Past Methods of Modeling Land Use Data

Peter Claggett, Fred Irani, Renee Thompson, Quentin Stubbs, and David Donato

Research Geographer
USGS Eastern Geographic Science Center

CBP Land Use Workgroup Inaugural Meeting
September 17, 2012

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

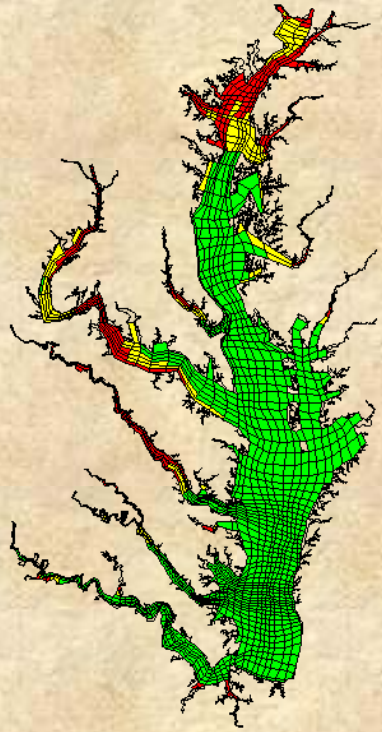
Chesapeake Bay
Modeling to Inform Management Decisions

Chesapeake Bay Living Resources

Water Quality Criteria

- **Dissolved Oxygen**
- **Water Clarity**
- **Chlorophyl- a**

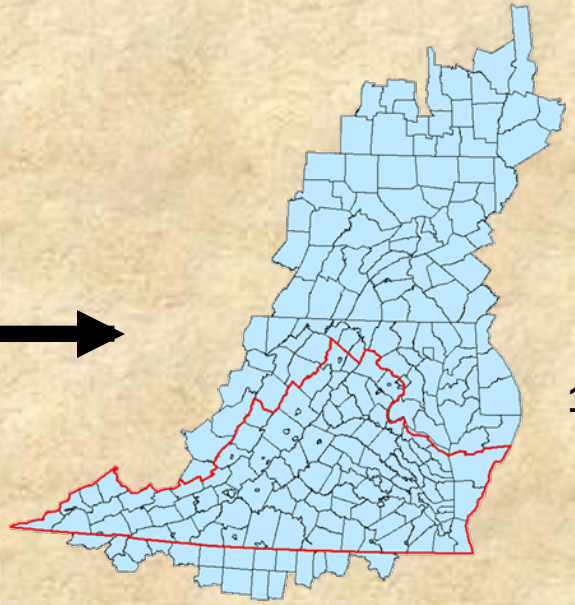
Water Quality Model



Chesapeake Bay
Modeling to Inform Management Decisions

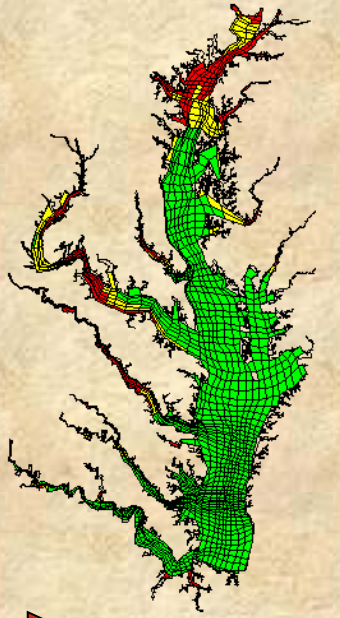
Land Change and Airshed Models

Watershed Model



186 million lbs. Total Nitrogen per year

Water Quality Model



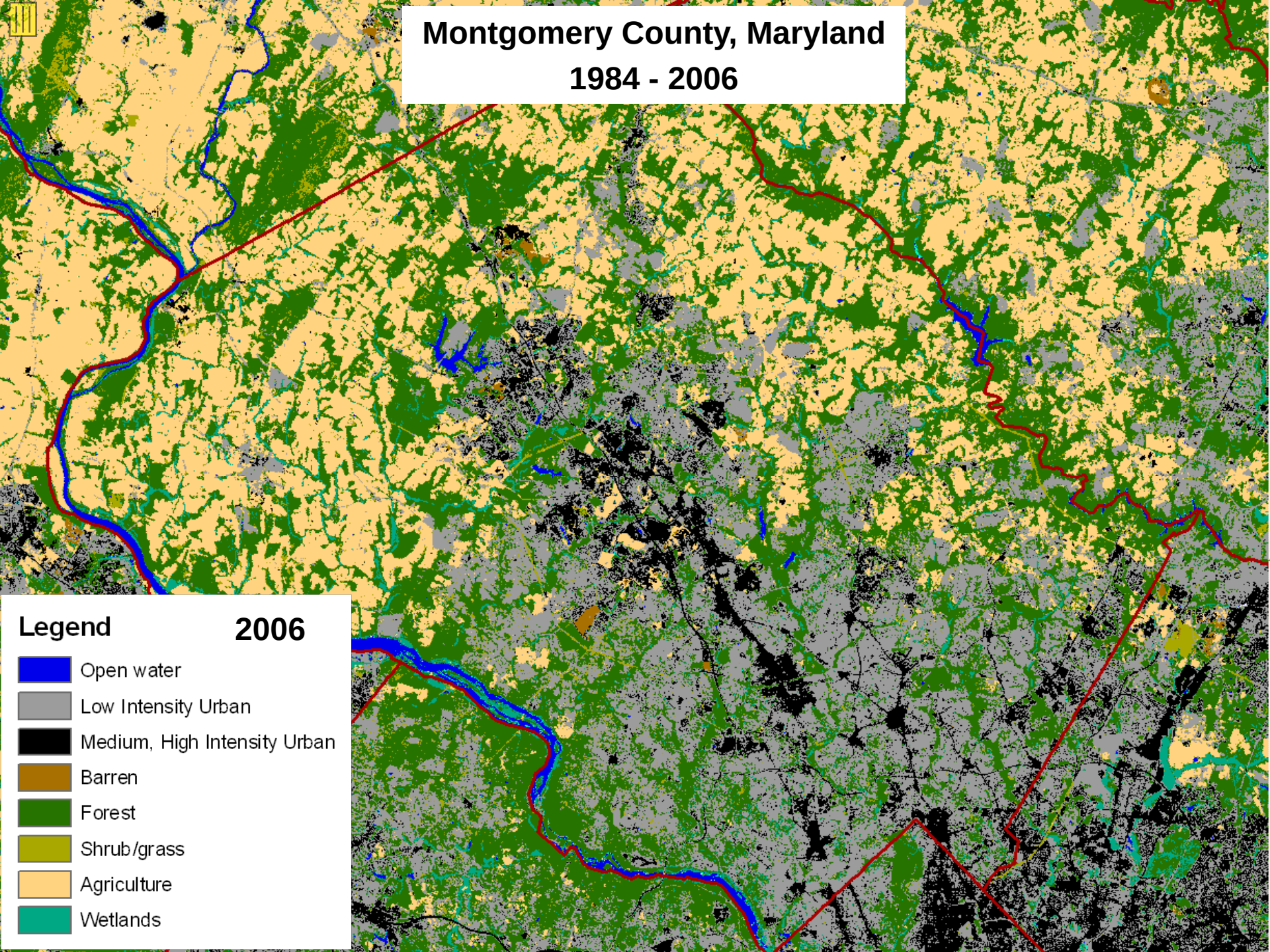
Assessment of nutrient load sources and effects

Allocation of nutrient load limits by County

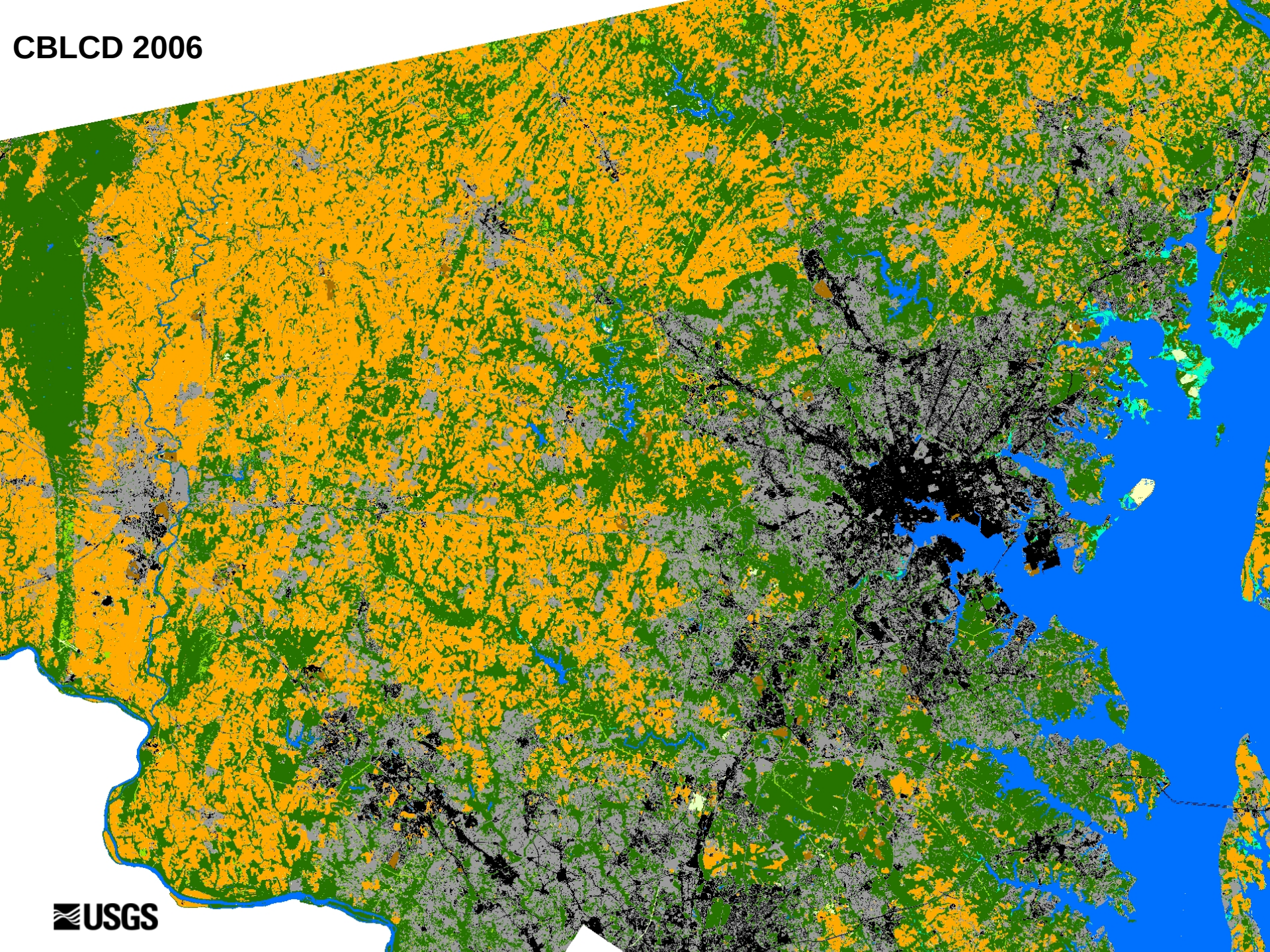
Chesapeake Bay Land Cover Data Series

1984 1992 2001 2006 2011

USGS

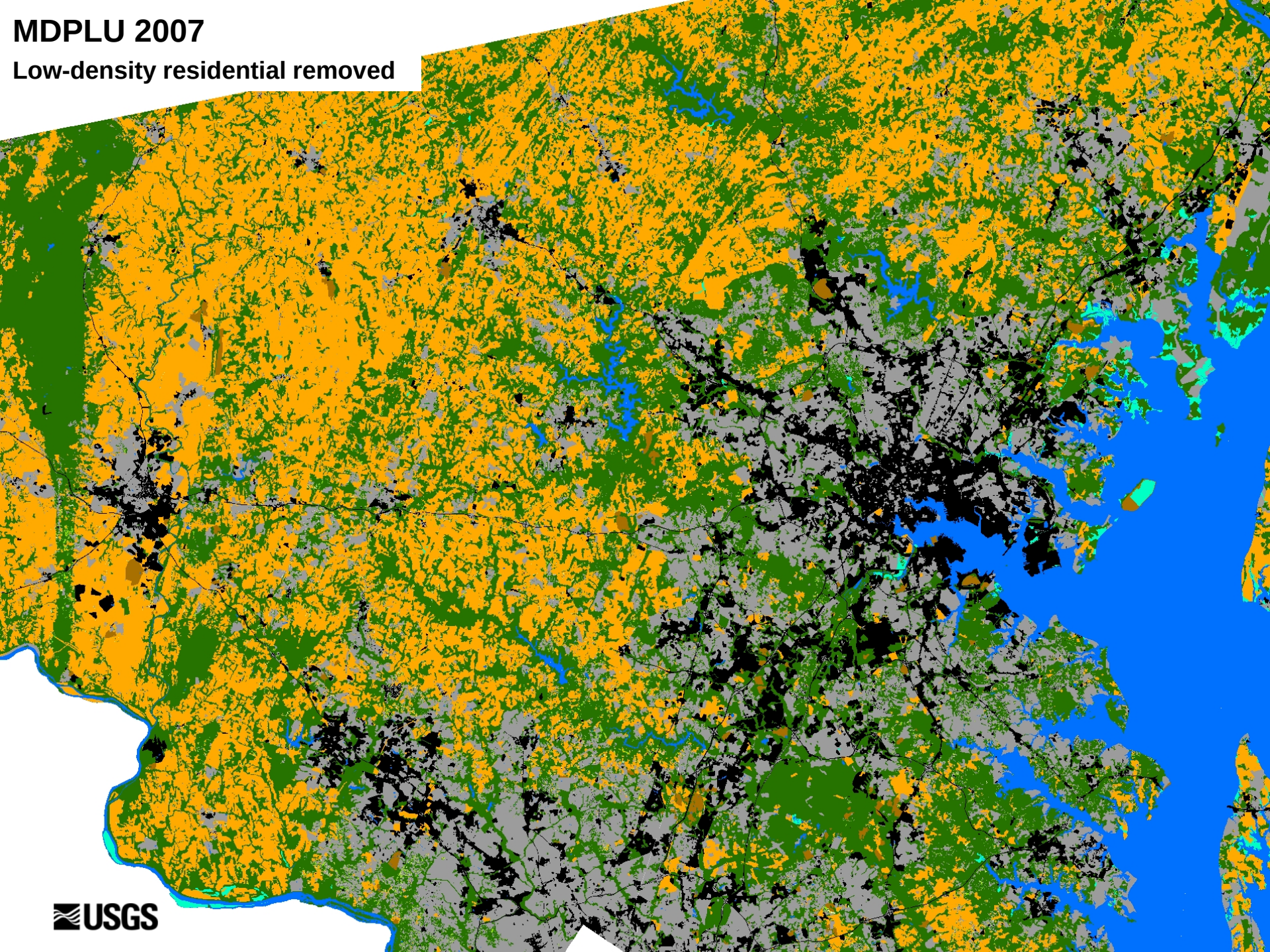

Montgomery County, Maryland
1984 - 2006
Legend
2006
Open water
Low Intensity Urban
Medium, High Intensity Urban
Barren
Forest
Shrub/grass
Agriculture
Wetlands

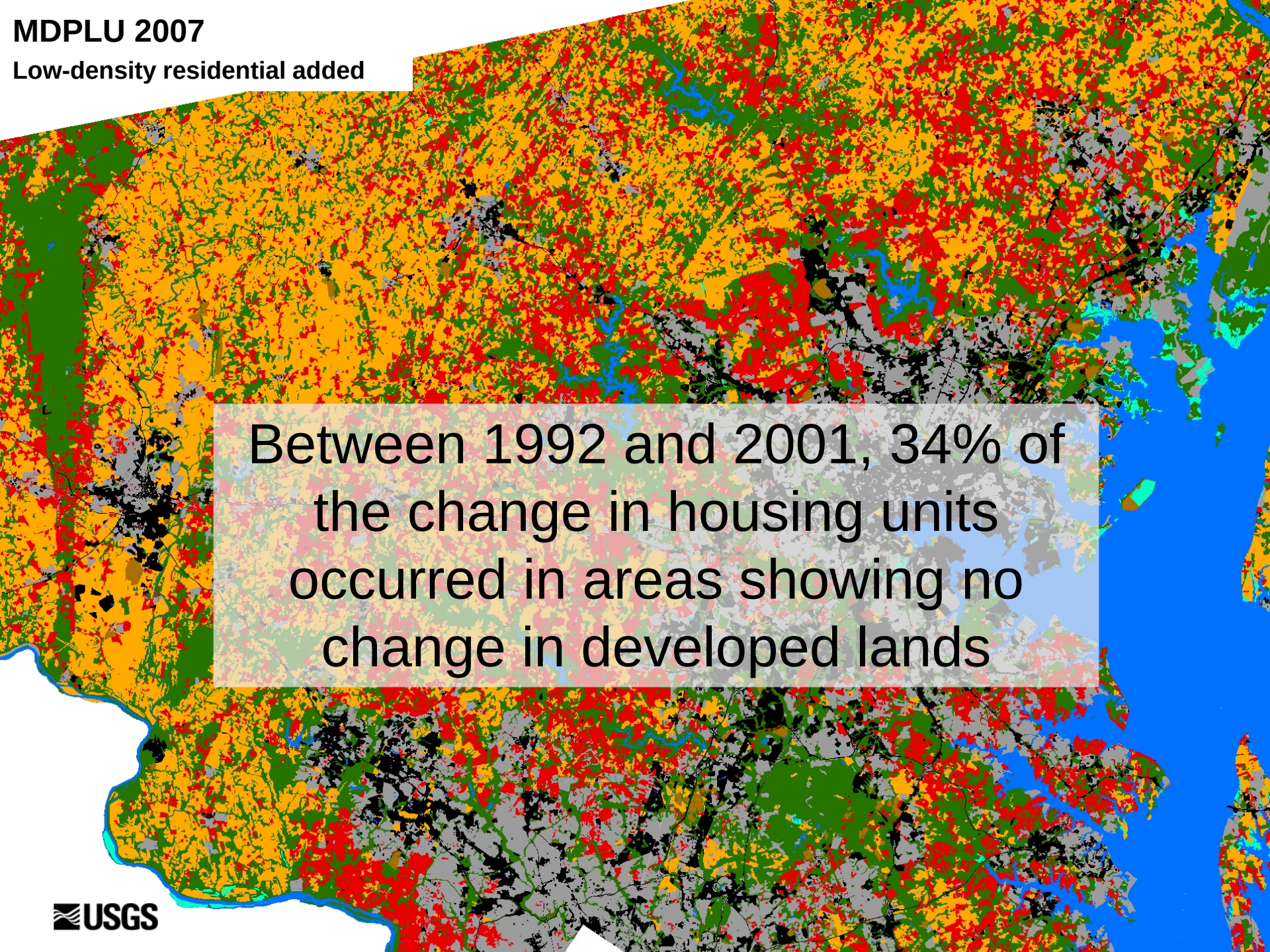
CBLCD 2006



MDPLU 2007

Low-density residential removed




MDPLU 2007
Low-density residential added
Between 1992 and 2001, 34% of the change in housing units occurred in areas showing no change in developed lands
USGS

Landsat Land Cover Change: 1984 –2006

- Tree canopy decreased 439,000 acres.
- Urban area increased 355,000 acres.
- Cropland and pasture decreased 93,000 acres.

CBP Modeled Land Use Change: 1985 –2005

- Other (forest) lands decreased 105,000 acres.
- Urban area increased 960,000 acres.
- Cropland and pasture decreased 856,000 acres.

USGS

Estimating Impervious Cover and Turf Grass in the Chesapeake Bay Watershed

Model Version	Impervious Surface (circa 2001/02)	Pervious Surface (circa 2001/02)
Phase 5.3.0 (land cover)	681,980	2,127,298
Phase 5.3.2 (land use)	1,207,346	3,143,388

Source:

Claggett, et al., submitted. Estimating the Extent of Impervious Surfaces and Turf Grass Across Large Regions. *Journal of the American Water Resources Association*

USGS

Phase 5.3.0

- Based on satellite derived land cover data (1984, 1992, 2001, 2006) and state mining information

Pros:

- Satellite data are comparable and consistent across space and time.
- Clear methodology.
- Impervious surfaces that may be most relevant to water quality are captured.

Cons:

- Low density residential development is not well represented.
- Roads are inconsistently represented.

Phase 5.3.2

- Based on a combination of land cover, roads, housing, impervious and road width coefficients, and state mining datasets.

Pros:

- Captures 94% (vs. 74%) of impervious surfaces in Montgomery County, MD.
- Pervious developed lands, representing mostly lawns, approximate the extent of turf grass estimated from Turf Grass Industry data (3.79 million acres).
- Estimates the number of septic systems within 1% of Maryland Dept. of Planning data (+ ~15% in Phase 5.3.0)

Cons:

- Very complex methodology involving a large number of assumptions.
- Impervious surface associated with farm buildings and rural warehouses are excluded.

P532 Turf Grass Acres in Maryland = 947,984 acres
NASS Estimate = 1,134,000 acres

Why the difference?

1. P532 does not capture turf grass associated road right-of-ways, and isolated commercial, industrial, and institutional establishments.
2. Turf Industry estimate is used to substantiate the economic importance of the industry. Therefore, it probably represents the upper bounds of the probable extent of turf grass.

Turfgrass areas used and maintained in Maryland, 2005

Sector	Turf Acres	Percent of Turf Acres	New Turf Established	Cost of Establishing New Turf	Average Cost per Acre to Establish New Turf
	- acres -	*- percent -*	*- acres -*	*- dollars -*	*- dollars -*
Airports	5,000	0.4	----	----	
Cemeteries	4,200	0.4	130	361,000	2,777
Religious Facilities	9,400	0.8	250	581,000	2,324
Parks and Athletic Fields	21,800	1.9	320	3,275,000	10,234
Golf Courses	16,400	1.4	310	2,105,000	6,790
County Government	78,200	6.9	480	3,914,000	8,154
State Highways	9,000	0.8	650	1,570,000	2,415
Apartments	7,500	0.7	200	765,000	3,825
Lawn Care	[1]		[1]	[1]	
Sod Farms	8,000	0.7	[2]	[2]	
Single Family Homes	936,900	82.6	28,190	73,112,000	2,594
Schools	38,400	3.4	360	3,481,000	9,669
Total	1,134,800		30,890	89,164,000	2,887

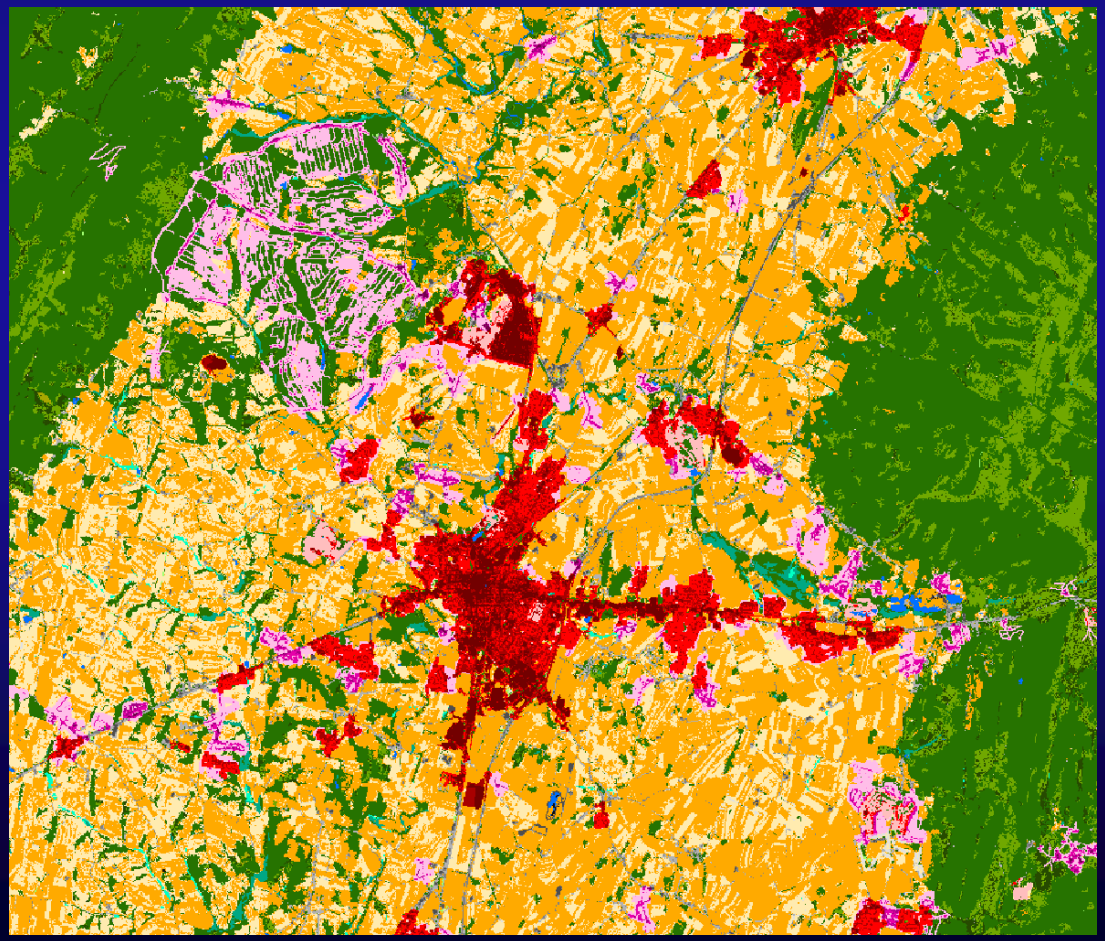
[1] Maryland Department of Natural Resources, 2006.
[2] USDA, National Agricultural Statistics Service, Maryland Field Office, 2006.

USGS

Capturing low density residential development improved accuracy of agricultural classes

P530 2006 Farmland Acres in Maryland	=	2,116,531 acres
P532 2006 Farmland Acres in Maryland	=	1,639,198 acres
USDA 2007 Ag Census	=	1,558,546 acres

P 5.3.0

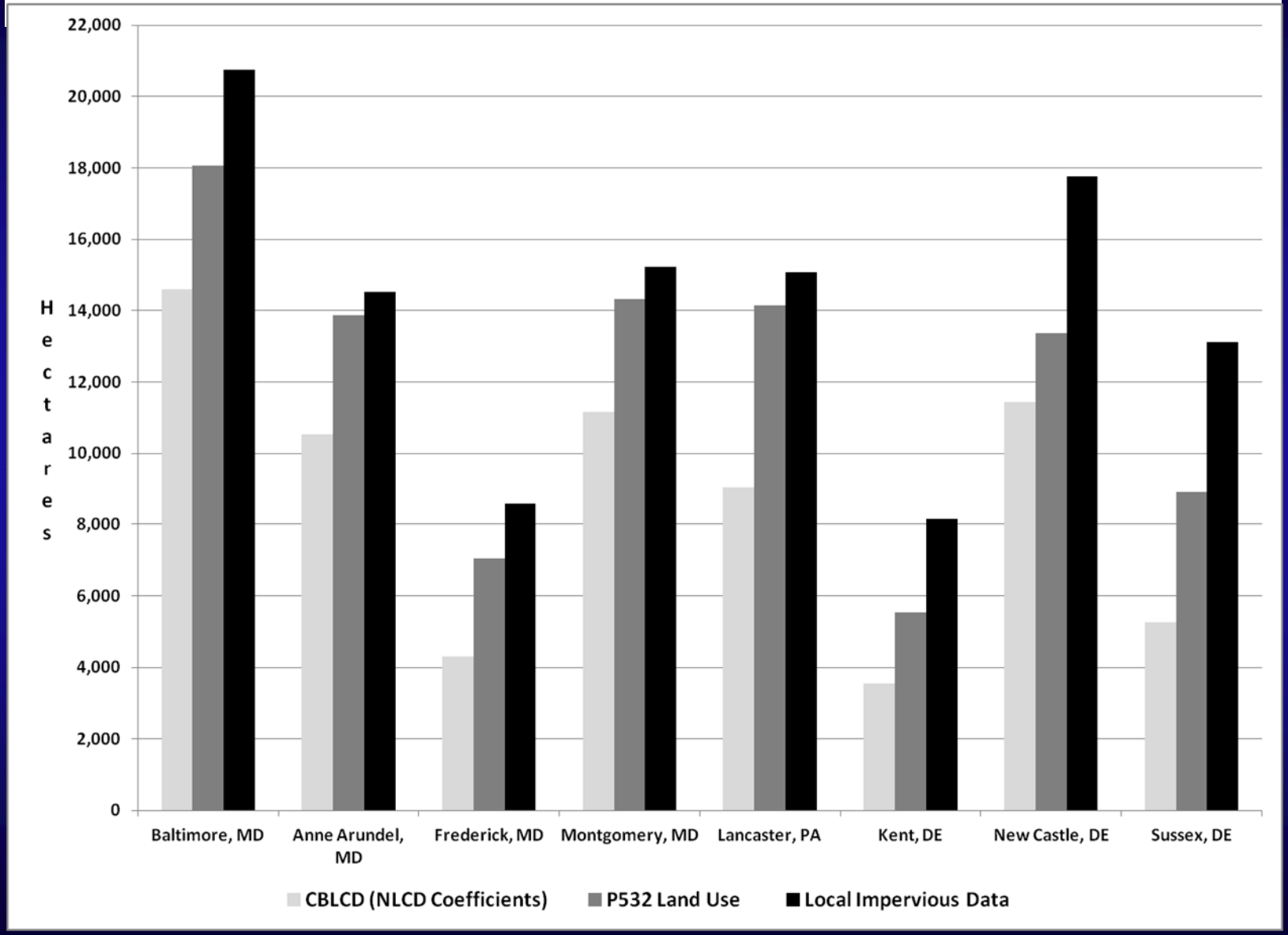


Chambersburg, PA

USGS

County-level Impervious Surface Estimates

Landsat (Phase 5.3.0), Modeled (Phase 5.3.2), and Local Data

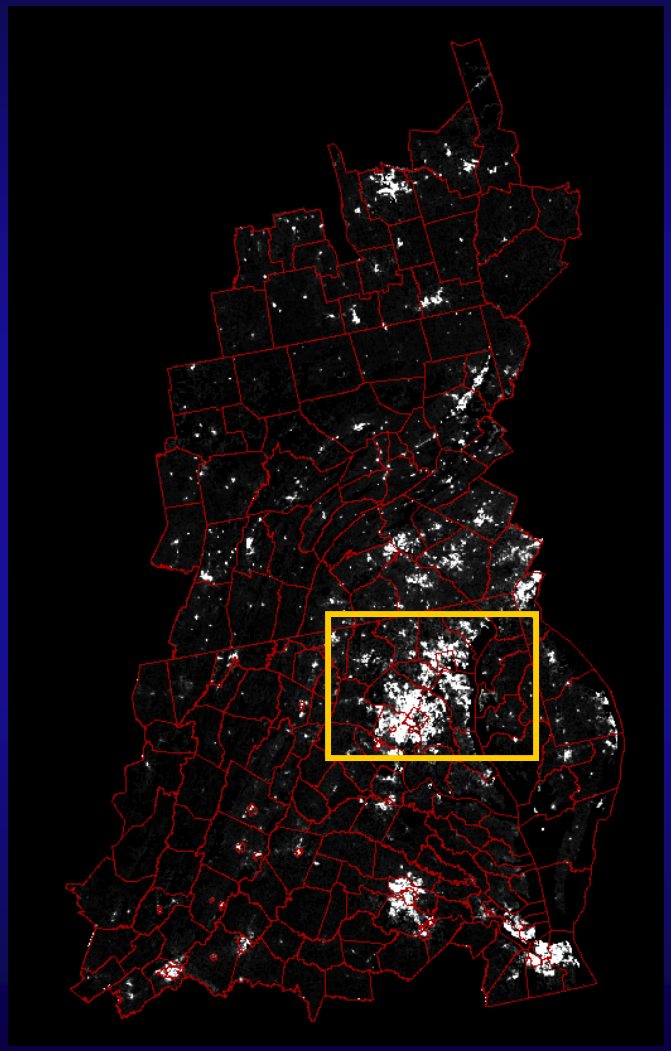


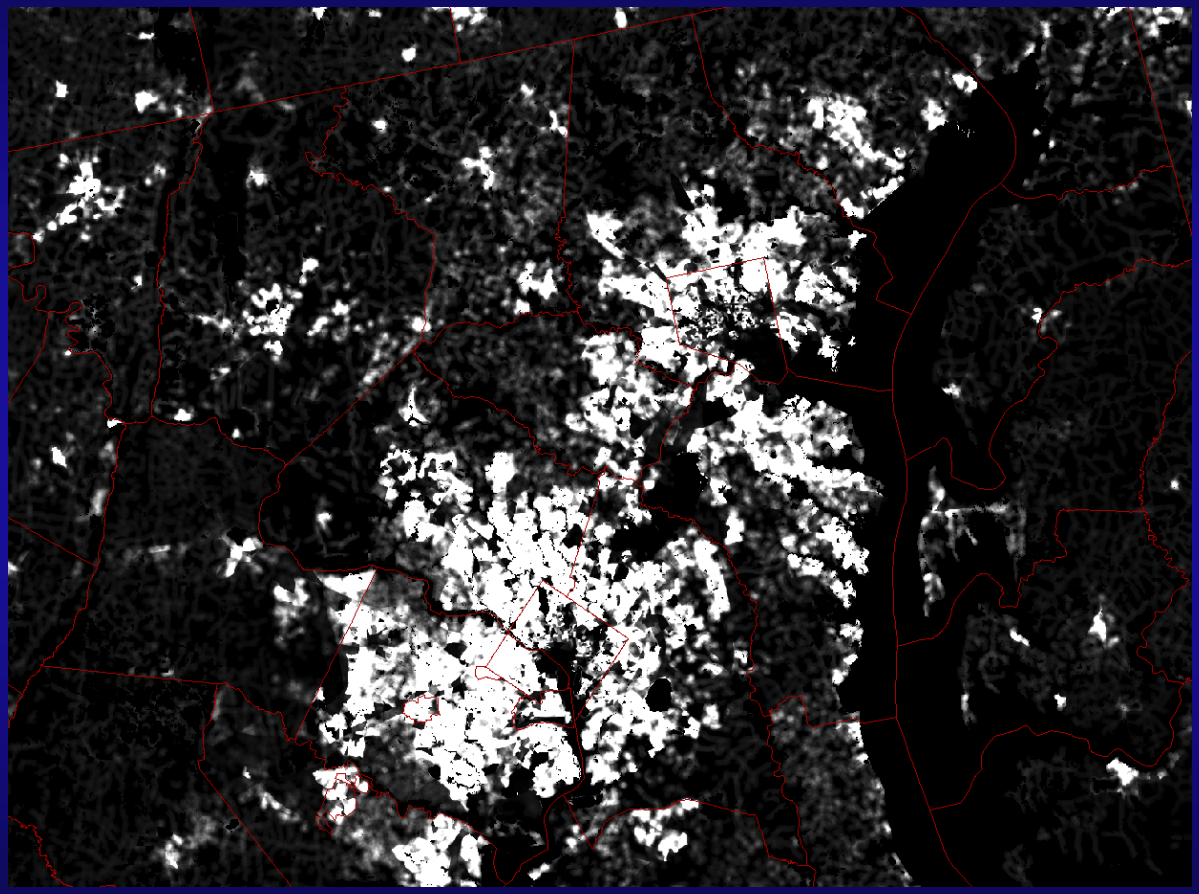
USGS

Tetra Tech 2009 Survey of WWTPs

- 403 major WWTPs in Bay watershed surveyed
- 257 facilities (~ 64%) responded
- Additional data collected in 2008 from:
  - Maryland Department of Planning
  - Delaware Counties (all)
  - Washington Council of Governments
  - Virginia: Albemarle, Arlington, Henrico, Loudoun, and Rockingham Counties and James City, Newport News City, Virginia Beach and Richmond City.
  - Pennsylvania: Perry, Dauphin, Lancaster, Lycoming, and Cumberland Counties.
  - New York: Broome County.

Dasymetric Mapping of Single-detached Housing Units

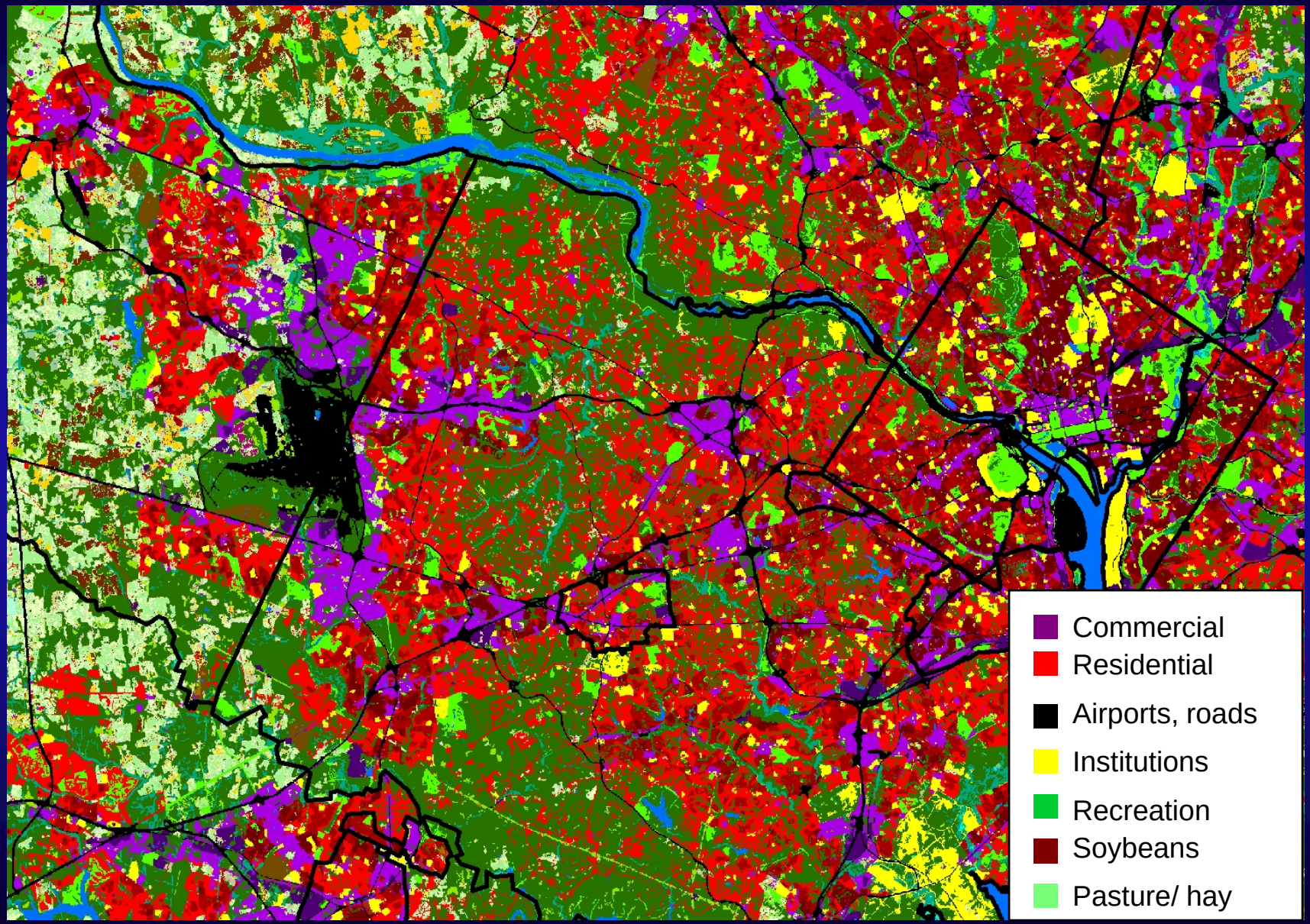




•Correlation with Census Block data at Modeling Segment Scale = 0.80

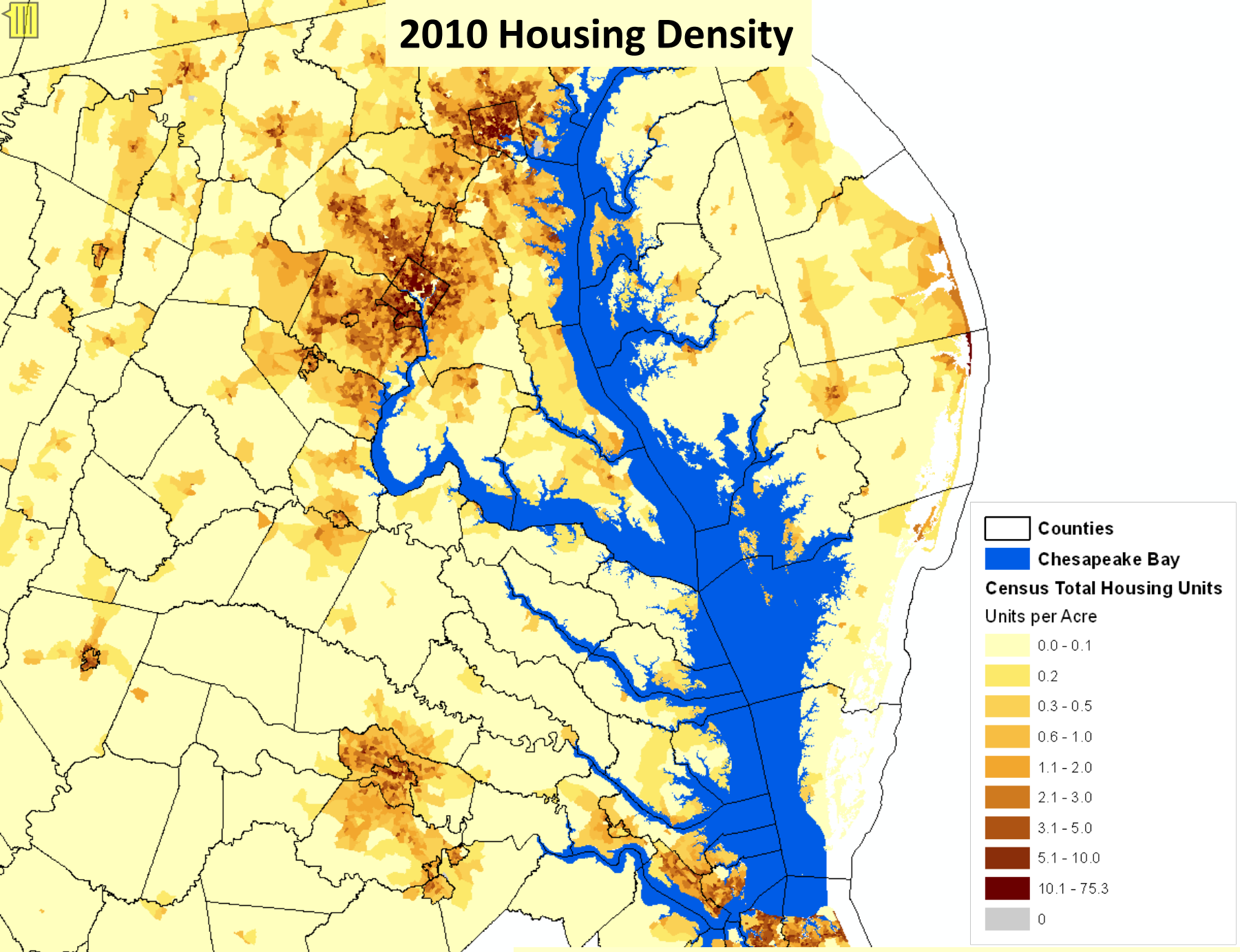
USGS

Urban land cover reclassed to land use + Cropland Data Layer



USGS

2010 Housing Density

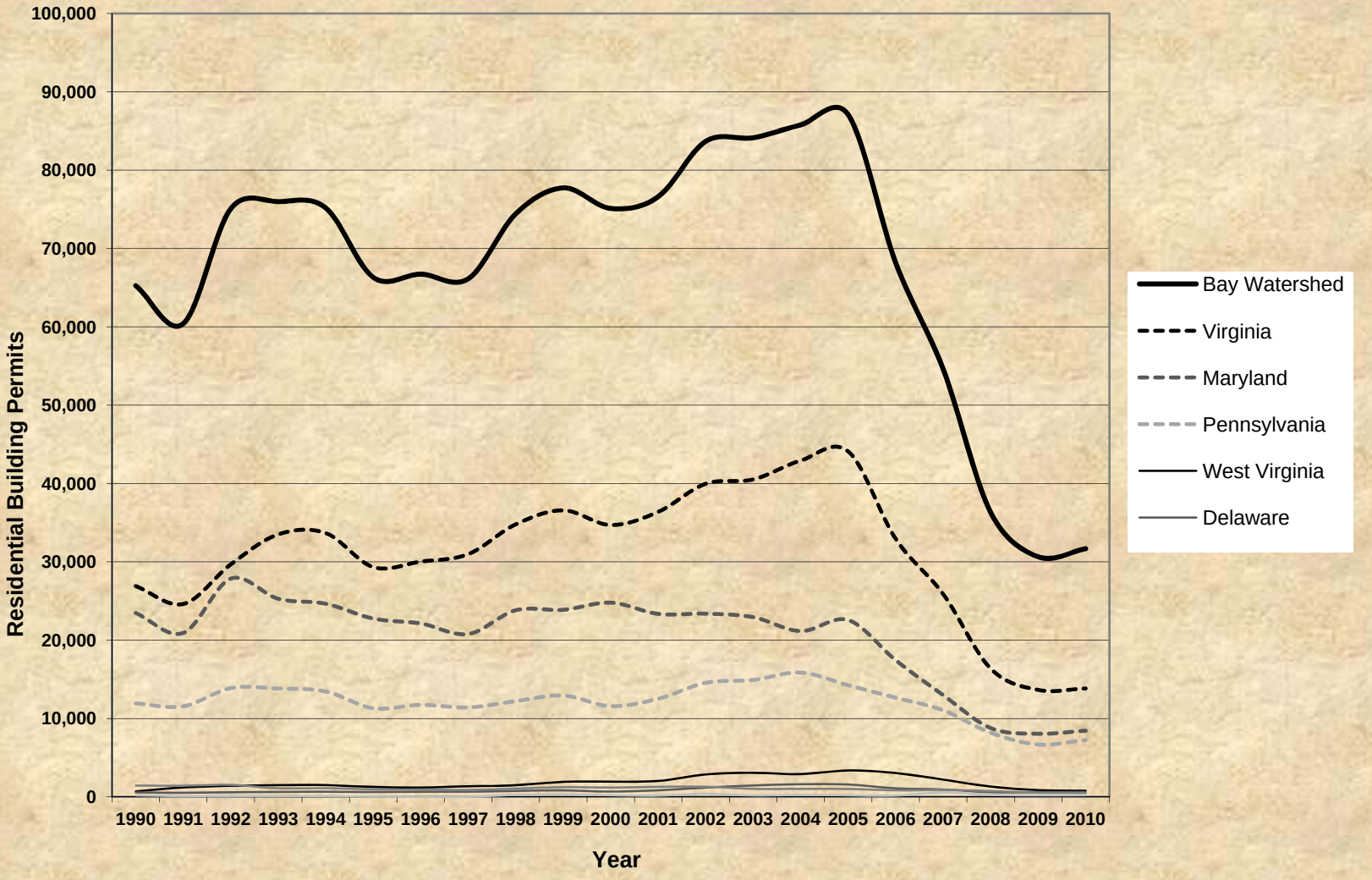


USGS

Updated analysis following methods outlined by Hammer, et al., 2004.

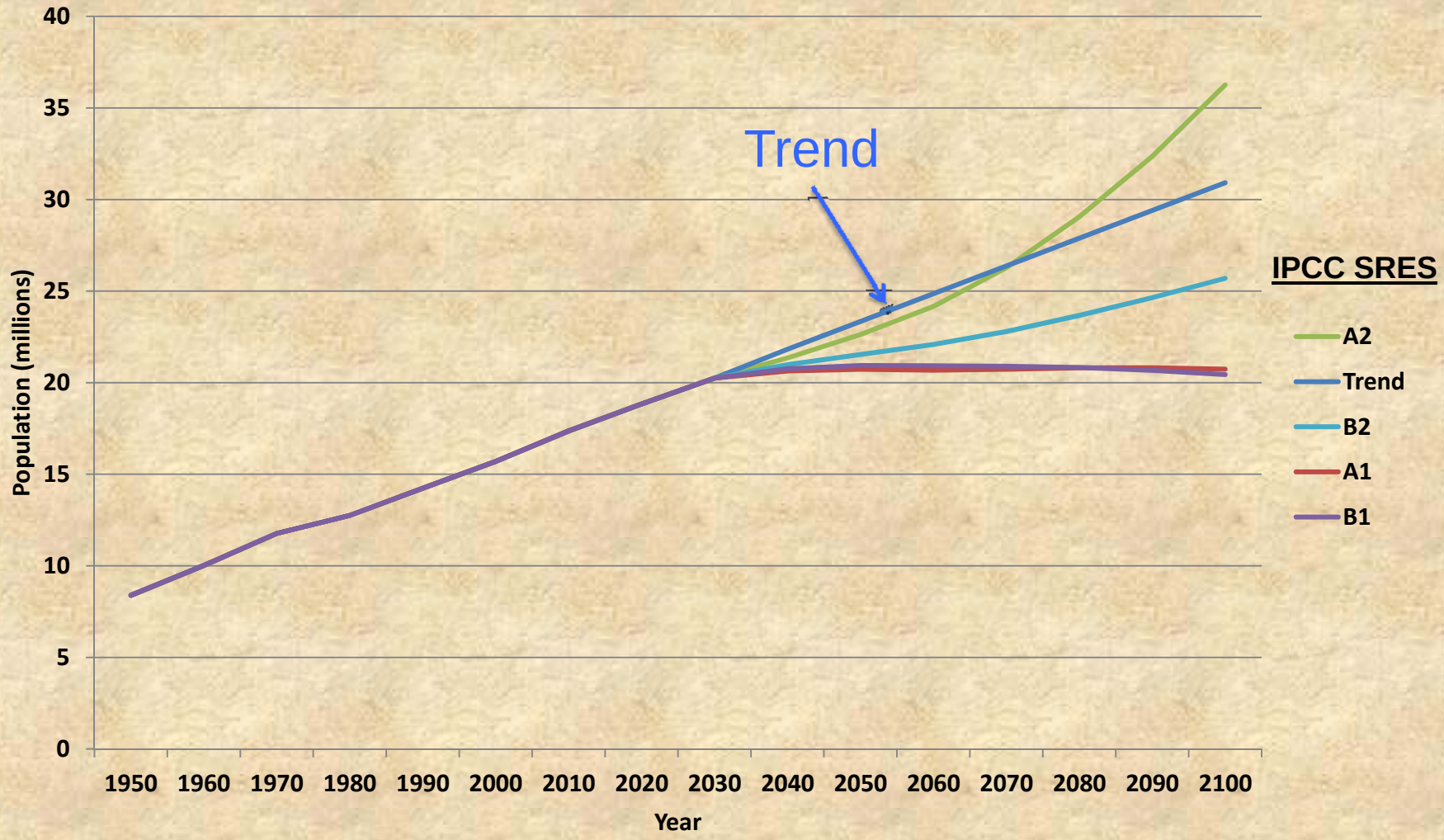
The Past is not Prologue:

Building permit trends (1990 – 2010)



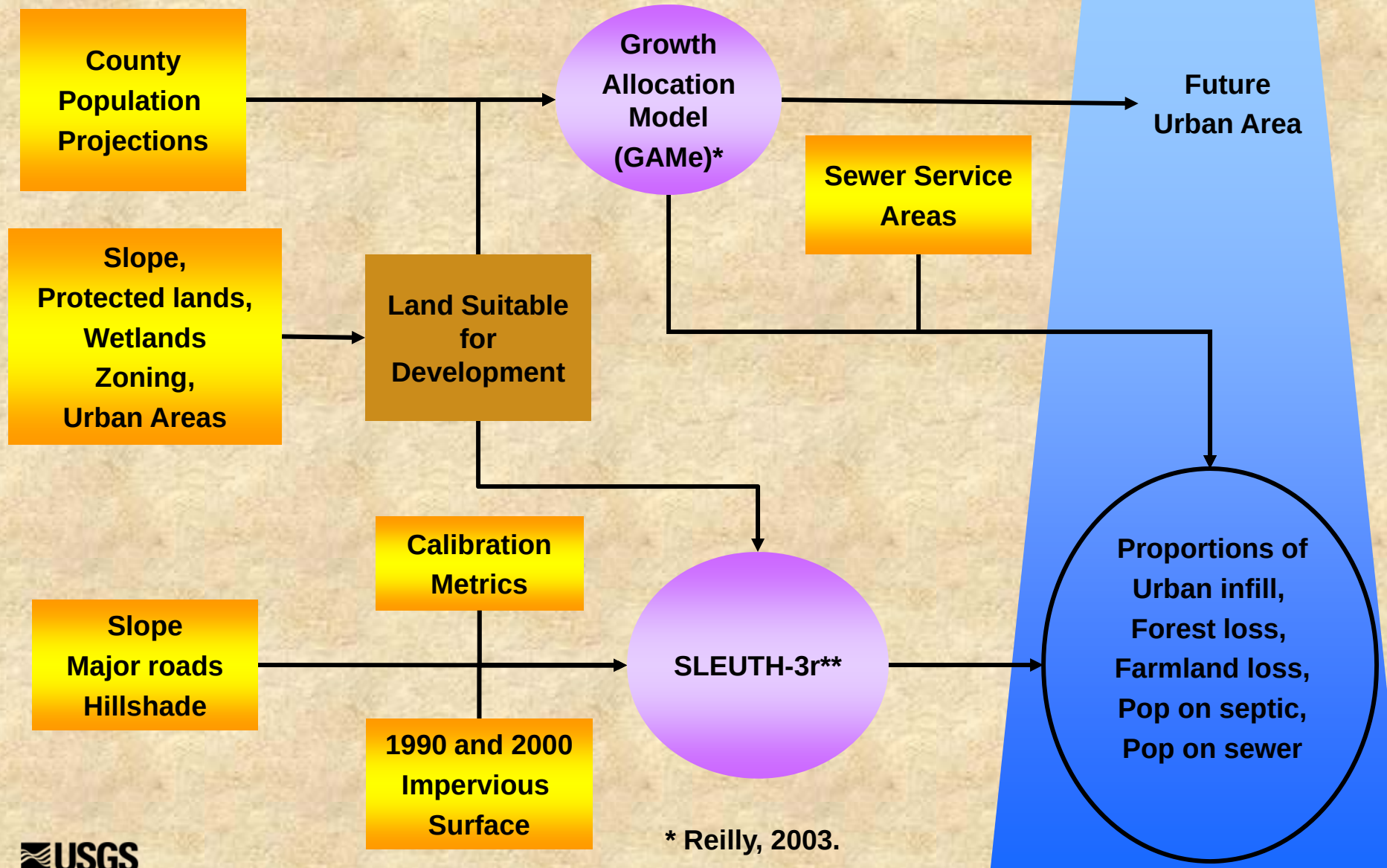
USGS

Future Bay population: beyond 2030



USGS

Chesapeake Bay Land Change Model (CBLCM v1, 2008)

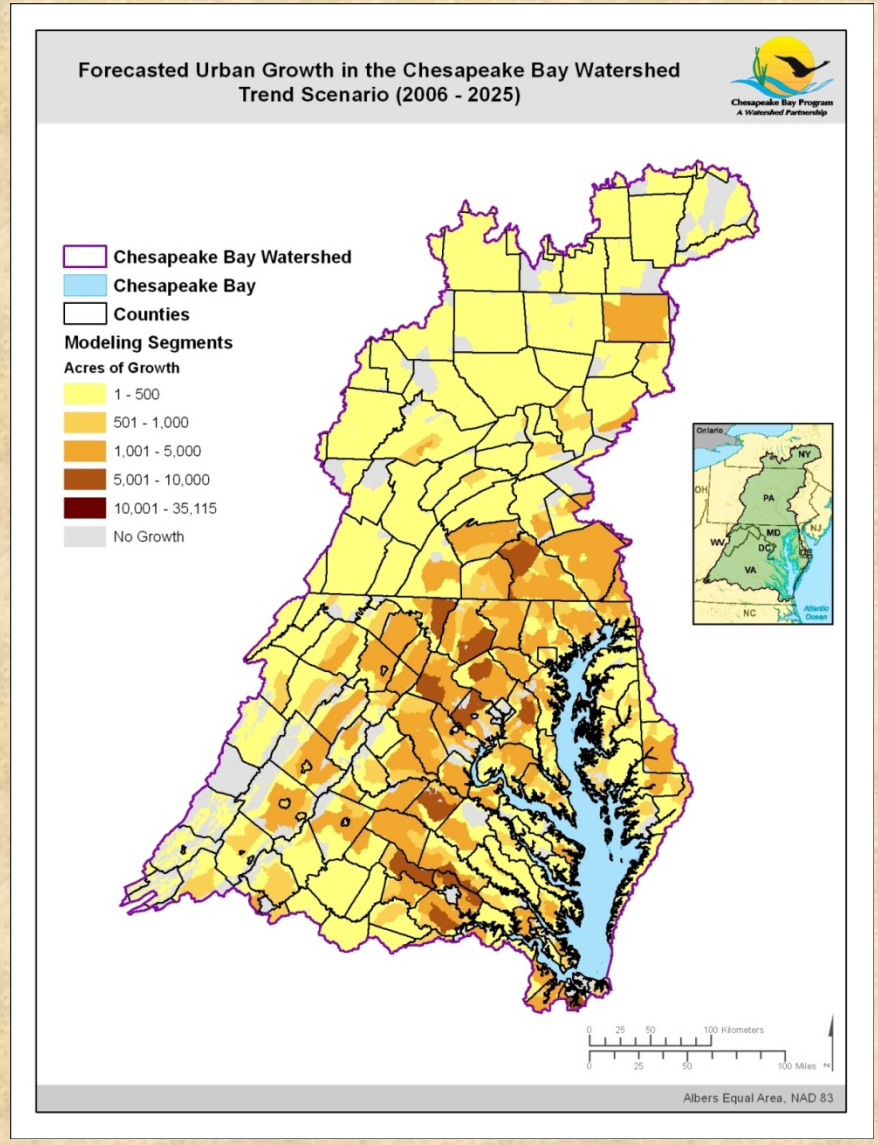


USGS

* Reilly, 2003.

** Jantz et al., 2010.

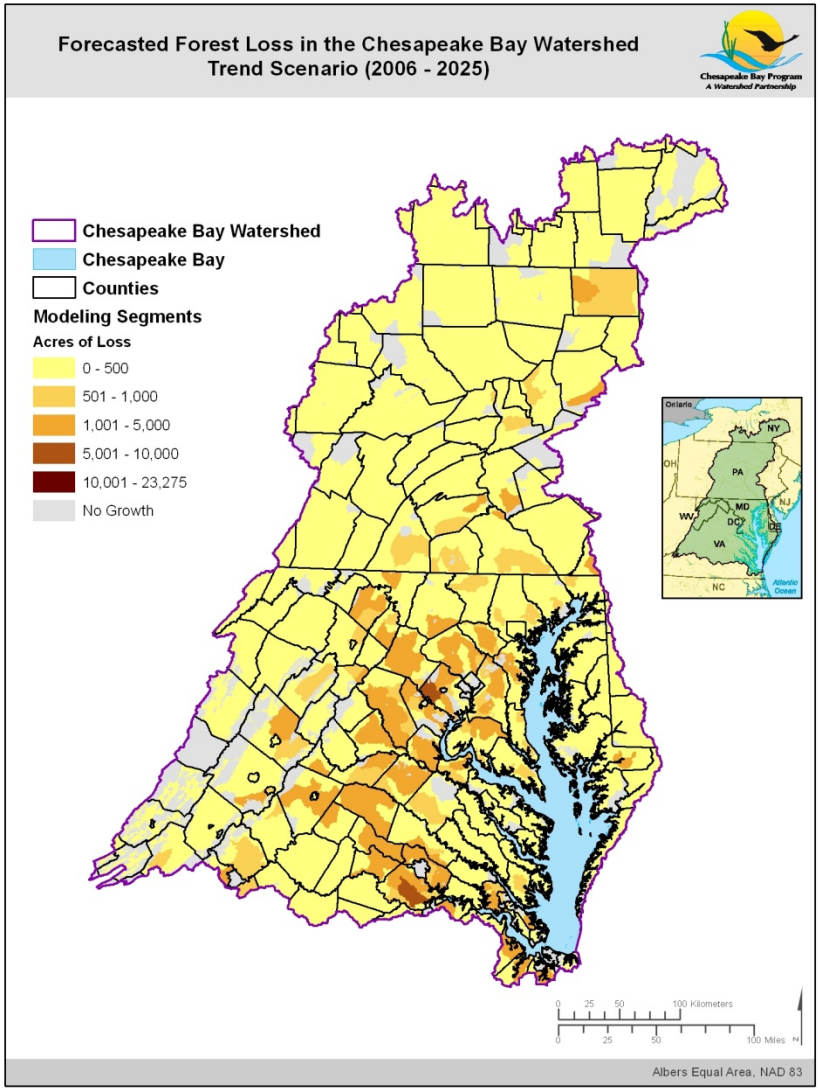
Forecasted Urban Growth in the Chesapeake Bay Watershed



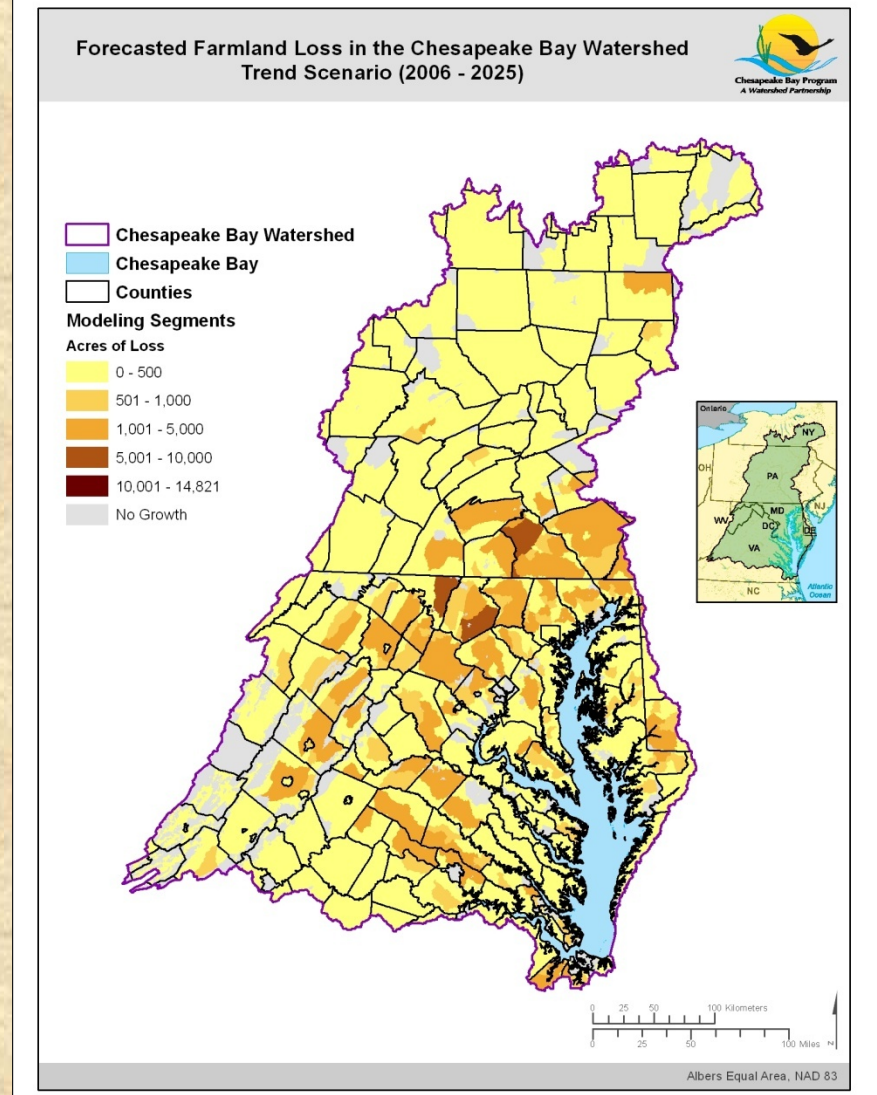
(2006 – 2025)

USGS

Forest Loss (2006 – 2025)



Farmland Loss (2006 – 2025)



USGS

Trend Scenario Nitrogen Loads (yr. 2025)

Impervious surface:
+ 122,000 acres = 1.5 million lbs. TN/yr

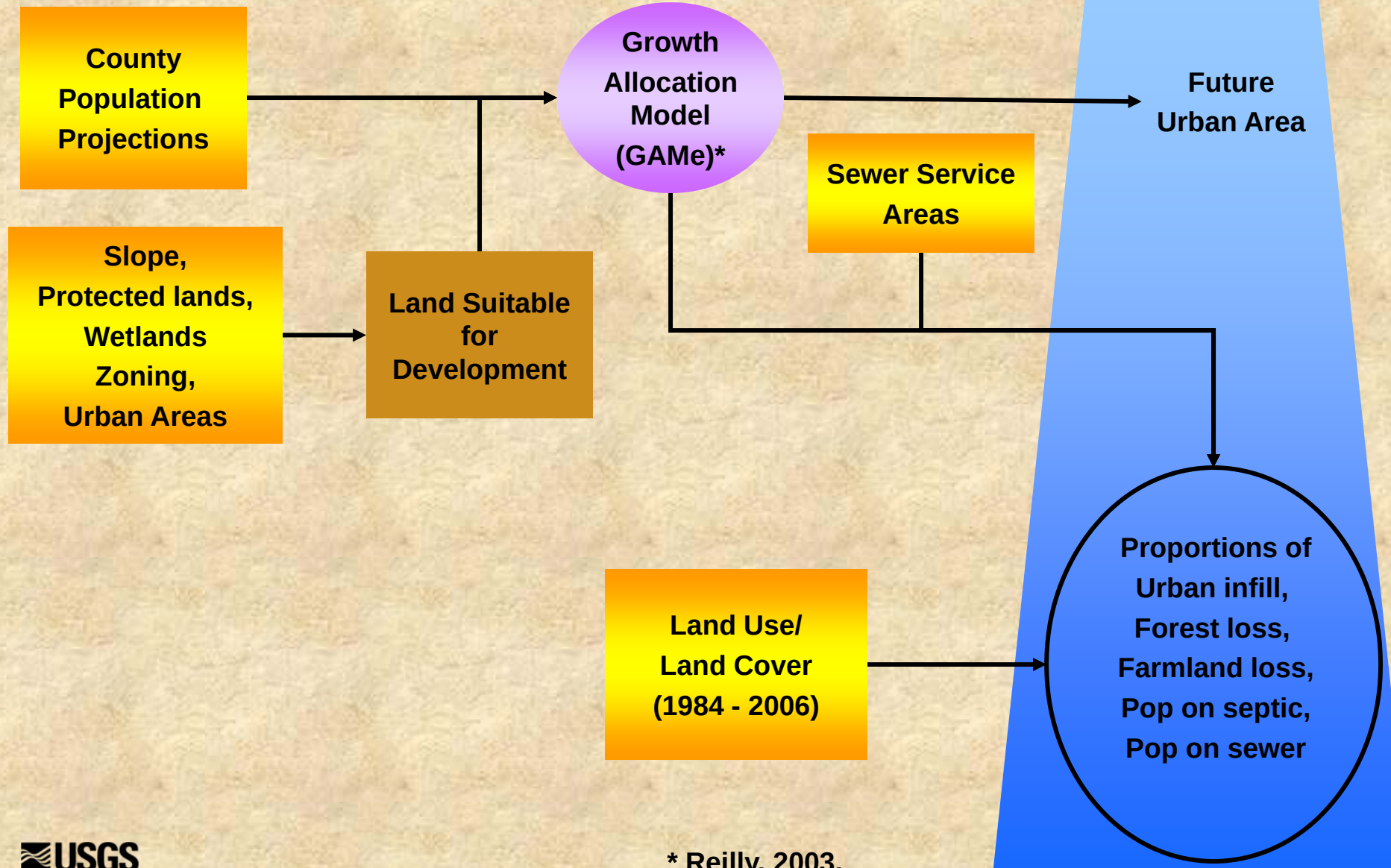
Pervious surfaces (lawns):
+ 596,000 acres = 6.3 million lbs. TN/yr

Sewer:
+ 2,160,000 people = 1.5 – 4.2 million lbs. TN/yr

Septic:
+ 236,000 systems = 0.9 – 2.6 lbs. TN/yr

USGS

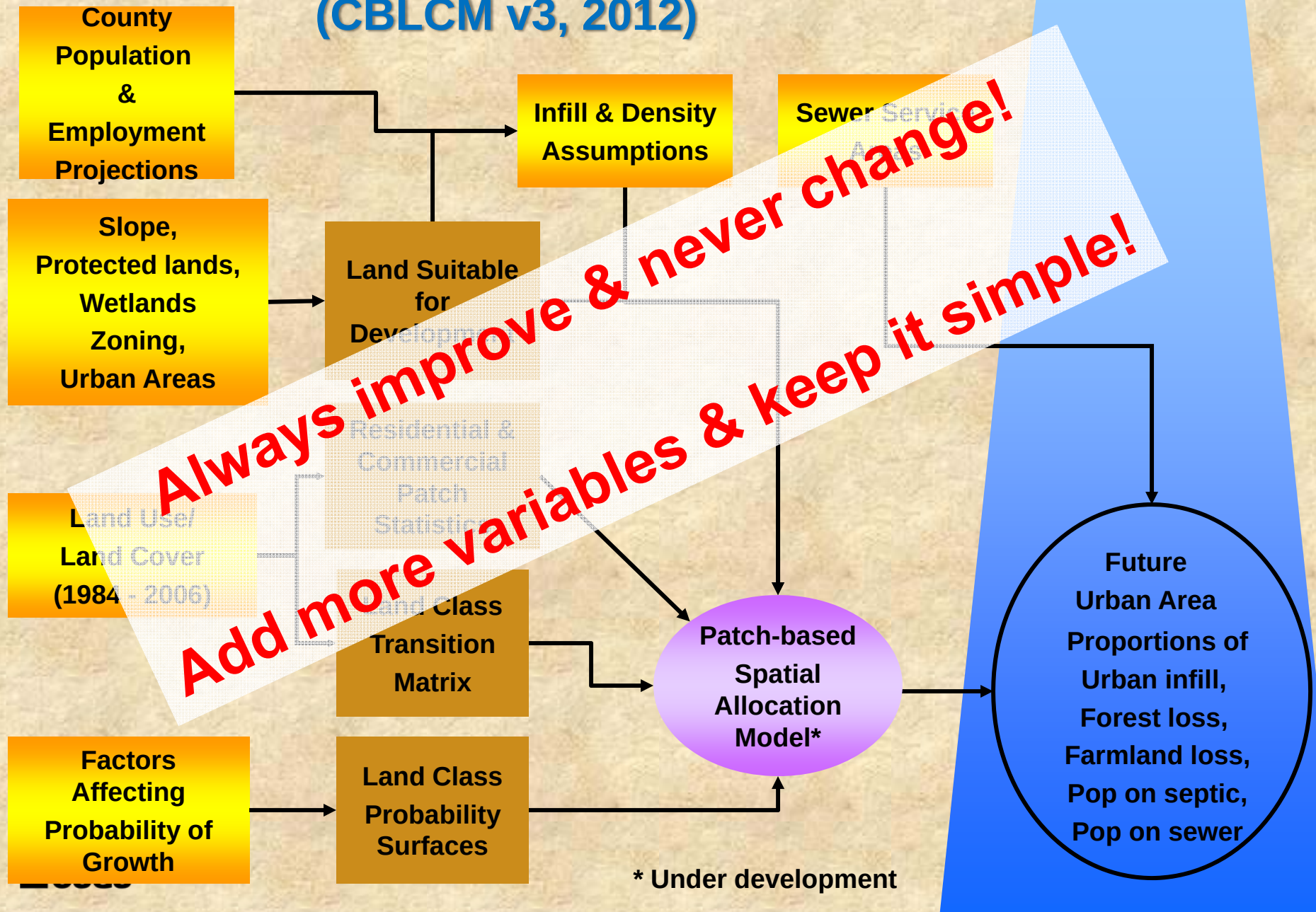
Chesapeake Bay Land Change Model (CBLCM v2, 2010)



USGS

* Reilly, 2003.

Chesapeake Bay Land Change Model (CBLCM v3, 2012)

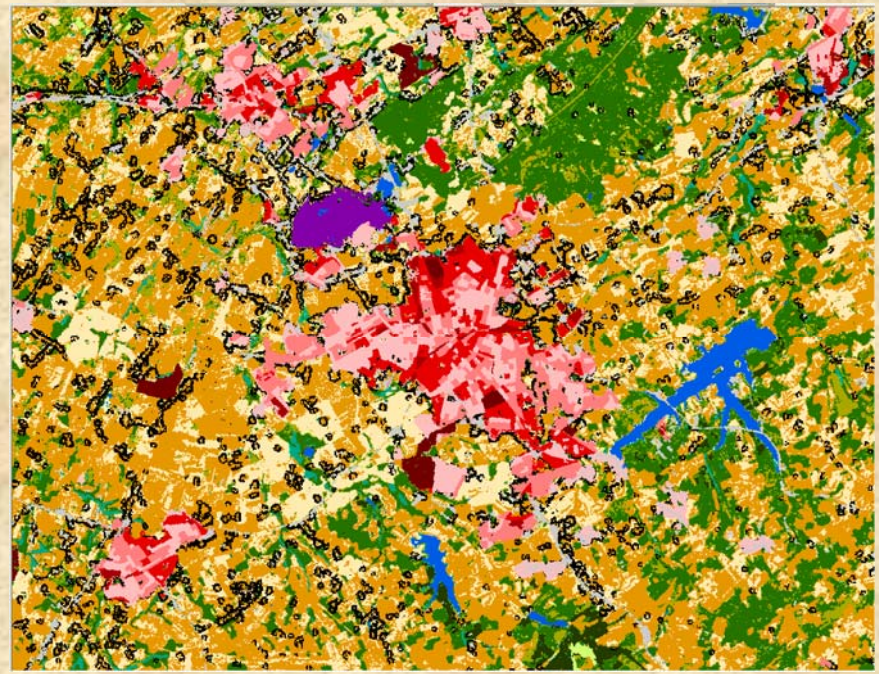


Always improve & never change!

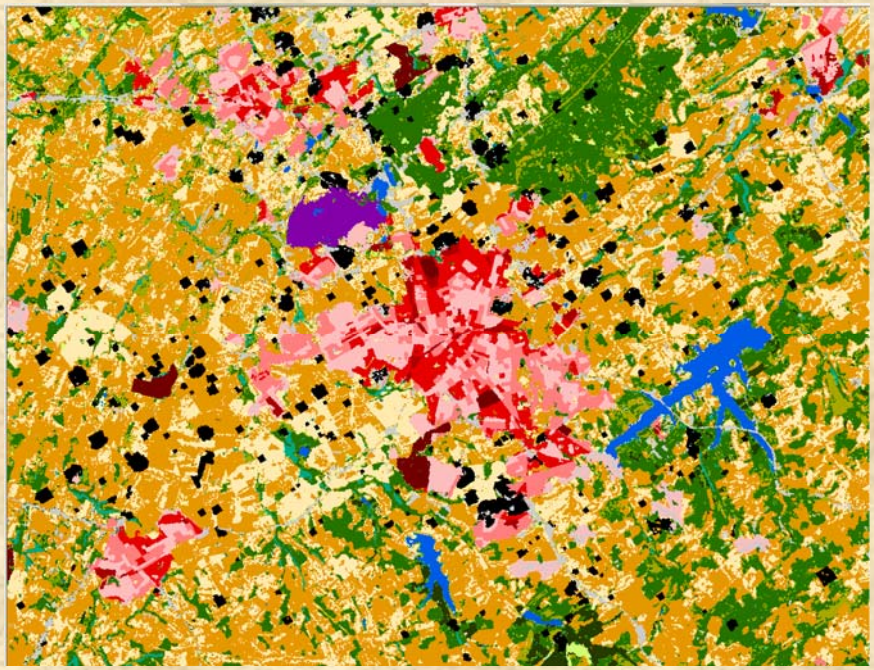
Add more variables & keep it simple!

CBLCM v3: a “new” patch-based land change model

CBLCM v1 (w/ SLEUTH)



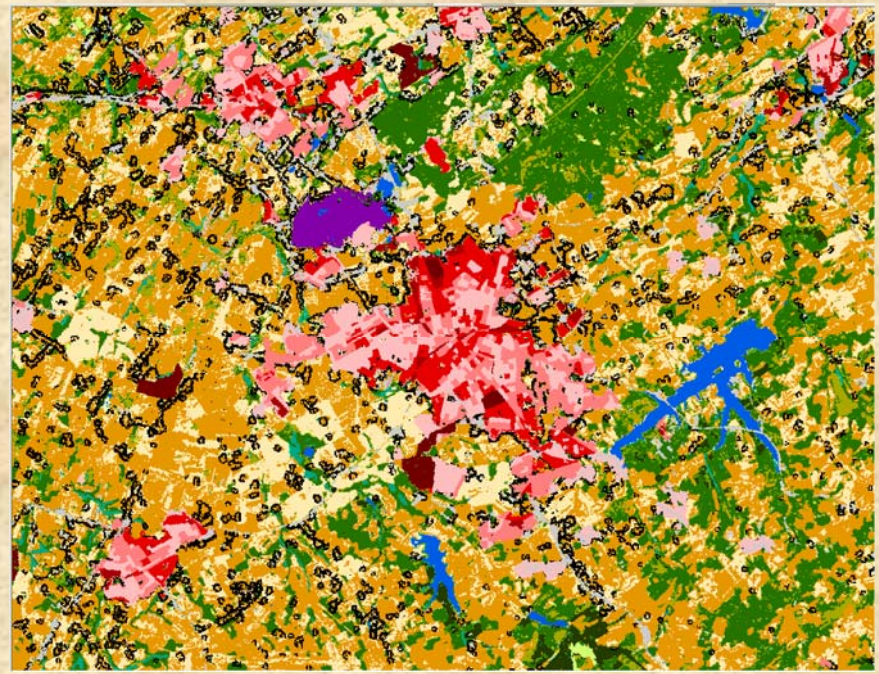
CBLCM v3 (patch-based)



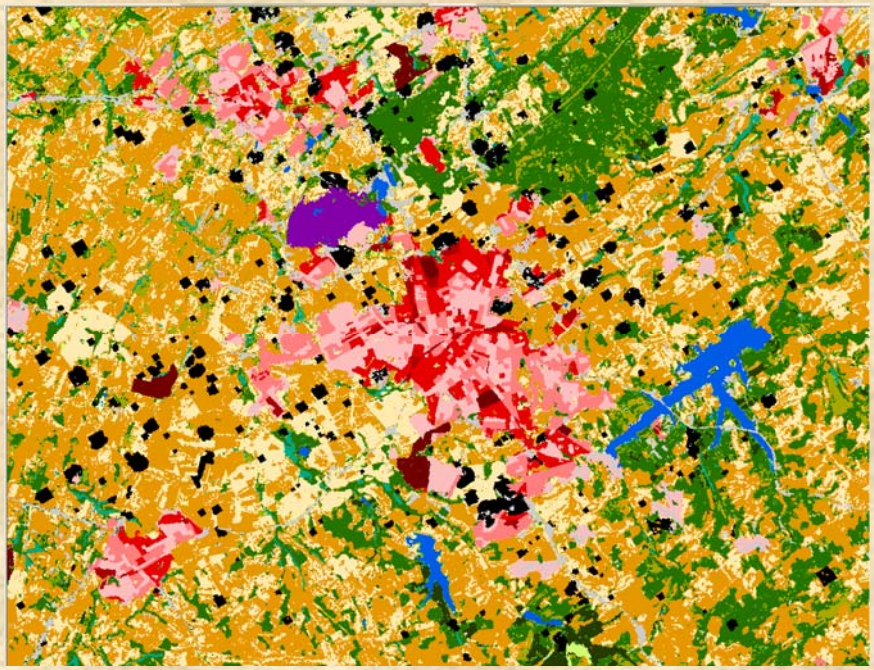
USGS

CBLCM v3: a “new” patch-based land change model

CBLCM v1 (w/ SLEUTH)

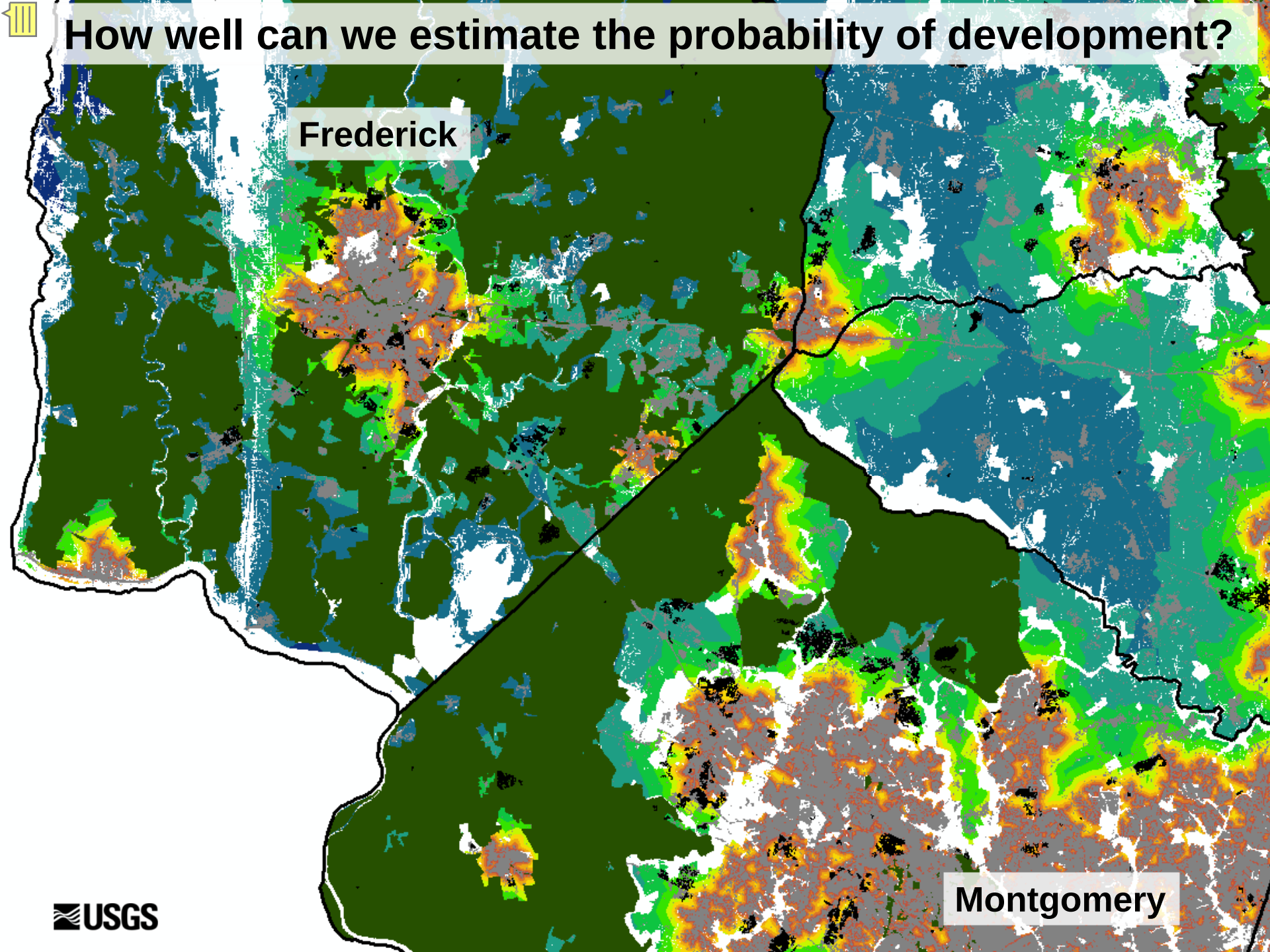


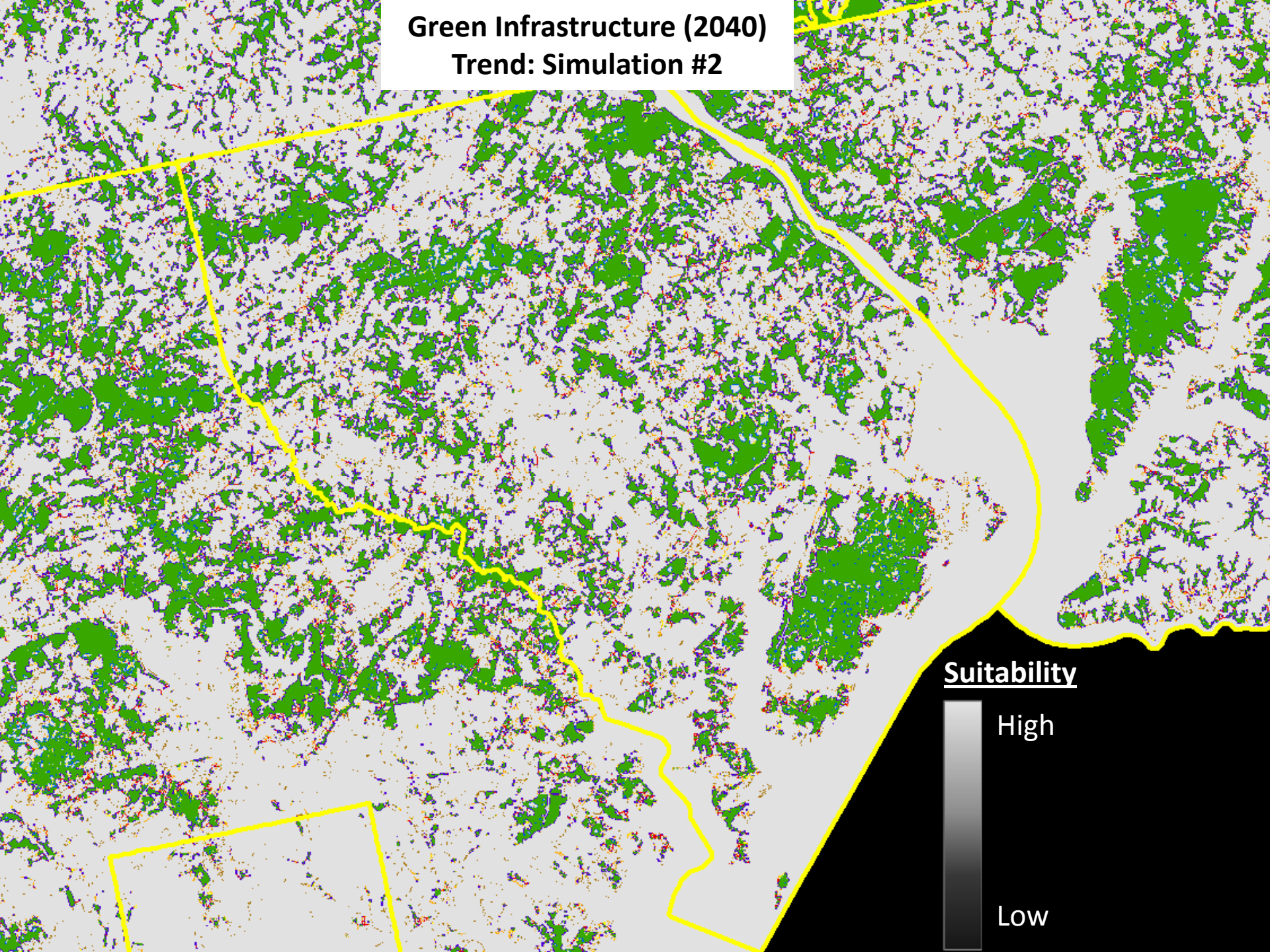
CBLCM v3 (patch-based)



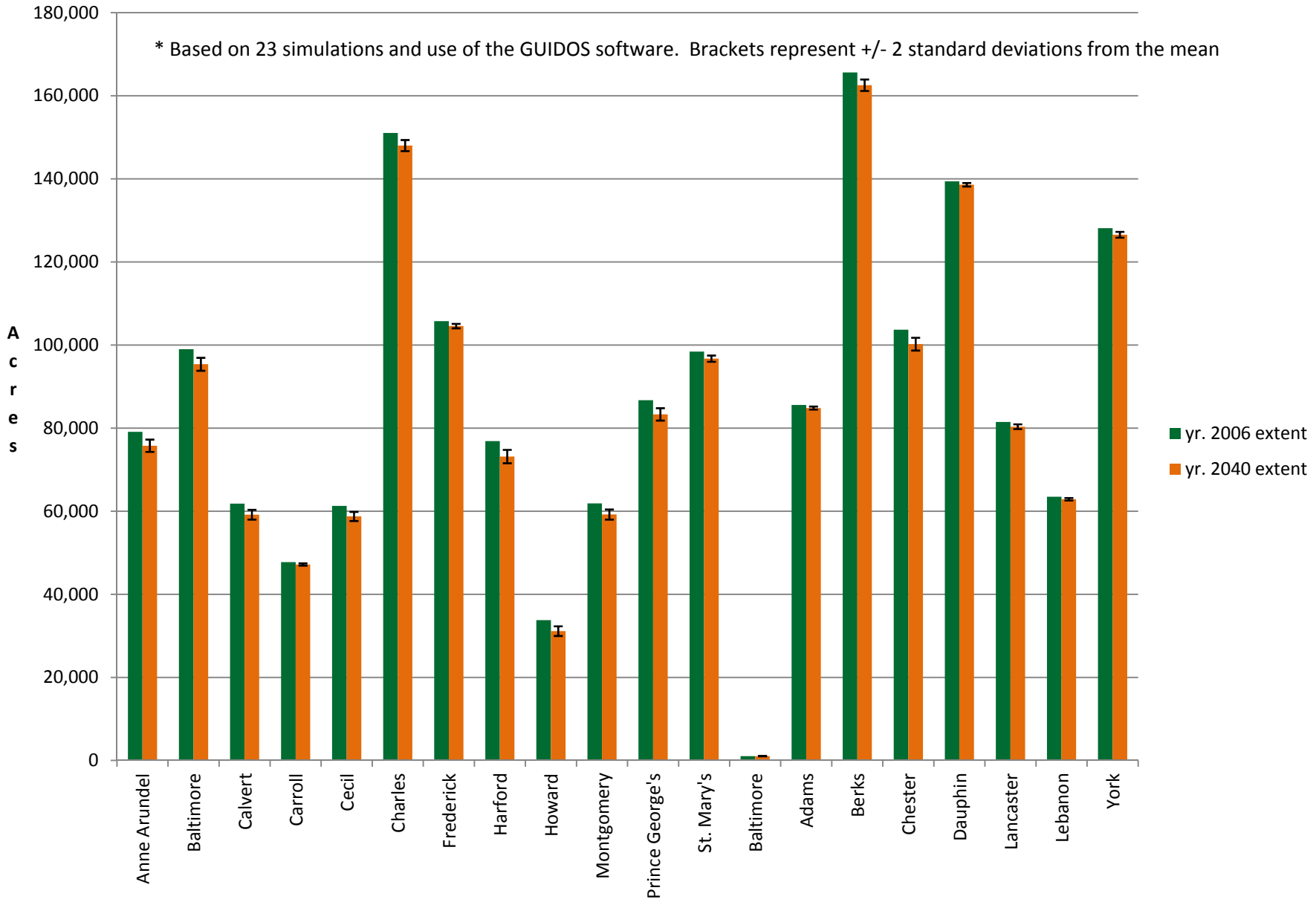
USGS

How well can we estimate the probability of development?




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

Core Forest Extent Pre- and Post-Development



Crafting Alternative Future Scenarios

Exclusion
- Wetlands and riparian zones
- Riparian buffers
- Critical areas
- Steep slopes
- Easements and protected lands
- Zoning and ordinances

Accessibility
- Travel time
- Proximity to major road intersections

Densification
- Zoning and ordinances
- Lot size (% impervious, % pervious)
- % single-unit , % multi-unit houses
- Population and housing density
- Priority funding areas

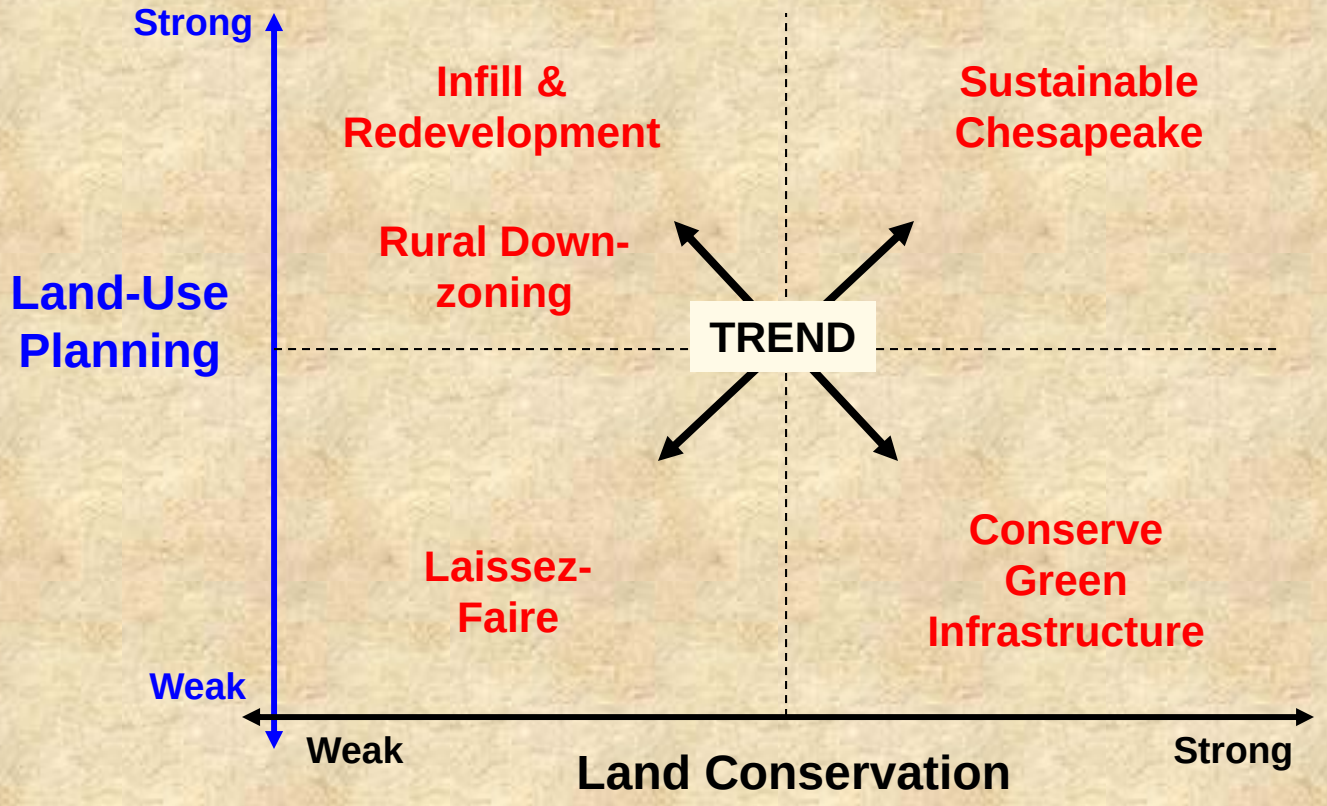
Demand adjustment
- Population projection
- Average household size
- Vacancy rate

Amenity attraction (proximity to…)
- Transit stations
- Parks, lakes, and golf courses
- Employment centers
- Activity centers
- Bay shoreline
- High performing schools
- Public water and sewer
- Zoning and ordinances

Disamenity repulsion
- Industrial areas
- Airports
- Landfills
- High-crime areas

USGS

Chesapeake Bay Alternative Future Development Scenarios



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