

Understanding and Simulating Spatially Explicit Global Urban Expansion in the Context of Climate Change

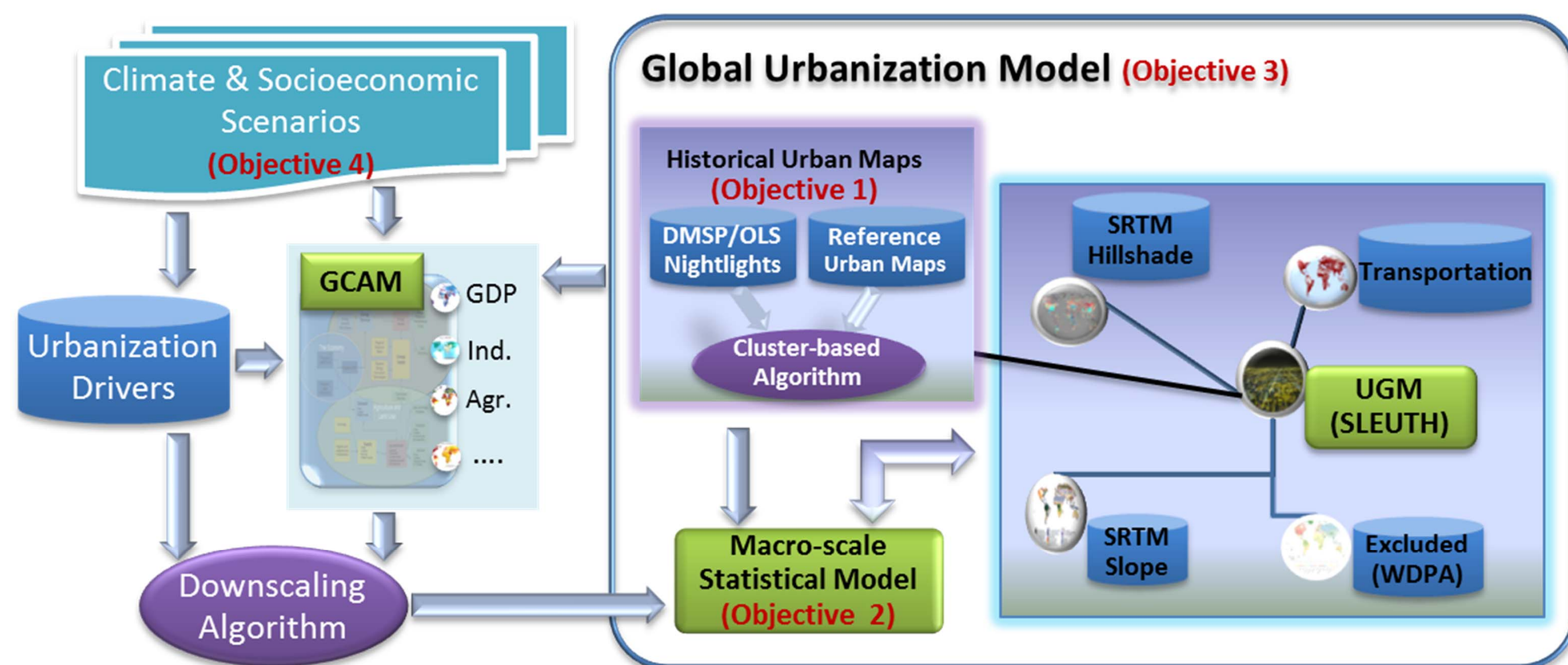
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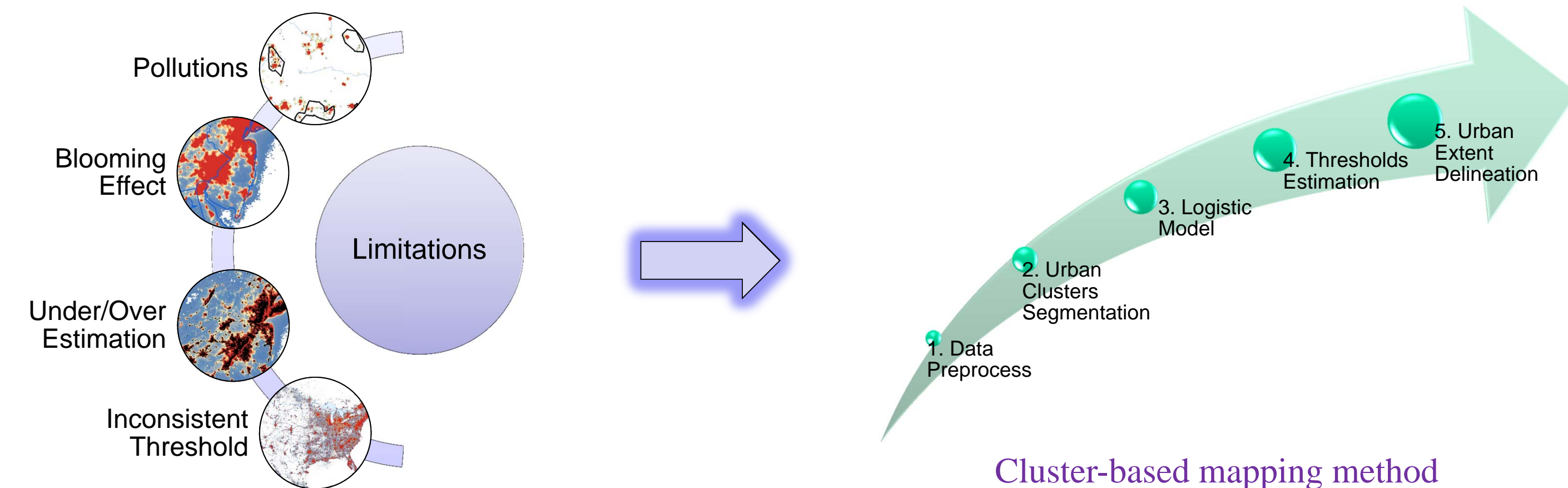
Pacific Northwest NATIONAL LABORATORY

Objectives

- Building a consistent global urban map series.** We will develop an algorithm to build a series of consistent maps of urban extent from 1992 to 2010 using NASA products and DMSP/OLS Nighttime Lights (NTL) data.
- Analyzing global urbanization and its driving forces and developing a region-specific macro-scale statistical model.** We will then develop a region-specific macro-scale statistical model for urbanization projection at the regional level. Special attention will be paid to the analysis in developing and underdeveloped countries, where methodological challenges exist and improvements are more needed.
- Developing an integrated framework to project future urban expansion.** We will combine the top-down macro-scale statistical model developed in Objective 2 with a bottom-up Cellular Automata (CA) based Urban Growth Model (UGM), and develop an integrated modeling framework to project urban expansion.
- Exploring scenarios of urbanization projection and its implications.** We will construct alternative socioeconomic scenarios to explore the robustness of the urbanization projection and improve our understanding of potential trajectories of future urbanization in the challenge of climate mitigation. Moreover, we will investigate the implication of spatially explicit urban projection using building energy demand as an example.



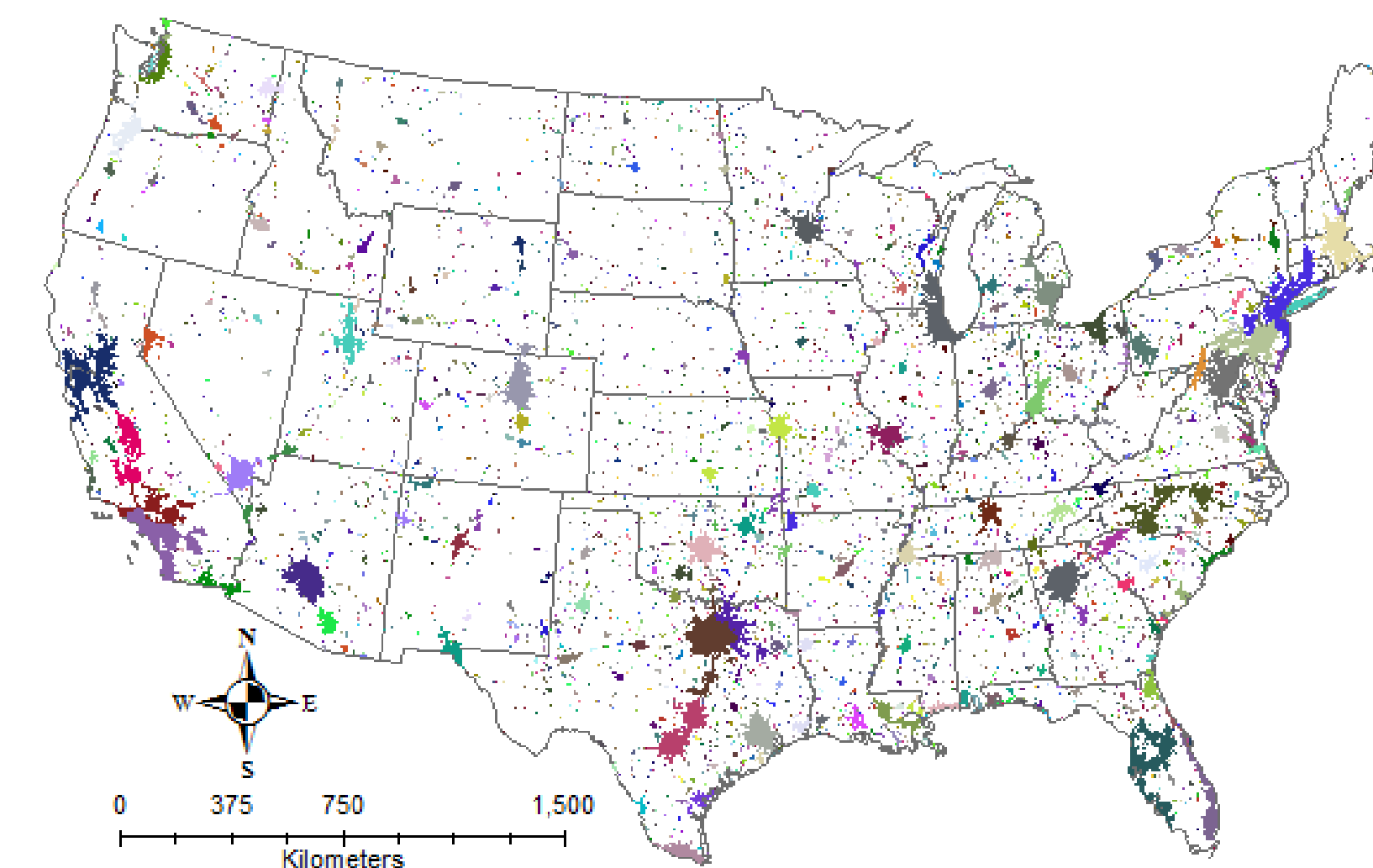
Urban Mapping From NTL Data



Step 1: Data preprocess.
e.g. removal of water and gas flares

Step 2: Potential Urban Clusters delineation using a segmentation algorithm.

The segmentation algorithm is developed and applied with NTL DN and cluster shape information used.



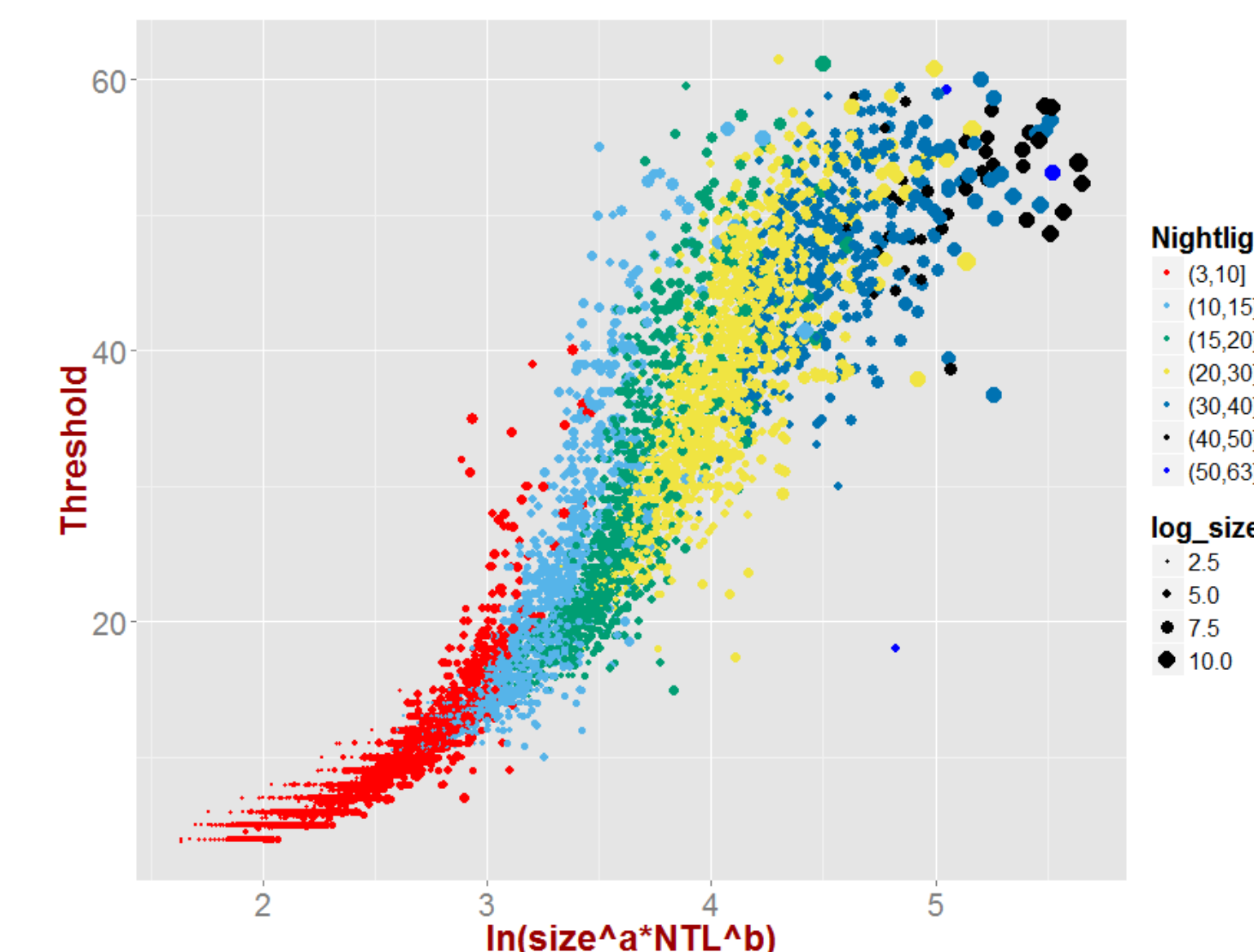
Potential urban clusters

Step 3: Develop a logistic model according to the relationship between thresholds and cluster and NTL mean.

The threshold is calculated from NLCD 2006 datasets, and cluster size and NTL mean are estimated from segmented NTL image.

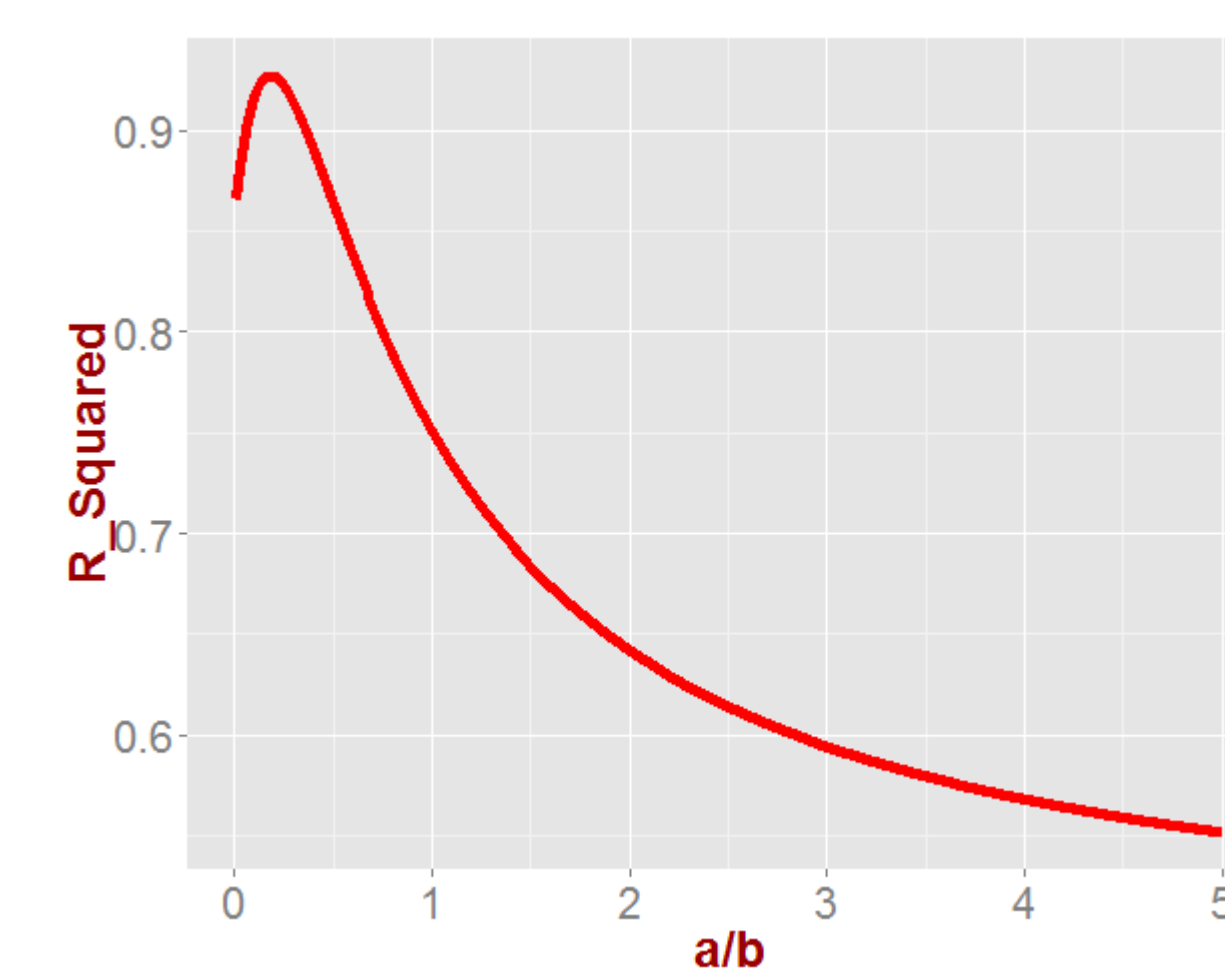
$$NTL_{thd} = \frac{1}{1 + e^{-fx}} (NTL_{max} - NTL_{min}) + NTL_{min}$$

$$x = \ln(\text{Size}^a \cdot NTL_{mean}^b)$$

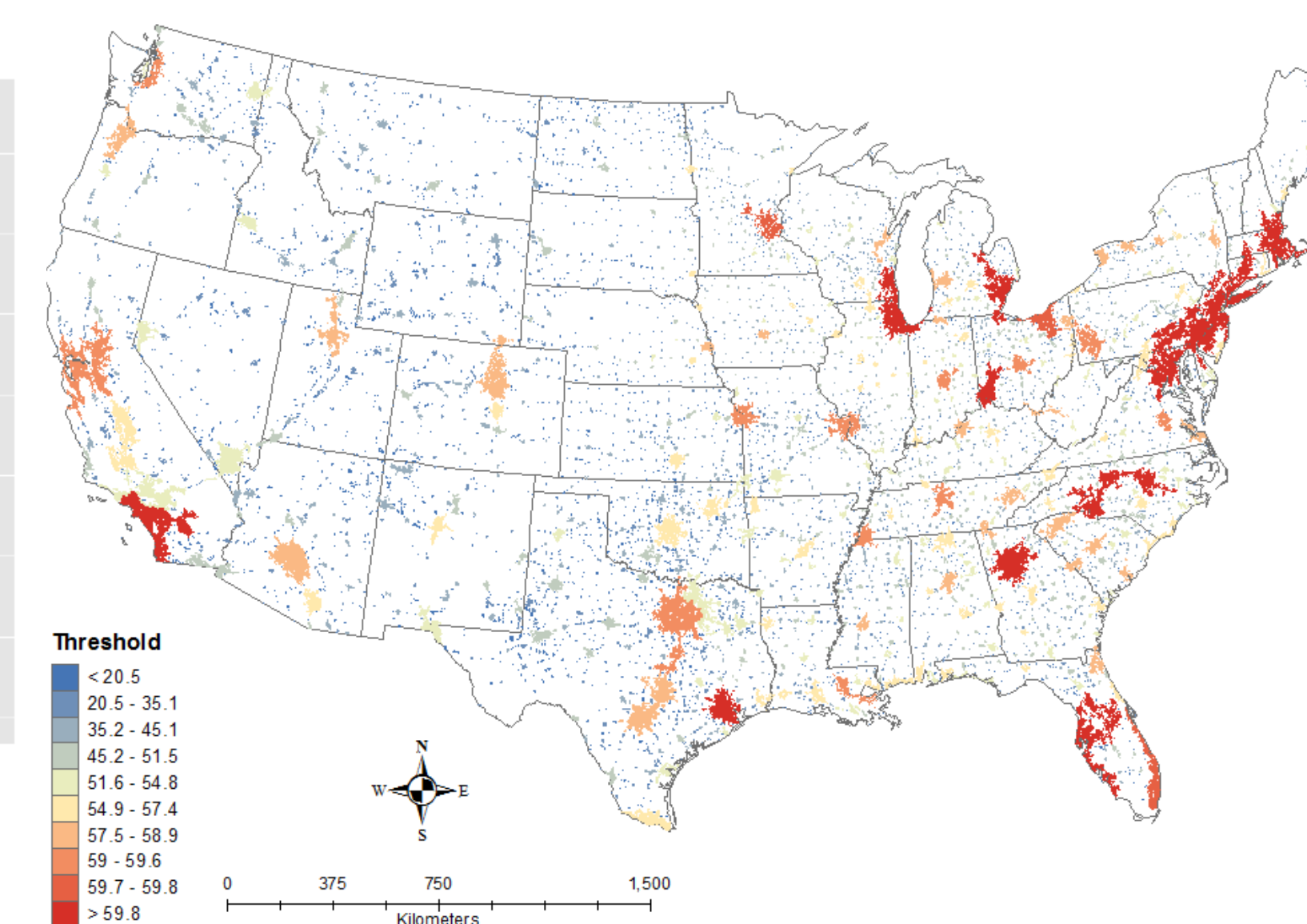


Relationship between thresholds and cluster size and NTL mean

Step 4: Find the parameter in the logistic model and derive the threshold in each cluster.

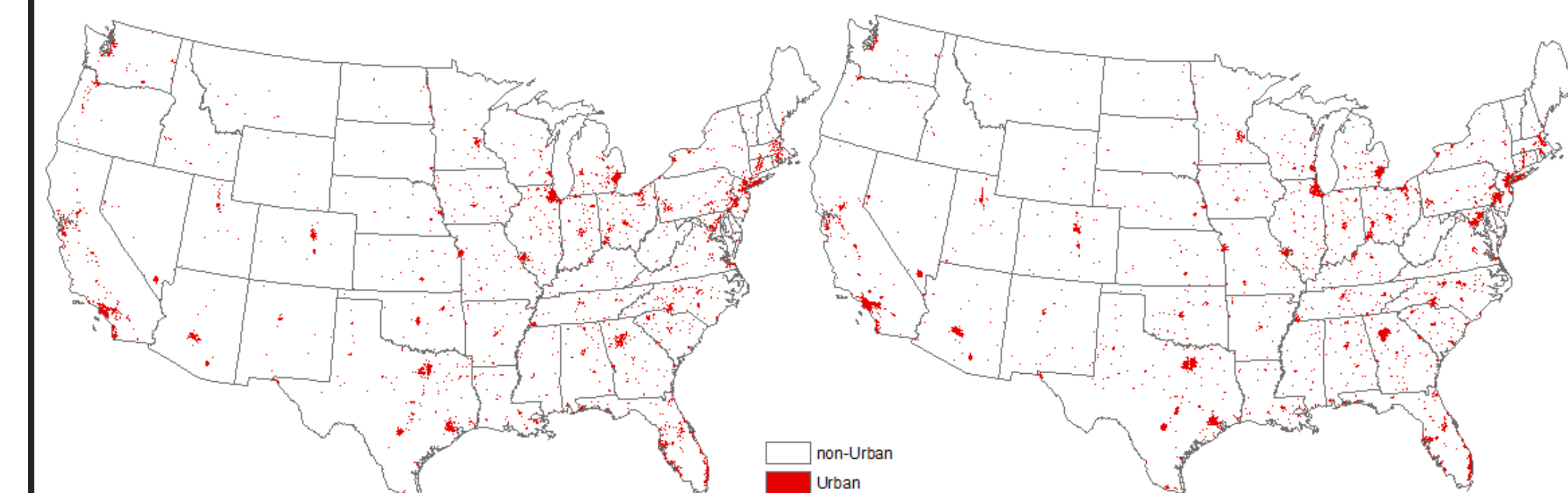


Parameters searching in logistic model



Cluster-based NTL thresholds

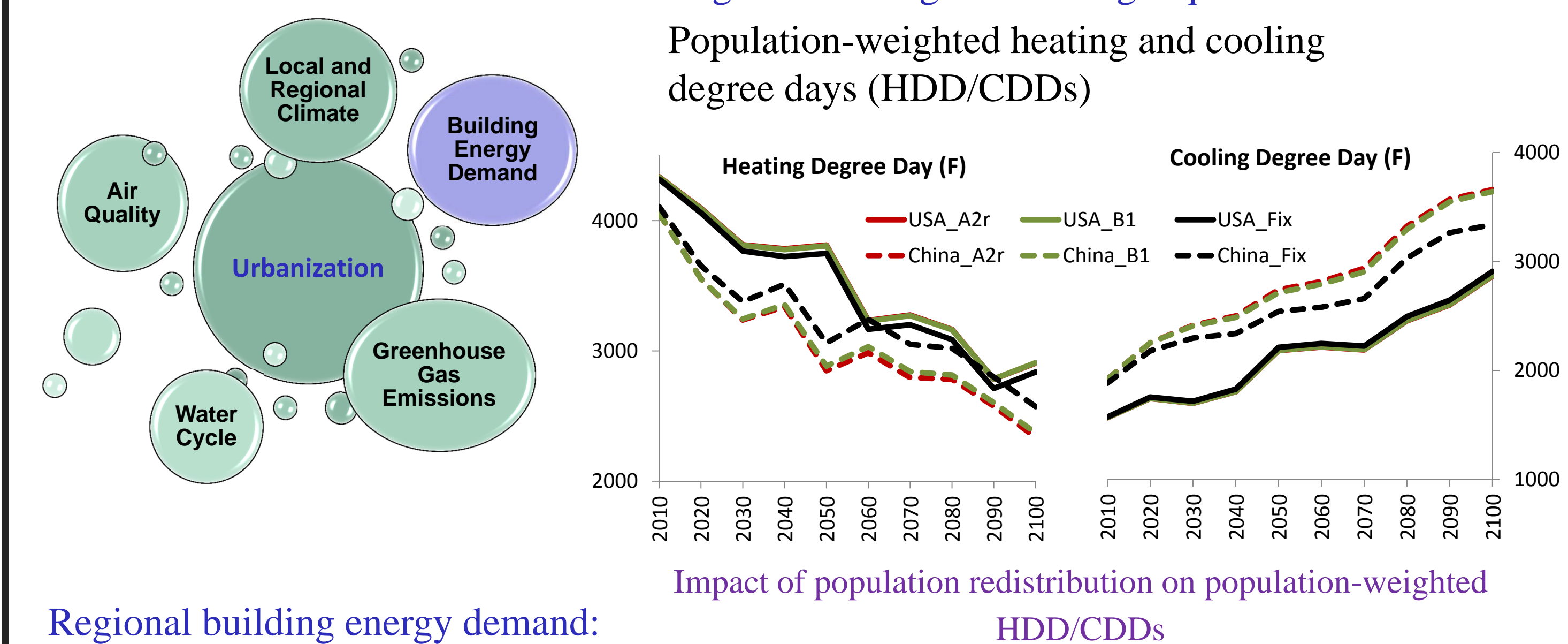
Step 5: Map the urban extent using the derived threshold in each cluster.



Urban extent from NLCD in 2006

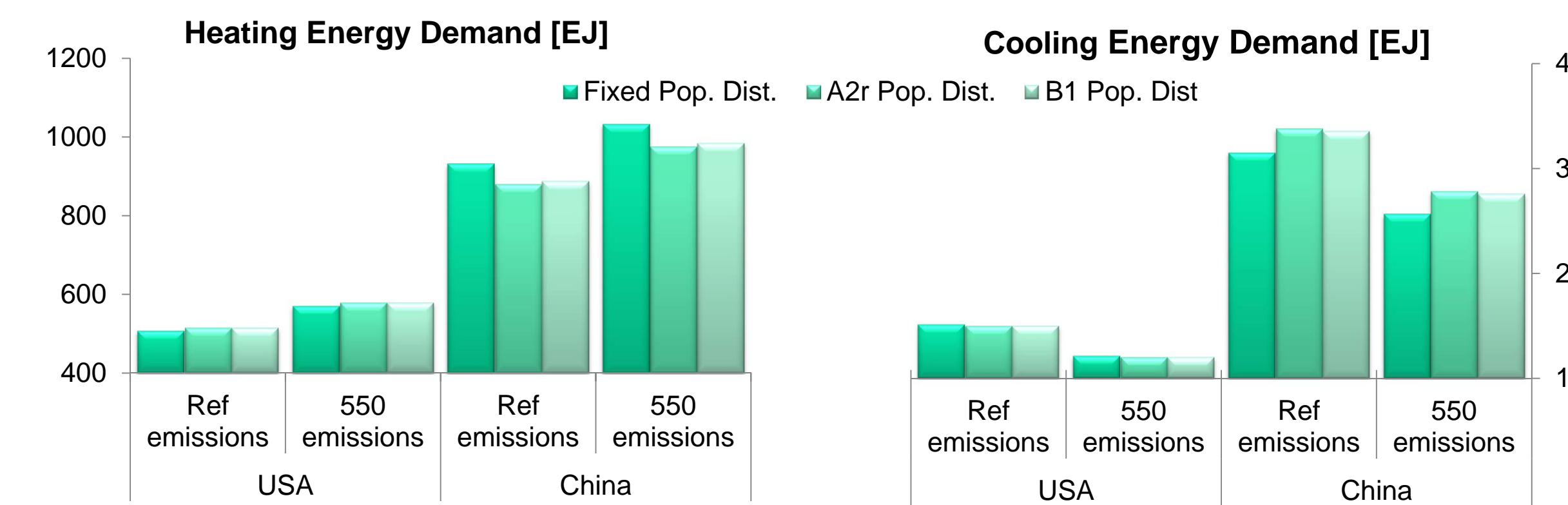
Urban extent derived from NTL in 2006

Potential Urbanization Impacts



Regional heating and cooling requirement:
Population-weighted heating and cooling degree days (HDD/CDDs)

Regional building energy demand:
Building energy model embedded in the GCAM framework driven by population-weighted HDD/CDDs



Impact of population redistribution on building energy use under climate change

References

- Elvidge CD, et al., 1997. Relation between satellite observed visible-near infrared emissions, population, economic activity and electric power consumption. *International Journal of Remote Sensing*, 18 (6):1373-1379
- Zhou, Y., et al., 2013. Coupling Building Energy Use with Spatially Explicit Scenarios of Climate Change and Population Distribution: The Case of the Two Largest Energy-Consuming Countries. *Climatic Change*, In review.

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The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security and the environment, and advances scientific frontiers in the chemical, biological, materials, environmental and computational sciences. The Laboratory employs 4,000 staff members, has a \$760 million annual budget, and has been managed by Ohio-based Battelle since 1965.



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