Land Use and Climate Change: Coupled Phenomena

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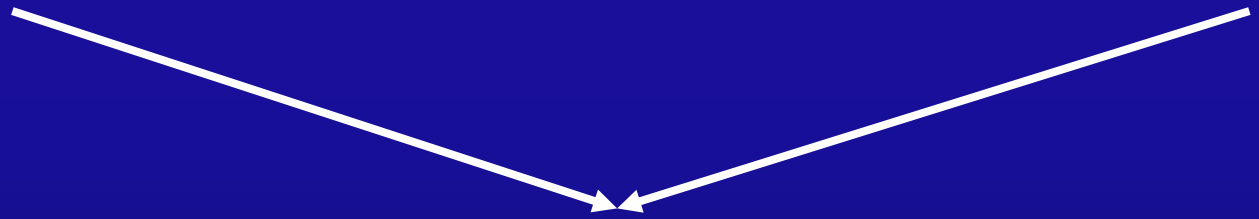
Climate Resiliency Workgroup

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

Synergistic hydrologic effects of land use and climate change

Land Use Change
- Rotational forest clearing
- Managed and natural succession
- Residential and commercial development
- Farmland irrigation and crop choice

Climate Change
- Frequency, duration, and intensity of rainfall
- Temperature rise
- Sea-level rise



Hydrologic Effects
- Alterations in stream flow
- Alterations in stream and surface temperatures
- Alterations in evapotranspiration
- Alterations in water availability
- Alterations in salinity

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Adapting to Climate Change via Changes in Land Use

Increased frequency and duration of droughts may lead to:

- increased irrigation (precision and center-pivot)
- shift to more drought tolerant crops
- development of new groundwater and surface water supplies

Increased frequency and severity of inland and coastal flooding and inundation may lead to:

- prohibitions on floodplain and coastal development
- targeted land protection in floodplains and along coastal shorelines
- enhanced stormwater management
- elevation and/or relocation of roads and structures
- abandonment of communities and farmland
- expansion of ghost forests
- alteration of shoreline dynamics (erosion and accretion)

Increased temperatures may lead to:

- latitudinal shifts in agricultural practices
- more heat-related stress on living organisms

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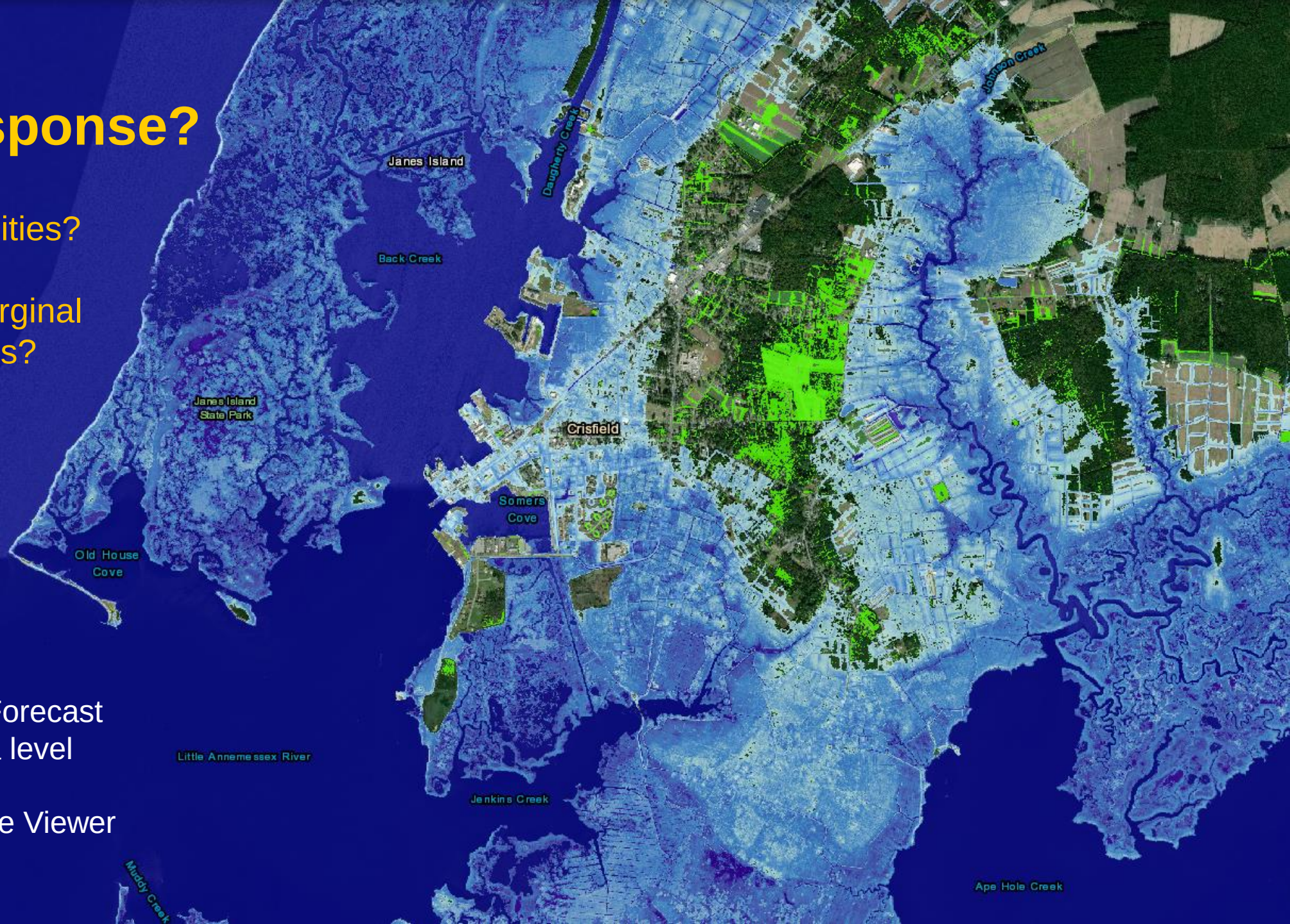
USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

Adaptive Response?

- Relocate communities?
- Convert future marginal lands to solar fields?



Intermediate 2060 Forecast
2.13-ft. rise in sea level

NOAA Sea Level Rise Viewer

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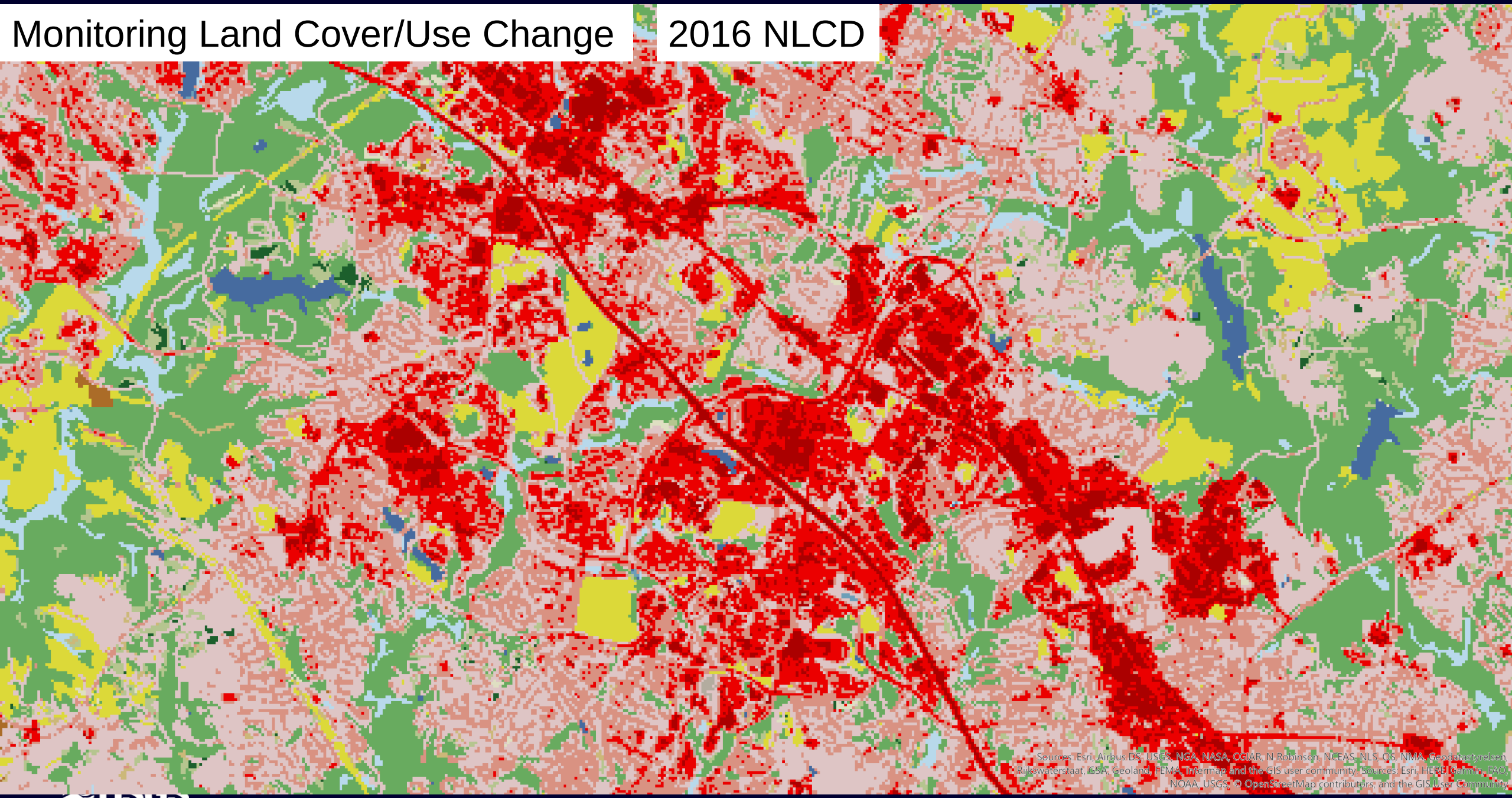
Enhancing Climate Resiliency via Changes in Land Use

- Maintain as much natural and undeveloped land as possible- particularly in areas prone to inundation
- Protect/acquire areas inland of coastal refuges
- Increase investments in urban tree planting, riparian forest buffers, and establishing grass buffers
- Assist farmers to diversify income streams and adapt to climate change via developing renewable energy and installing BMPs

Monitoring Land Cover/Use Change

2016 NLCD



Land Cover Change: 2001 – 2016 (NLCD)
4.9% of Landscape Changed

2016

2001	Water	Development				Barren	Natural					Agriculture		Natural	Water
	11	21	22	23	24	31	41	42	43	52	71	81	82	90	95
11		0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.4%
21	0.0%		0.5%	1.6%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22	0.0%	0.0%		0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
23	0.0%	0.0%	0.0%		0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
24	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
31	0.1%	0.0%	0.0%	0.1%	0.1%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
41	0.1%	1.9%	1.3%	1.0%	0.3%	0.1%		1.3%	1.2%	10.6%	9.8%	0.3%	0.8%	0.0%	0.1%
42	0.1%	0.2%	0.2%	0.2%	0.1%	0.0%	0.6%		0.4%	6.6%	4.0%	0.0%	0.3%	0.0%	0.0%
43	0.0%	0.3%	0.2%	0.1%	0.0%	0.0%	0.5%	0.5%		1.6%	1.2%	0.0%	0.1%	0.0%	0.0%
52	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	4.8%	3.7%	3.2%		0.2%	0.0%	0.1%	0.0%	0.0%
71	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	1.9%	4.9%	1.0%	0.8%		0.0%	0.2%	0.0%	0.0%
81	0.1%	1.4%	0.9%	0.7%	0.2%	0.1%	1.9%	0.4%	1.4%	0.5%	0.8%		8.9%	0.1%	0.3%
82	0.1%	0.9%	0.8%	0.6%	0.3%	0.0%	0.1%	0.2%	0.1%	0.0%	0.0%	1.0%		0.0%	0.0%
90	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		1.5%
95	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	3.0%	

Moderate

High

Rank	Transition	Proportion of All Change
1	Forest -> Grass/Shrub	33.8%
2	Grass/Shrub -> Forest	19.5%
3	Natural -> Development	6.4%
4	Agriculture -> Development	5.8%
5	Agriculture -> Natural	5.4%

G:\ImageryServer\NLCD\2016_NLCD_CBW\combo_2001_2016.xlsx

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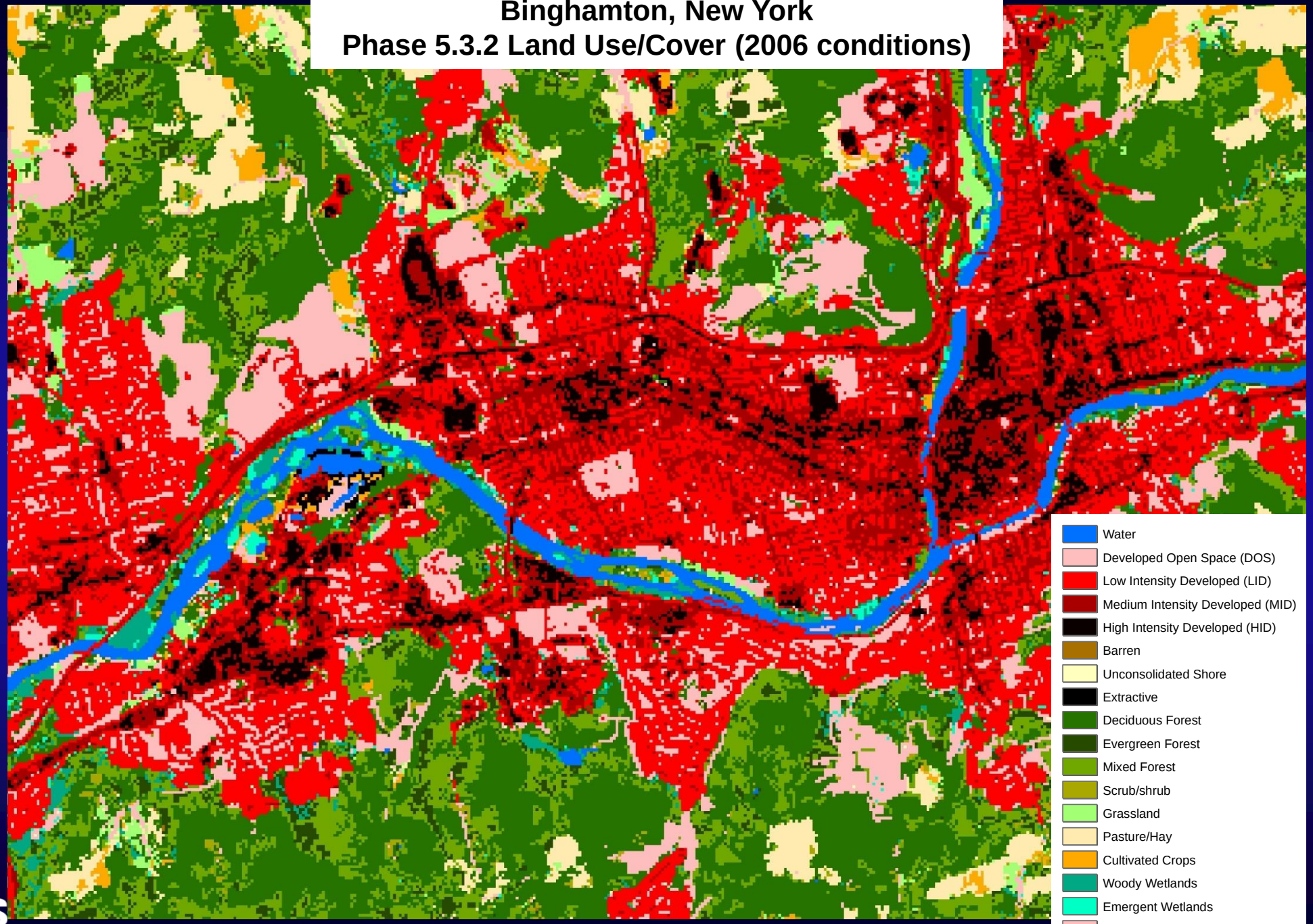
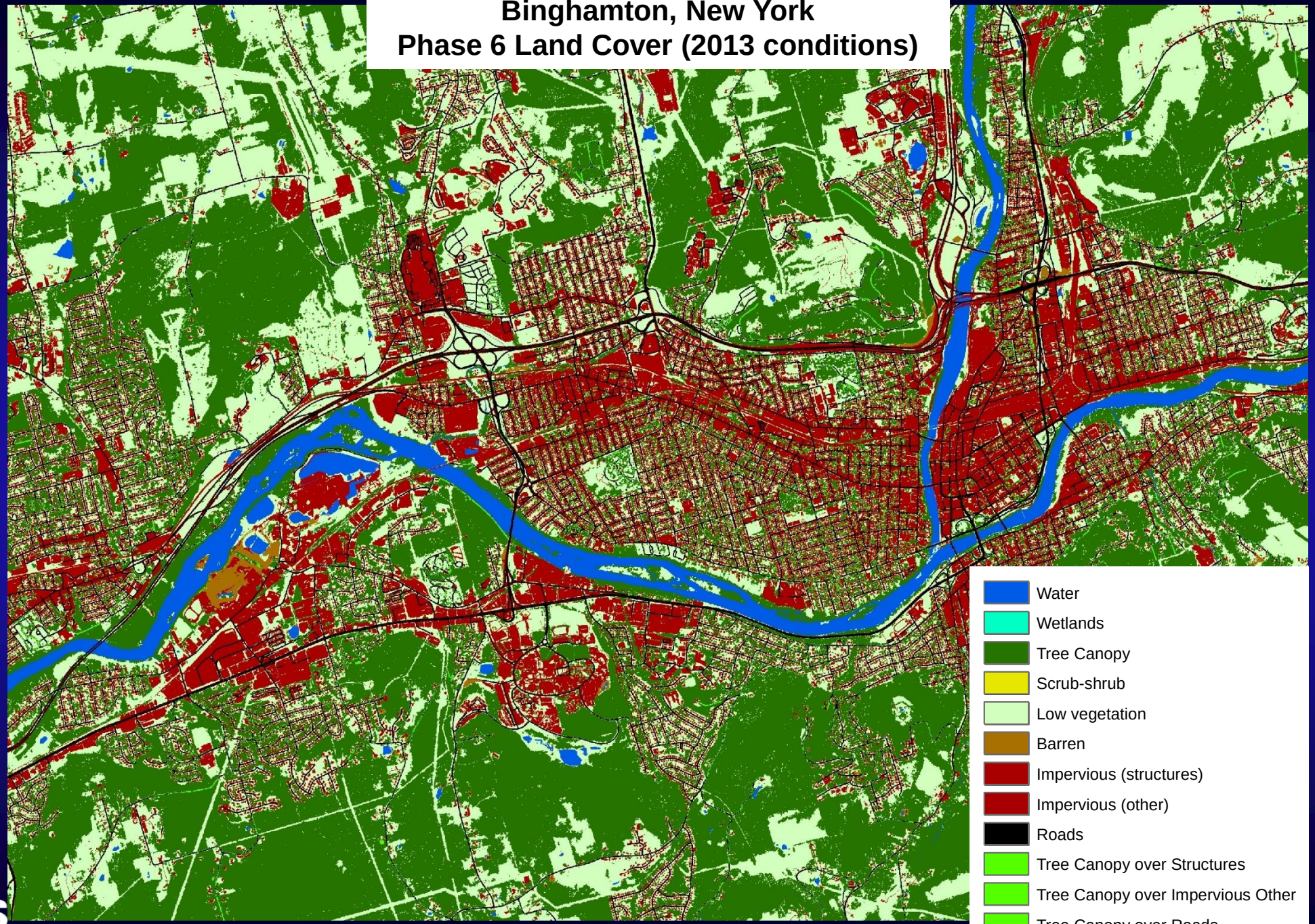
Binghamton, New York
Phase 5.3.2 Land Use/Cover (2006 conditions)



USGS

Binghamton, New York
Phase 6 Land Cover (2013 conditions)



USGS


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


10/2018
N
Google Earth

Tree Canopy Change, Prince George's County, Maryland: 2014 – 2018
Wall-to-Wall High-Resolution (1-meter) Data

TC Change (acres)

BaseClass	NoChange	Gain	pGain	Loss	pLoss
IR	81	2	0.4%	5	0.1%
INR	220	6	1.2%	16	0.2%
TCI	4,030	2	0.4%	648	8.4%
WAT	447	6	1.1%	30	0.4%
WLT	2,164	8	1.5%	154	2.0%
WLF	11,447	16	3.2%	382	5.0%
WLO	1,236	3	0.5%	41	0.5%
FOR	113,399	56	10.8%	3,908	50.9%
TCT	21,427	9	1.8%	2,097	27.3%
MO	3,918	110	21.3%	343	4.5%
FracTurf_1	177	26	5.1%	7	0.1%
FracTurf_2	70	24	4.6%	2	0.0%
FracTurf_3	72	19	3.6%	2	0.0%
FracImp	39	4	0.9%	1	0.0%
TG	958	74	14.3%	26	0.3%
AG	367	152	29.4%	10	0.1%
Total	160,053	518		7,673	

TC Loss:

- 59% of loss change occurred within forest or wetlands
- 41% of loss occurred in developed areas

TC Gain:

- 16% of gain occurred within forest or wetlands
  - shrub/scrub; edge of forest
- 54% of gain occurred in developed areas
- 29% of gain occurred on agricultural lands

TC Change Patch Size Statistics High-Res (m^2)

Change	Count	Min	Median	Max	Mean
Loss	256,864	1	48	170,114	121
Gain	42,831	1	6	24,828	49

TC Change Patch Size Statistics NLCD (m^2)

Change	Count	Min	Median	Max	Mean
Loss	877	900	900	132,300	5,642
Gain	674	900	900	46,800	2,711

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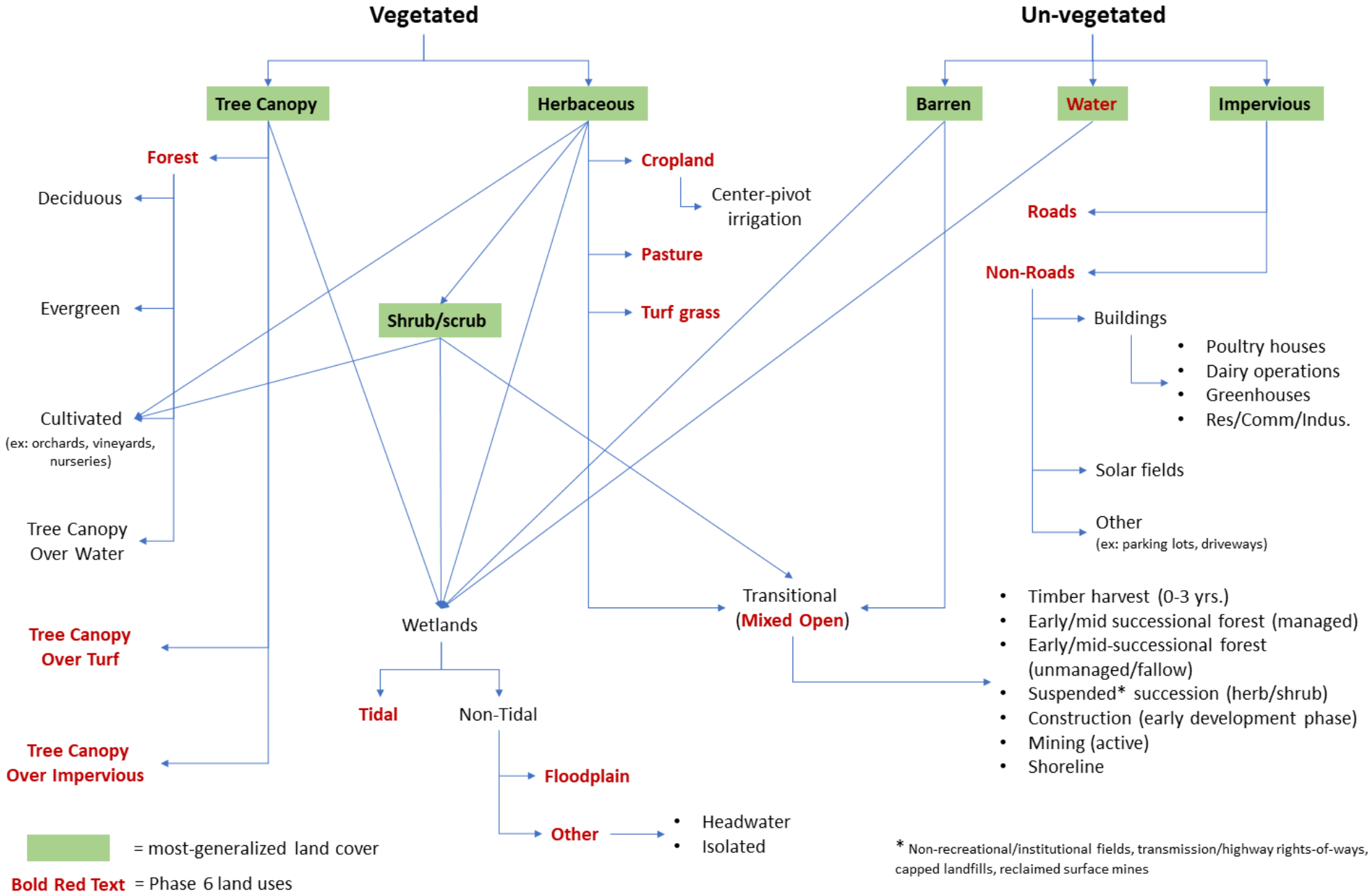
Proposed CBP High-resolution Land Cover/ Land Use Classification System:



Forecasting Land Use and Climate Change

IPCC AR5 climate change scenarios are based on Representative Concentration Pathways (RCPs): 2.6, 4.5, 6.0, and 8.5. The CBP is modeling RCP 4.5 and 8.5 to simulate and bracket climate change effects on pollutant loads.

IPCC AR5 Shared Socioeconomic Pathways (SSPs) compliment RCPs with demographic, economic, technological, energy, and policy storylines that could result in one or more RCP:

SSP1: sustainability-focused growth and equality
SSP2: trends broadly follow their historical patterns
SSP3: resurgent nationalism
SSP4: ever-increasing inequality
SSP5: rapid and unconstrained growth in economic output and energy use .

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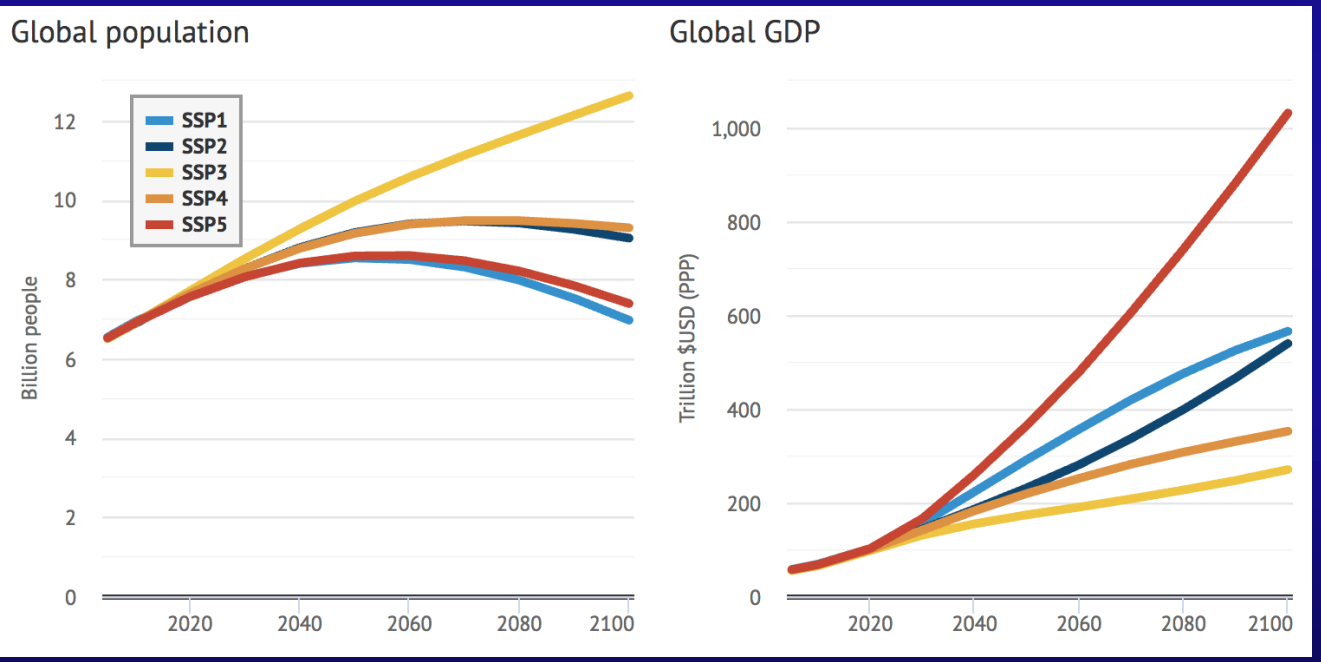
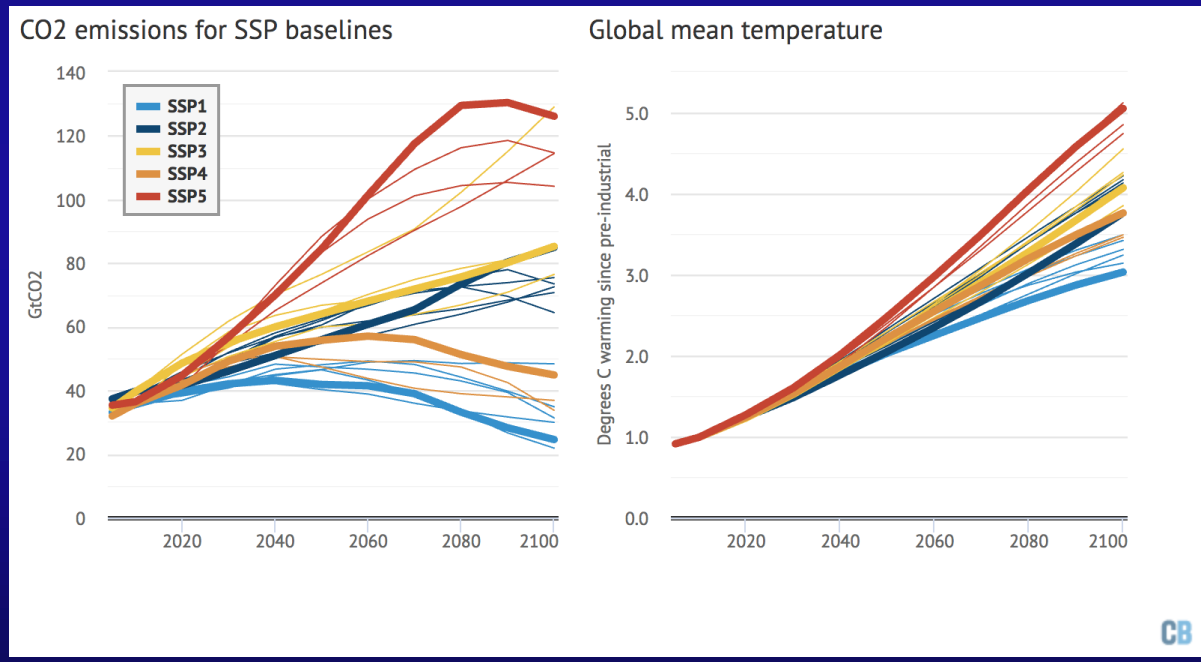
Shared Socioeconomic Pathway Characteristics





CB

https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change

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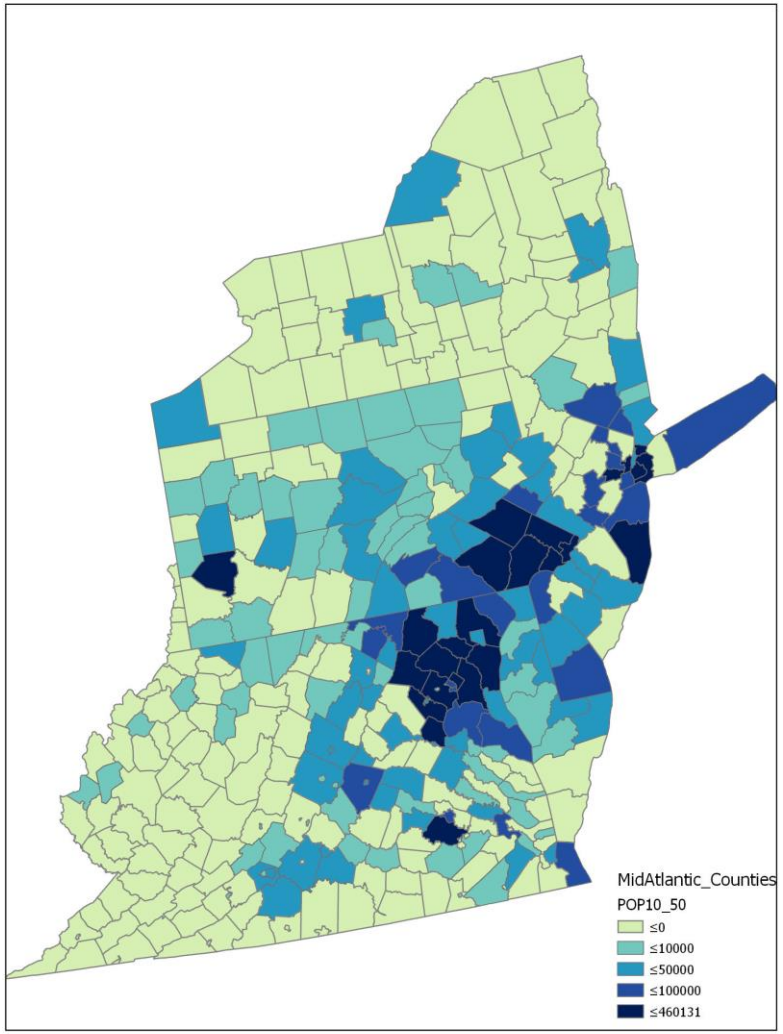
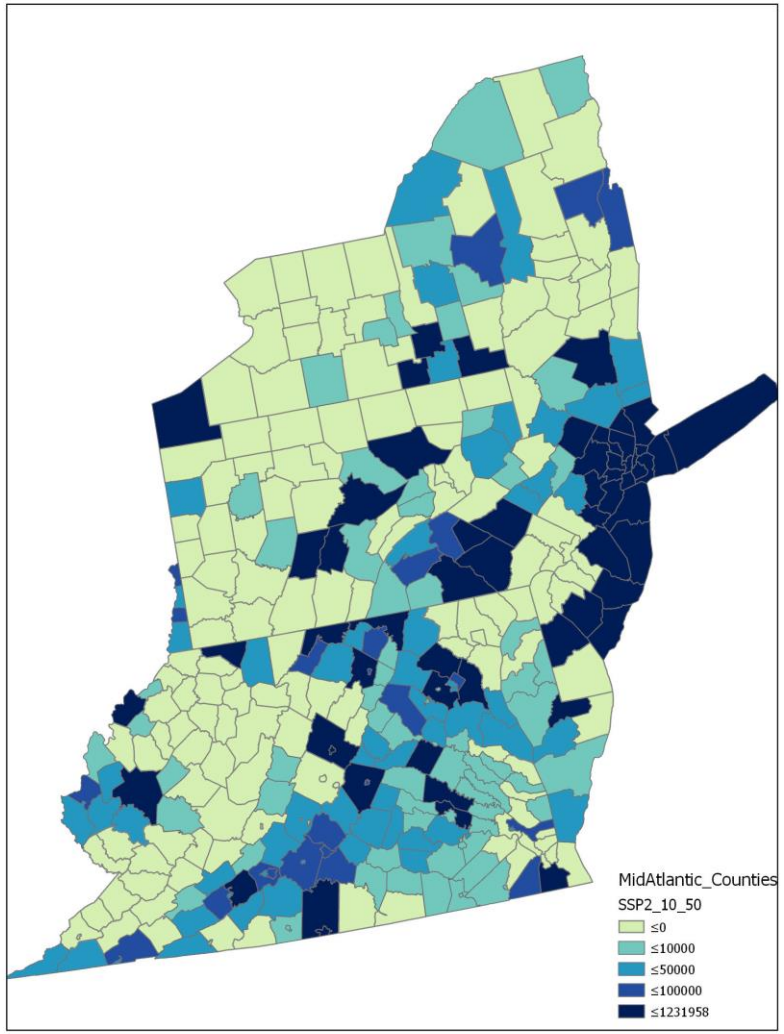
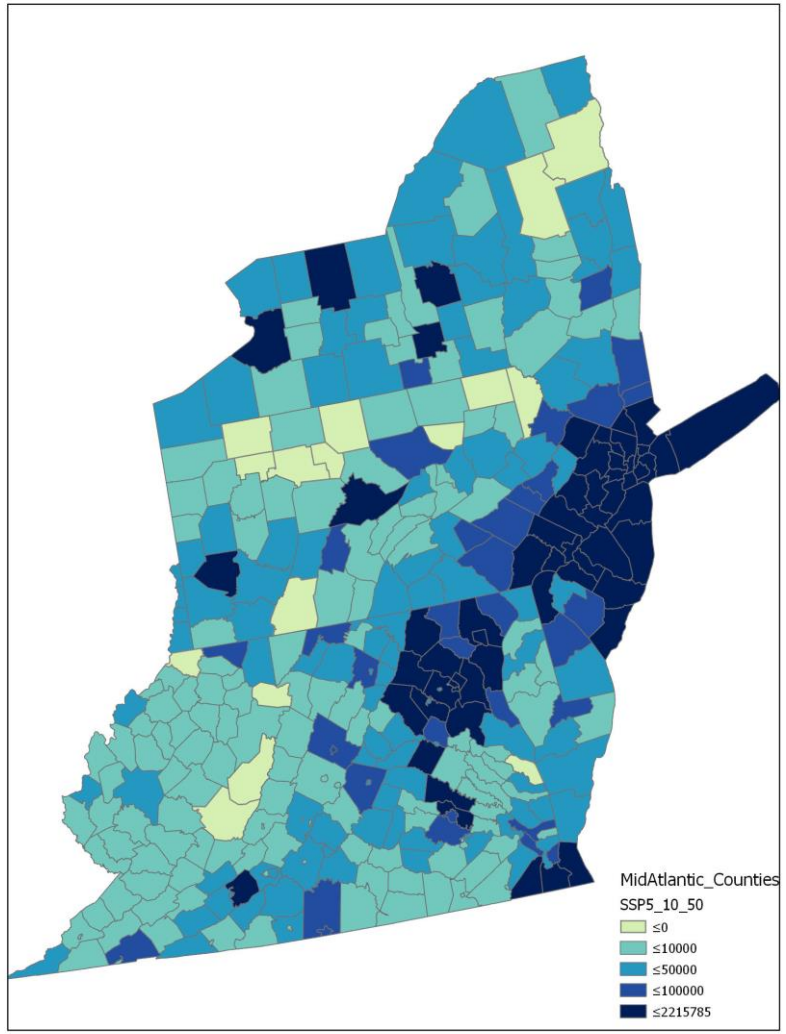
Population Change: 2010 - 2050

CBLCMv4	SSP2_ICLUSv2*	SSP5_ICLUSv2*







county projections	“historical trends and patterns”	“rapid and unconstrained growth”

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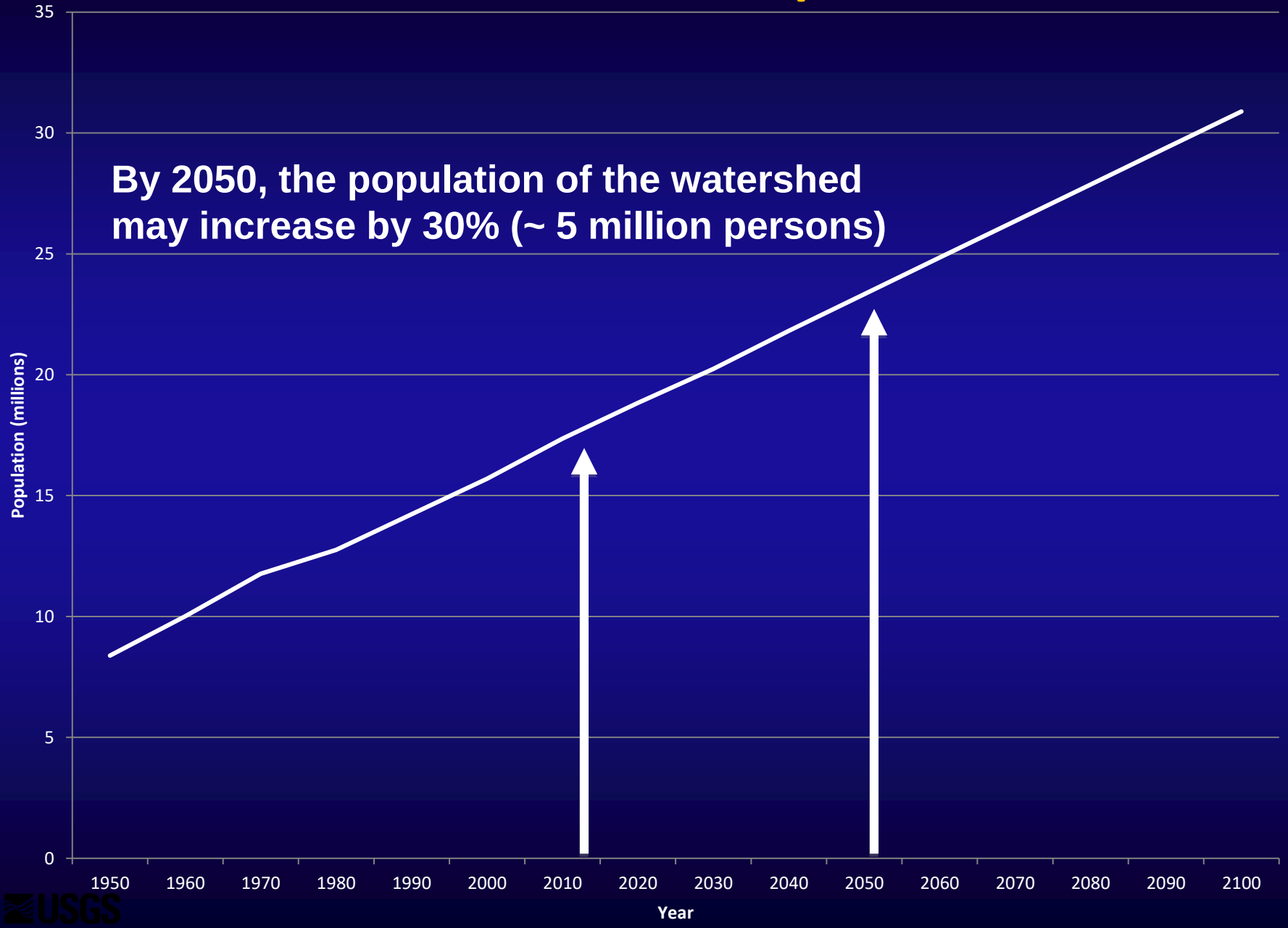
* Used in the 4th National Climate Assessment

Future Watershed Population



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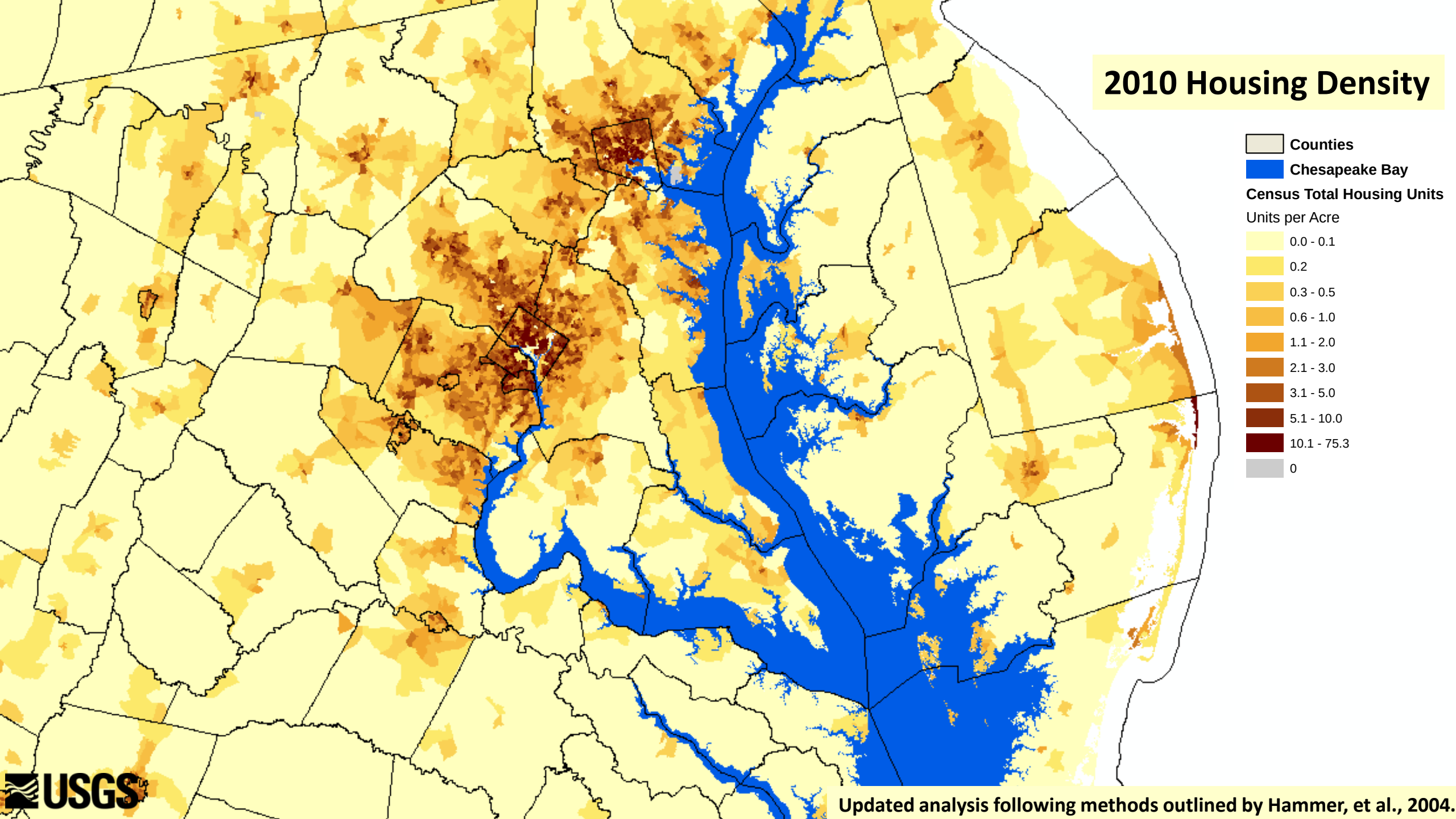
2010 Housing Density
Counties
Chesapeake Bay
Census Total Housing Units
Units per Acre
0.0 - 0.1
0.2
0.3 - 0.5
0.6 - 1.0
1.1 - 2.0
2.1 - 3.0
3.1 - 5.0
5.1 - 10.0
10.1 - 75.3
0
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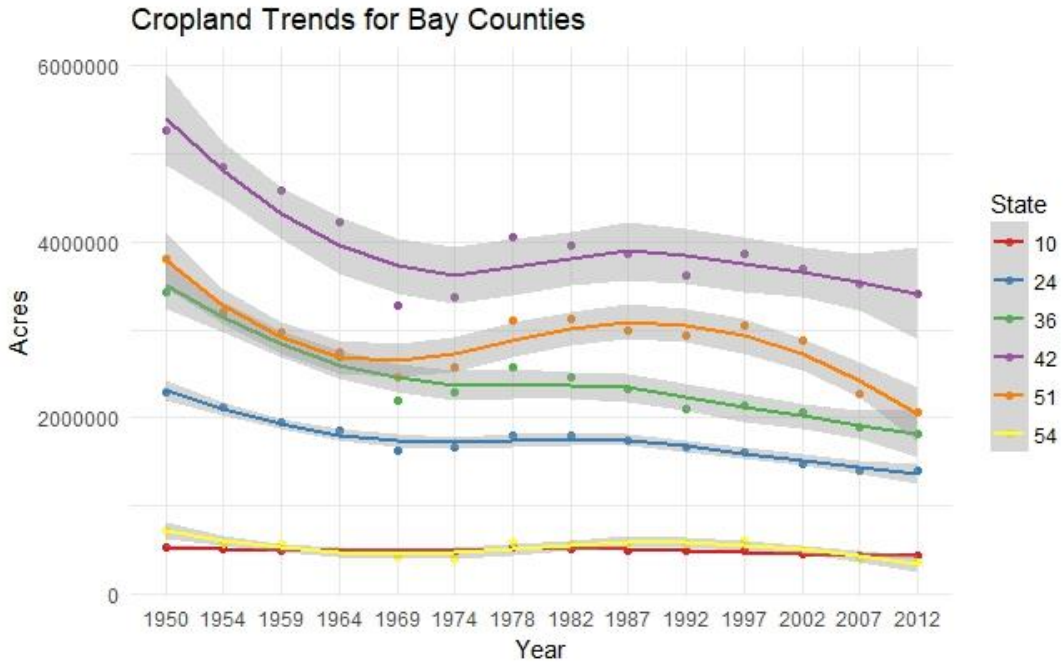
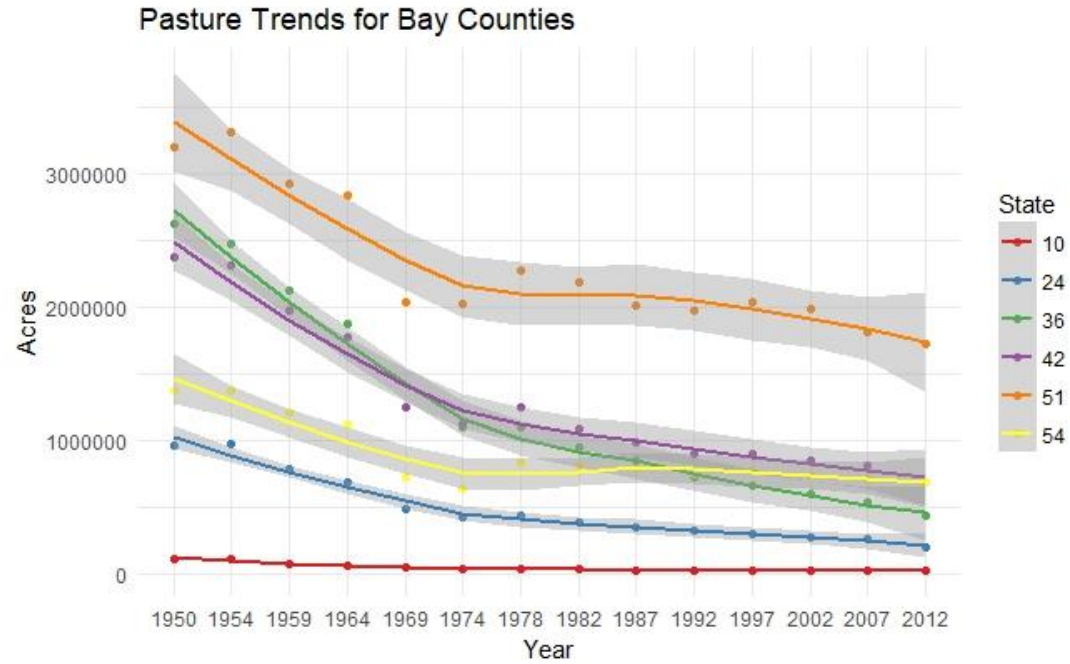
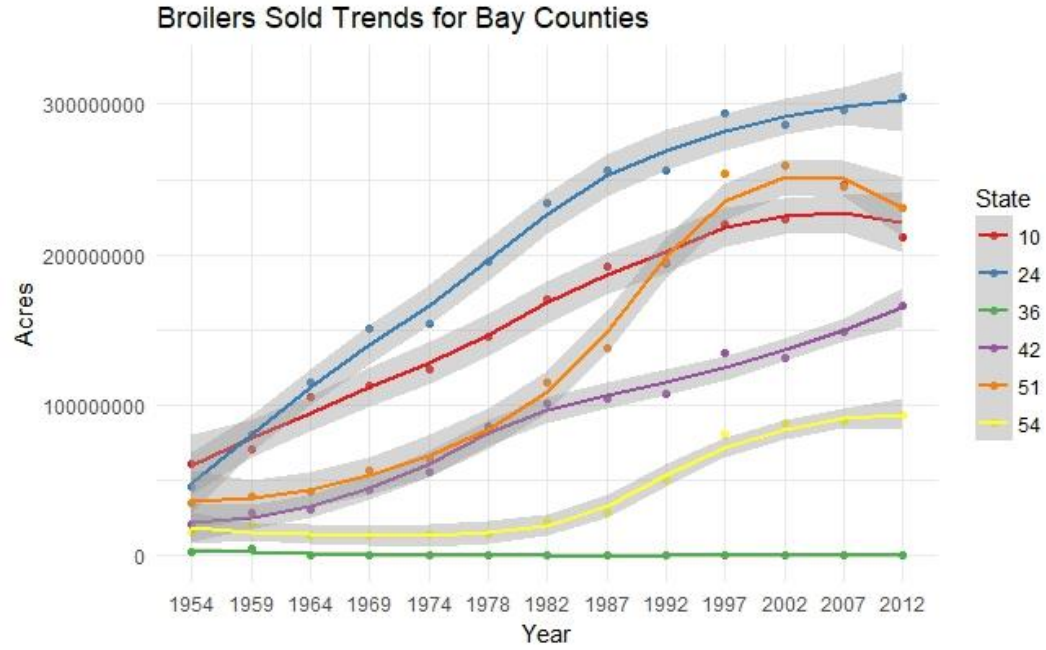
Updated analysis following methods outlined by Hammer, et al., 2004.


Cropland Trends for Bay Counties
Acres
6000000
4000000
2000000
0
1950 1954 1959 1964 1969 1974 1978 1982 1987 1992 1997 2002 2007 2012
Year
State
10
24
36
42
51
54


Pasture Trends for Bay Counties
Acres
3000000
2000000
1000000
0
1950 1954 1959 1964 1969 1974 1978 1982 1987 1992 1997 2002 2007 2012
Year
State
10
24
36
42
51
54


Broilers Sold Trends for Bay Counties
Acres
300000000
200000000
100000000
0
1954 1959 1964 1969 1974 1978 1982 1987 1992 1997 2002 2007 2012
Year
State
10
24
36
42
51
54

Chesapeake Bay 2050 Land Use Scenarios

- Historic Trends
- Historic Trends (with current zoning enforced)
- Growth Management
- Forest Conservation
- Agricultural Conservation
- State Custom Scenarios (DC, DE, MD, PA, VA, WV)

These CBP scenarios are most closely aligned with SSP1 (sustainability) and SSP2 (historical patterns) narratives and can logically support RCP's 2.6, 4.5, or 6.0.

None of the CBP scenarios logically support the realization of RCP 8.5 which is associated with SS5: rapid and unconstrained growth.

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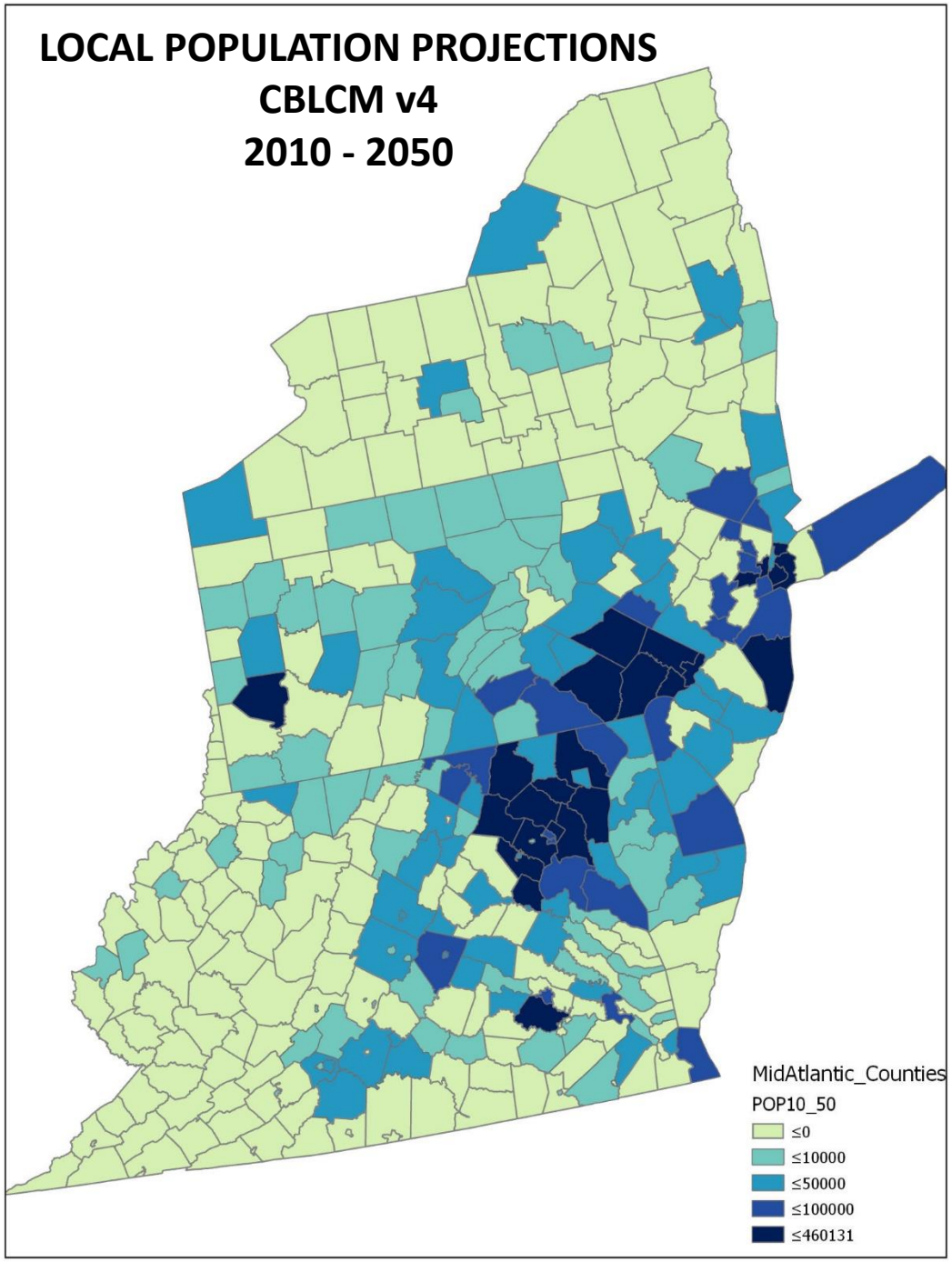
Modeling the Effects of Population Growth on Land Use Change and Pollutant Loads

Modeling Assumption:

Urban development results from growth in population and employment.



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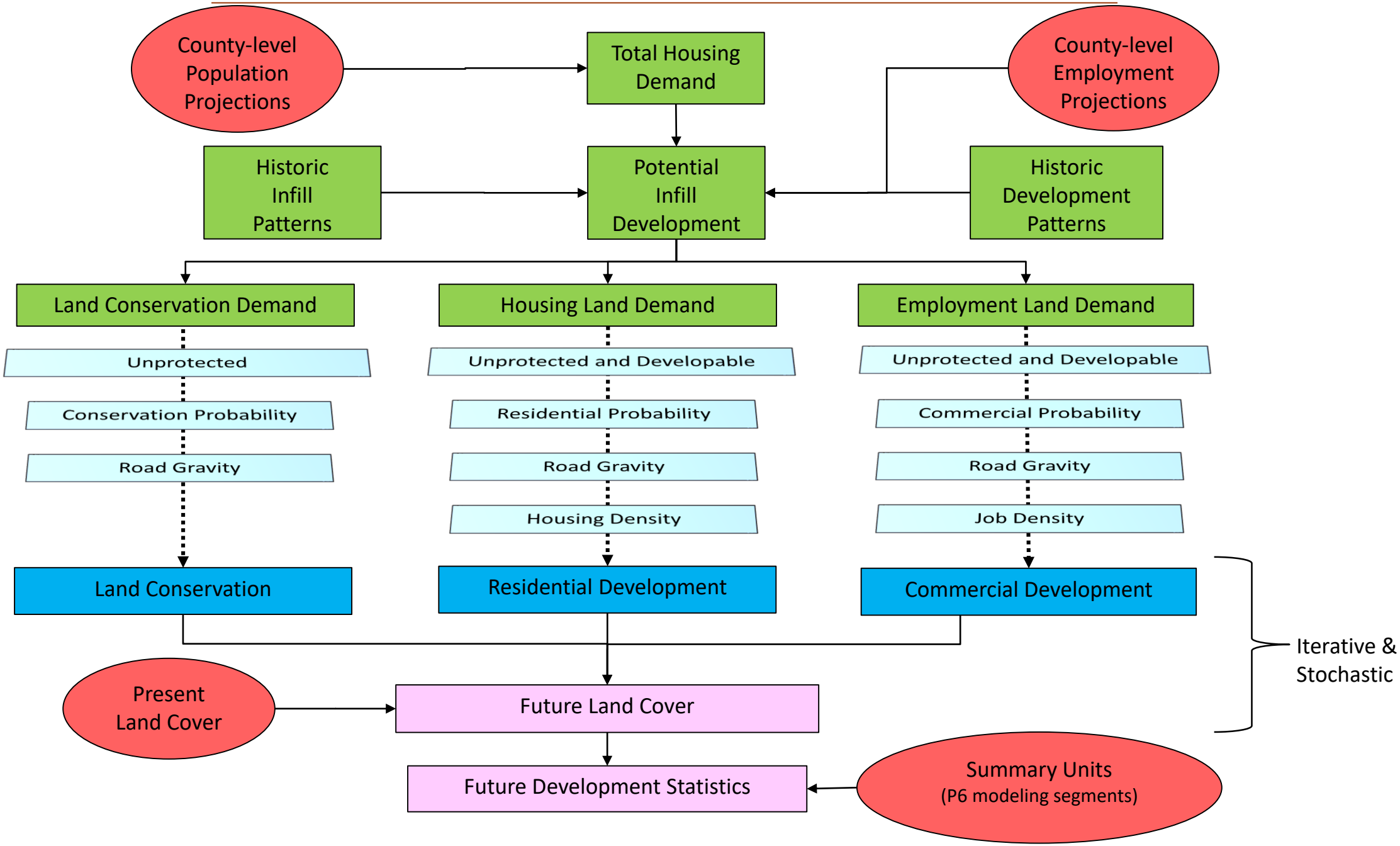
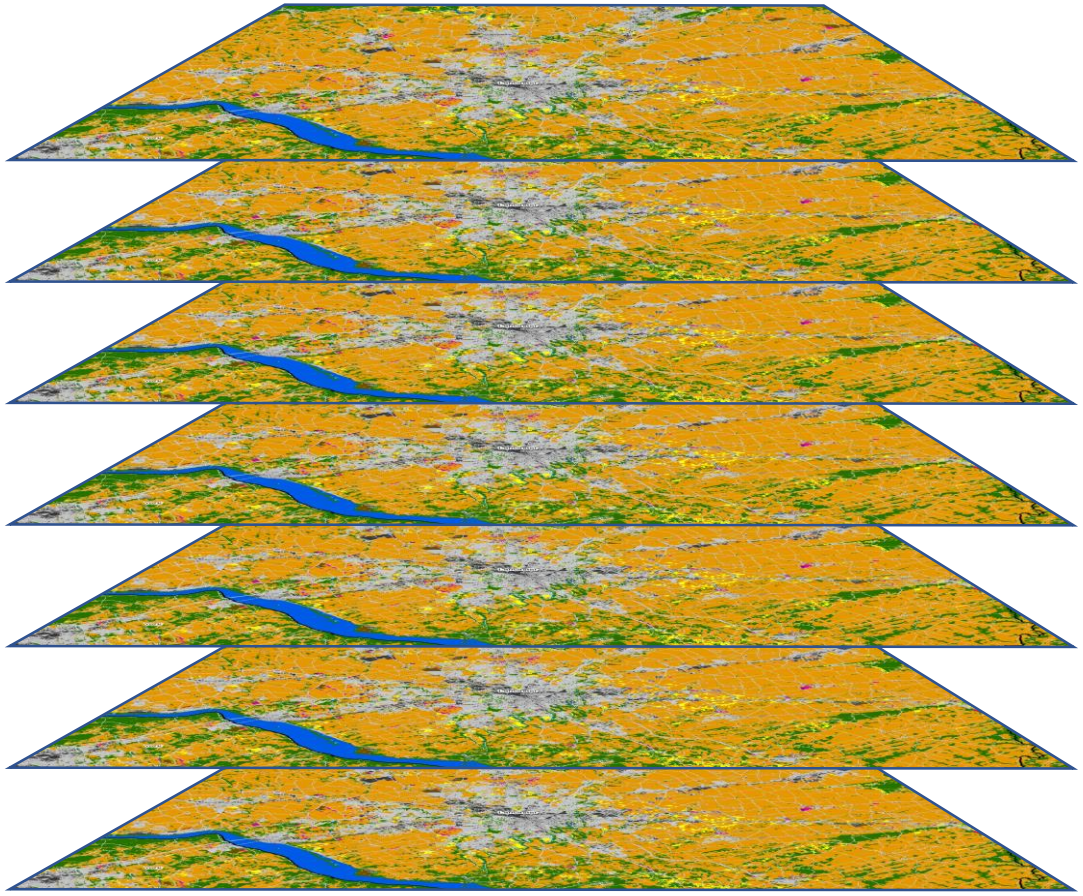
Chesapeake Bay Land Change Model v4

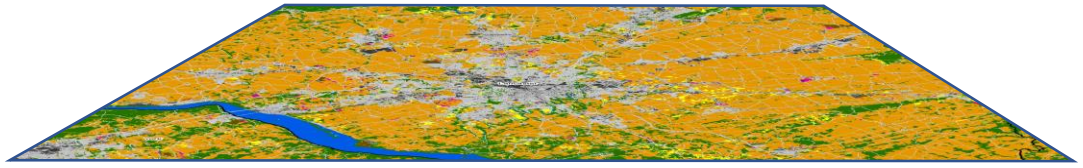


Multiple Stochastic Iterations



Every county is simulated 101 times for each scenario and target year, i.e., 2025.

Average of simulations by summary unit = future development

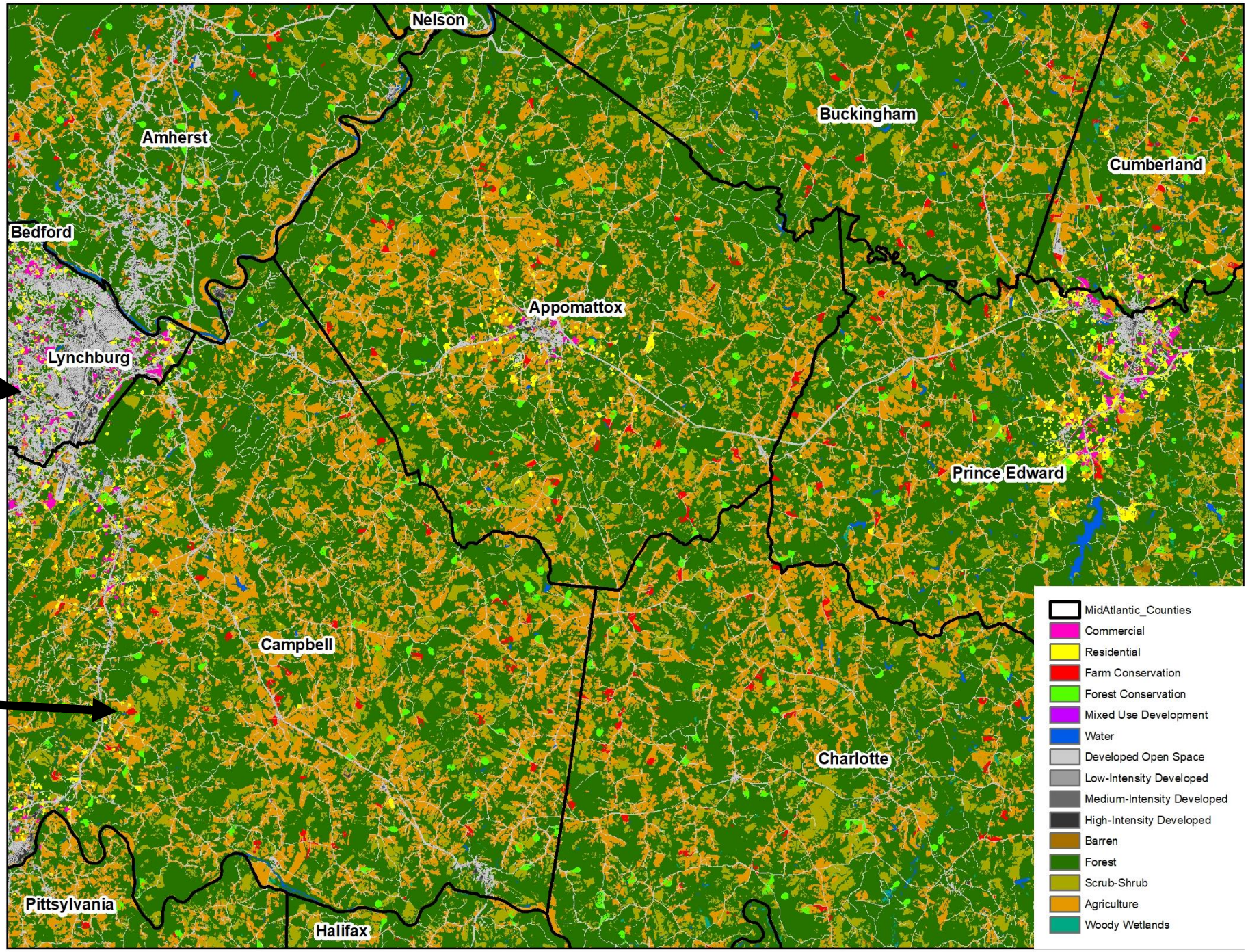


Relative Standard Deviation = estimate of uncertainty

Land Change Model Outputs

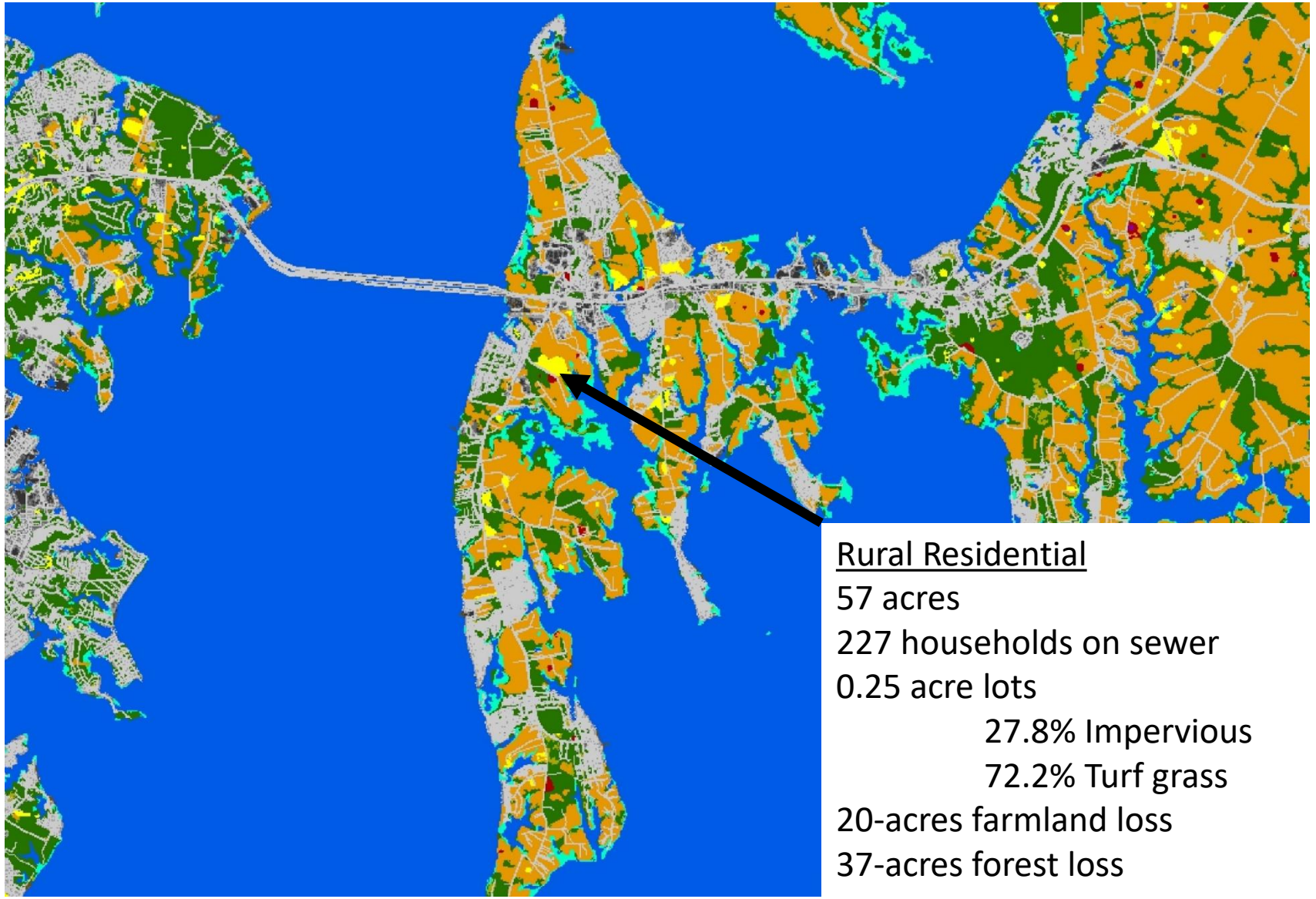
Commercial and Residential Growth

Farmland and Forest Conservation



Land Change Model Outputs: Summary Statistics

- Impervious surface and turf grass expansion
- Forest conversion to development
- Farmland conversion to development
- Future population on sewer and septic



<u>Rural Residential</u>
57 acres
227 households on sewer
0.25 acre lots
27.8% Impervious
72.2% Turf grass
20-acres farmland loss
37-acres forest loss

To inform CBP climate resilience, adaptation, and mitigation decisions and outcomes:

What types of land cover/use transitions are most important to monitor?

What future scenarios are needed?

Is there a need for consistency with national-to-global scale scenario assumptions (IPCC-AR5 SSPs)?

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science for a changing world