay Decision Support System

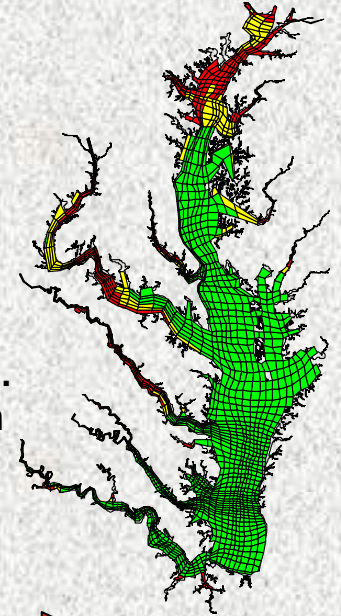
Land Change and
Airshed Models



Watershed
Model



Water Quality
Model

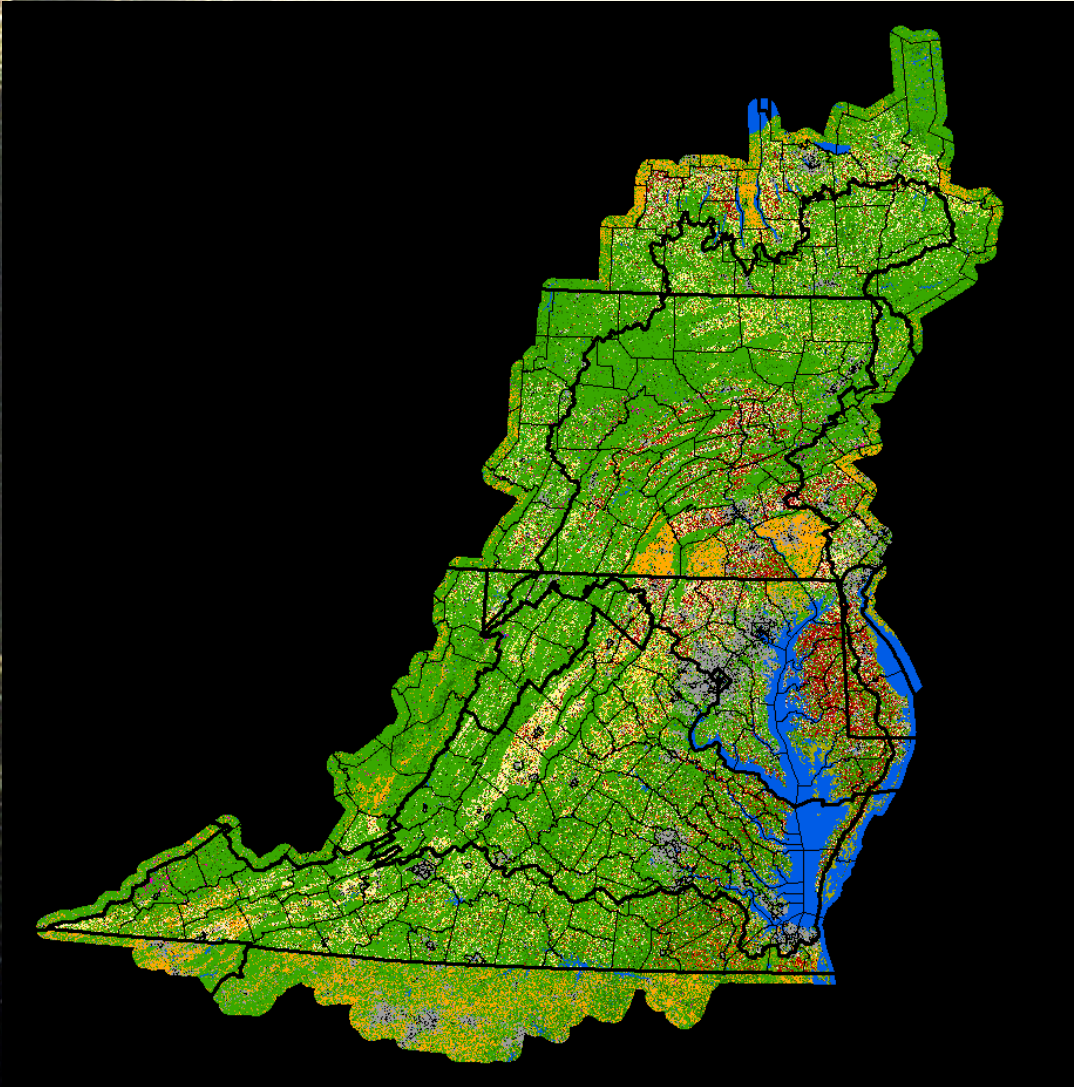


175 million lbs.
Total Nitrogen
per year

Assessment of nutrient load sources and effects





Allocation of nutrient load limits by County

Chesapeake Bay Land Cover

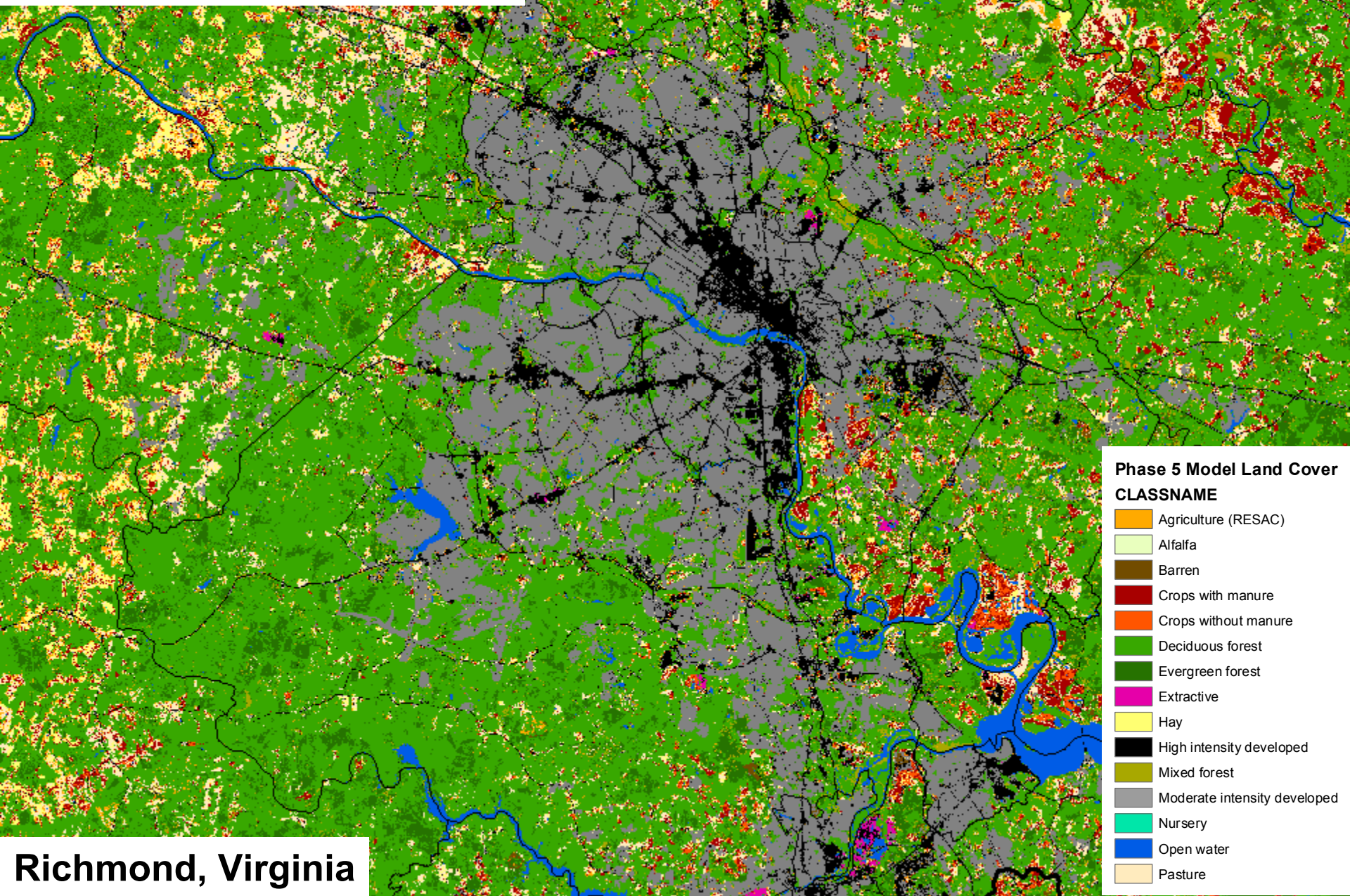


Phase 5 Model Land Cover

CLASSNAME

	Agriculture (RESAC)
	Alfalfa
	Barren
	Crops with manure
	Crops without manure
	Deciduous forest
	Evergreen forest
	Extractive
	Hay
	High intensity developed
	Mixed forest
	Moderate intensity developed
	Nursery
	Open water
	Pasture

Chesapeake Bay Land Cover, yr. 2000



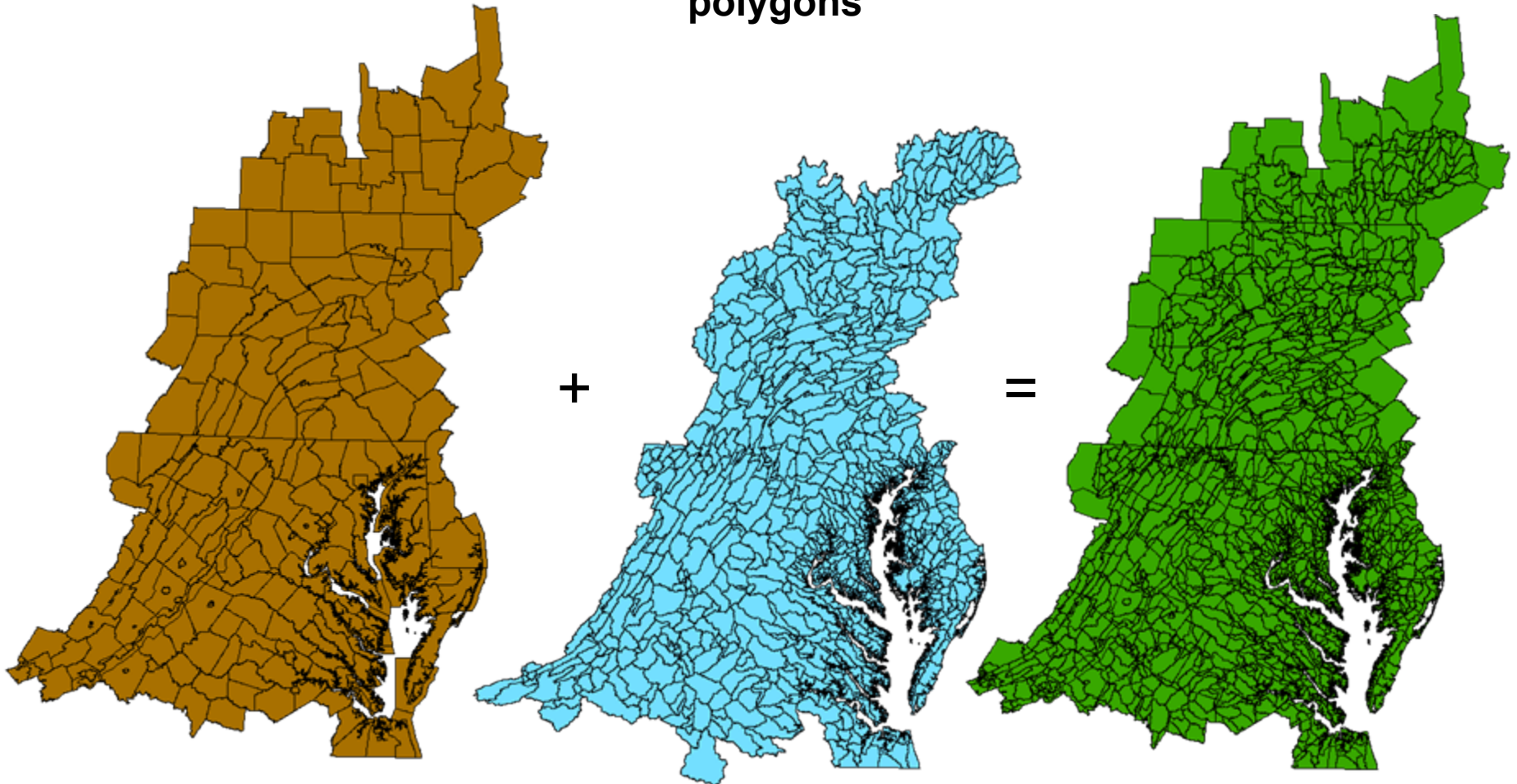
Phase 5 Model Land Cover
CLASSNAME

- Agriculture (RESAC)
- Alfalfa
- Barren
- Crops with manure
- Crops without manure
- Deciduous forest
- Evergreen forest
- Extractive
- Hay
- High intensity developed
- Mixed forest
- Moderate intensity developed
- Nursery
- Open water
- Pasture

Richmond, Virginia

Watershed Modeling Scale

284 land polygons + 964 river polygons = 2,346 modeling units



Median area: 10
4,085 hectares



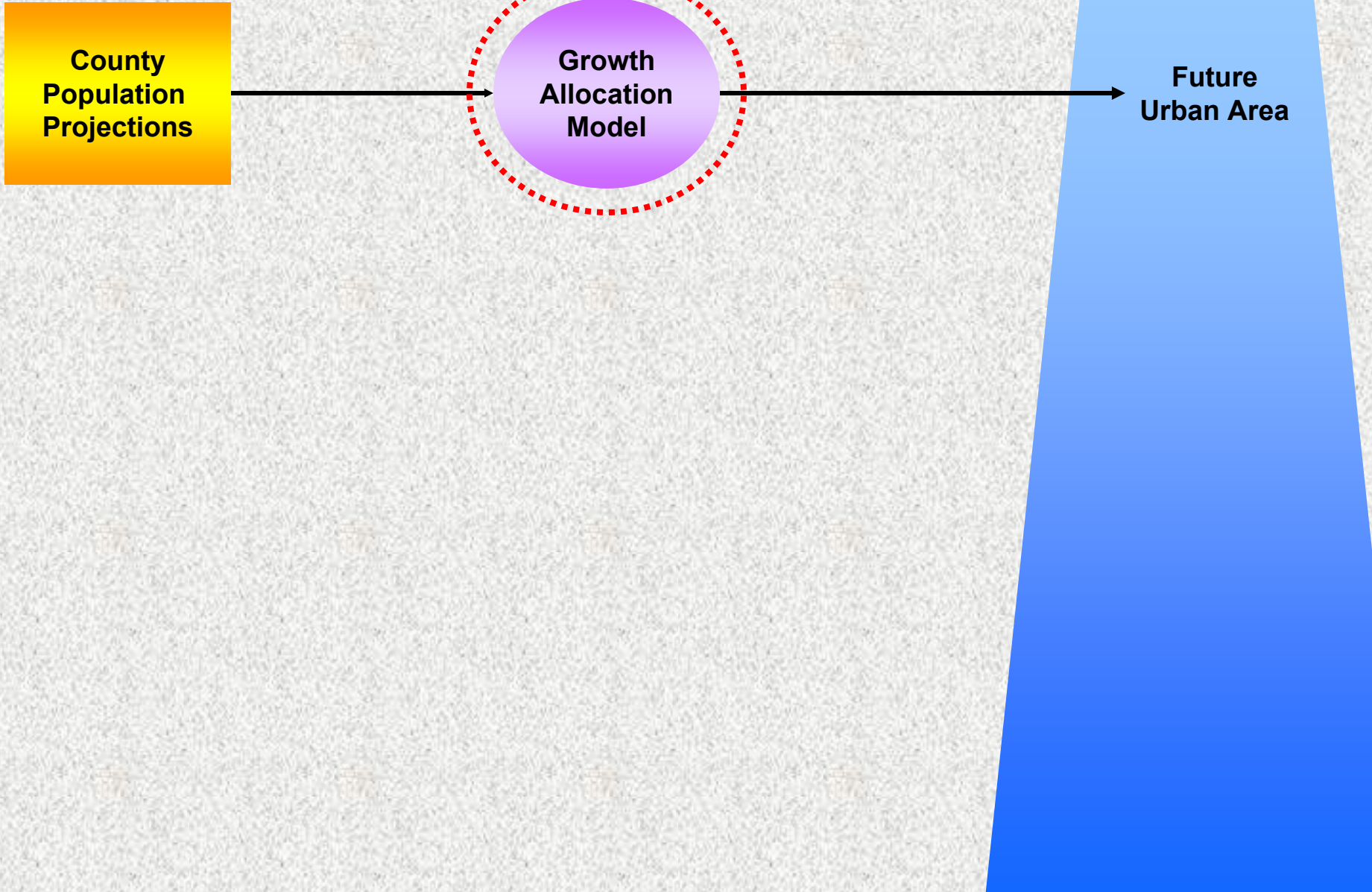
Chesapeake Bay Land Change Model (CBLCM)

Watershed Model
Input Data

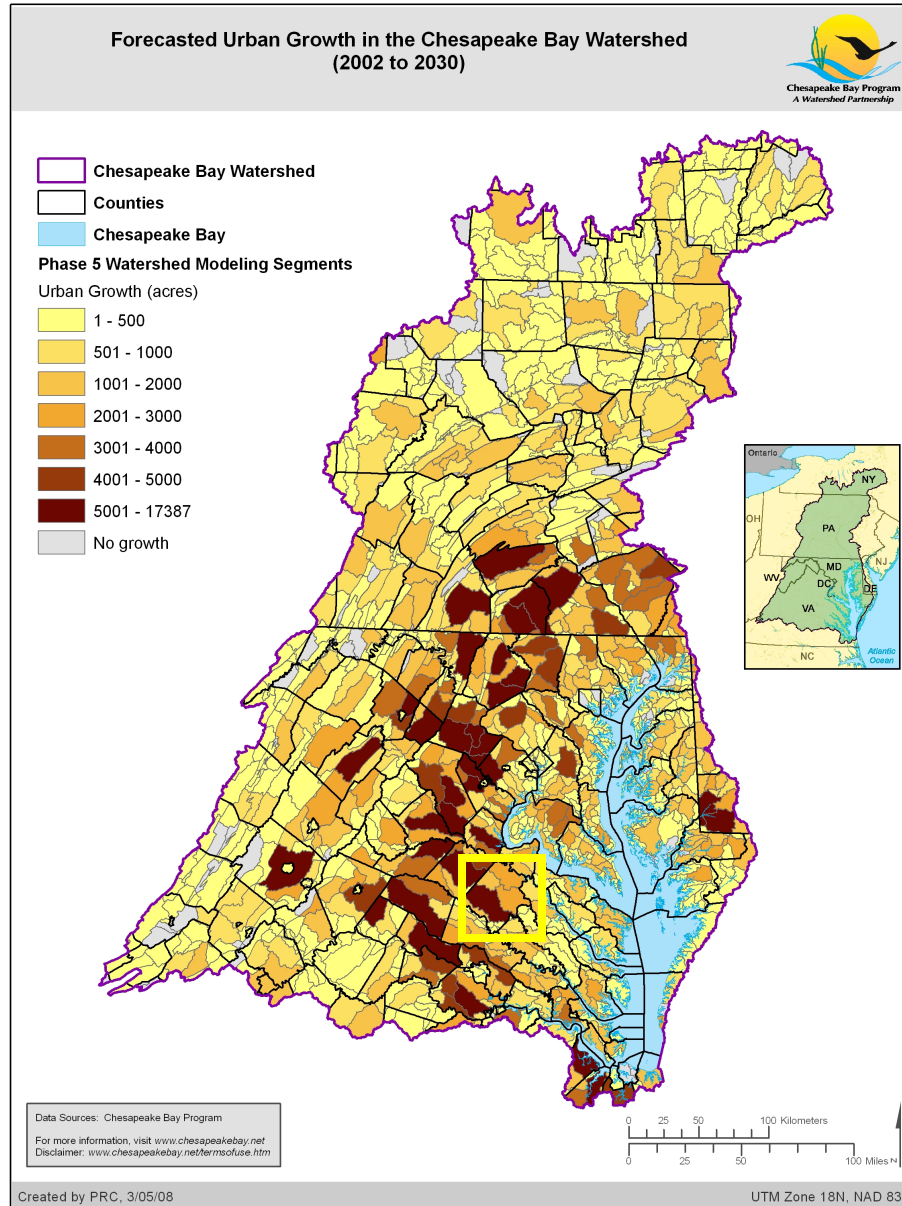
County
Population
Projections

Growth
Allocation
Model

Future
Urban Area



Forecasted Urban Growth (2000 to 2030)



15970

1599

510

2171

1226

474

Caroline

99

2121

10658

353

125

1560

614

57

315

8

151

33 37

150



Caroline County, Virginia

Historic Population (U.S. Census):

Year 1990 = 19,227

Year 2000 = 22,121

Historic Housing (U.S. Census):

Year 1990 = 7,290

Year 2000 = 8,889

Projected Population (VEC):

Year 2010 = 29,201

Year 2020 = 36,058

Year 2030 = 43,662

Projected Housing:

Year 2010 = 12,777

Year 2020 = 17,026

Year 2030 = 22,441



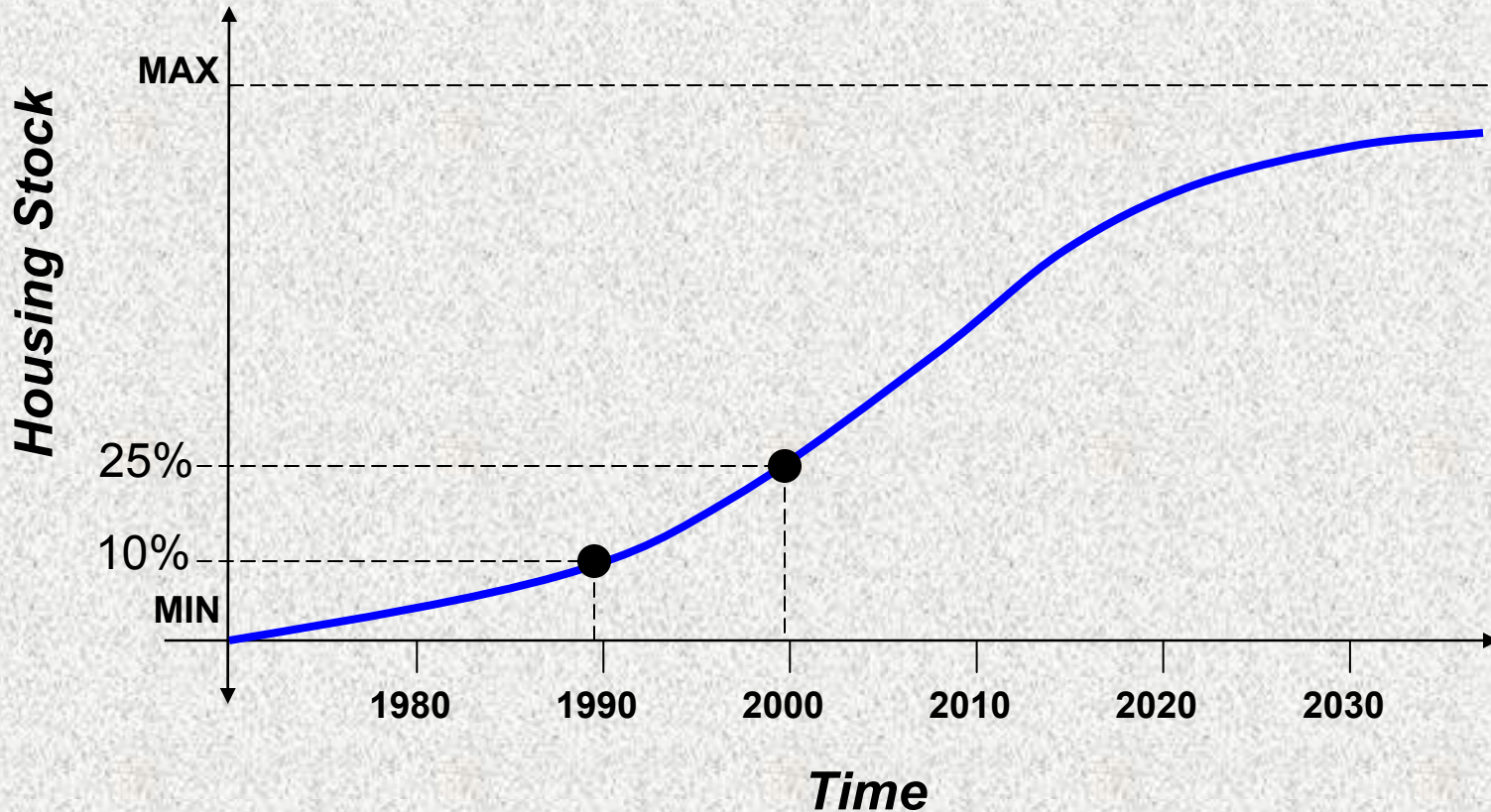
+ Estimated vacant housing



Gompertz Curve

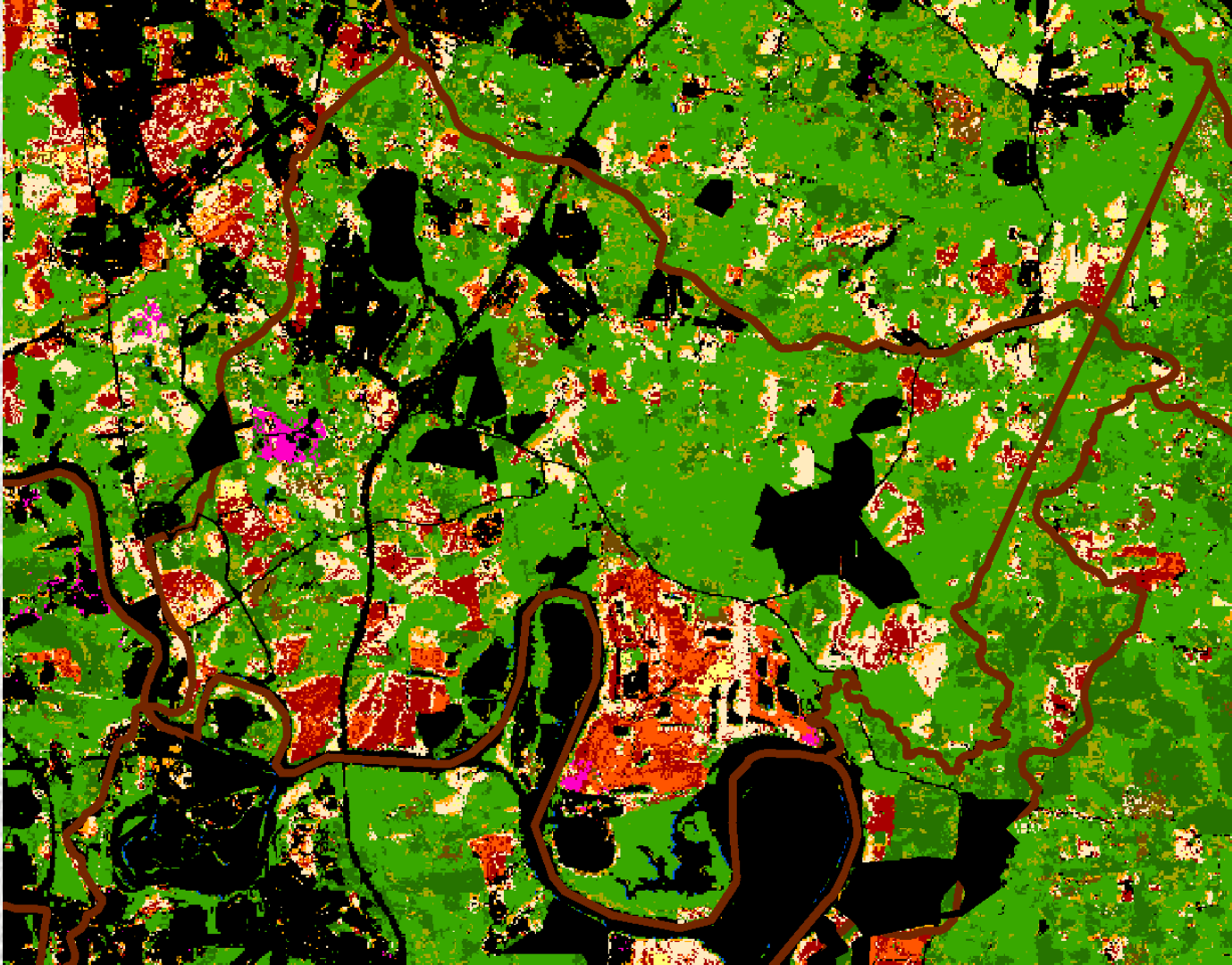
Future housing stock =

f (growth rate, maximum housing stock, and time)



Maximum Housing Stock =

$$\text{Total Housing in 2000} + \frac{\text{Available land for development}}{\text{Developed acres per house}}$$



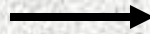


Local scale: southern Caroline County segment

Residential Housing (GIS analysis):

Year 1990 = 3,996 units

Year 2000 = 5,087 units



Future Housing (Gompertz curve)

Year 2010 = 6,351 units

Year 2020 = 7,789 units

Year 2030 = 9,397 units

County: Gompertz Ratios:

Year 2010 = 1.19

Year 2020 = 1.33

Year 2030 = 1.48



Adjusted Future Housing:

Year 2010 = 7,559 units

Year 2020 = 10,341 units

Year 2030 = 13,910 units



Future Urban Area in Southern Caroline County, Virginia

Year 2000 = 5,087 units..... 7,391 acres

Year 2030 = 5,087 existing units + 8,823 new units..... ? acres

**2030 Urban Area = 2000 Urban Area +
(additional units * urban land per house * density
adjustment factor)**

= 7,391 acres + (8,823 units * 1.45 * 0.91)

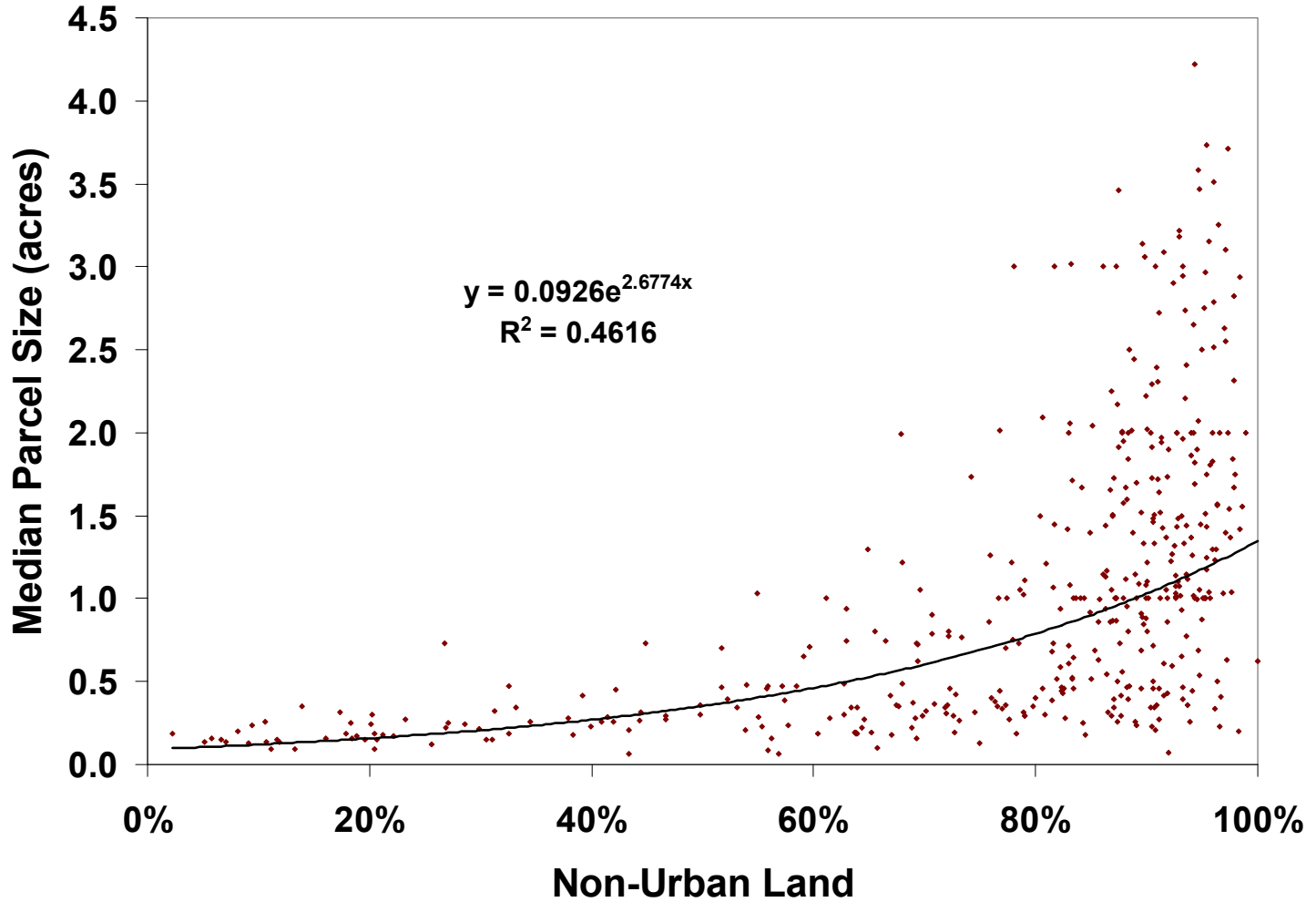
= 19,089 acres (subtract for infill growth and barren)

= 18,333 acres



Density Factor Adjustment

f (% non-urban land in modeling segment)

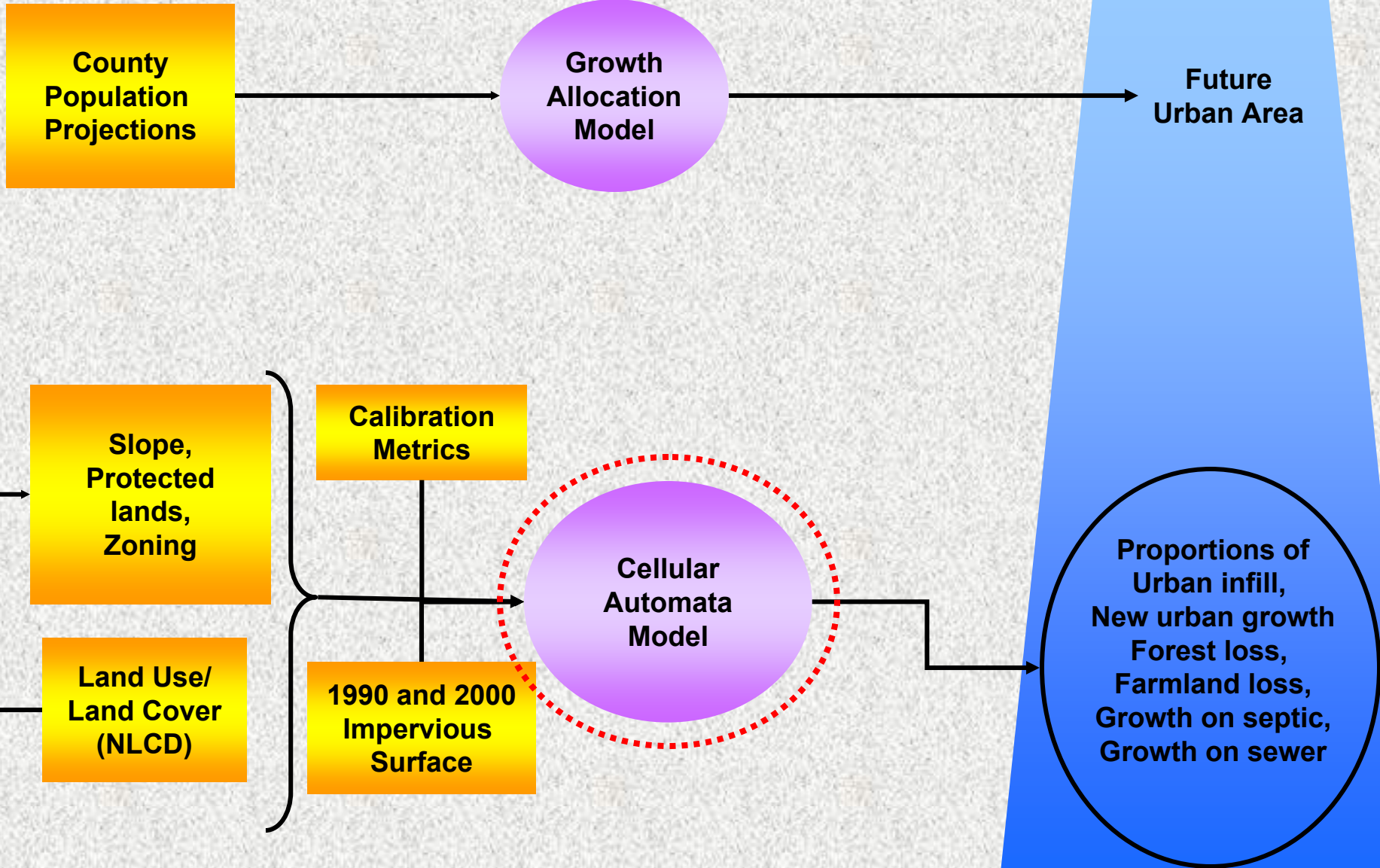


• Phase 5 Land-River Segment — Expon. (Phase 5 Land-River Segment)



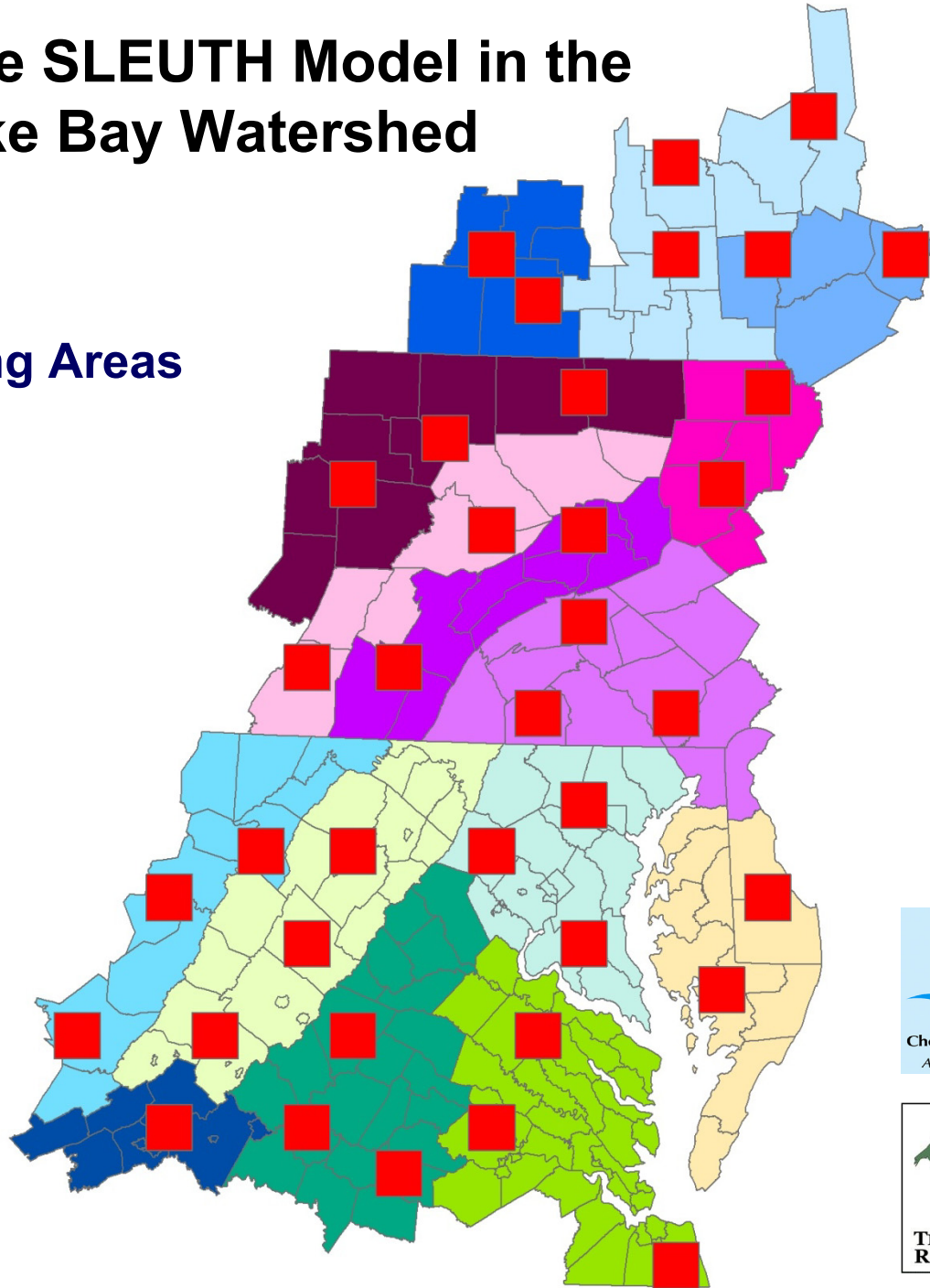
Chesapeake Bay Land Change Model (CBLCM)

Watershed Model
Input Data



Calibration of the SLEUTH Model in the Chesapeake Bay Watershed

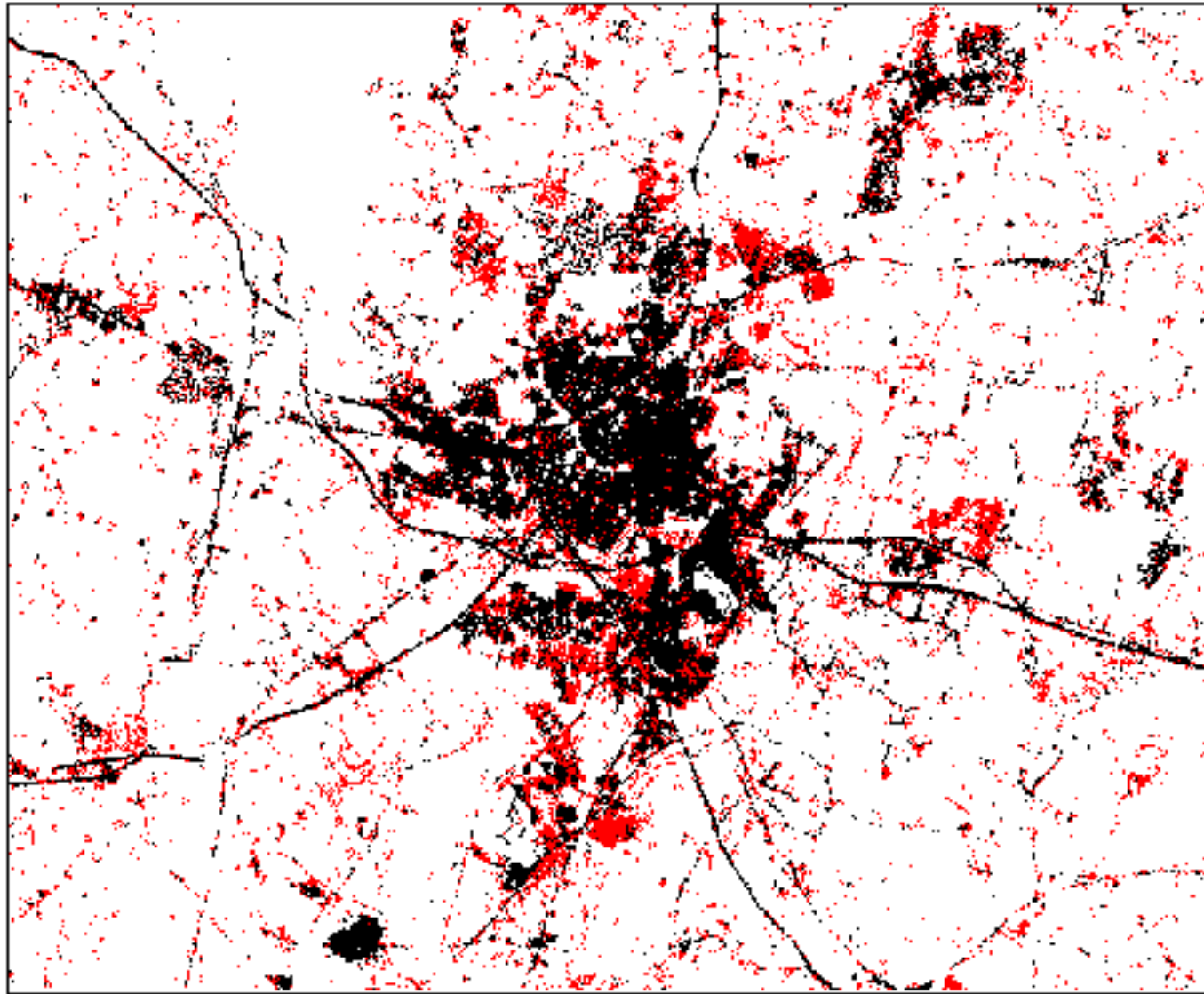
Stratified by:
Rural to Urban Commuting Areas
State Boundaries
Ecoregional Boundaries



Stratified, unaligned,
random sampling



Urban area represented by impervious surfaces



Year 1990 (BLACK)
Year 2000 (RED)

Urban/non-urban

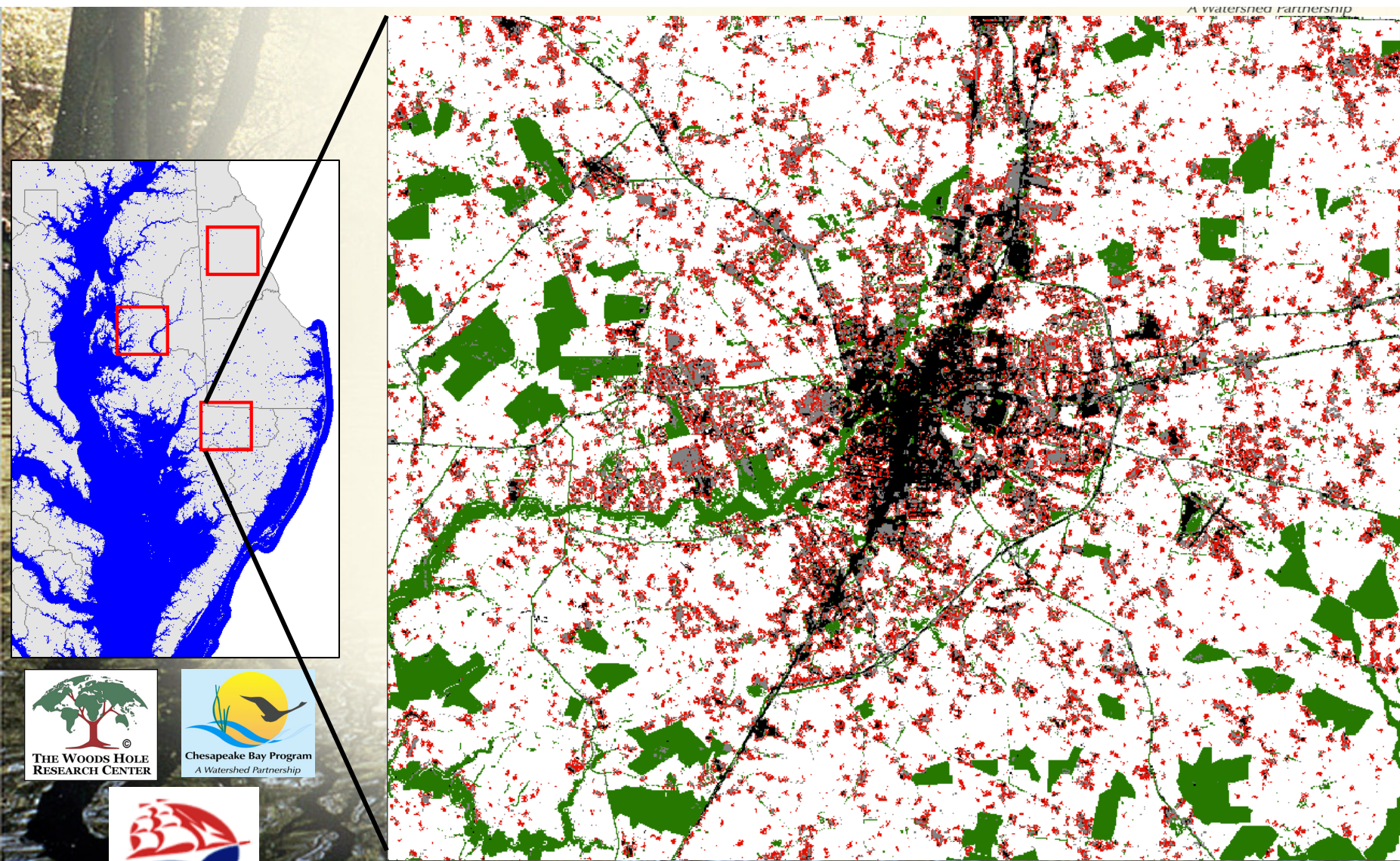
1990 accuracy
>79%

2000 accuracy
>83%

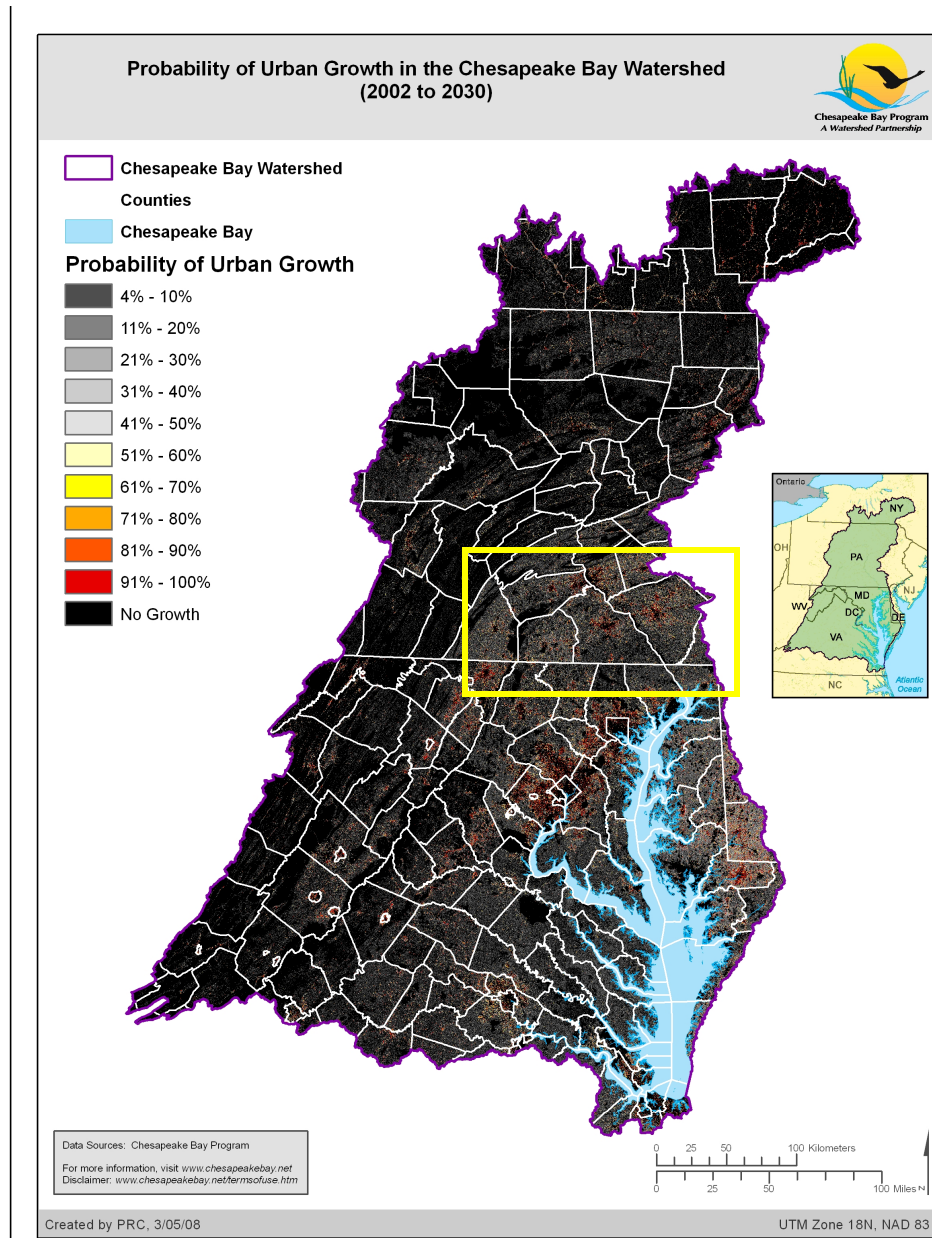
0 1 2 3 Miles

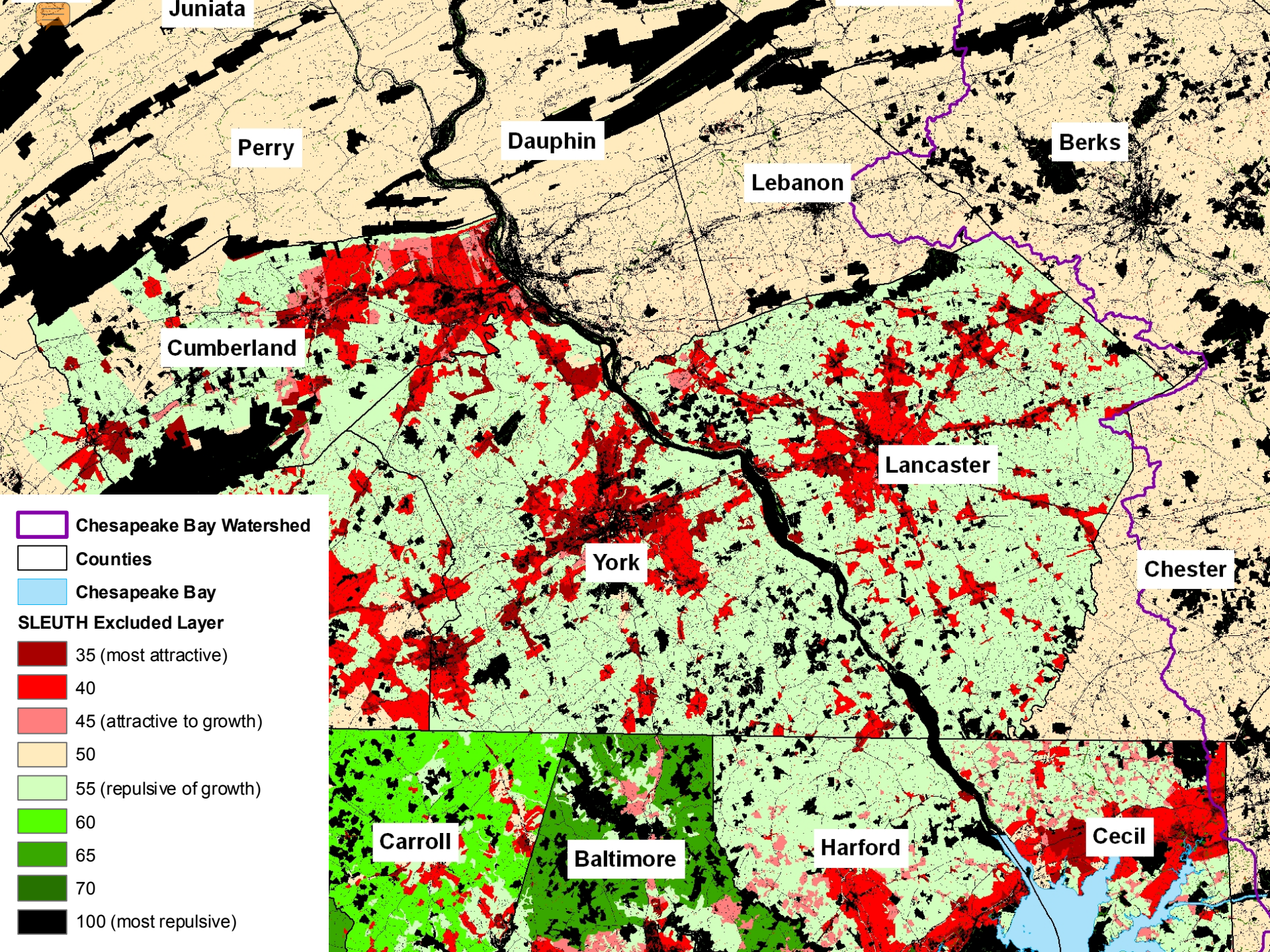
Determining Proportions of Farmland and Forest Loss: Using SLEUTH

Results: Salisbury, MD 2030 Urban growth



The Pattern of Urban Growth (2000 to 2030)





Juniata

Perry

Dauphin

Lebanon

Berks

Cumberland

Lancaster

York

Chester

Carroll

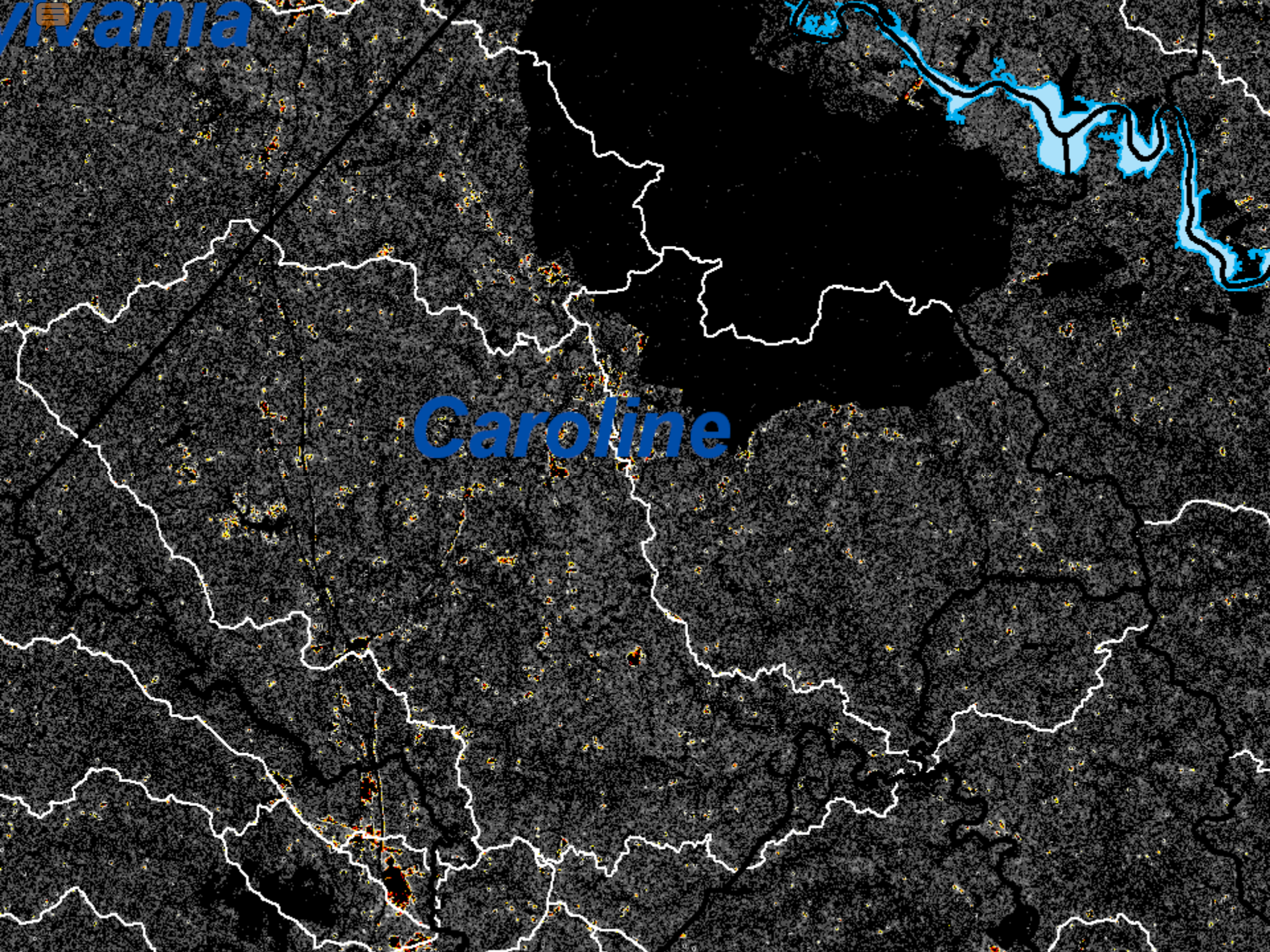
Baltimore

Harford

Cecil

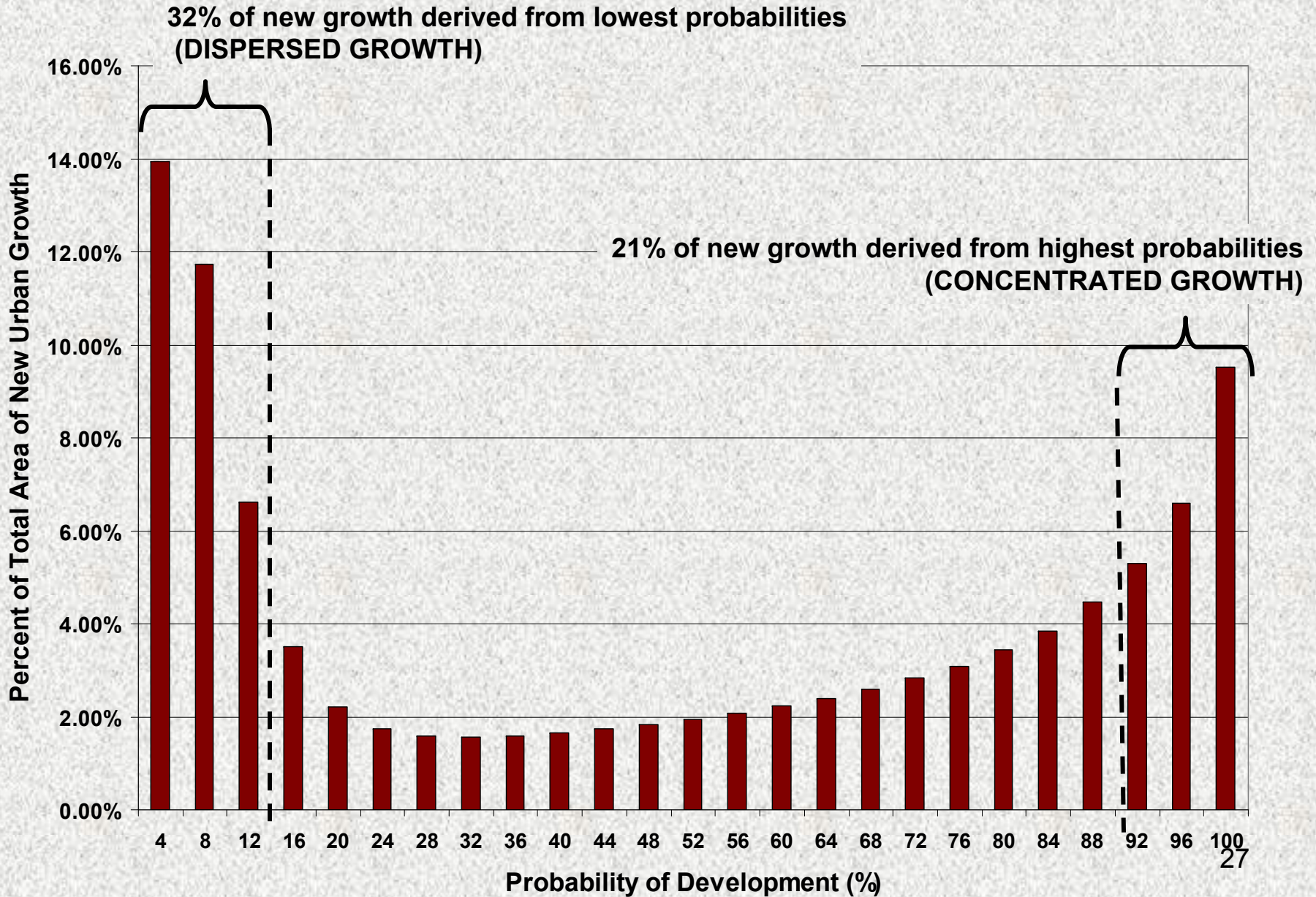
Ivania

Caroline





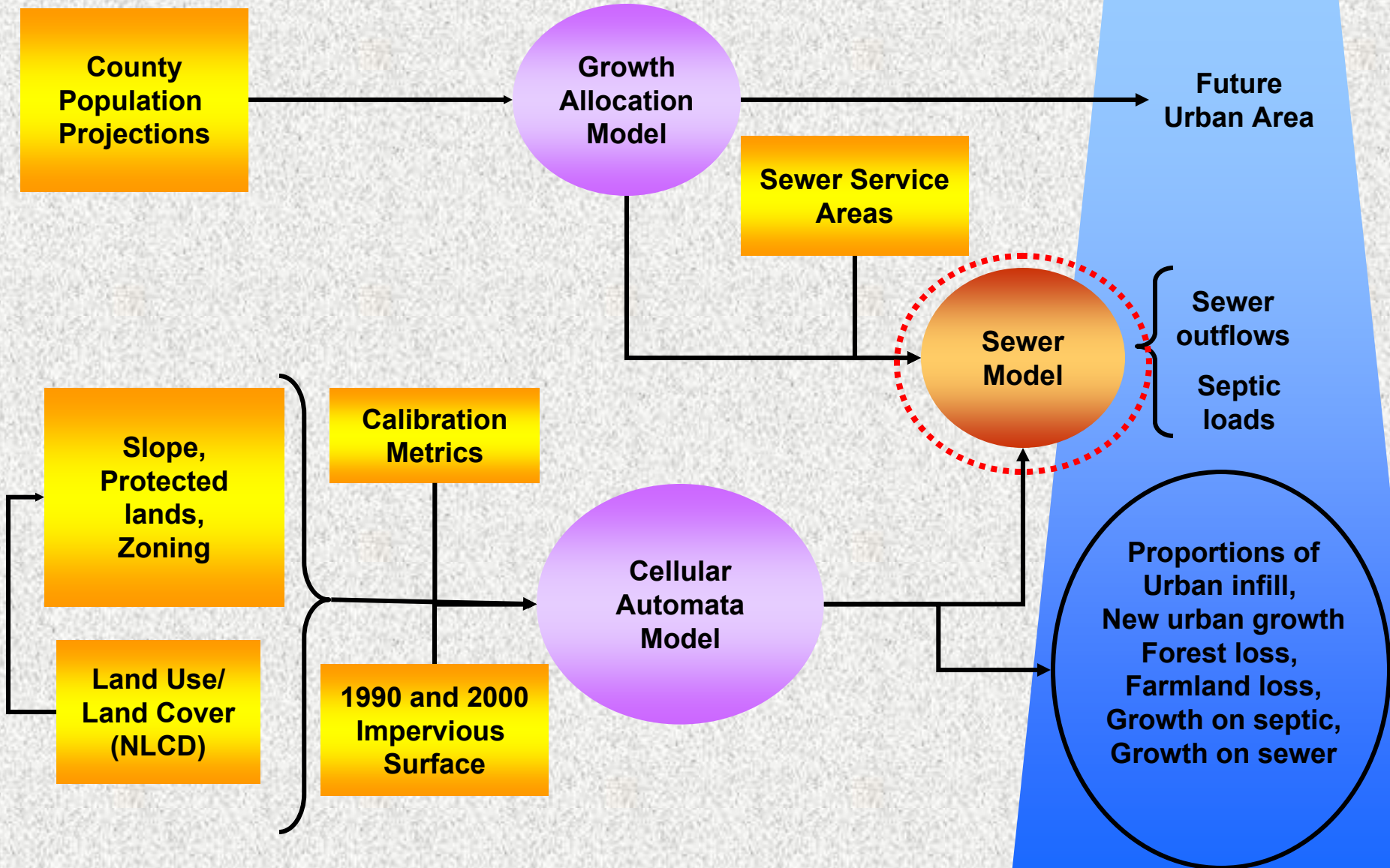
SLEUTH Probability Distribution (VA Trend 3.0)








Chesapeake Bay Land Change Model (CBLCM)

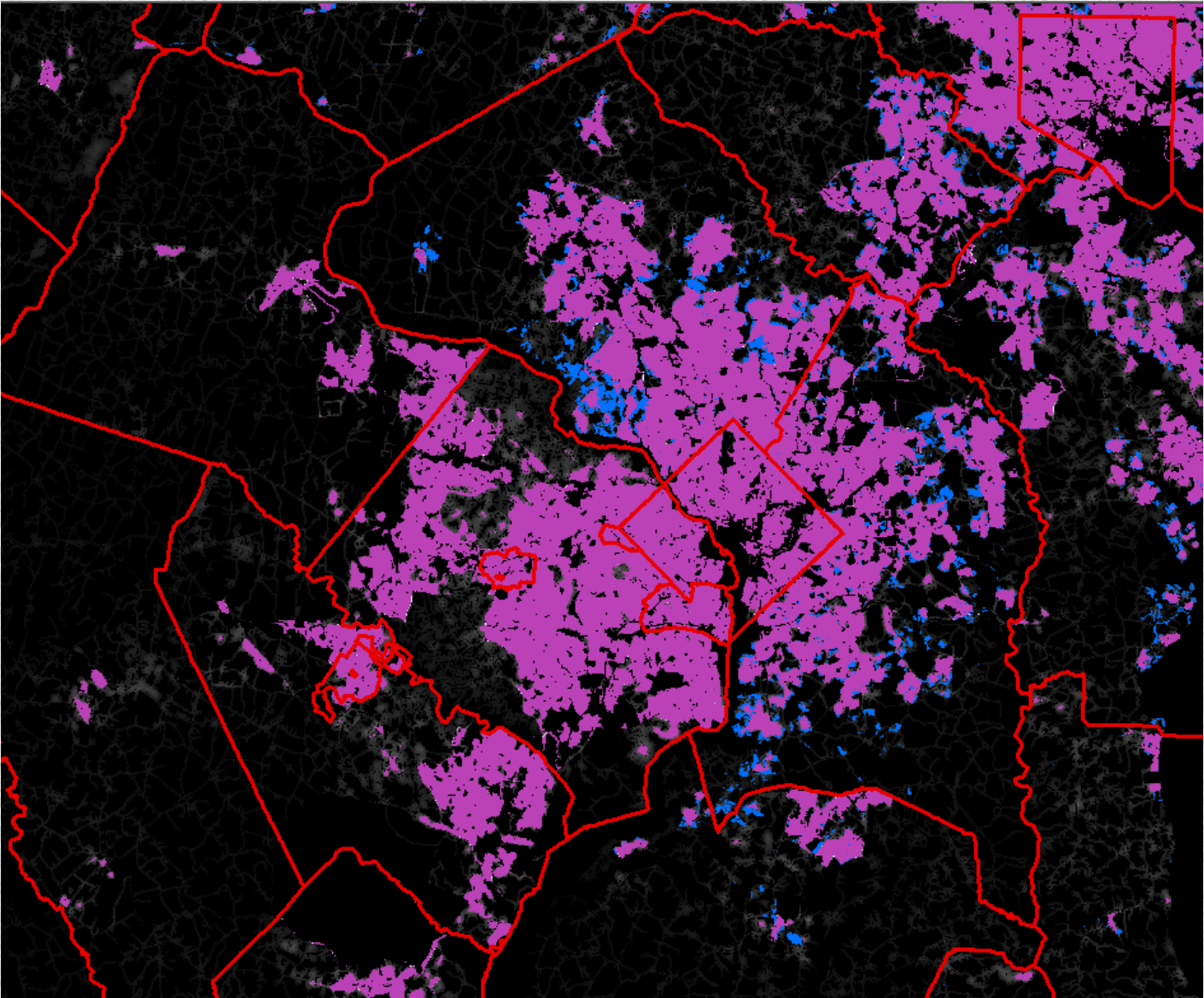
Watershed Model
Input Data





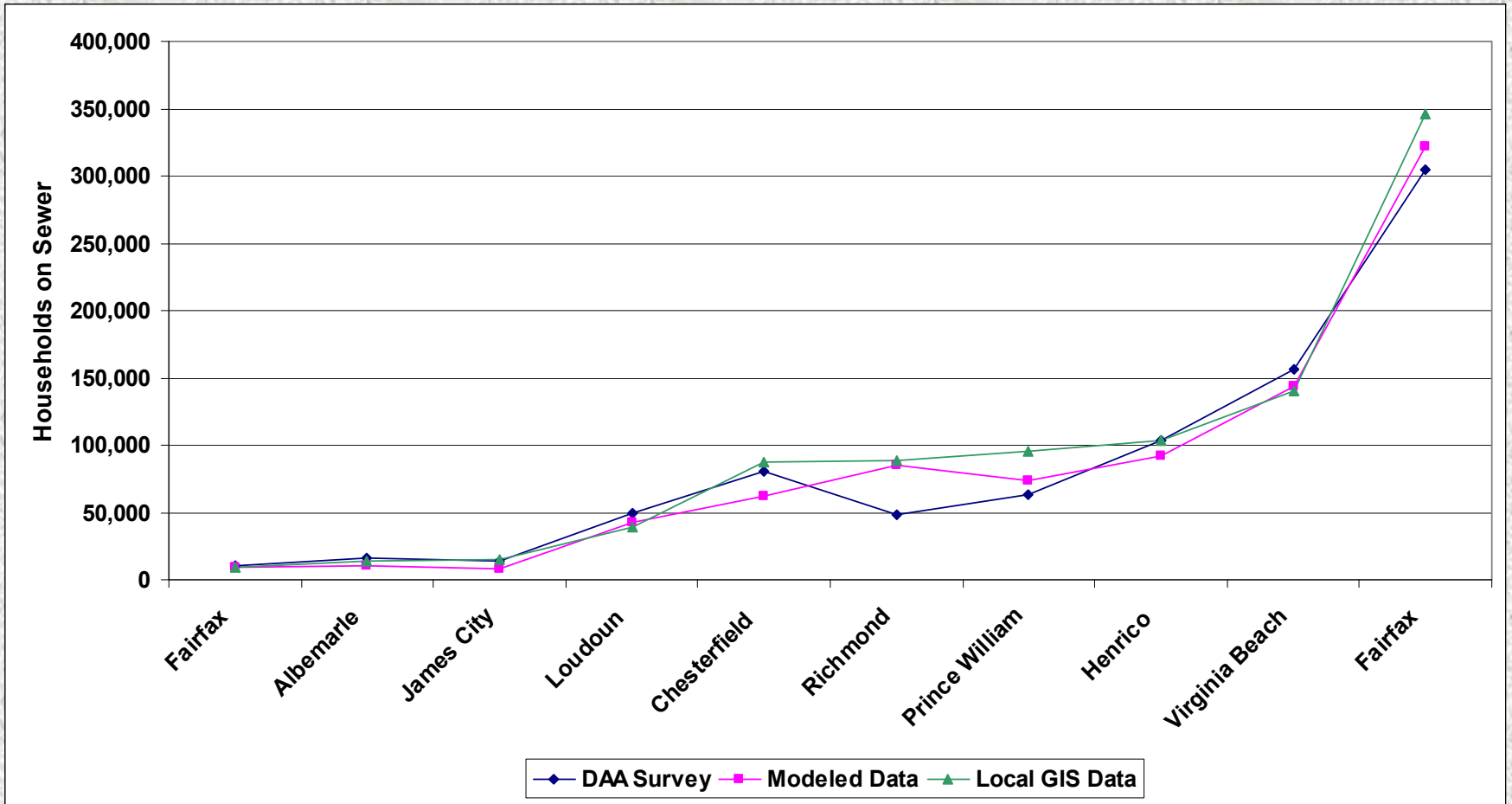
Forecasting Population on Sewer vs. Septic: Modeling service area based on population distribution

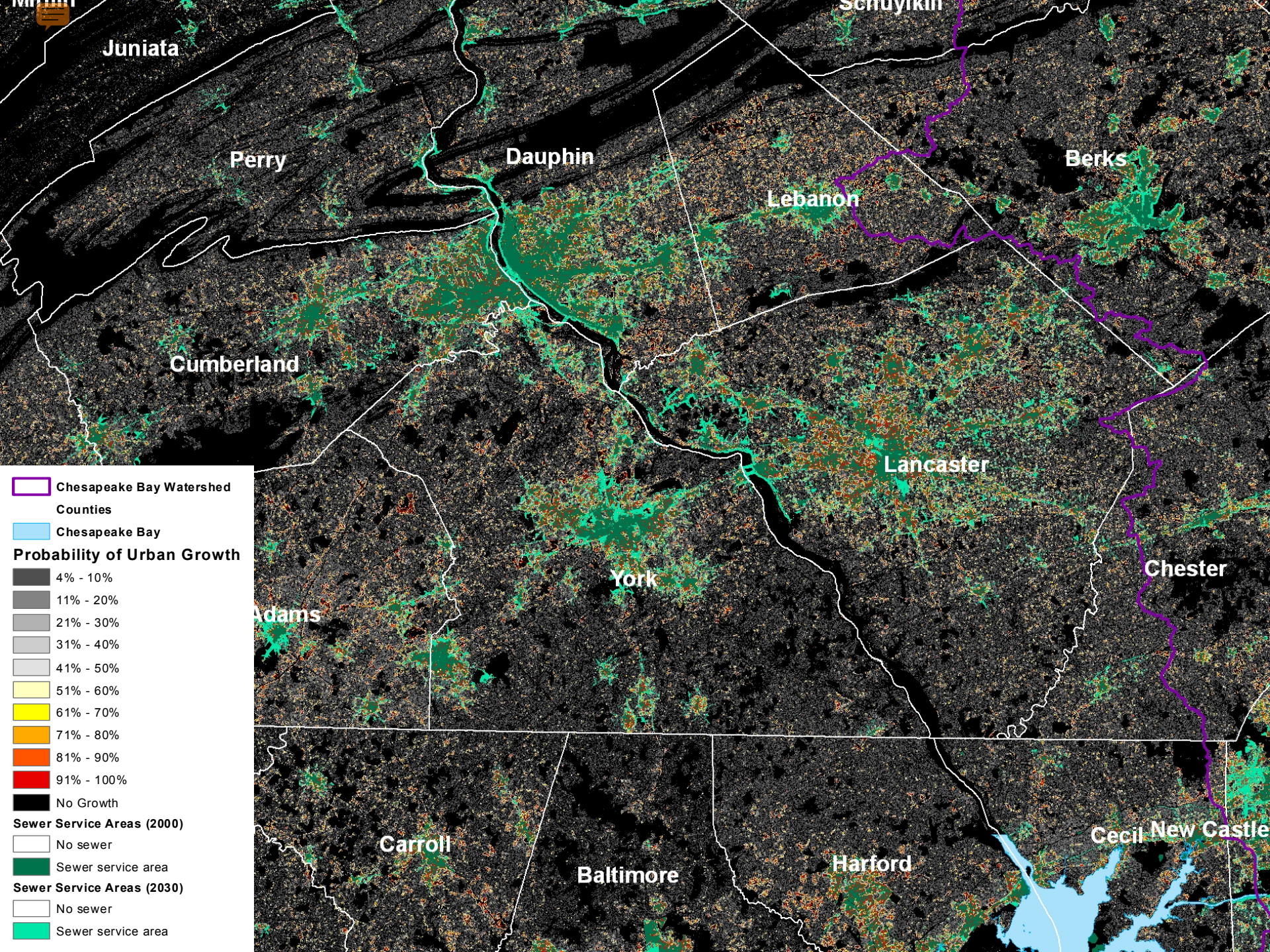
-  Population density
-  CBP Modeled Areas
-  MDP Sewered Areas





Comparing Simulated Population on Sewer with DAA Survey Results in Virginia



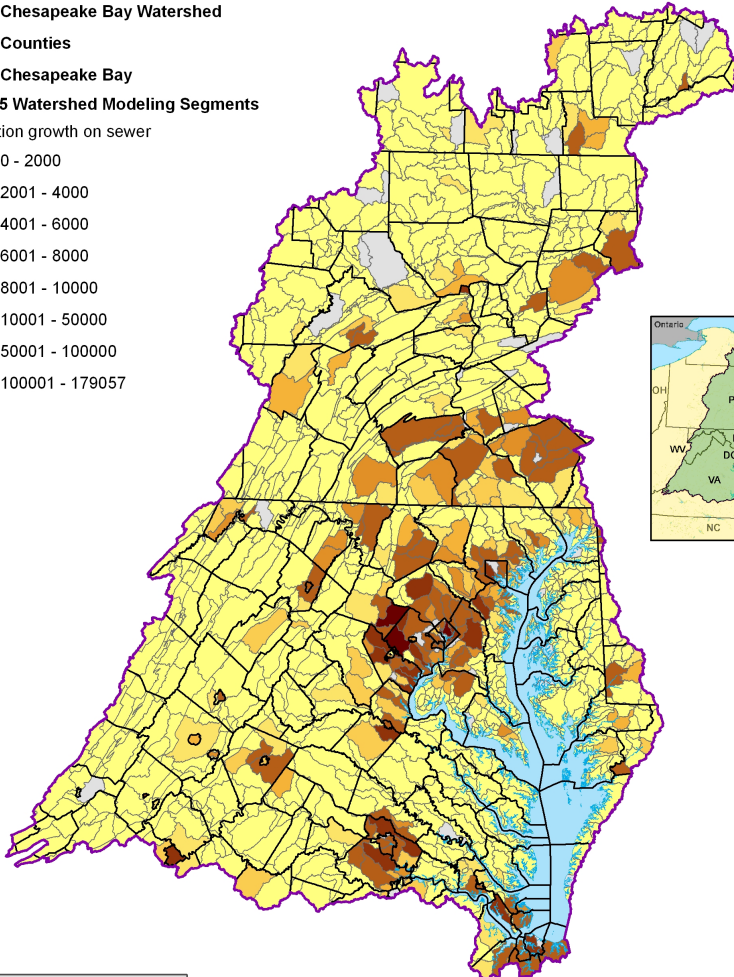
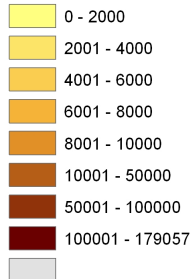


Forecasted Population Growth on Sewer vs. Septic (2000 to 2030)

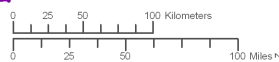
Forecasted Population Growth on Sewer in the Chesapeake Bay Watershed (2002 to 2030)



- Chesapeake Bay Watershed
 - Counties
 - Chesapeake Bay
- Phase 5 Watershed Modeling Segments**
Population growth on sewer



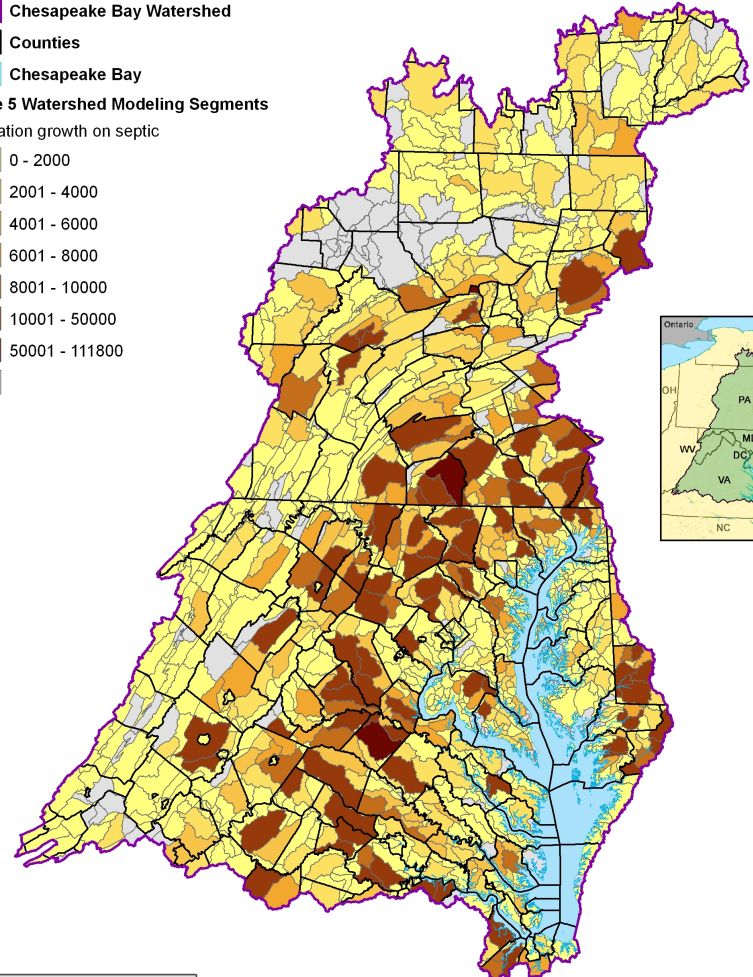
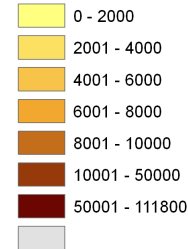
Data Sources: Chesapeake Bay Program
For more information, visit www.chesapeakebay.net
Disclaimer: www.chesapeakebay.net/terms_of_use.htm



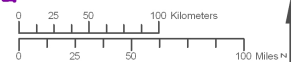
Forecasted Population Growth on Septic in the Chesapeake Bay Watershed (2002 to 2030)



- Chesapeake Bay Watershed
 - Counties
 - Chesapeake Bay
- Phase 5 Watershed Modeling Segments**
Population growth on septic



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Farmland and Forest Land Loss (2000 to 2030)

Forecasted Farmland Loss in the Chesapeake Bay Watershed (2002 to 2030)

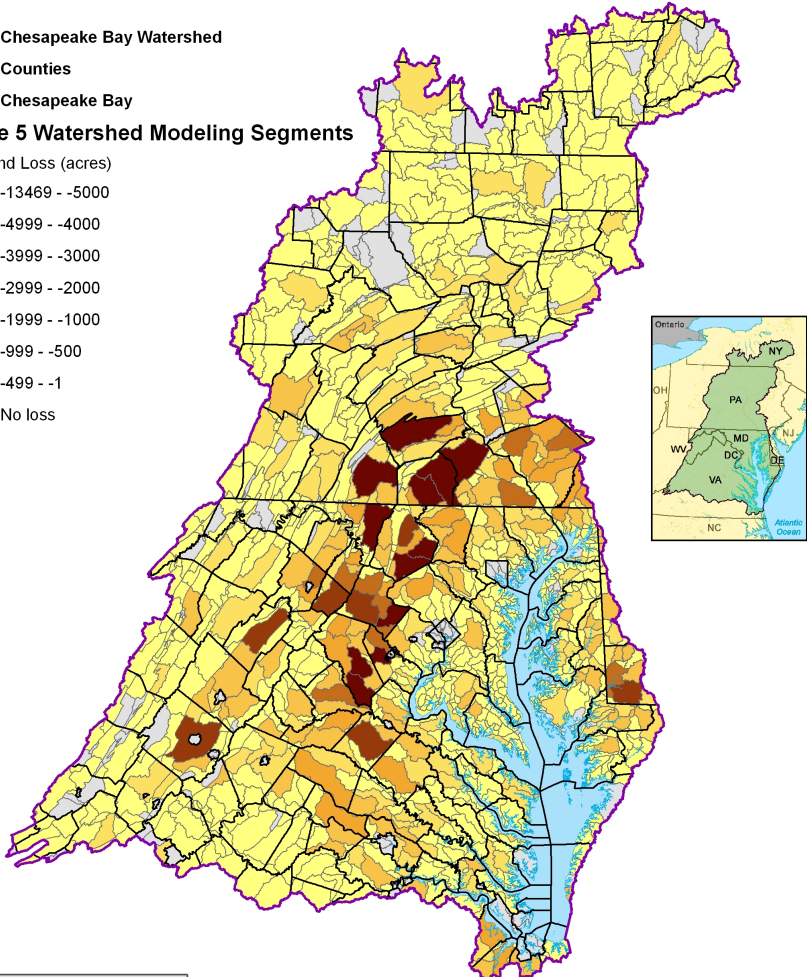


- Chesapeake Bay Watershed
- Counties
- Chesapeake Bay

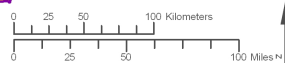
Phase 5 Watershed Modeling Segments

Farmland Loss (acres)

- 13469 - -5000
- 4999 - -4000
- 3999 - -3000
- 2999 - -2000
- 1999 - -1000
- 999 - -500
- 499 - -1
- No loss



Data Sources: Chesapeake Bay Program
 For more information, visit www.chesapeakebay.net
 Disclaimer: www.chesapeakebay.net/termsofuse.htm



UTM Zone 18N, NAD 83

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Forecasted Forest Loss in the Chesapeake Bay Watershed (2002 to 2030)

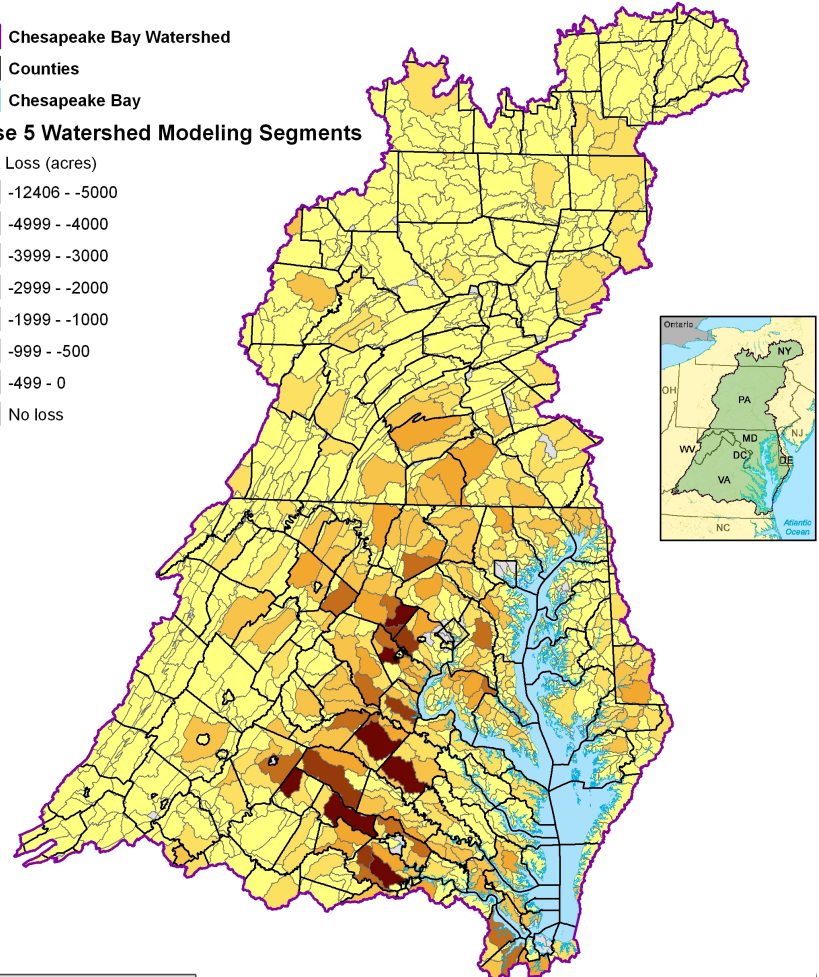


- Chesapeake Bay Watershed
- Counties
- Chesapeake Bay

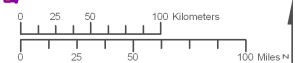
Phase 5 Watershed Modeling Segments

Forest Loss (acres)

- 12406 - -5000
- 4999 - -4000
- 3999 - -3000
- 2999 - -2000
- 1999 - -1000
- 999 - -500
- 499 - 0
- No loss



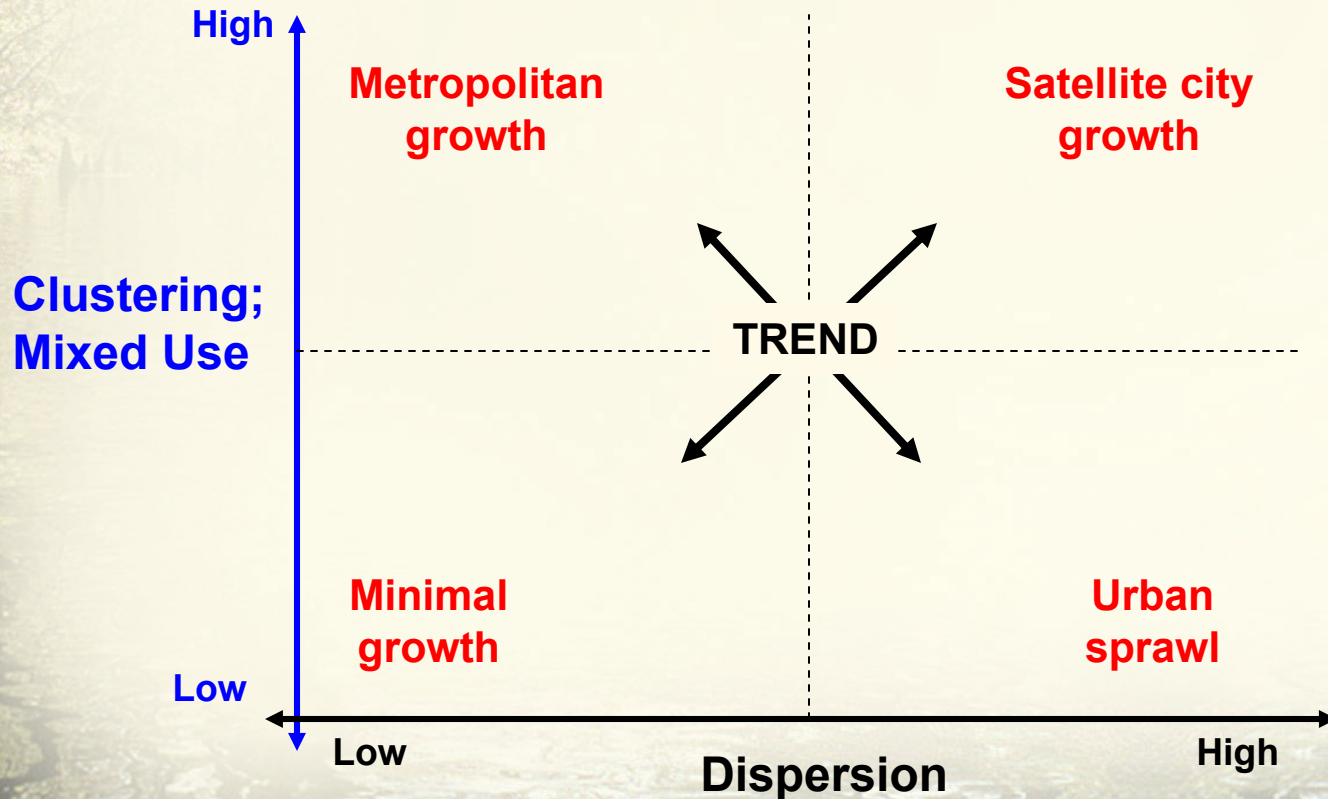
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Alternative Future “What If” Scenario Examples





Chesapeake Bay Program
A Watershed Partnership

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