Modeling Land Use Change in the Chesapeake Bay Watershed

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Land Use Workgroup

U.S. Department of the Interior
U.S. Geological Survey

The Chesapeake Bay Land Change Model (CBLCM)

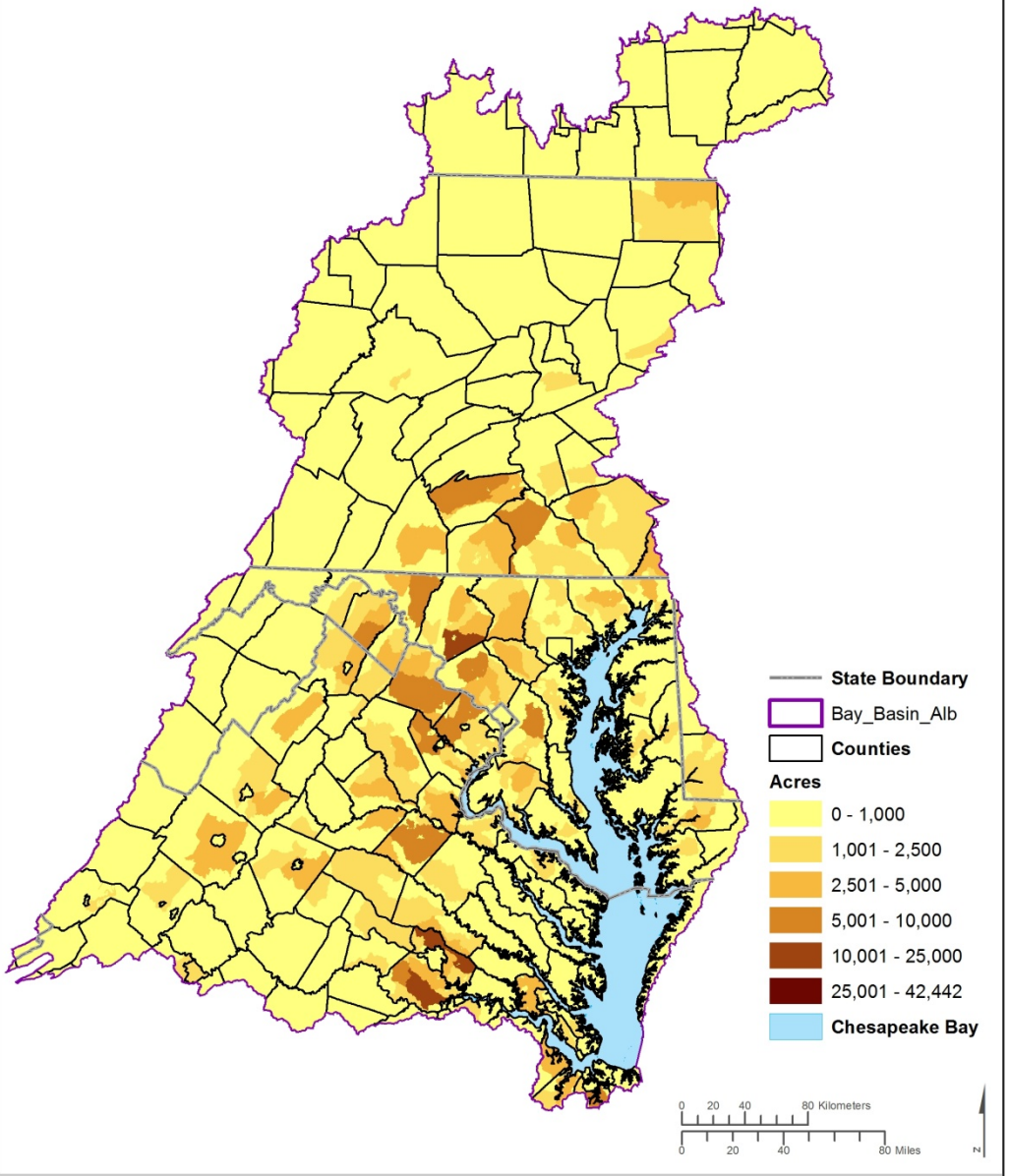
Purposes:

1. Provide the specific land-use data input needs for the Watershed Model and to accommodate the best available regional data.
2. Inform State offset and trading policies and Phase III Watershed Implementation Plan development through simulating alternative future land use scenarios (in absence of jurisdictional forecasts).
3. Provide an objective basis for evaluating jurisdictional forecasts.

USGS

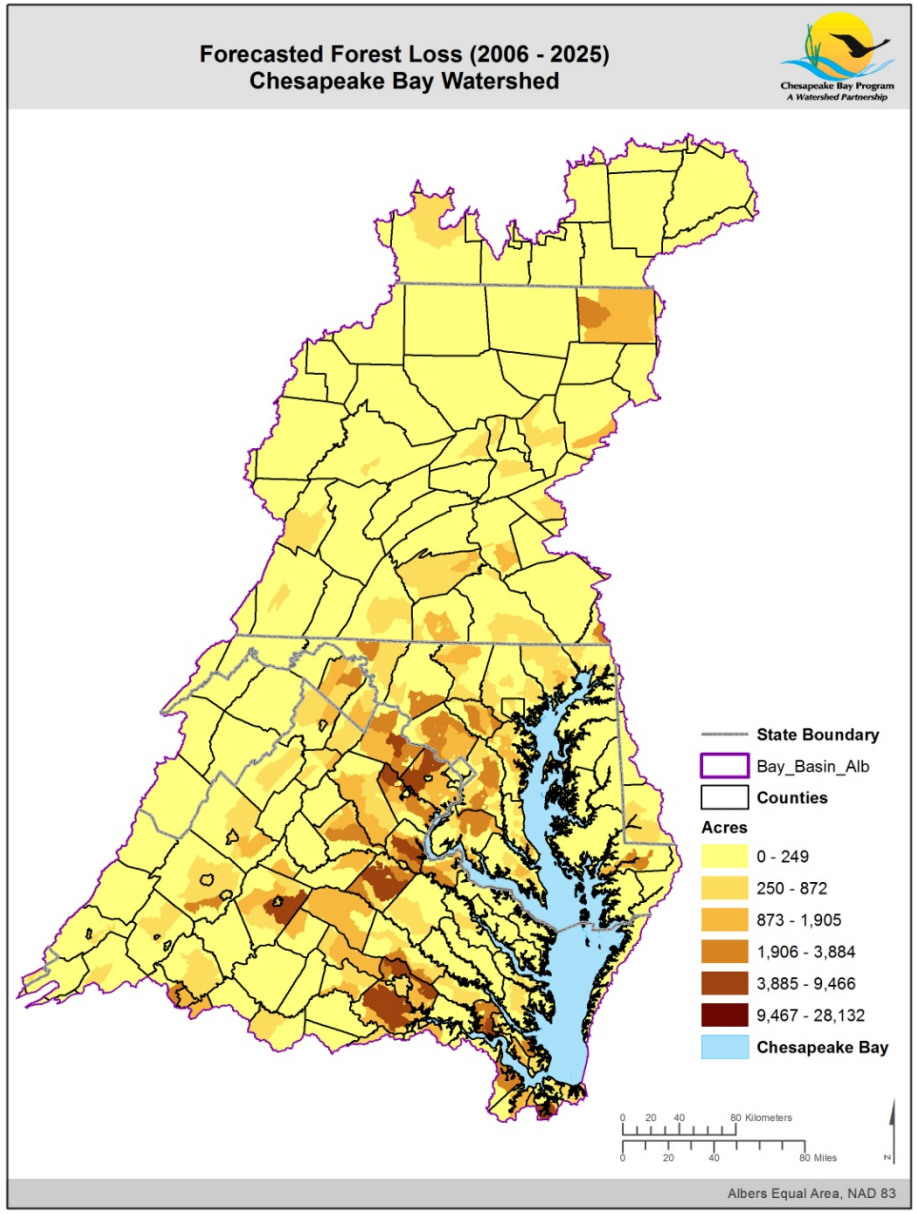
Forecasted Urban Growth (2006 - 2025)
Chesapeake Bay Watershed

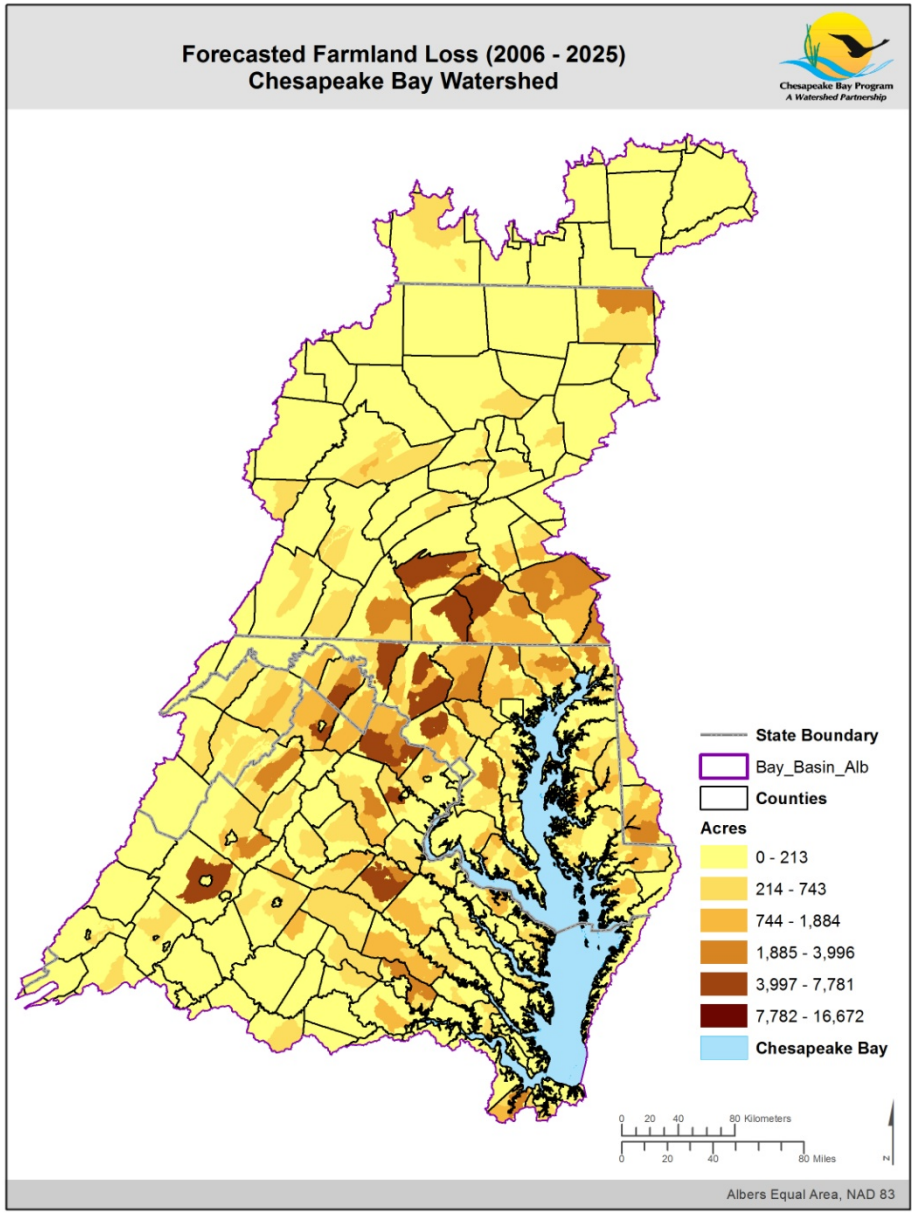
Chesapeake Bay Program
A Watershed Partnership



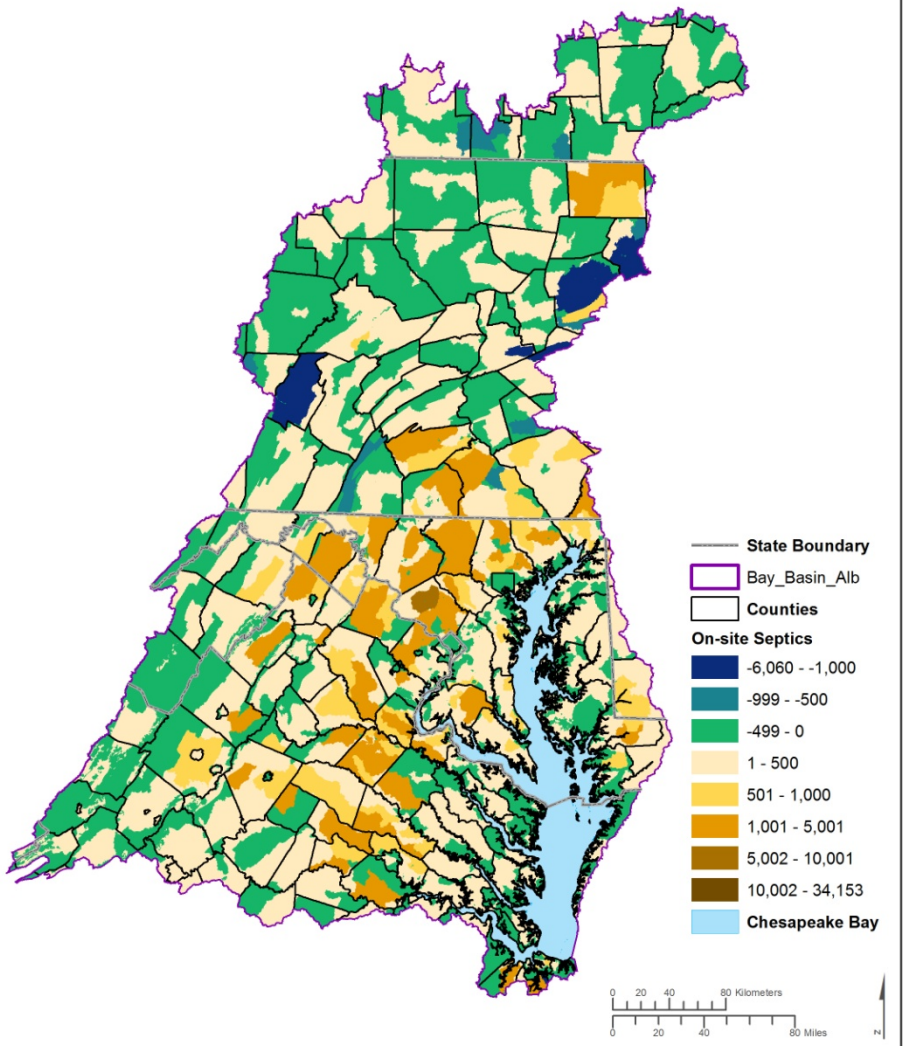
Albers Equal Area, NAD 83

USGS


Forecasted Forest Loss (2006 - 2025)
Chesapeake Bay Watershed
Chesapeake Bay Program
A Watershed Partnership
State Boundary
Bay_Basin_Alb
Counties
Acres
0 - 249
250 - 872
873 - 1,905
1,906 - 3,884
3,885 - 9,466
9,467 - 28,132
Chesapeake Bay
0 20 40 80 Kilometers
0 20 40 80 Miles
N
Albers Equal Area, NAD 83

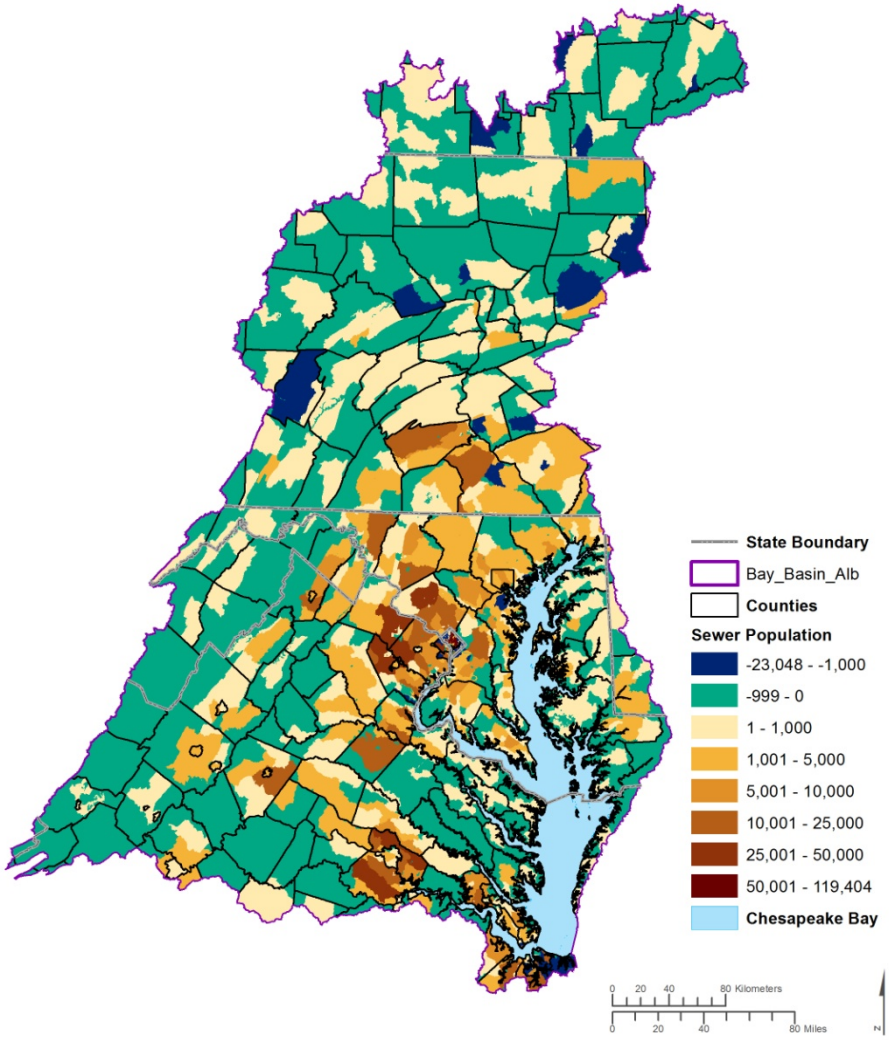

Forecasted Farmland Loss (2006 - 2025)
Chesapeake Bay Watershed
Chesapeake Bay Program
A Watershed Partnership
State Boundary
Bay_Basin_Alb
Counties
Acres
0 - 213
214 - 743
744 - 1,884
1,885 - 3,996
3,997 - 7,781
7,782 - 16,672
Chesapeake Bay
0 20 40 80 Kilometers
0 20 40 80 Miles
N
Albers Equal Area, NAD 83

Septic Systems (2010 - 2025)
Chesapeake Bay Watershed



Albers Equal Area, NAD 83

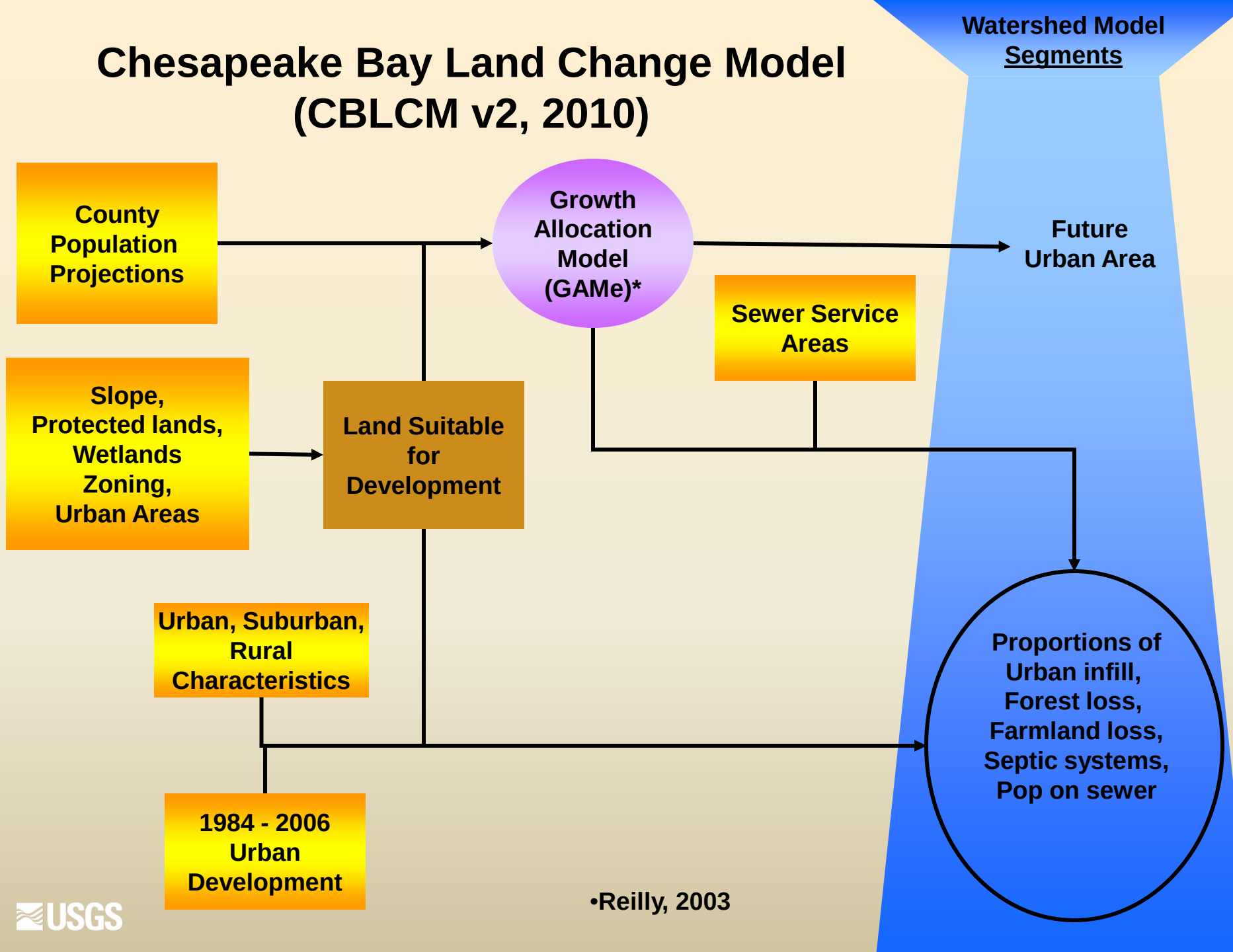
Sewer Population (2010 - 2025)
Chesapeake Bay Watershed



Albers Equal Area, NAD 83

USGS

Chesapeake Bay Land Change Model (CBLCM v2, 2010)



•Reilly, 2003

USGS

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

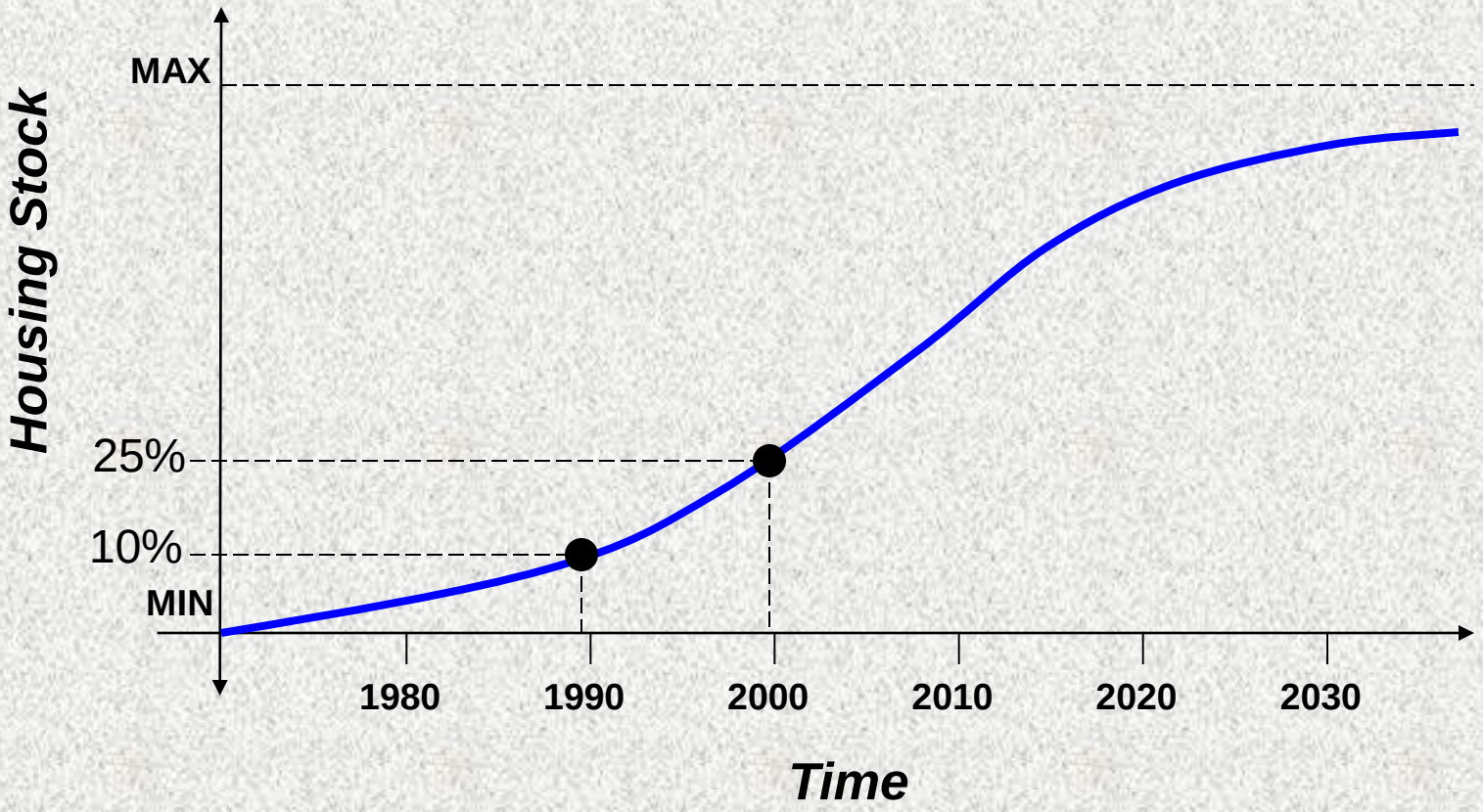
Population projection - Pop in group housing
Estimated future average household size

+ Estimated vacant housing

Gompertz Curve

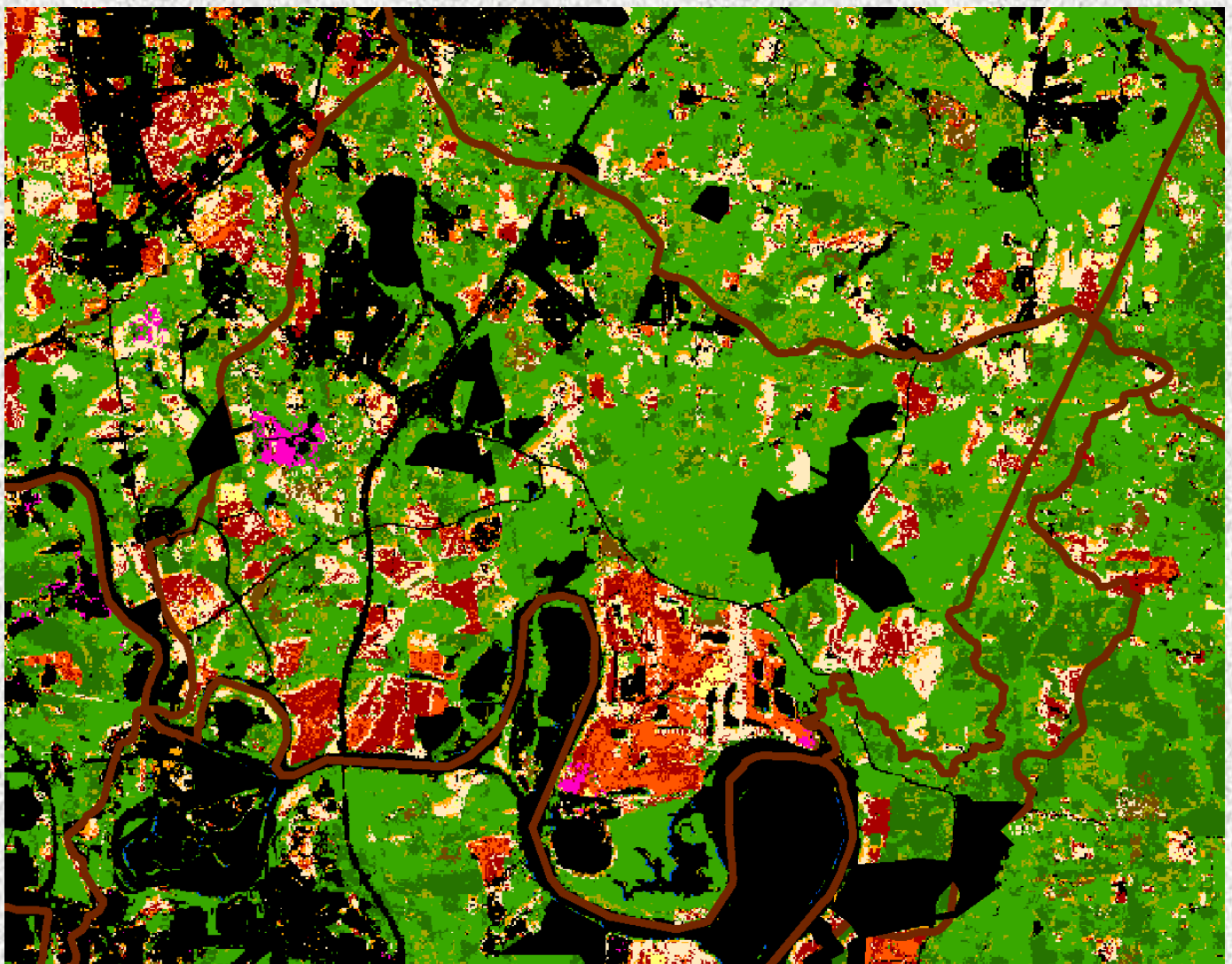
Future housing stock =

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



Maximum Housing Stock =

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

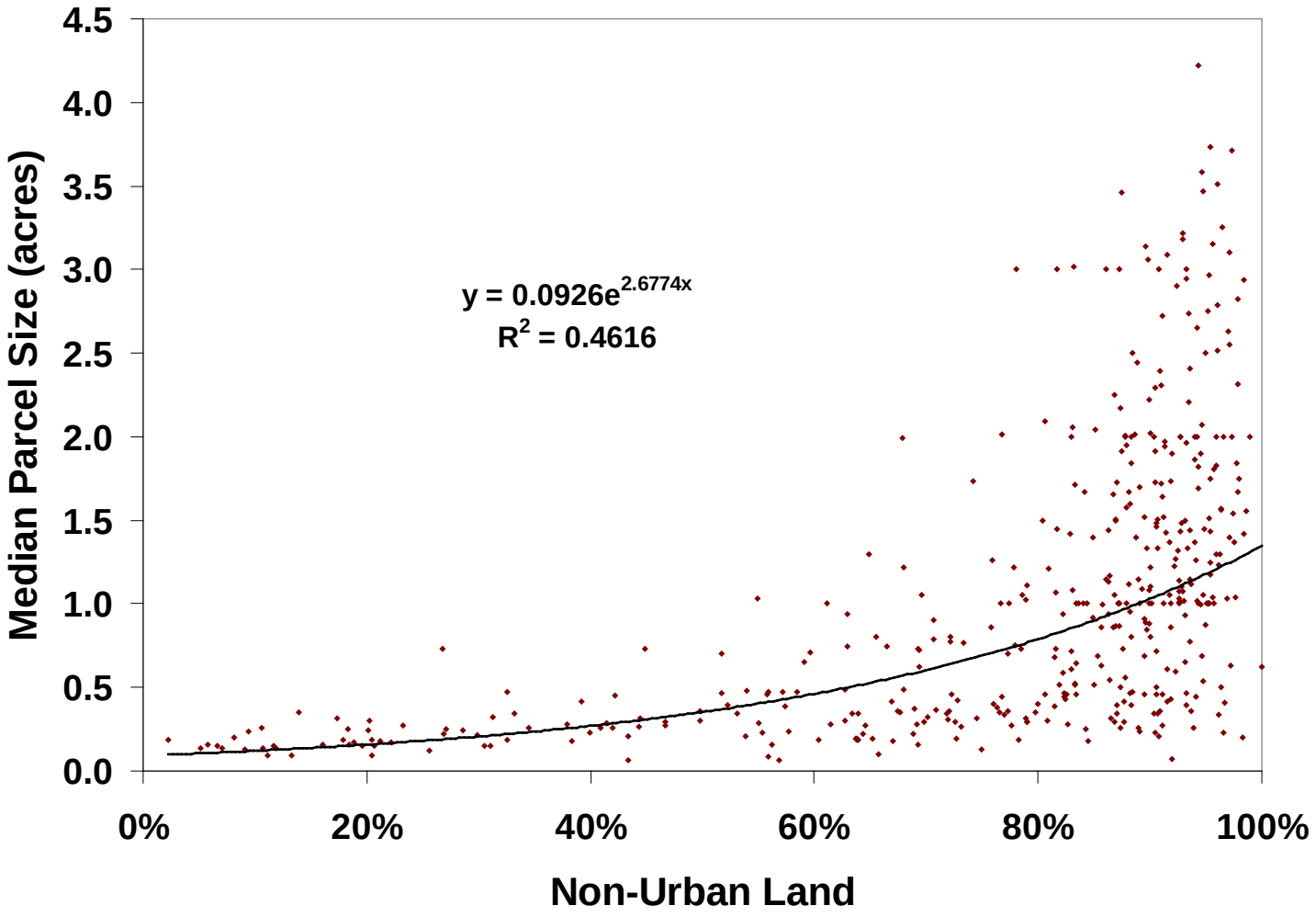
2030 Urban Area = 2000 Urban Area +
(additional units * urban land per house * density adjustment factor)

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

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

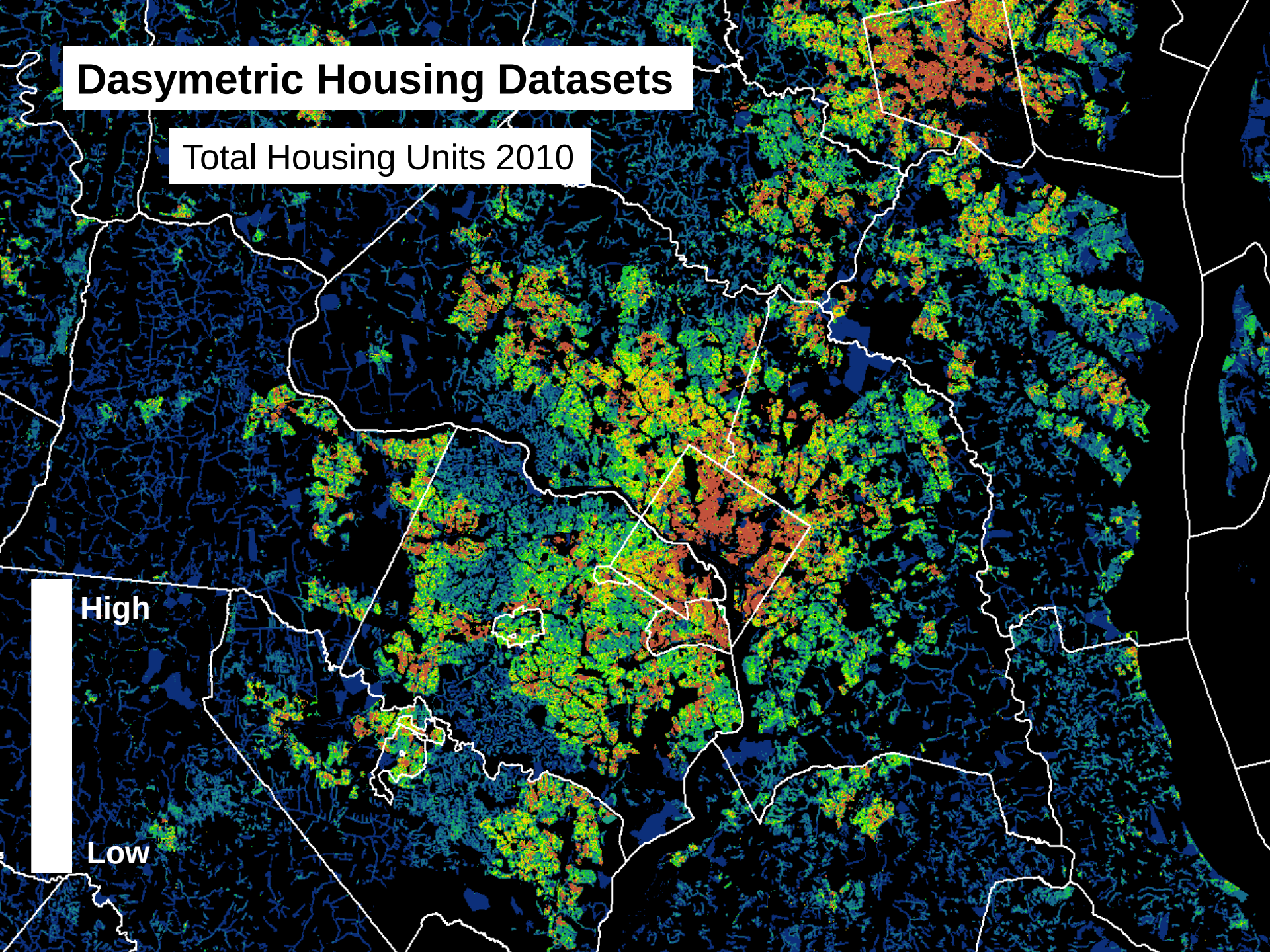
= 18,333 acres

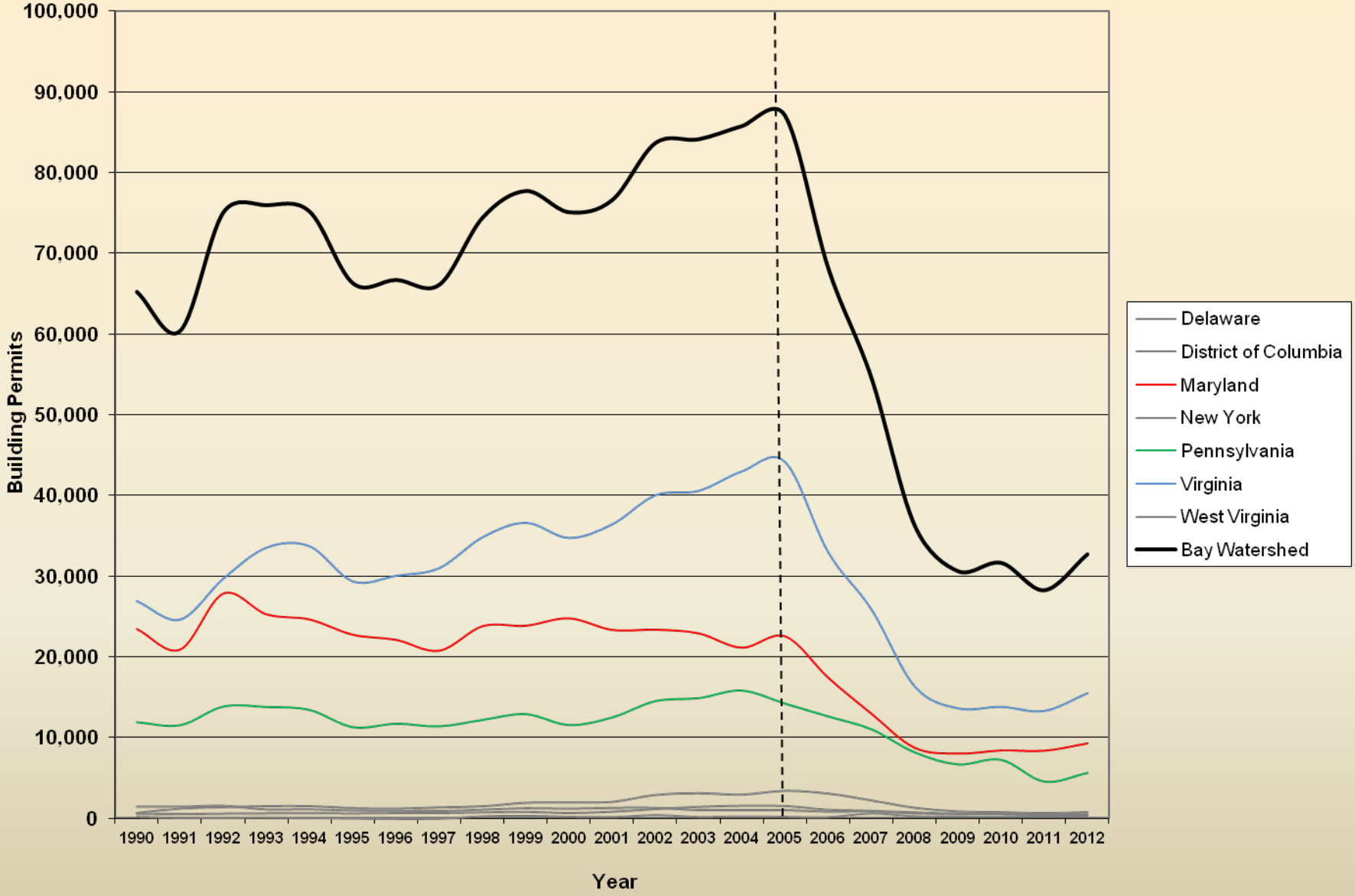
Density Factor Adjustment
f (% non-urban land in modeling segment)



Dasymetric Housing Datasets

Total Housing Units 2010




100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Building Permits
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Year
Delaware
District of Columbia
Maryland
New York
Pennsylvania
Virginia
West Virginia
Bay Watershed

Estimating Population on Sewer and On-site Septic Systems 2010 – 2015 by Modeling Segment

# of septic systems in 2010 =

total housing units outside yr. 2000 sewer service areas * ratio of single-detached households to total housing units outside sewer service areas

# of septic systems in 2015 = septics in 2010 +

total housing units change (2010 – 2015) * potential growth on septic† * ratio of single-detached households to total housing units outside future sewer service areas * County 5-yr rate of change in proportion of single-unit building permits

† **Potential growth on sewer considers:**

proportion of historical growth (1984 – 2006) on sewer
proportion of change in total housing units on sewer (2000 – 2010)
proportion of remaining land available for development within future sewer service area

Estimating Population on Sewer by Modeling Segment

Population on Sewer in 2010 =

(Total Population 2010)

- (# of Septic Systems / Average Household Size 2010)

Population on Sewer in 2015 =

(Total Population 2015)†

- (# of Septic Systems / Average Household Size est. 2015)

† **Total population in future years =**

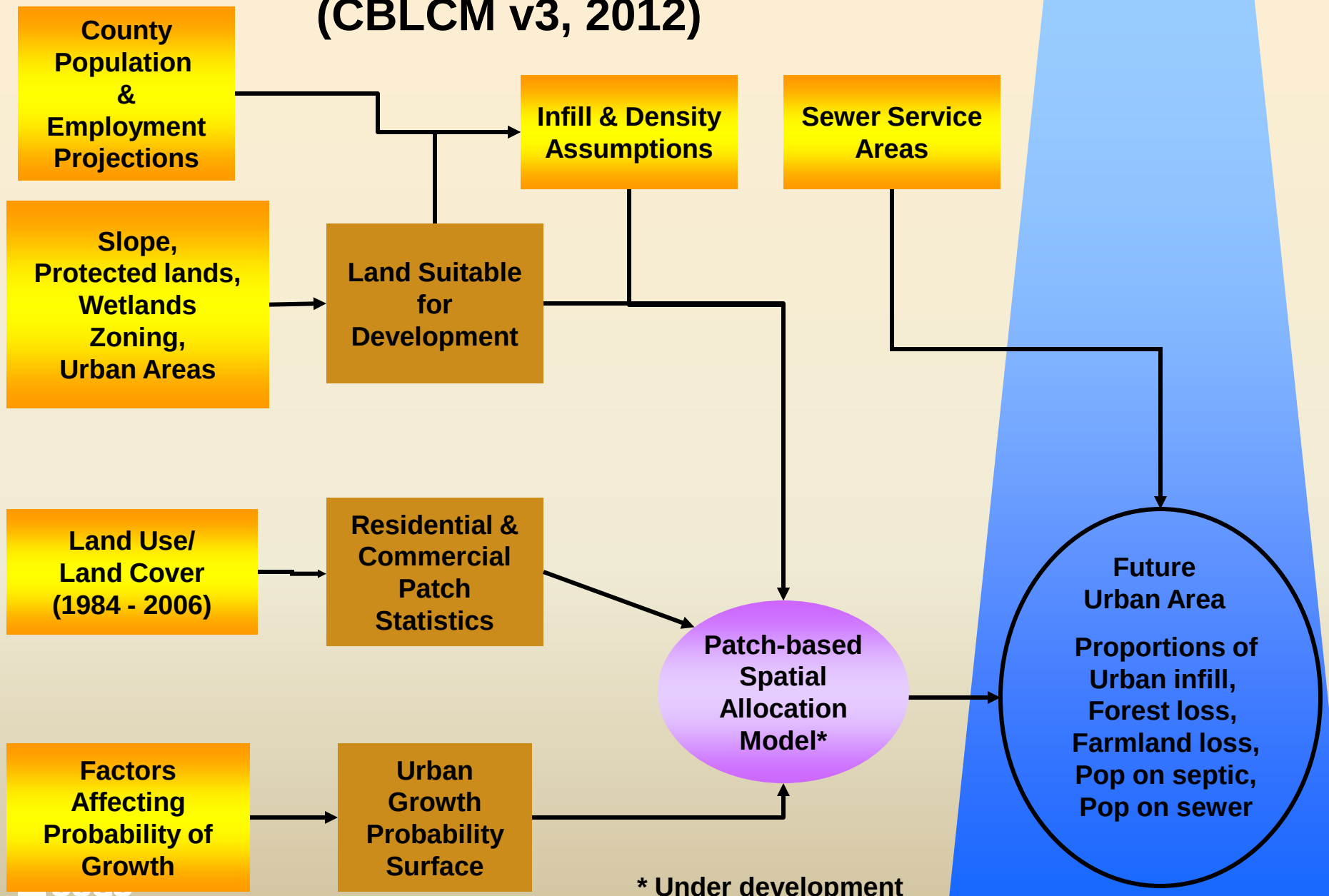
[Total housing unit change * ratio of households to housing units * average household size in 2010 * (1- proportion of pop change due to migration)] +

[Total housing unit change * ratio of households to housing units * average household size in 2015 * (proportion of pop change due to migration)]

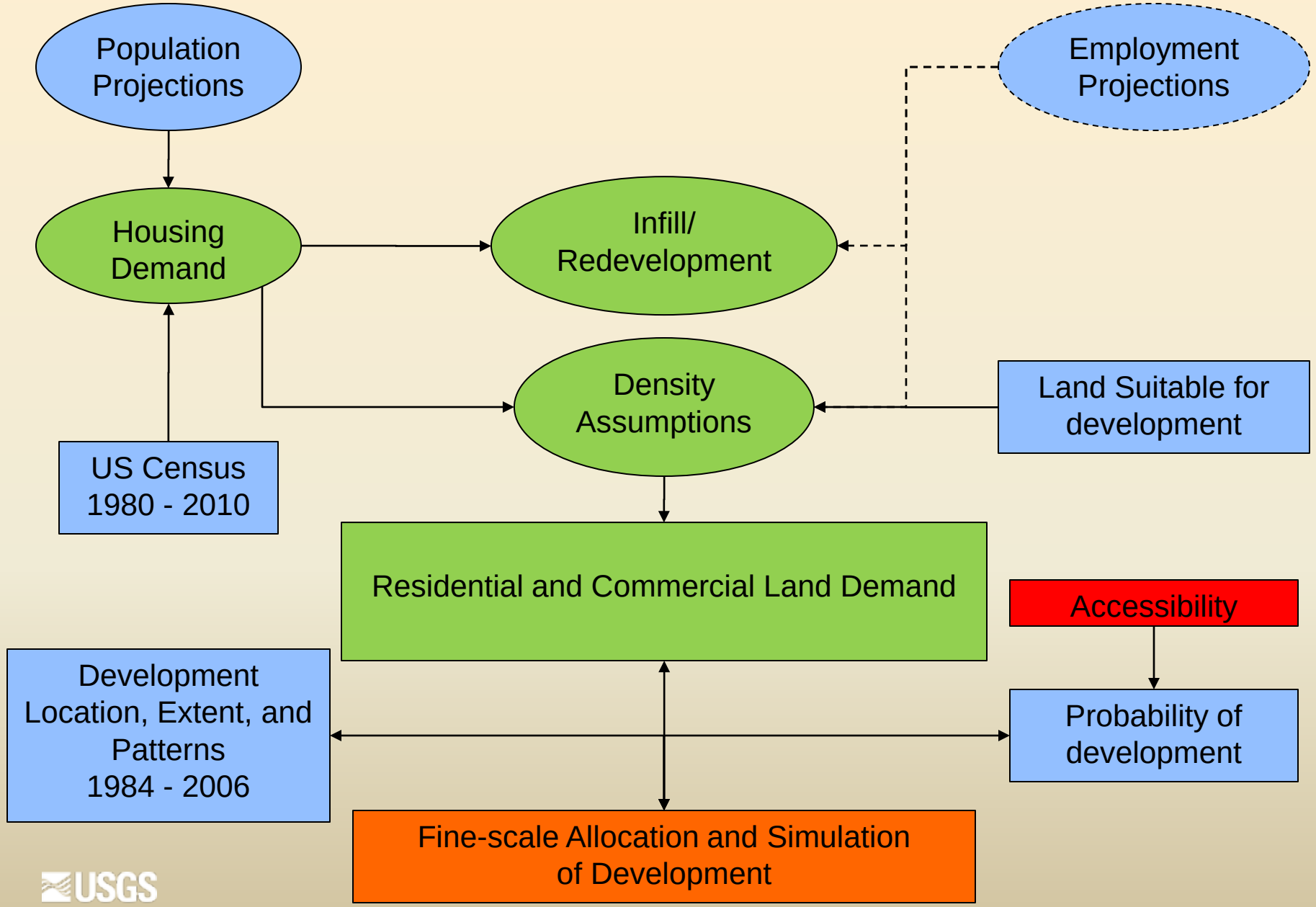
Some Important Issues

- Ground-truth data comparison
- Single-attached households on septic?
- Vacant housing units on septic?
- Segment vs County vs State scale generalizations
- Consideration of migration when converting households to population

Chesapeake Bay Land Change Model (CBLCM v3, 2012)



Chesapeake Bay Land Change Model v3a



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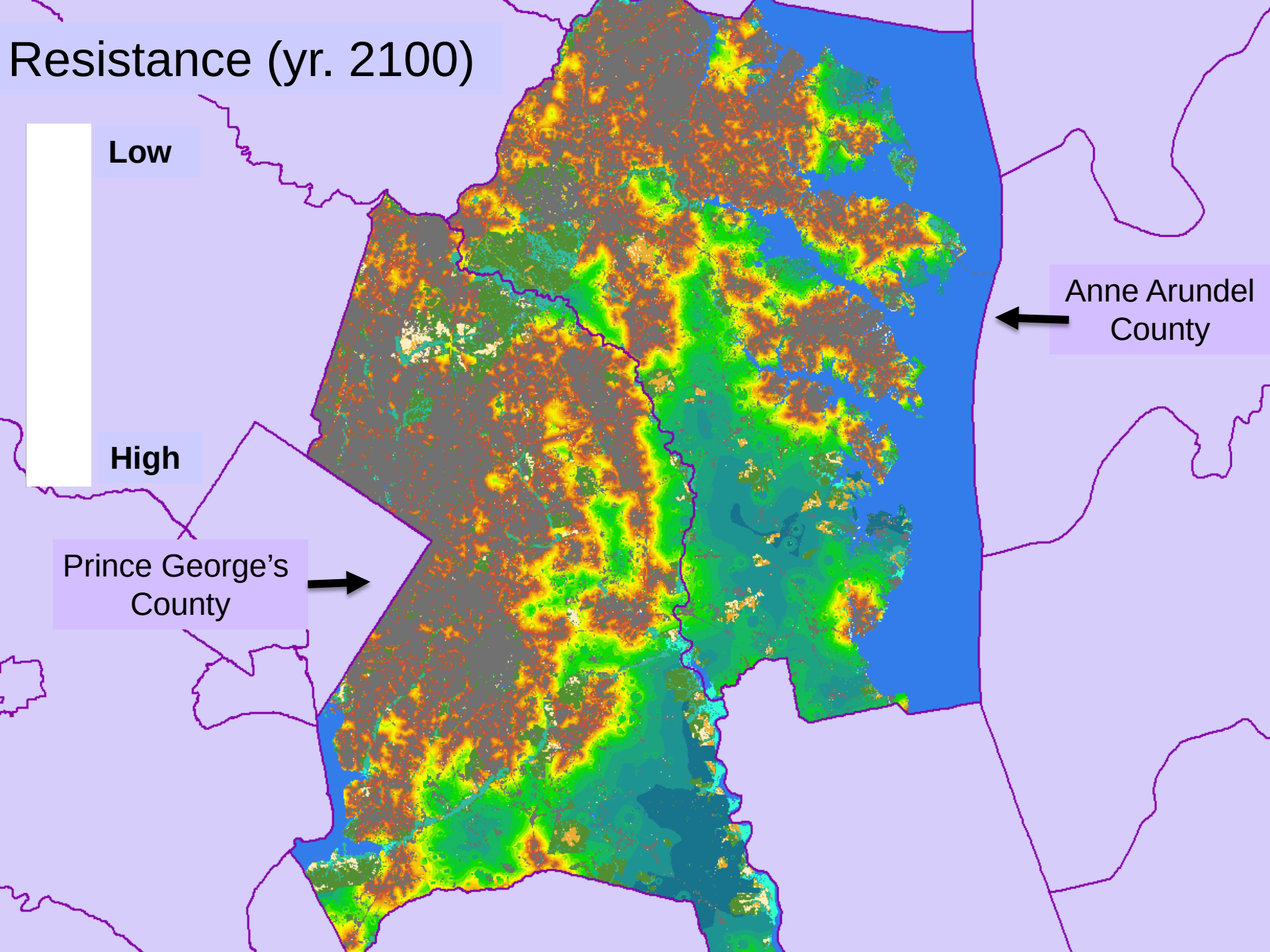
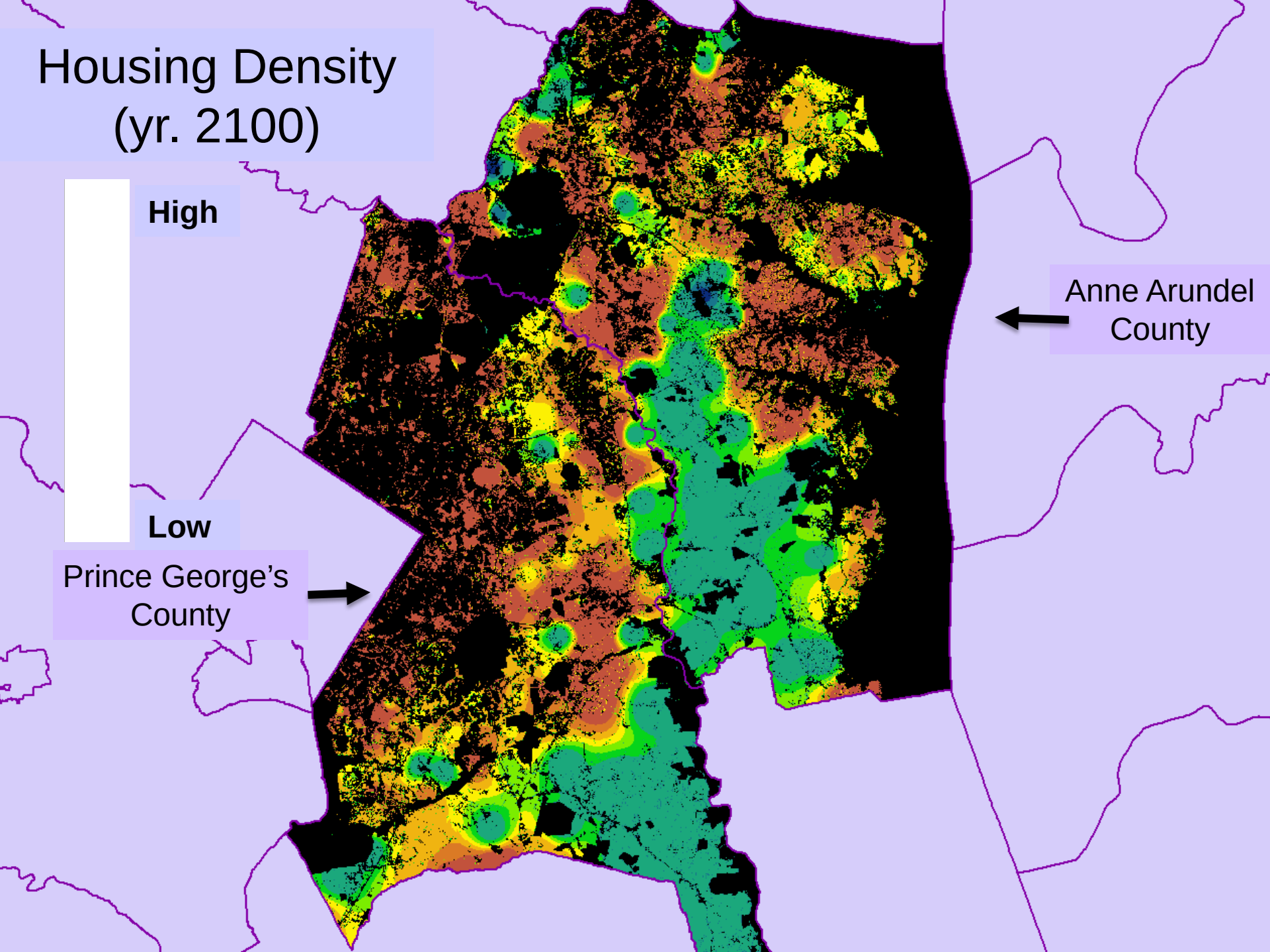
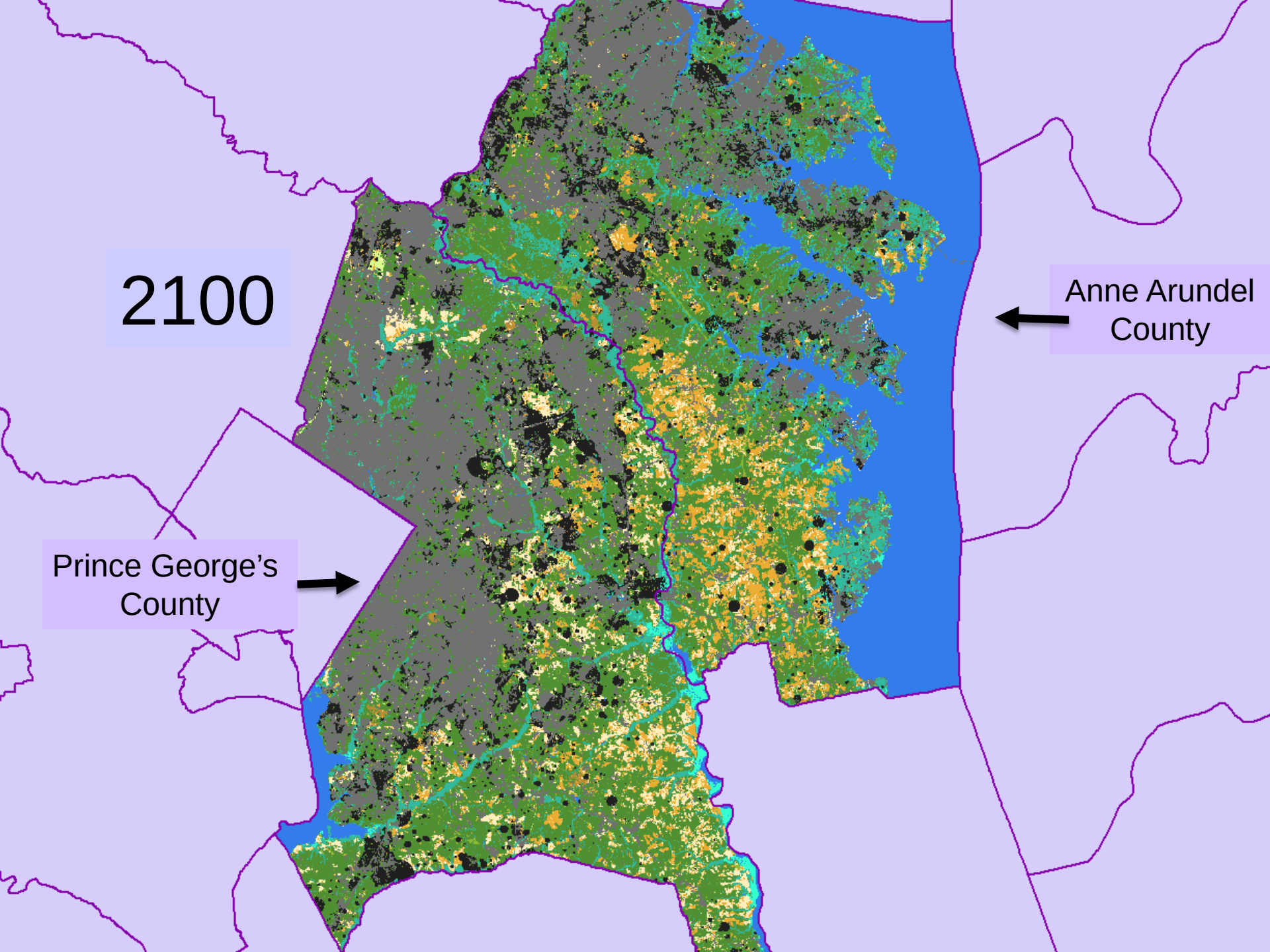
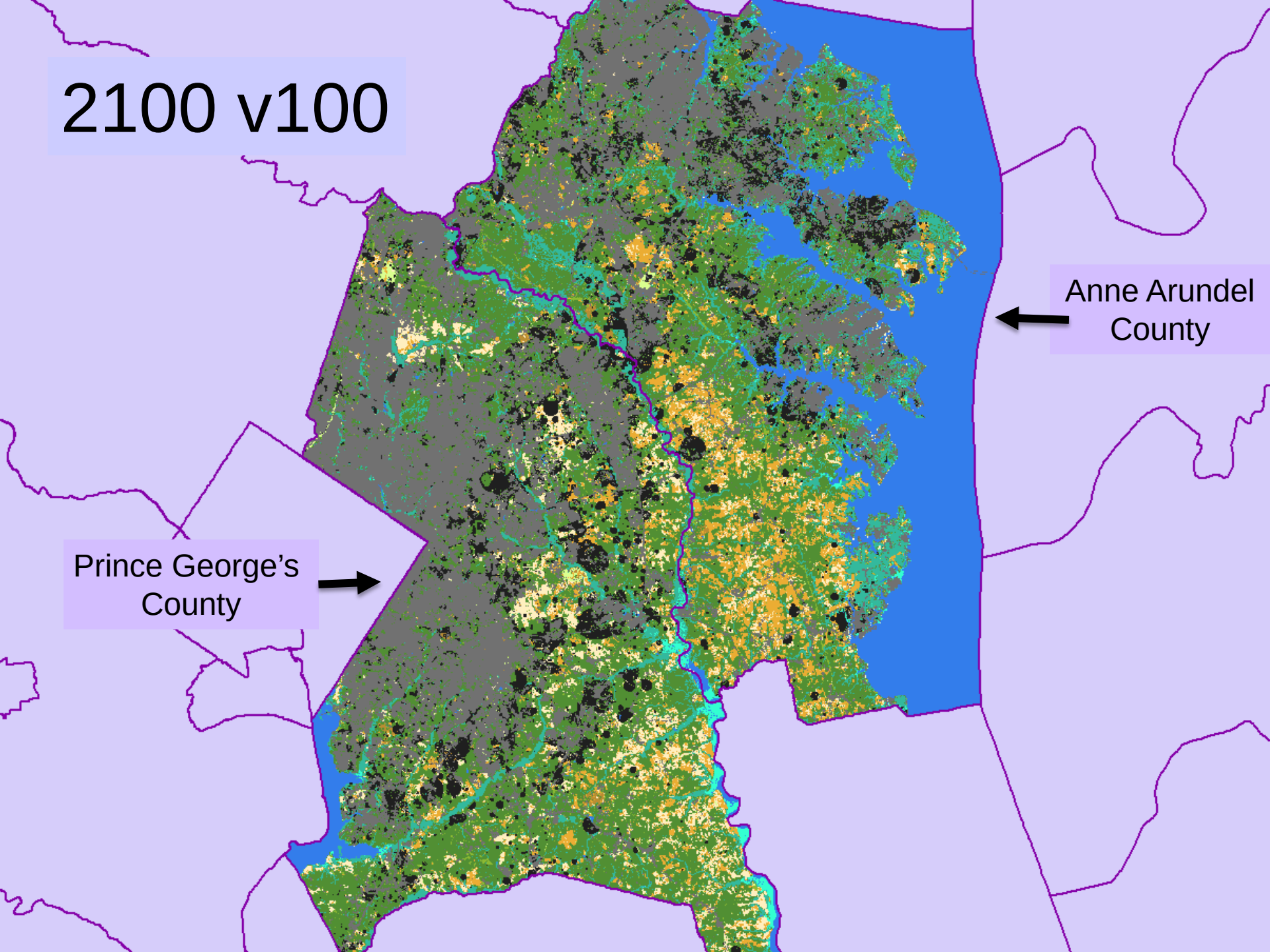
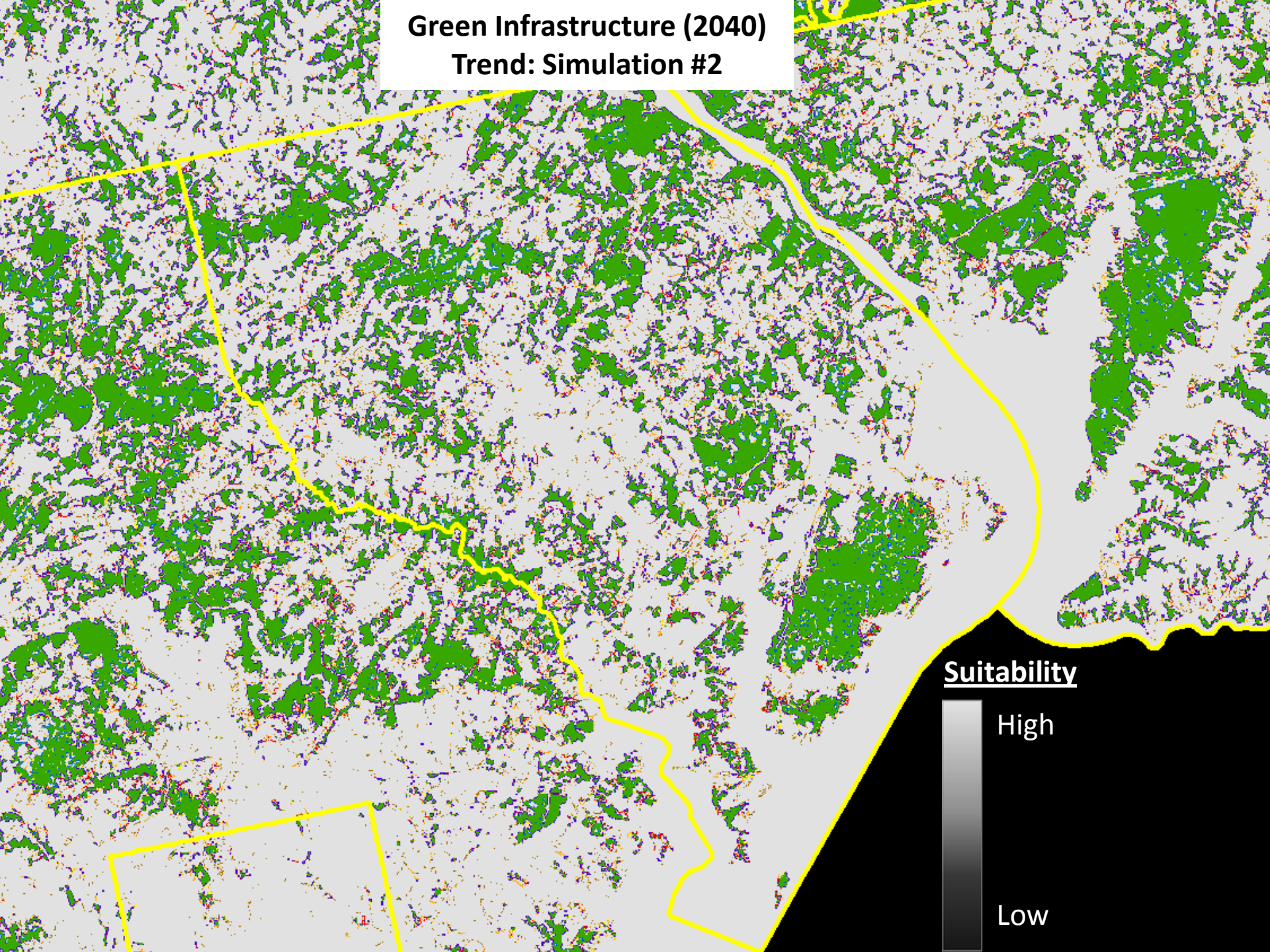

Resistance (yr. 2100)
Low
High
Anne Arundel County
Prince George's County

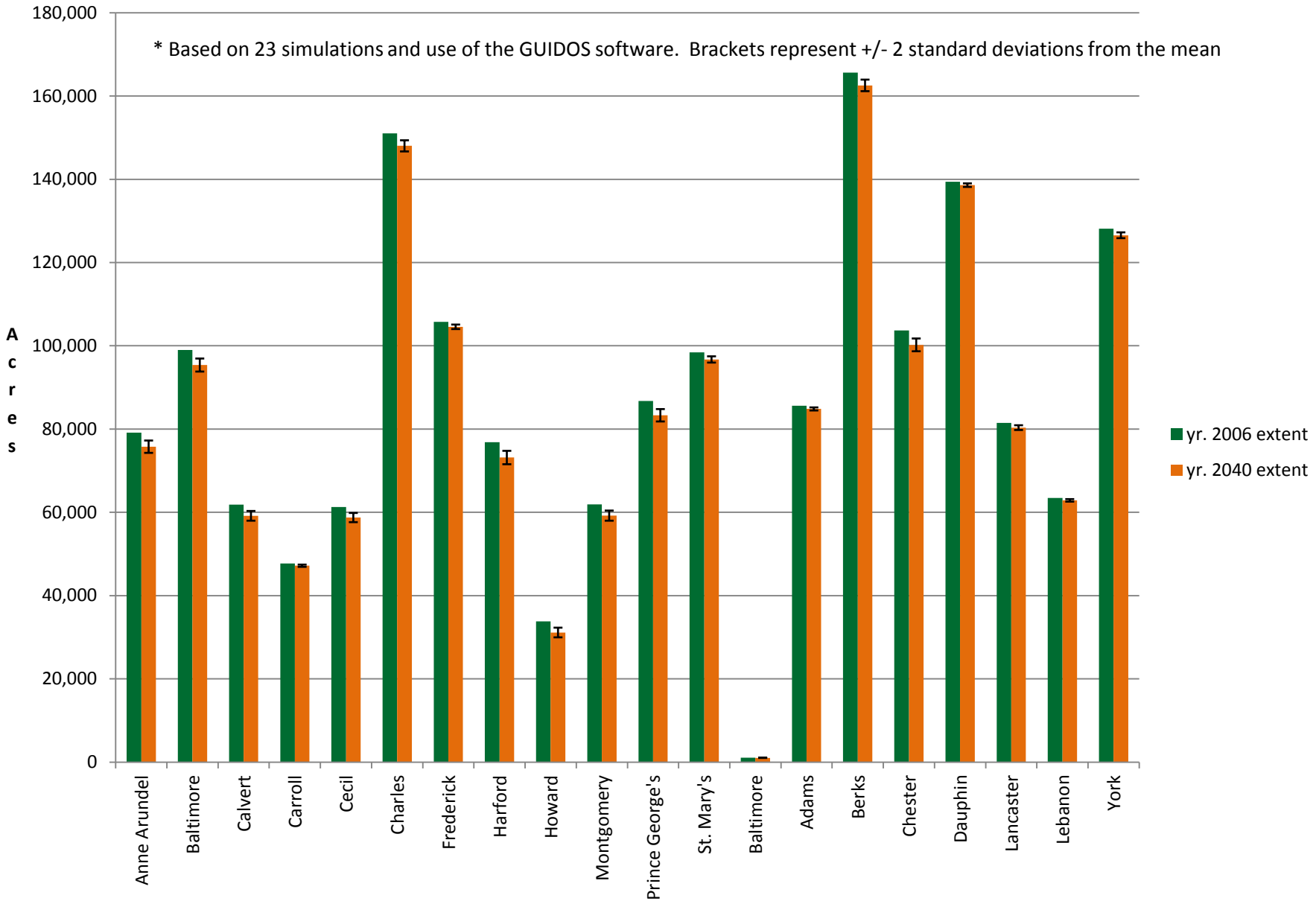

Housing Density
(yr. 2100)
High
Low
Prince George's
County
Anne Arundel
County


2100
Anne Arundel County
Prince George's County

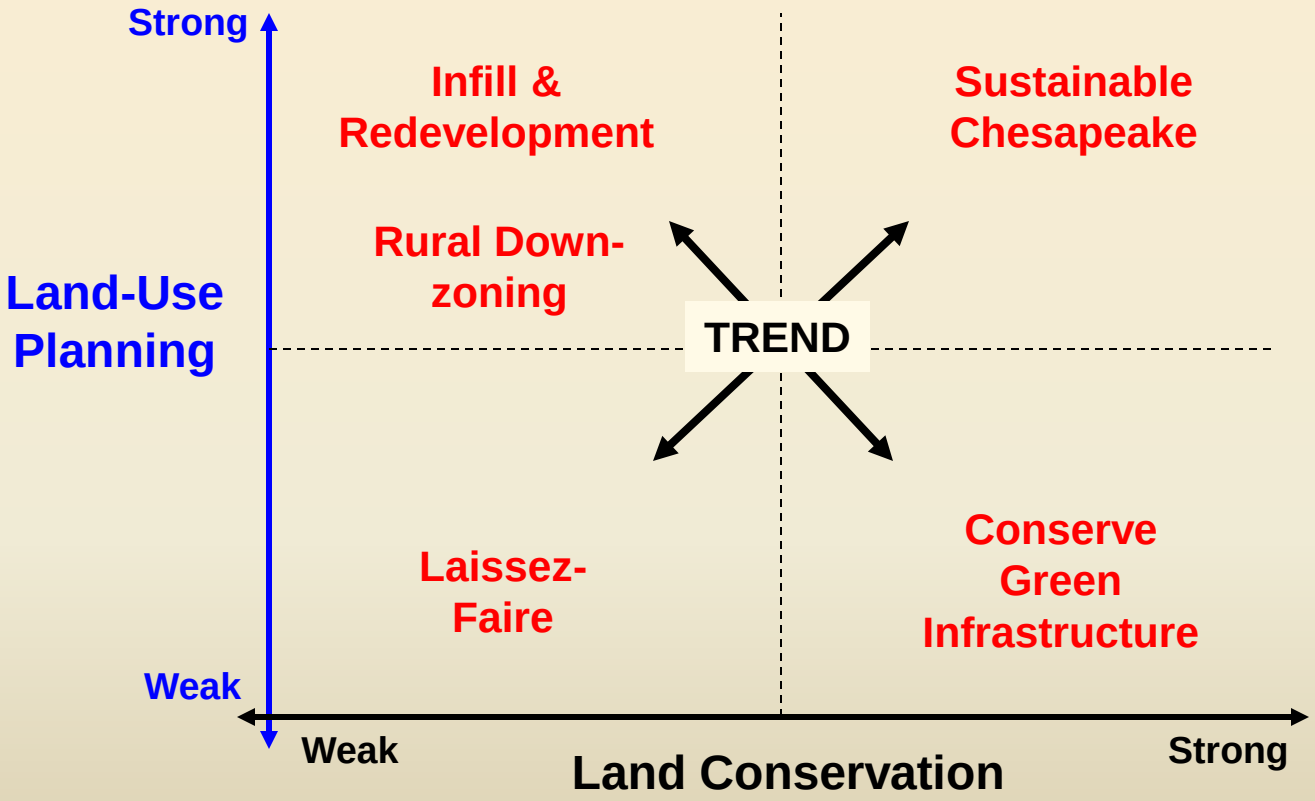

2100 v100
Anne Arundel County
Prince George's County


Green Infrastructure (2040)
Trend: Simulation #2
Suitability
High
Low

Change in Core Forest Extent 2006 - 2040



Chesapeake Bay Alternative Future Development Scenarios



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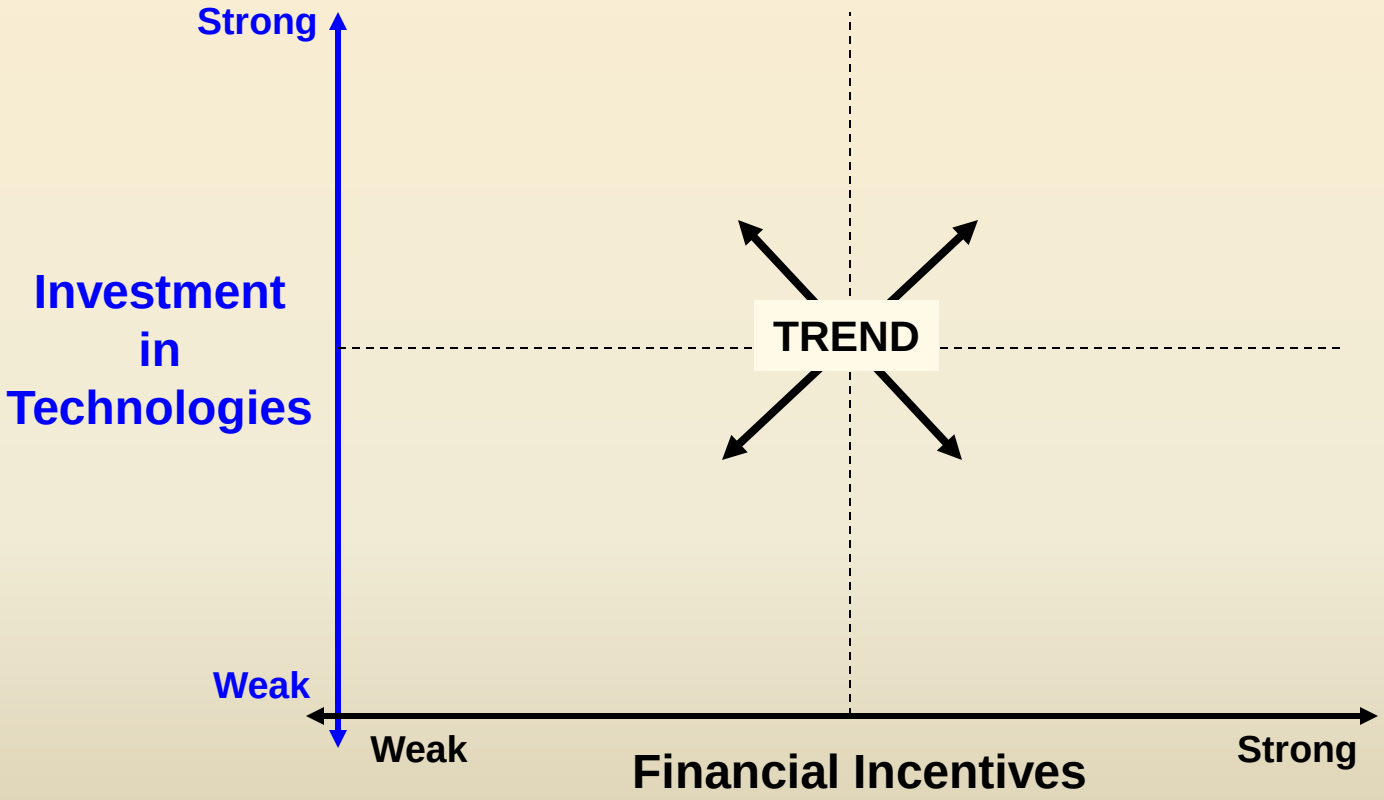

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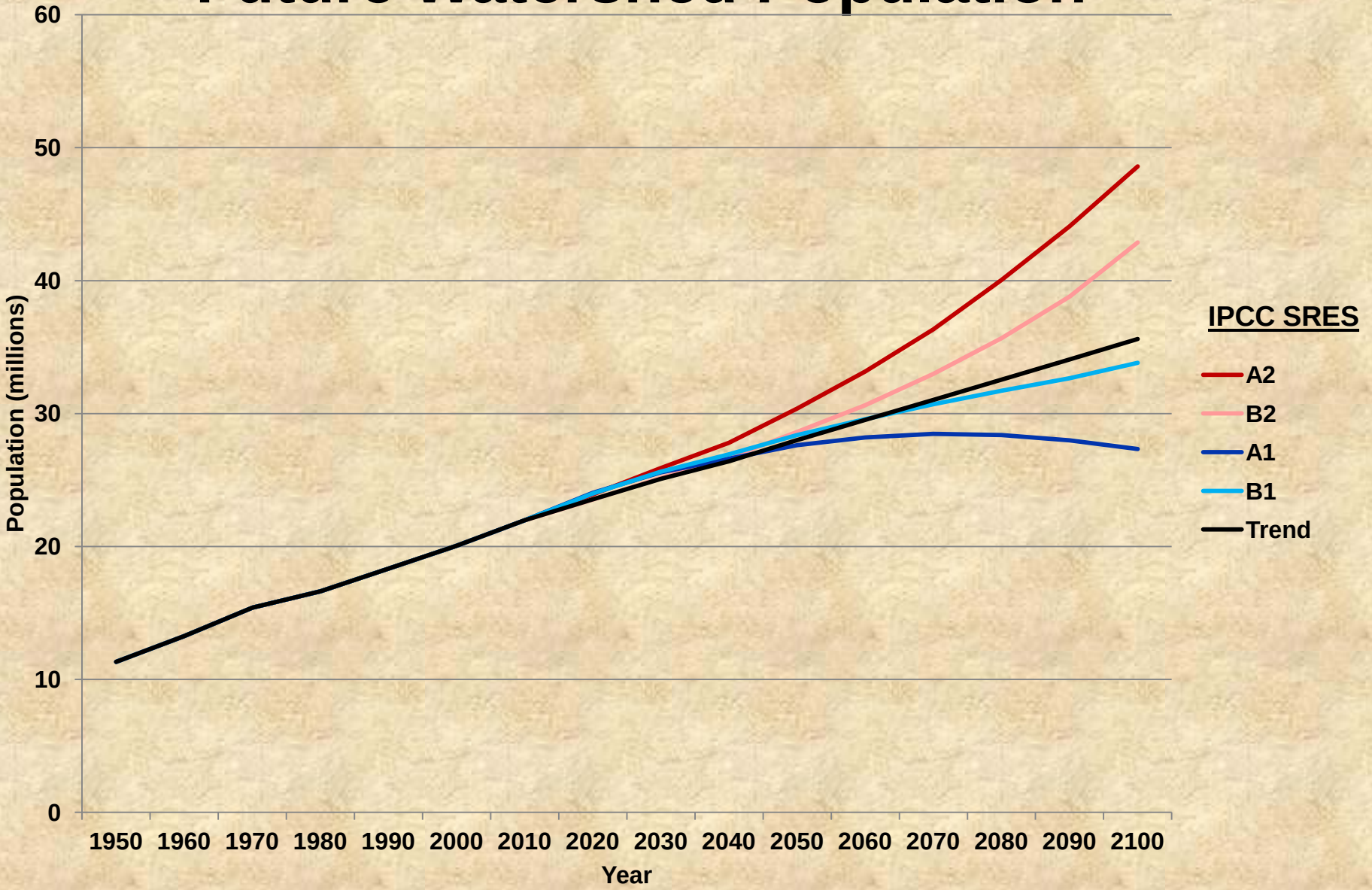
Future Watershed Population



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Major Assumptions in CBLCM v2

1. Urban growth is dictated by population growth

2. Onsite wastewater treatment systems = occupied single-detached housing units outside sewer service areas

3. Historic urban growth patterns at the sub-county level will continue if the county population is projected to increase and land remains available for development.

4. Historic proportions of forest to farmland converted to development are fixed.

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Criteria for Evaluating Projections

- Credible:
  supported by the best available information and data, assumptions, and by comparisons with independent information demonstrating accuracy.

- Transparent:
  based on thoroughly documented, published, and accessible methods and/or data sources.

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