Global Future Population Grids

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Retooling population forecasts

o *Aspatial approaches* typically use the "cohort component method" which is unsuitable to fine-scale population distributional changes

o However, *spatial approaches* are demographically naïve.

- GHSL offers promise for improvements.

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Part I

o Population over space vs. over time

- Most previous efforts are over space or time, not both

- Most efforts attempting both are at a coarse resolution.

- GHSL offers some new possibilities

o GHSL vs. Census

- Changes in "Urban Status"

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GHSL + Census: 1990-2010

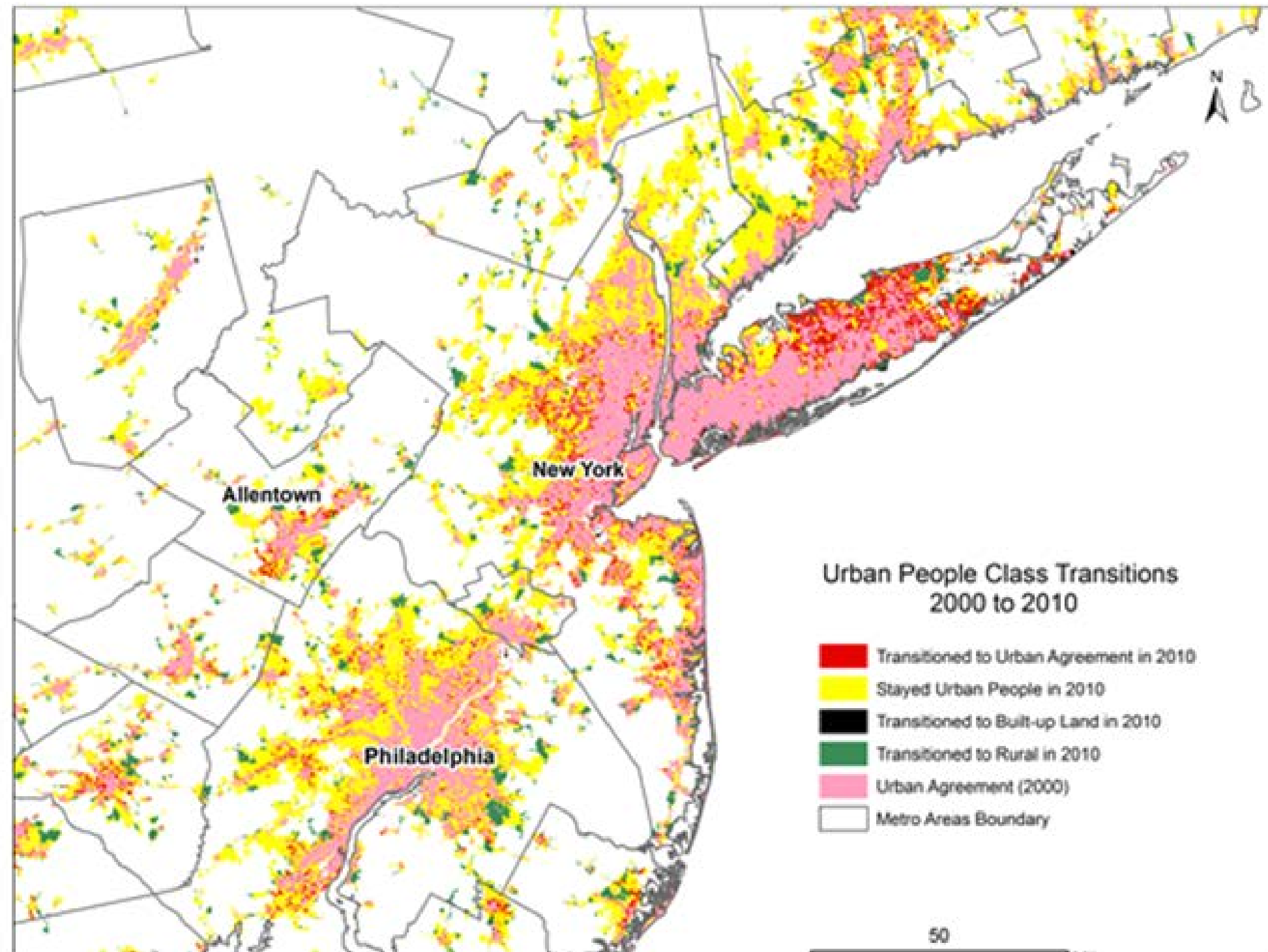Figure 2. Venn diagram showing possible subsets created from combining layers and resulting classification schema.
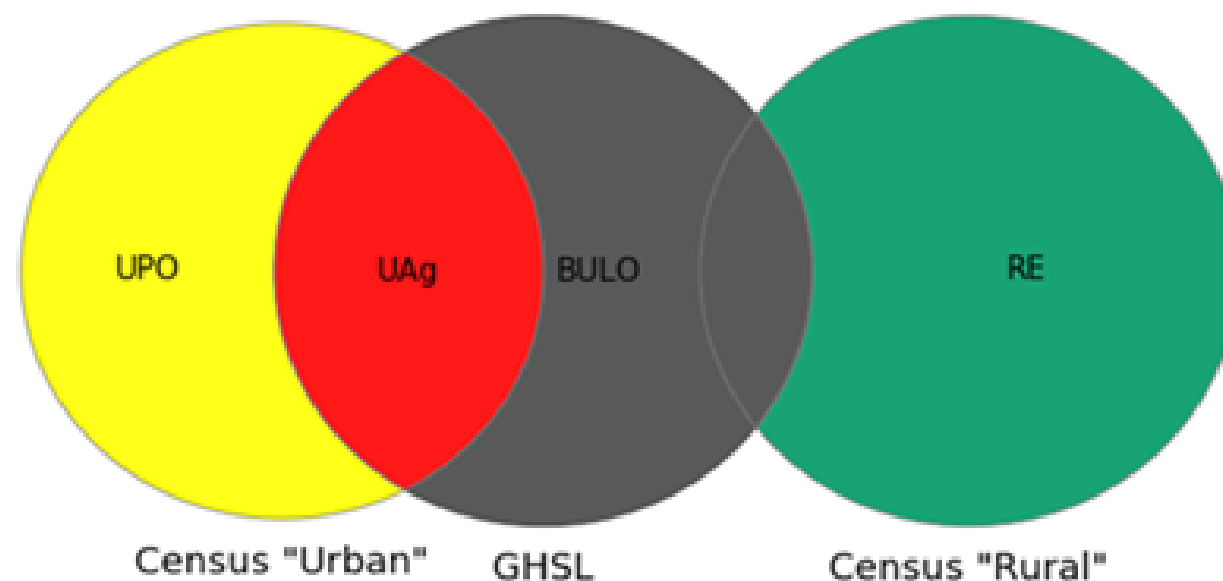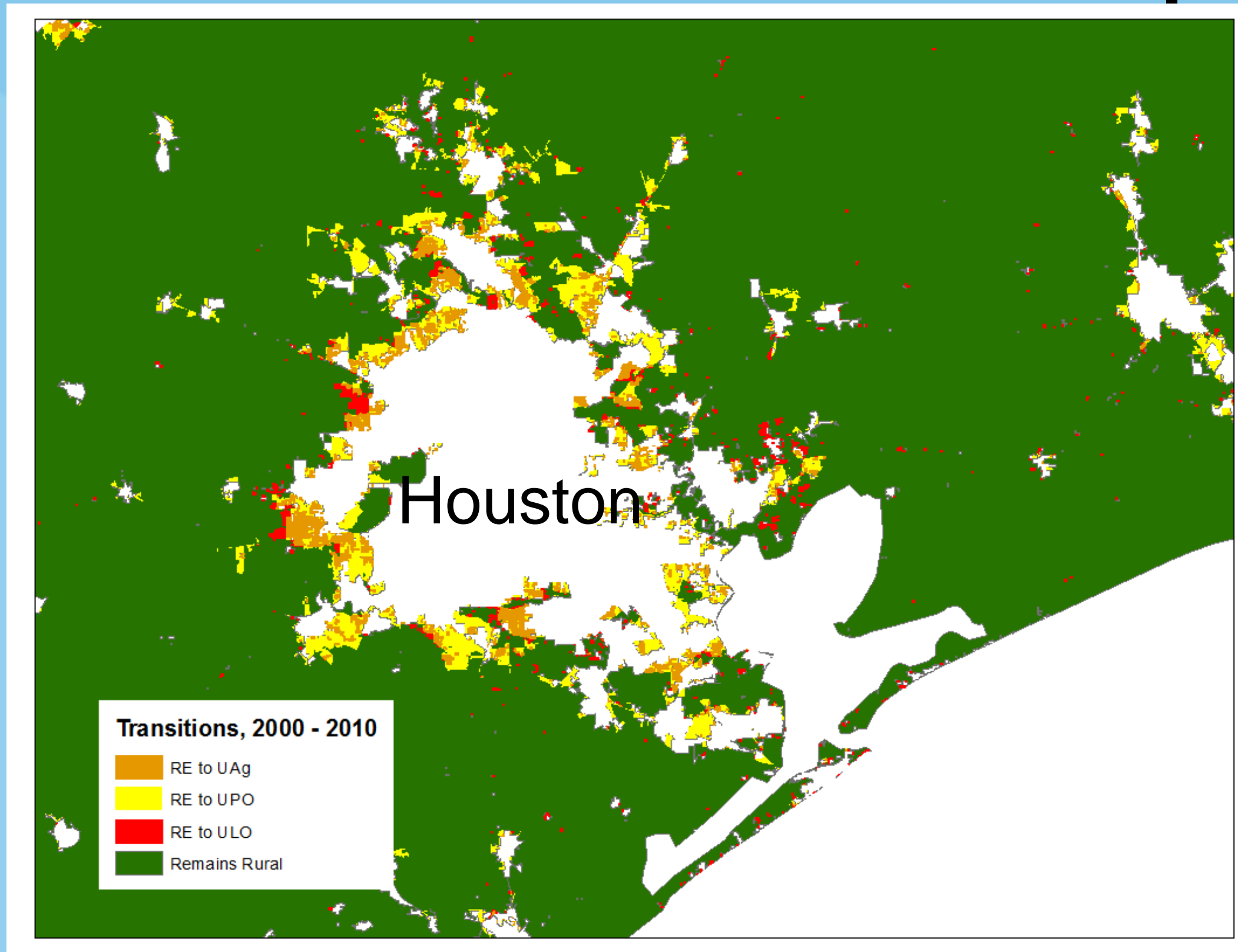
Not shown: $UI = UAg \cup BULO \cup UPO$

Concept	Shorthand (Acronym)
Urban inclusive (based on built-up threshold OR census definition)	Urban inclusive (UI)
Urban agreement (based on built-up threshold AND census definitions)	Urban agreement (UAg)
Urban land-focused: GHSL built-up threshold	Built-up land only (BULO)
Urban people-focused: Census-defined urban blocks	Urban people only (UPO)
All else (includes rural, protected and uninhabited areas)	Rural Extents (RE)

Changes in Urban Classification

Figure 4. Change in urban classification, 2000-2010, New York City MSA.

Urban People Class Transitions 2000 to 2010

- Transitioned to Urban Agreement in 2010
- Stayed Urban People in 2010
- Transitioned to Built-up Land in 2010
- Transitioned to Rural in 2010
- Urban Agreement (2000)
- Metro Areas Boundary

Rural land → Built-up

Houston

Transitions, 2000 - 2010

- RE to UAg
- RE to UPO
- RE to ULO
- Remains Rural

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Estimating transitions

Urban Class	Area (sq km)		Land Classification and Area, in the following decade			Change as % of the Original Area		Overall Transitions: Stay Urban		Transition to Rural Extents	
	1990	2000	Layer	2000	2010	2000	2010	2000	2010	2000	2010
Uag	78,216	89,510	UAg	74,964	88,847	95.84%	99.26%	100.0%		0.0%	
			BULO	3,252	663	4.16%	0.74%				
			UPO	0	0	0.00%	0.00%				
BULO	10,717	13,770	UAg	4,200	7,040	39.19%	51.12%				
			BULO	6,516	6,731	60.81%	48.88%				
			UPO	0	0	0.00%	0.00%				
UPO	146,931	150,701	UAg	7,368	15,227	5.01%	10.10%	66.6%	89.7%	33.4%	10.3%
			BULO	933	712	0.64%	0.47%				
			UPO	89,484	119,194	60.90%	79.09%				
								Stay Rural		Transition to Urban	
RE	7,574,457	#####	UAg	2,976	4,230	0.04%	0.68%	99.1%	99.1%	0.9%	0.9%
			BULO	3,039	10,918	0.04%	0.06%				
			UPO	61,153	51,149	0.81%	0.14%				

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GHSL in forecasting

o Areas detected as built-up, remain built-up.

o About 50% of area detected as built-up but not classified as urban by the census transition to census-urban a decade later.

- But 30% of the census-designated urban areas do not meet a GHSL threshold of 50%.

  - Improves if threshold is lowered.

  - Expected to improve with GHSL-Sentinel

o Rural transitions to built-up land occur on the edges of existing urban locations.

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Part II:
SSP Spatial Population Forecasts
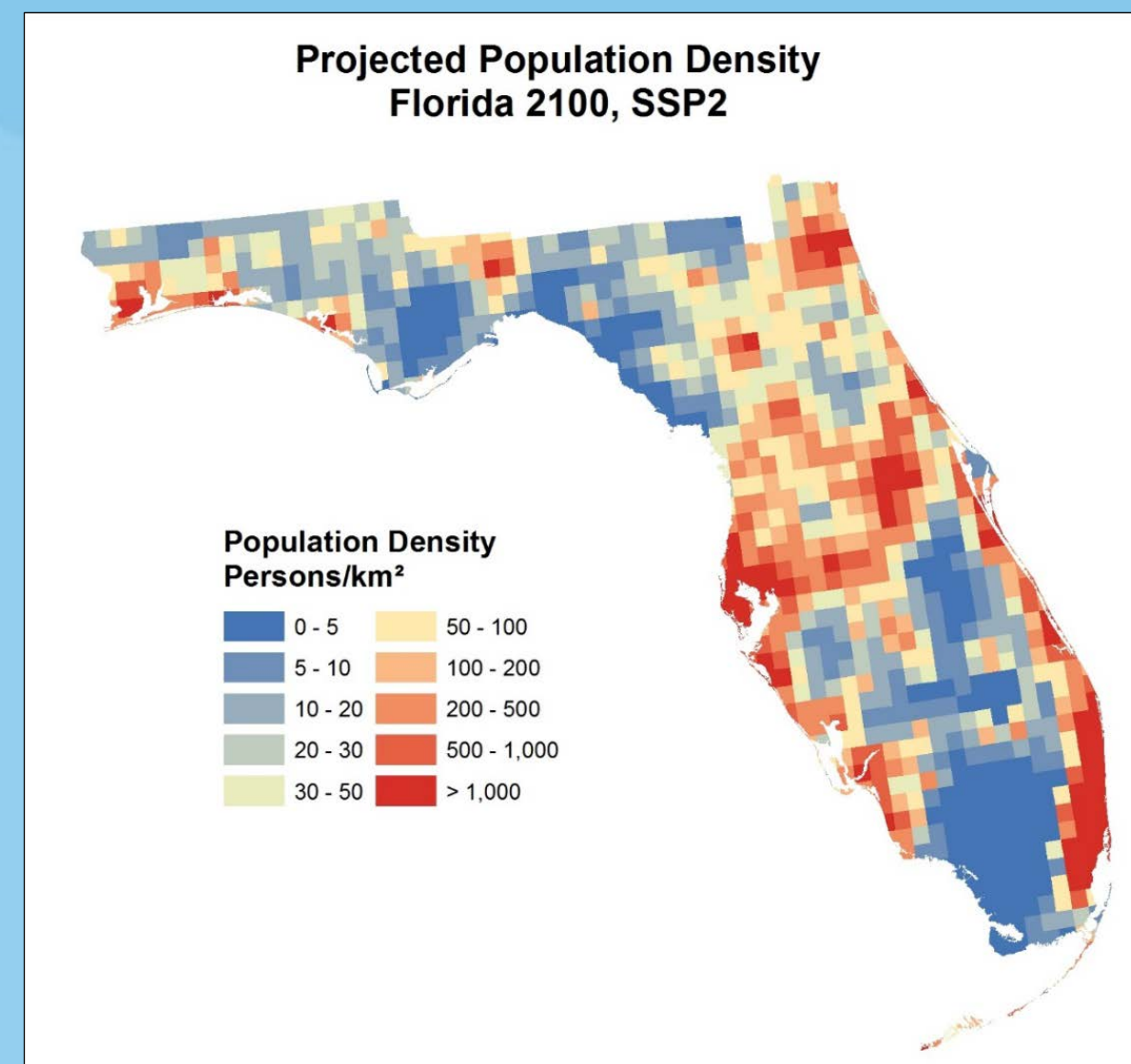
CIDR/NCAR downscaling model

To develop an improved methodology for constructing large-scale, plausible future spatial population scenarios which may be calibrated to reflect alternative regional patterns of development for use in the scenario-based assessment of global change.

Characteristics

- Gravity-based downscaling model
- Captures observed geographic patterns
  - Calibration
- Flexible framework
  - Data
  - Resolution (temporal & spatial)

SSP-based spatial population scenarios

- 232 countries/territories
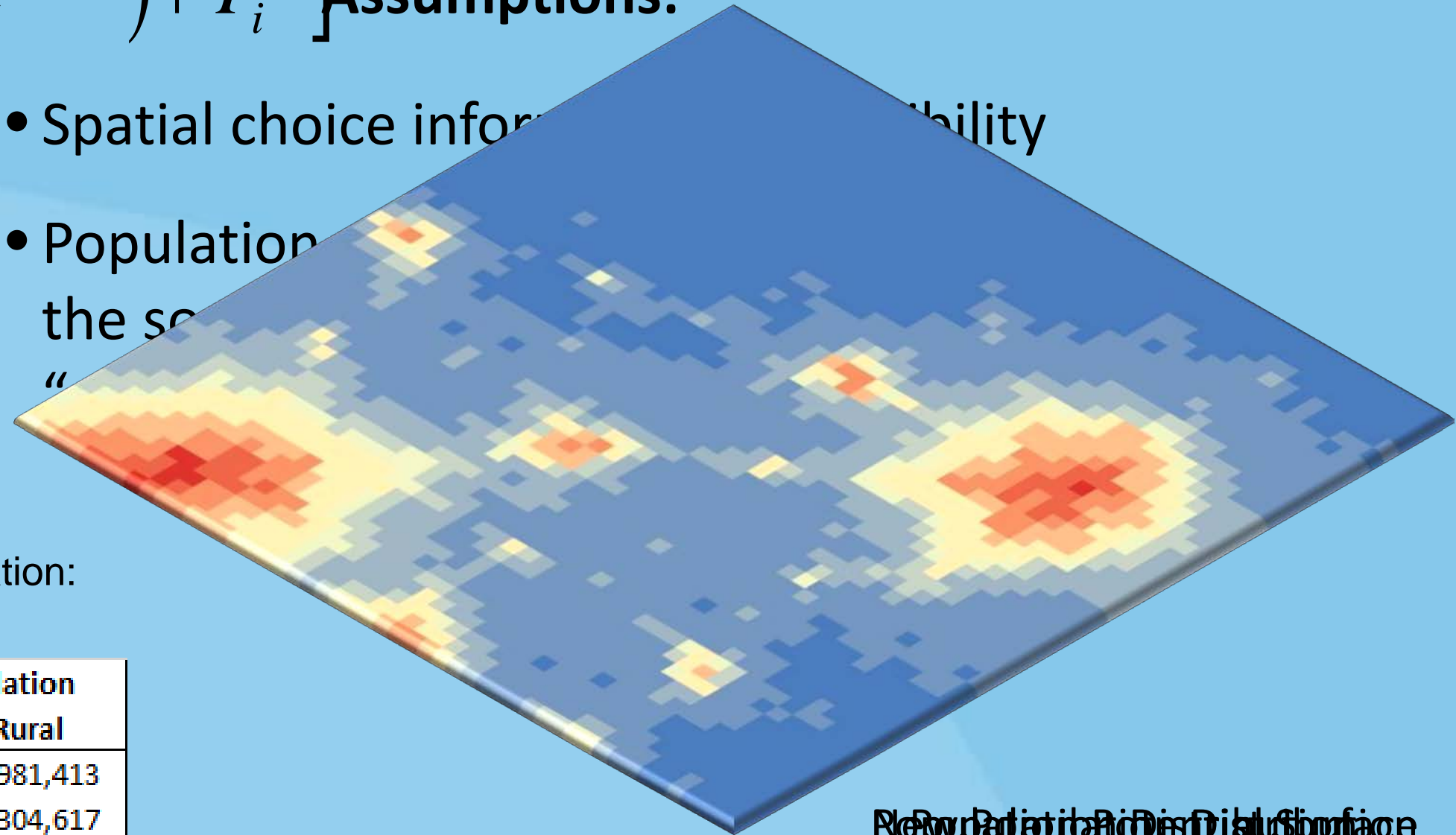- Urban, rural, and total populations
- 10-year time steps, 1/8th degree

Projected Population Density Florida 2100, SSP2

Population Density Persons/km²

0 - 5	50 - 100
5 - 10	100 - 200
10 - 20	200 - 500
20 - 30	500 - 1,000
30 - 50	> 1,000

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CIDR/NCAR Spatial Population Downscaling Model

$$v_i = a_i l_i \sum_{j \neq i}^{m} \left[\left(P_j e^{-\beta d_{ij}} \right) + P_i^{\alpha} \right]$$ **Assumptions:**

- Spatial choice infor... ...bility

- Population ... the s...

Projected US Population: SSP 1

Year	Projected Population	
	Urban	Rural
2010	255,402,535	54,981,413
2020	286,417,662	50,304,617
2030	318,137,168	45,549,066
2040	348,191,432	40,609,471
2050	375,413,486	35,644,671
2060	400,977,524	30,977,872
2070	424,302,444	26,660,041
2080	442,644,461	22,611,644
2090	451,842,189	18,759,475
2100	451,283,127	15,223,964

Population Distribution Surface

- Allocation is limited by a geospatial mask indicating land not suitable for development.

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CIDR/NCAR Spatial Population Downscaling Model

Adjustment Factor

Distance Parameter

Distance

Population Parameter
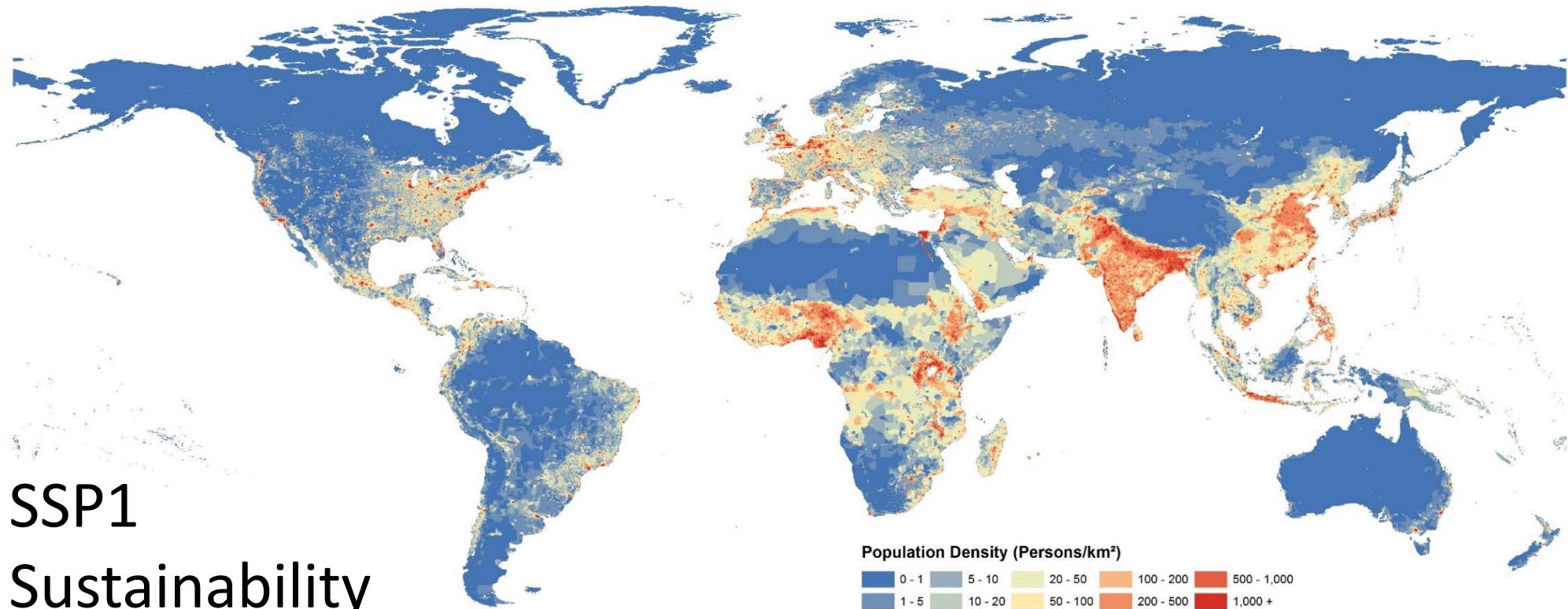
Spatial Mask

Population

$$v_i = a_i l_i \sum_{j \neq i}^{m} \left[\left(P_j e^{-\beta d_{ij}} \right) + P_i^{\alpha} \right]$$

- Potential is calculated for each cell over a window of 100km.

- Currently: Urban and rural populations coexist within grid cells.
- Future: GHSL will be used to refine the agglomeration effect, urban/rural distributions, and predict likely new development

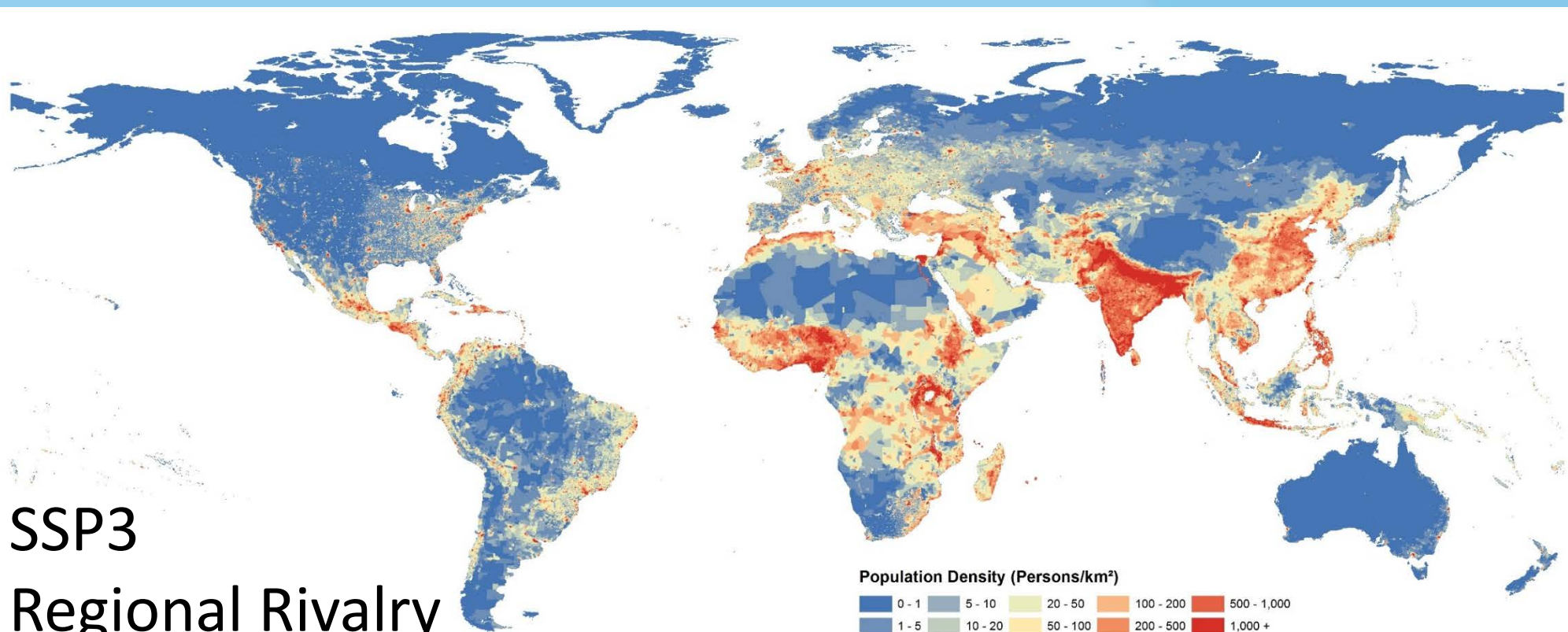- Parameters (α and β) are estimated from historical data for both urban and rural distributions.

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Projected Population (2100)

SSP1
Sustainability

SSP3
Regional Rivalry

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Projected Population Change (2010-2100)

SSP1
Sustainability

Population Change

< - 5,000	-1,000 to -500	0 to 10,000	50,000 to 100,000
-5,000 to -1,000	-500 to 0	10,000 to 50,000	> 100,000

SSP3
Regional Rivalry

Population Change

< - 5,000	-1,000 to -500	0 to 10,000	50,000 to 100,000
-5,000 to -1,000	-500 to 0	10,000 to 50,000	> 100,000
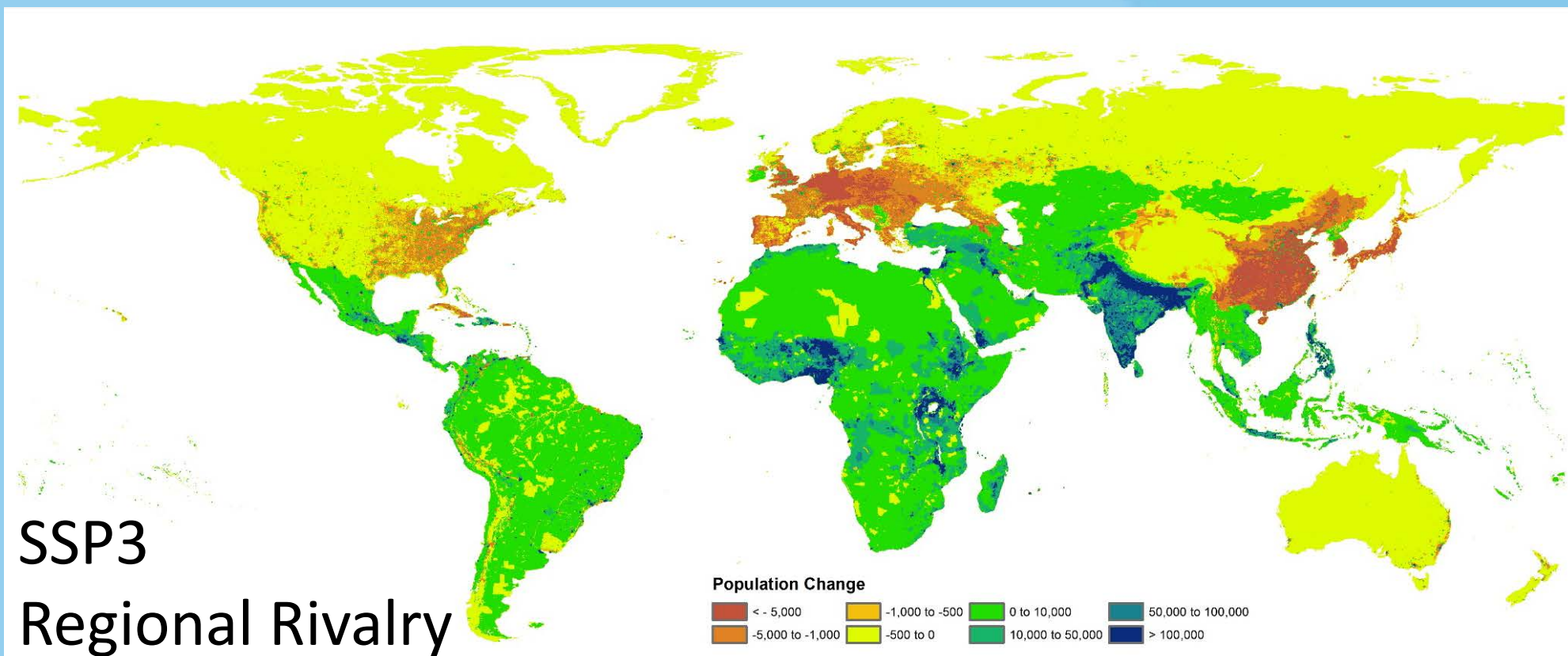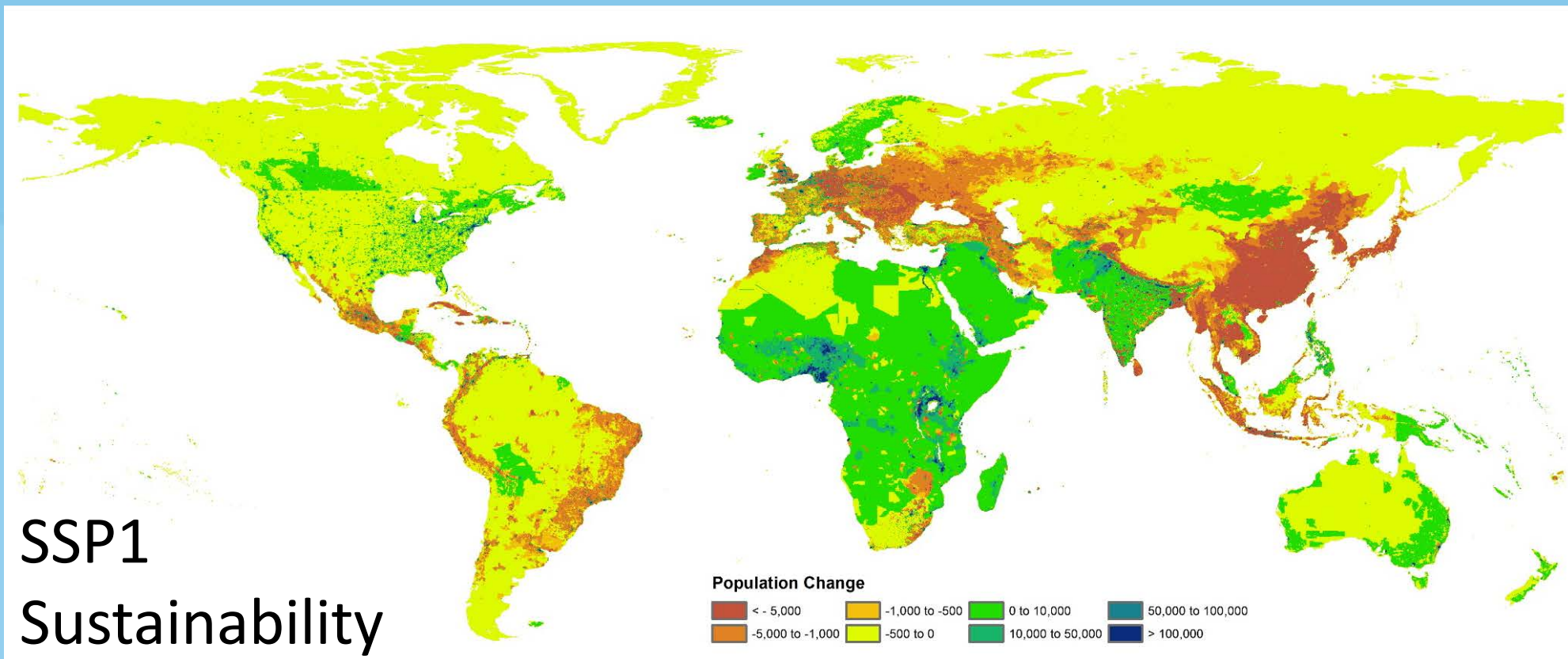
Part III: Where are the cities?

Urban Extents
(night lights)

Dryland
Ecosystems

Low Elevation
Coastal Zones
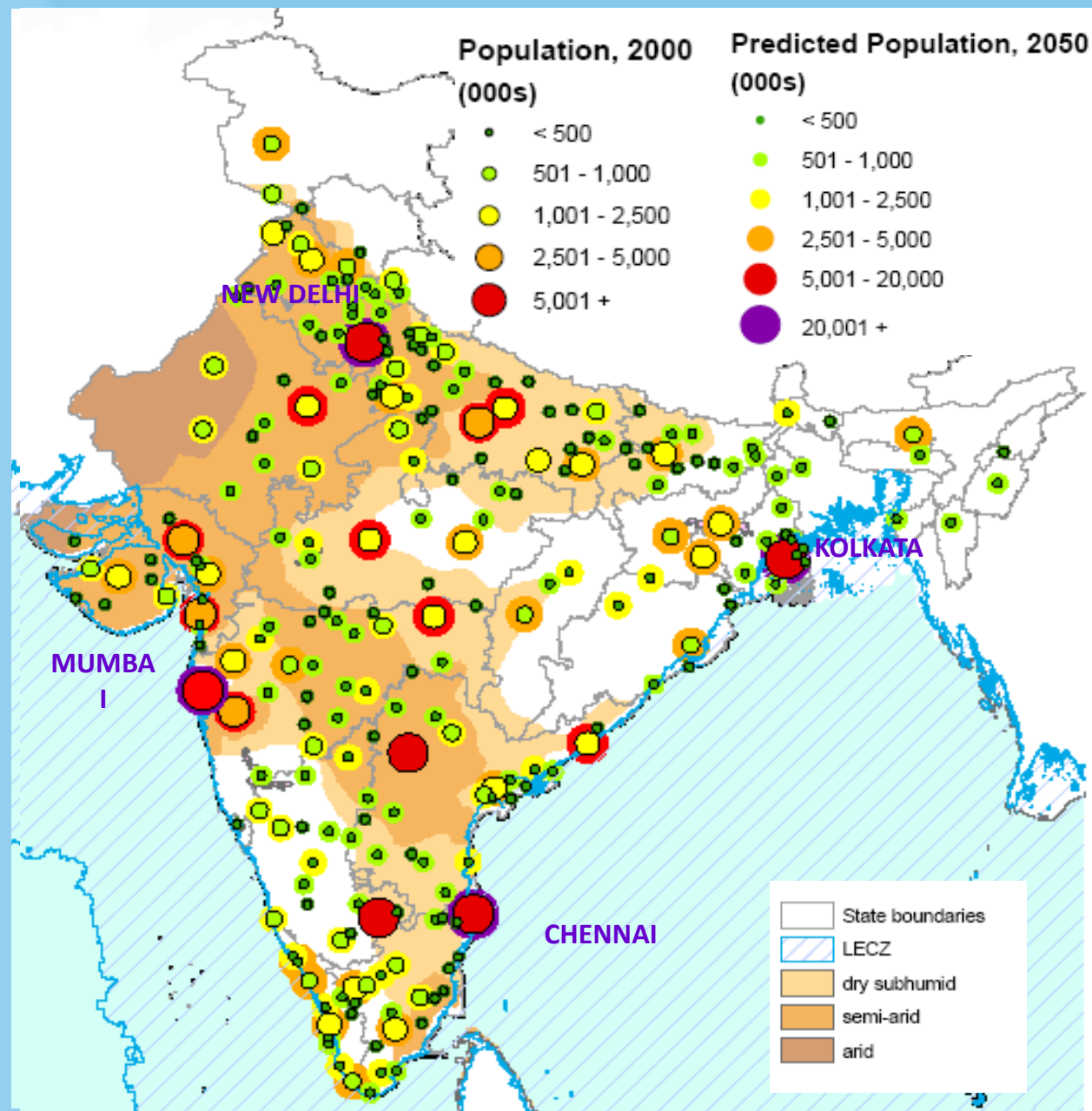(LECZ)
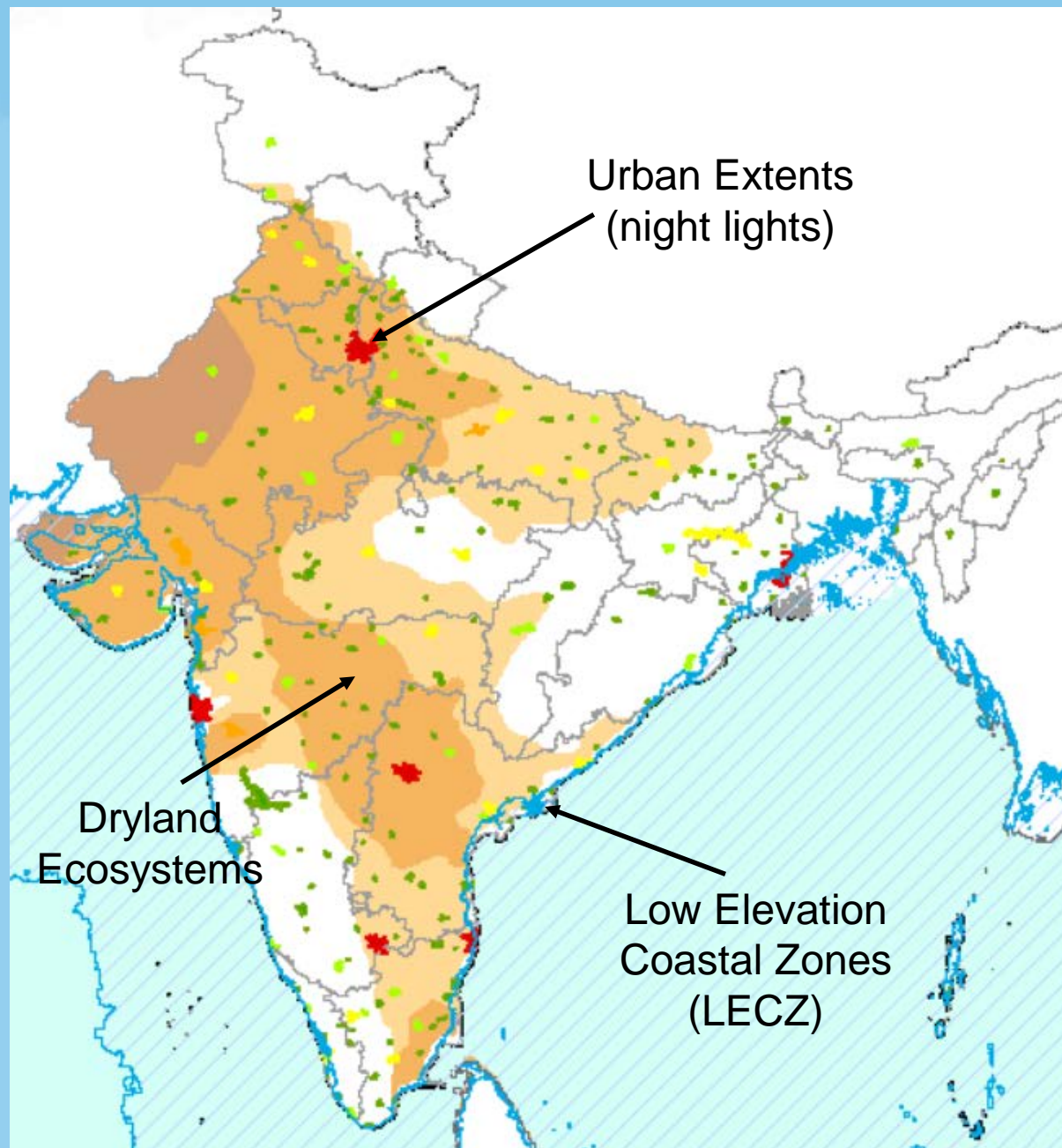
- Remarkably current urban projections are aspatial: They are not city-growth forecasts!

- Satellite data consistently give shape to cities where administrative data do not.

  - Currently: shown with GRUMP

  - Future: GHSL to be used for refined spatial features and to detect spatial changes at the city-scale

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How Will They Grow?

Population, 2000 (000s)

- · < 500
- ○ 501 - 1,000
- ○ 1,001 - 2,500
- ○ 2,501 - 5,000
- ● 5,001 +

Predicted Population, 2050 (000s)

- · < 500
- ● 501 - 1,000
- ● 1,001 - 2,500
- ● 2,501 - 5,000
- ● 5,001 - 20,000
- ● 20,001 +

NEW DELHI
KOLKATA
MUMBAI
CHENNAI

- State boundaries
- LECZ
- dry subhumid
- semi-arid
- arid

Source: Balk, Montgomery et al., 2009

$$g_{i,t} = \beta_0 + \beta_1 TFR_{i,t} + \beta_2 Q_{i,t} + \beta_3 NM_{i,t} + \beta_4 X_i + \beta_5 V_{i,t} + u_{i,t}$$

- This is what aspatial city growth models look like.

- Departing from urban projections, however, at least these are are demographically informed (still working on migration)

  - At the scale of a city, we don't typically have demographic rates. We have subnational demographic rates for urban residents. We use these.

  - Demographic/socio-economic data help us understand the causes and implications of that change.

  - GHSL and other spatial information will help us to understand how cities change in space.

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Conclusion

o 3 decades of US census data + GHSL shows that GHSL holds much promise for use in spatially-explicit forecasts of population and city-growth

- Refining variables/inputs to statistical models

- Provides an improved understanding of spatially explicit patterns of urban change

  - Which in turn improves our knowledge of the drivers of urban change

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