Geography 4203 / 5203

GIS Modeling

Class 10: Dasymetric Mapping

Some Updates

- Grading:
- Lab1 Hydro: model-paper-total
- Readings summaries[pencil lines] I-III
- Reading summaries - some comments
- …

Last Lecture

- We are done with **Geostatistics**… (almost)
- Not yet with spatial estimation and prediction issues but Kriging lies behind you, **congrats**!
- You had a quite deep insight into the mechanics how **kriging** works, what the basic assumptions are and why the **variogram** is so important
- You perfectly can describe **spatial autocorrelation** and its use for spatial **prediction** in kriging algorithms
- But you have also seen why statistics is important

Today‘s Outline

- Today we will talk about **Areal Interpolation** and **Dasymetric Mapping** - related to the lab exercises you are currently doing
- We will look at some methods of dasymetric mapping to better understand the use of limiting and related variables
- You will see what stands **behind** these terms
- You will once again see why **map algebra** and its fundamental **concepts** are so important

Learning Objectives

- You will understand what **areal interpolation** is
- You will also understand how areal interpolation and **dasymetric mapping** are related to each other
- You will see how dasymetric maping can **improve estimations** of variables of interest by addressing the **underlying statistical surface**
- You will learn how to implement the different ideas of dasymetric mapping into **map algebra** commands and **syntax (rather during your current lab)**
- You will get (hopefully) some ideas how you can use these techniques for your *own* **project** and **research** ideas

Background I

- Traditional choropleth map designs give the impression of **homogeneous distributions** of the variable of interest (e.g. population density, cropland density) throughout the **areal unit**
- In fact, these density measures often **vary** within the “enumeration unit”
- Thus the **boundaries** often have nothing to do with changes in the **underlying statistical surface** but pretend **abrupt shifts**

Background II

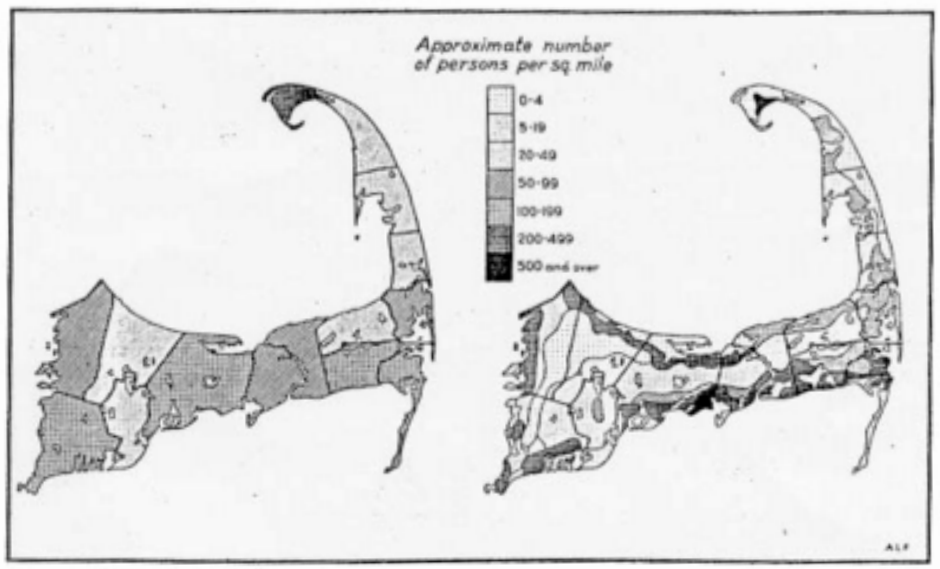
- Need to create **surface-based representations** from these areal units: **areal interpolation** (AI)
- To address **heterogeneity** within units
- To **refine** the **estimates** by using additional **ancillary** data and **relationship** between these data and our orig. estimations
- **Dasymetric mapping** as a kind of AI is a relatively unknown method
- Few publications on dasymetric mapping (some you can find at the end)

The Beginning

- John K. **Wright** (1936) produced a **population distribution map** of Cape Cod using the census data
- Population counts assigned to towns in a standard **choropleth** map
- Wright saw that the choropleth map **masked** important **details**
- Population density seemed to depend more on amount of **marsh** & **wasteland** than on the density in the inhabitable area

Wright's Improved Map Versions

- First he cut out "**uninhabited**" areas and **recalculated** the density for the town based on the **reduced area**
- Then divided each town into regions of **land use** and **settlement**
- Assigned densities to all but one land use classes, the density of the last class could be calculated from the **residual population** of that town
- Puzzle of densities from many **assumptions** and **relationships** within the region

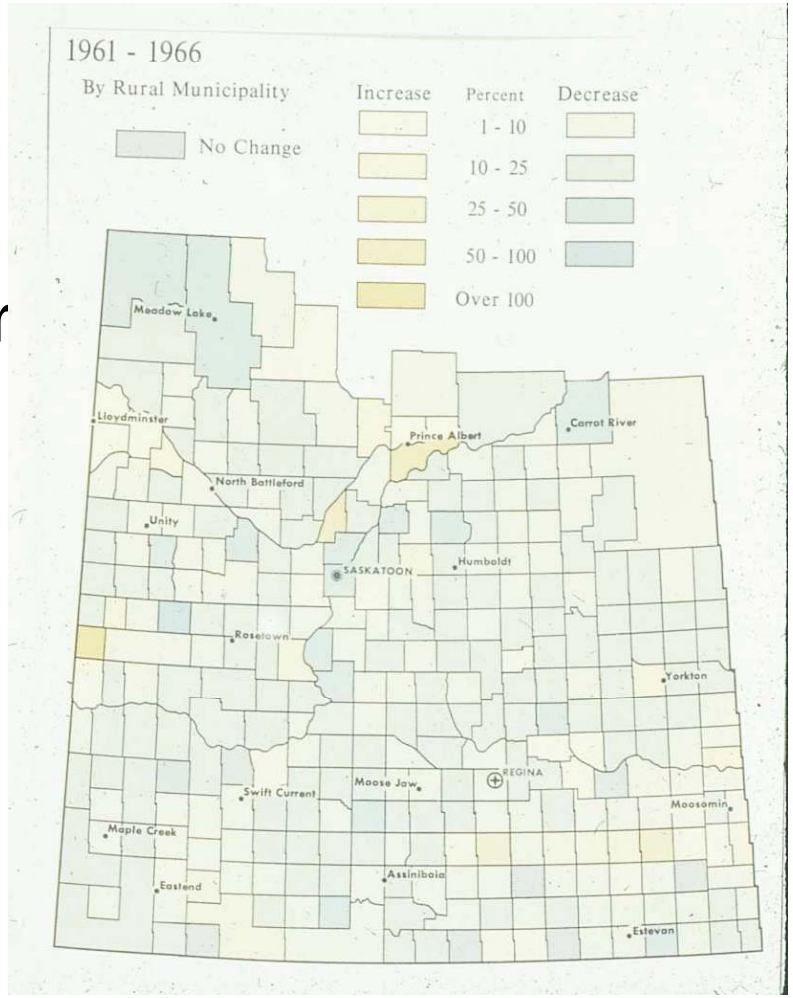


Aggregated Data in Maps (Volumetric Surfaces)

- **Choropleth Maps:**

  - Individual spatial units (polygons) are filled with **uniform** colors or patterns

  - **Enumeration unit** is the same as the **mapping unit** (administrative, municipal boundaries,…)



from http://www.gis.unbc.ca/courses/geog205/lectures/theme_map_la/index.php

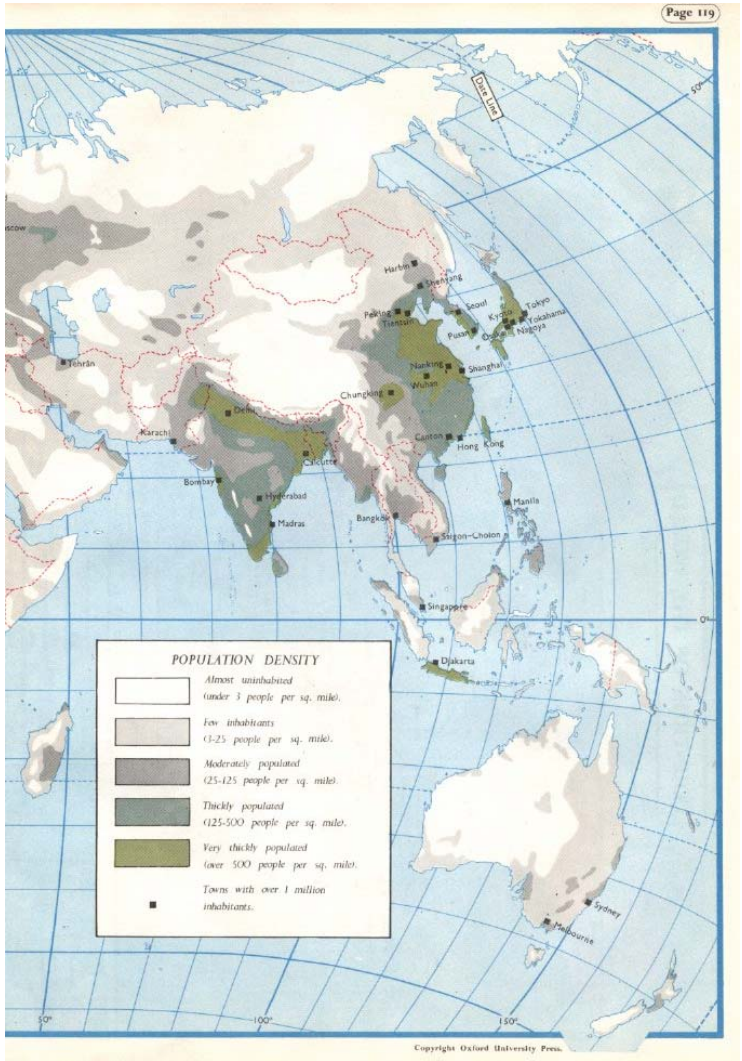
Aggregated Data in Maps (Volumetric Surfaces)

- **Dasymetric Maps:**

  - Individual spatial units (polygons or grid cells) are filled with **uniform** colors or patterns

  - Mapping unit is based on **sharp changes** in the **statistical surface** of data

  - Spatially **disaggregate aggregated data**



from http://www.gis.unbc.ca/courses/geog205/lectures/theme_map_la/index.php

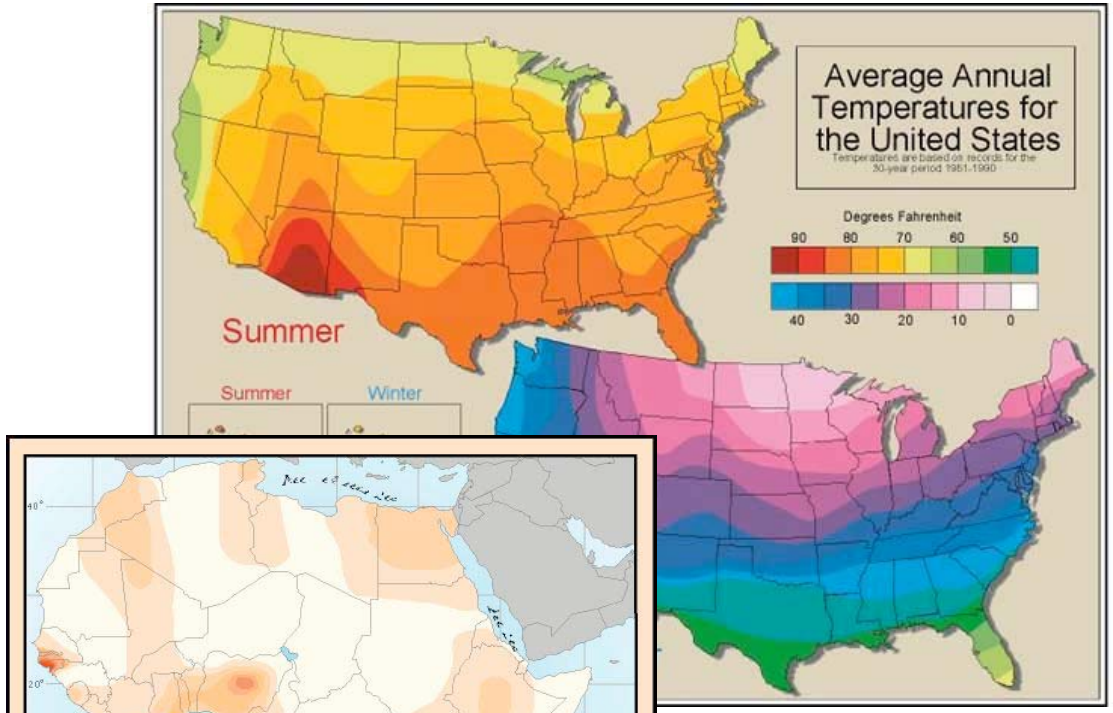
Aggregated Data in Maps (Volumetric Surfaces)

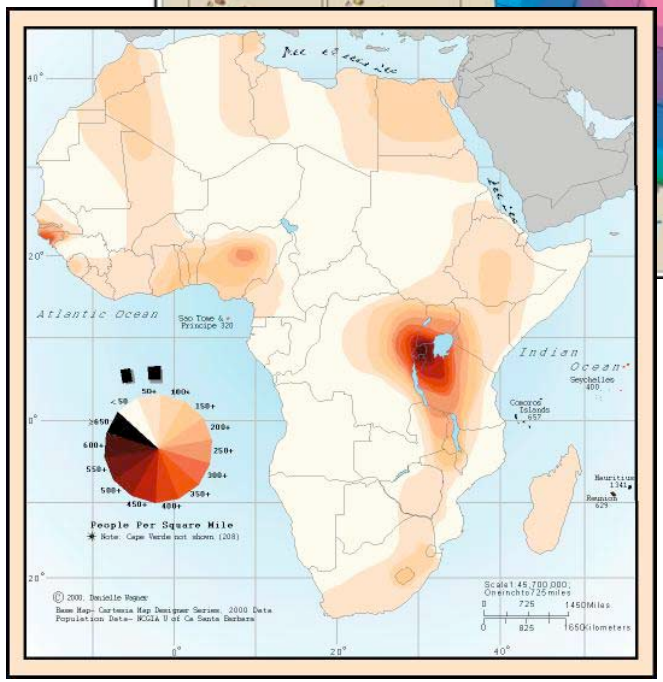
- **Isopleth/isarithmic Maps:**

  - **No** pre-defined mapping unit

  - Data associated with **point locations**

  - Can be represented by **lines** of **equal attribute value** (we have a name for that!!!)

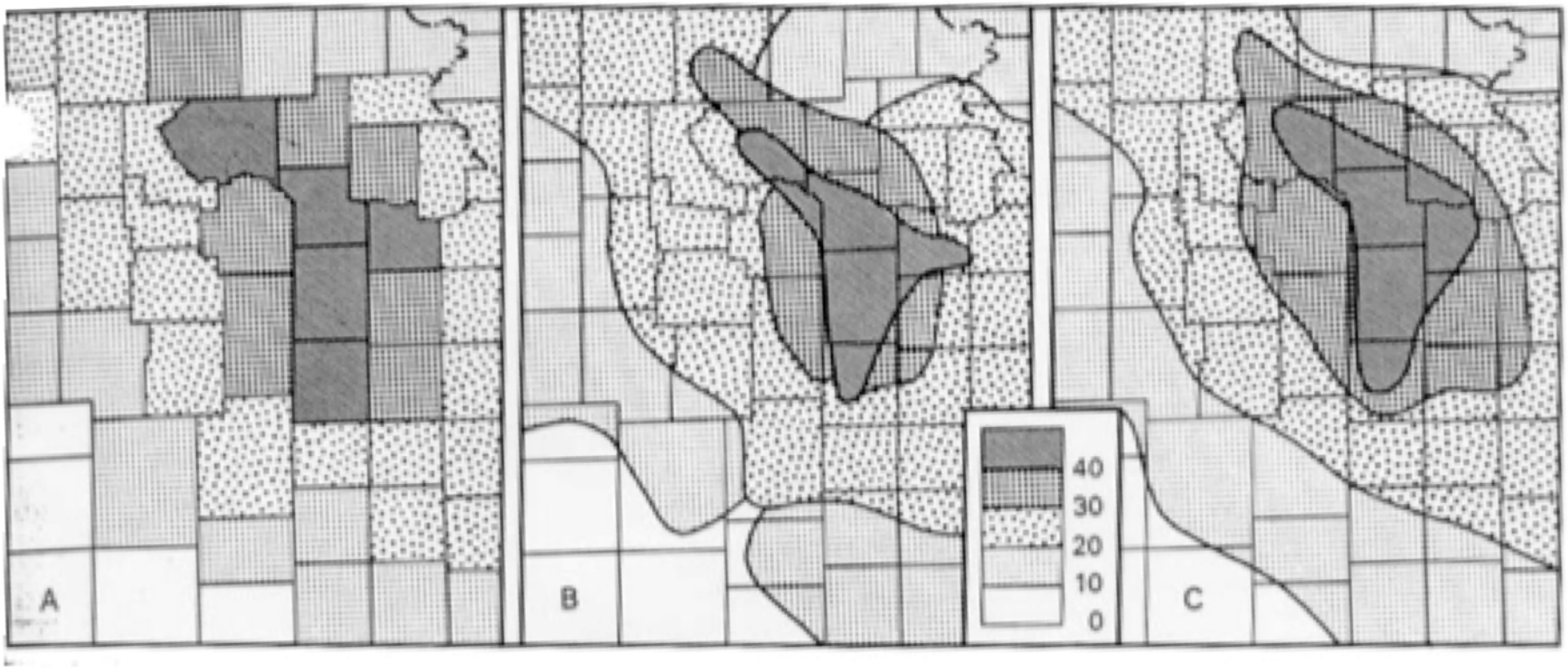




from http://www.d.umn.edu/geog/cartfolder/HTML%20Pages/Isarithmic.htm

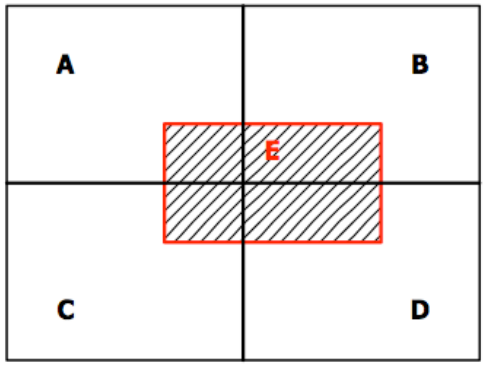
… a way of Cartographic Thinking & Modeling?

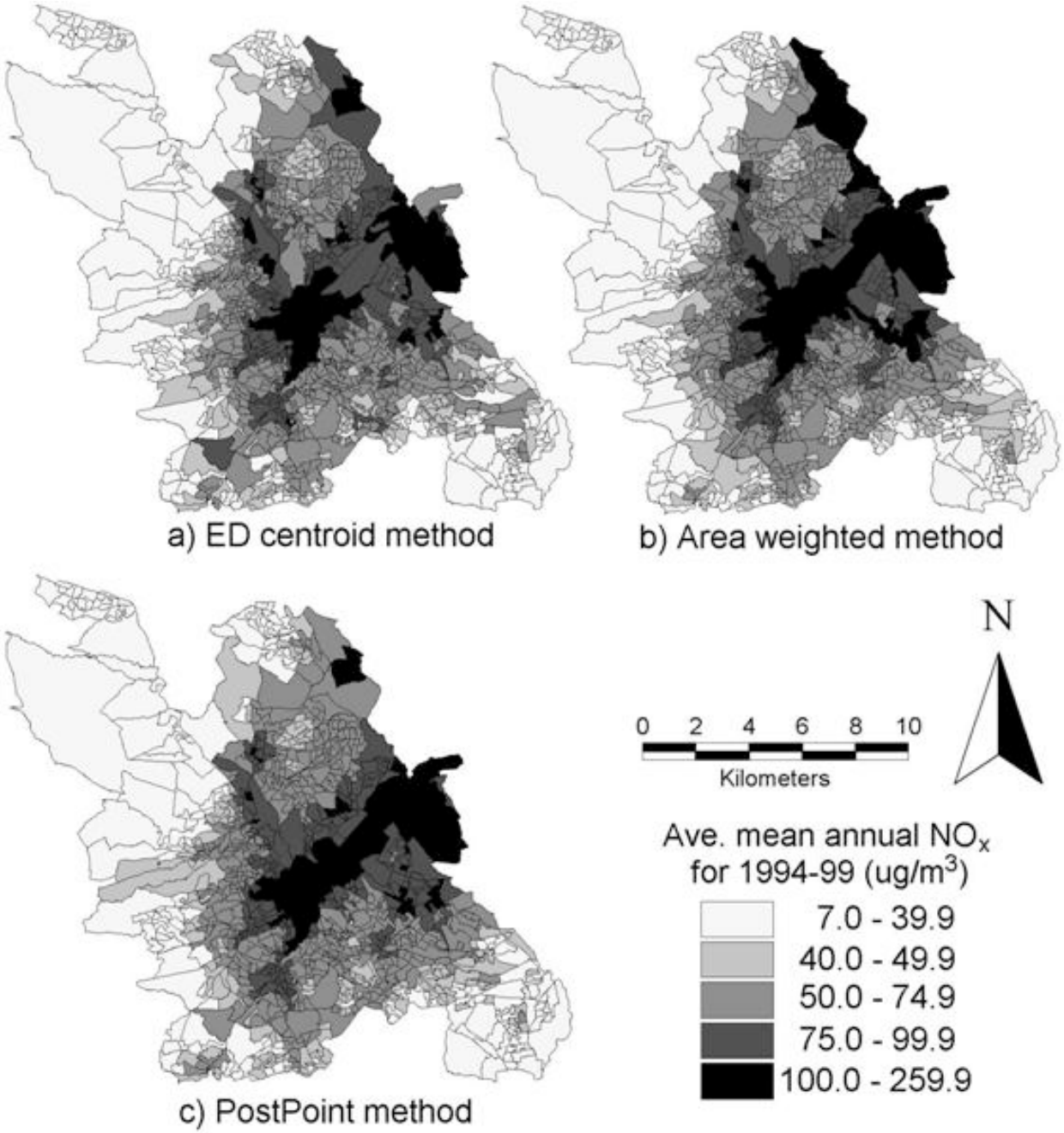
- … it’s even more…



Areal Interpolation

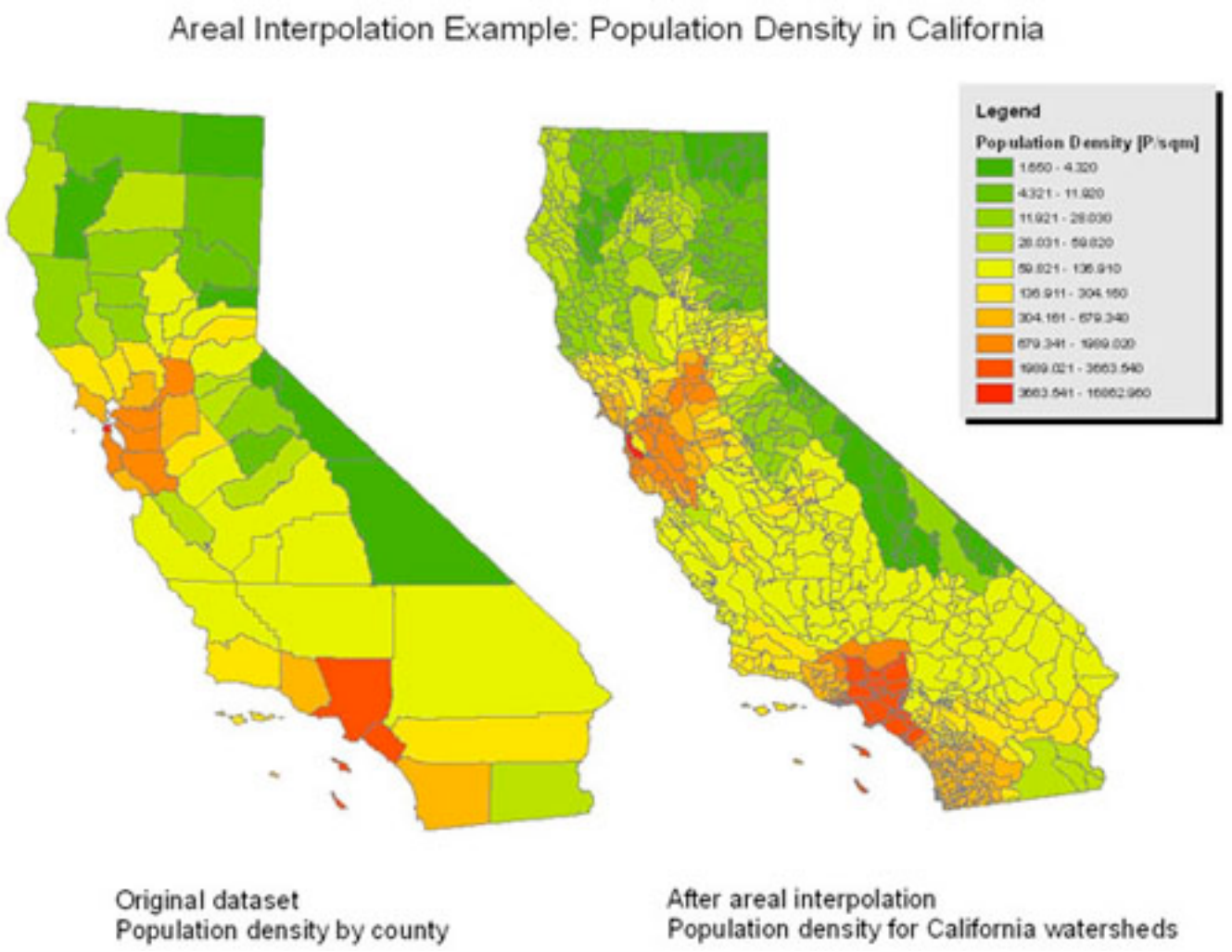
- **Transformation** of an attribute attached to one kind of choropleth map to **another** set of **choropleth zones**
- Or -- **Estimating** the value of a mapping unit based on the values of **associated enumeration units**
- **Volume preserving** methods (areal weighting (pycnophylactic), overlay (binary method))
- **Non-volume preserving** methods (e.g. interpolating population counts from census tracts to school districts) -- critiques volume loss





from http://www.geog.cam.ac.uk/research/projects/geographicalepidemiology/

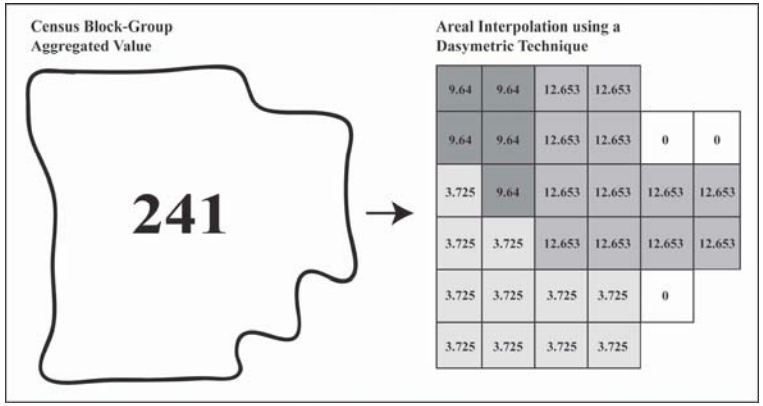
Areal Interpolation



from www.geog.ucsb.edu/~phil/aitoolbox/

Dasymetric Maps & Mapping

- To display statistical surface data by **partitioning** space into (**homogeneous**) **zones** where the zone boundaries reflect the underlying **statistical surface variation** (sharp changes)
- The process of **dasymetric mapping** is the **transformation** of data from a set of arbitrary **source zones** to a dasymetric map via the overlay of the source zones with an **ancillary dataset**
- Dasymetric mapping is considered a particular type of **areal interpolation** (where source zone data are **excluded from** or **related to** certain classes in a categorical ancillary dataset)



from http://geography.wr.usgs.gov/science/dasymetric/methods.htm

Ancillary Information

- **Limiting Variable**:

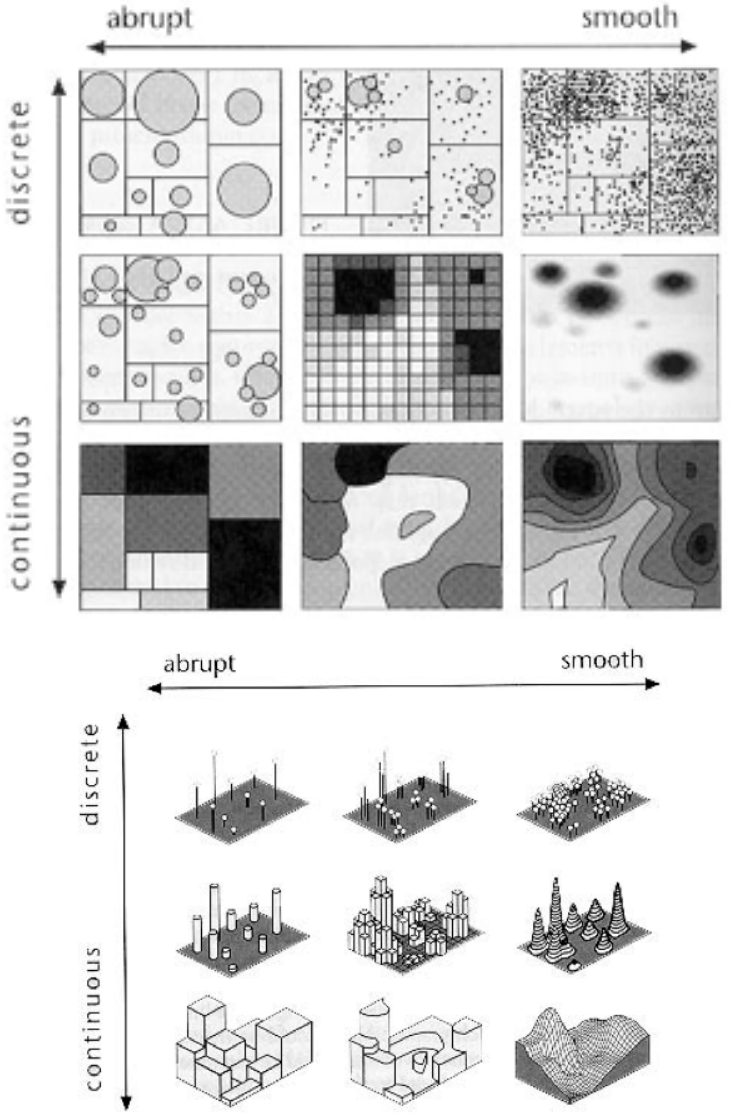
  restrict possible occurrences in the original unit (its percentage **limits** the **percentage** of the variable of interest within the same unit)
- **Related Variable**:

  associated with the variable of interest in complex ways

  you can define a **set of rules** which variable will **influence** our variable in what way… (economy, terrain)

In Context

- McEachren (1994) placed dasymetric maps in the continuum **between isopleth** and **choropleth** maps (betw. **smooth** and **stepped** statistical surfaces)



Case Study Eicher & Brewer (2001)

- **Refining** population data and housing price data given at the county level (enumeration unit) by **overlay** with **land use** classes (to create **dasymetric zones** within the counties)
- Using **land use** from USGS as ancillary data
- Testing different **methods** of **dasymetric mapping** and **evaluate** their **accuracy** against census block groups (RMSE)

Enumeration and Mapping Units

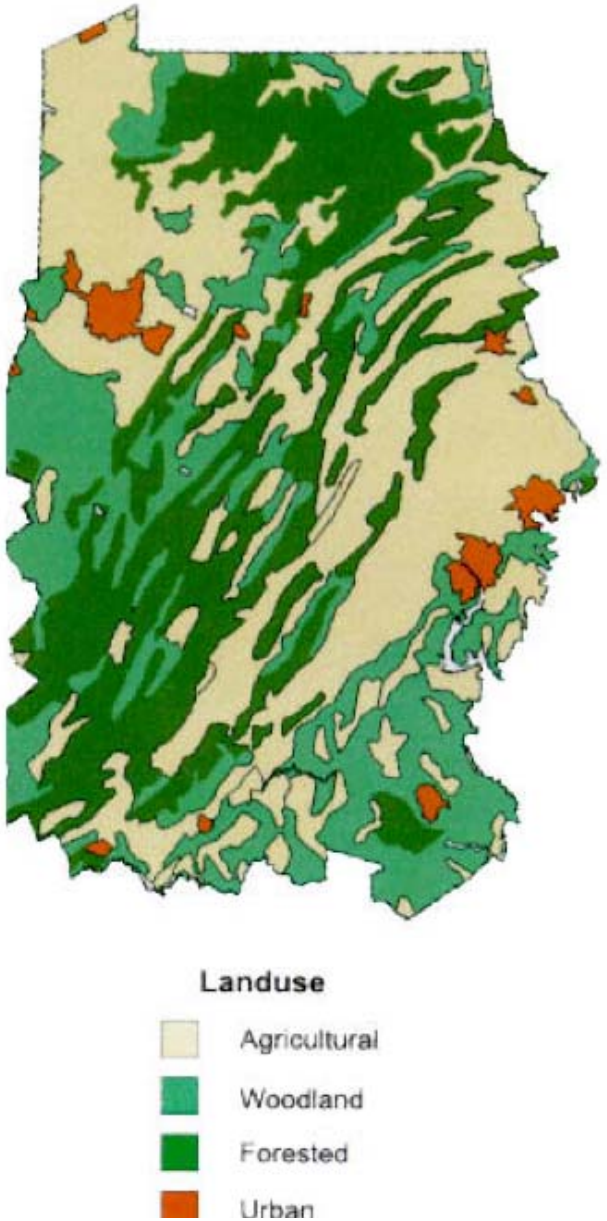
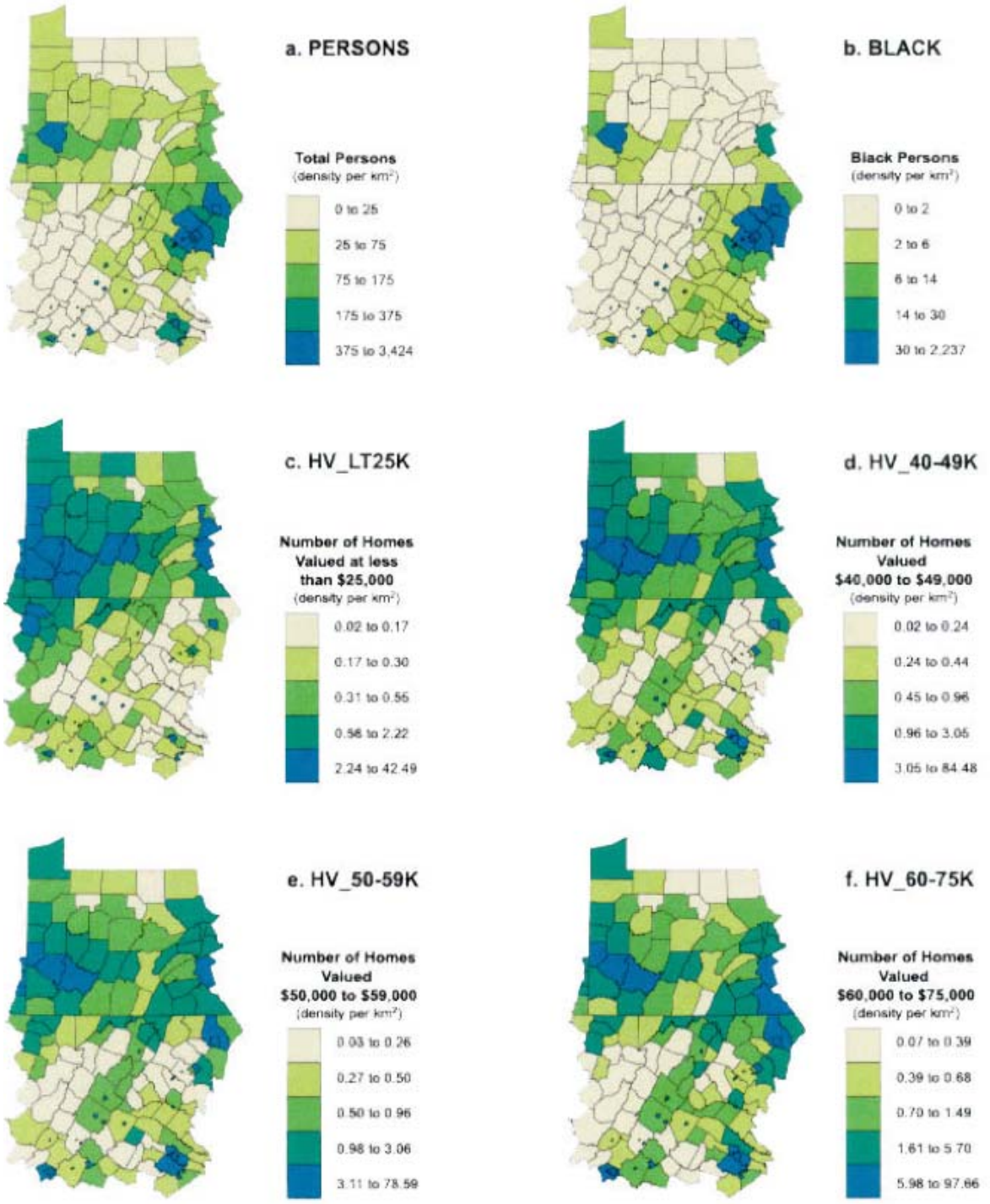


Figure 1. Dasymetric map zones that result from overlay of county and landuse boundaries in the study area. State boundaries and example cities are included for reference.

Tested Variables



Dasymetric Mapping Methods

- **Binary** Method (P,G)

  inhabitable/ uninhabitable regions (“binary”) and conclusions for **corrected densities**
- **Three-Class** Method

  (subjective) fractions defined to create a **weighting scheme** for assigning population data to **three** different **land use classes**

  (70-20-10 % for urban-agr./woodl.-forestl. [+ water = 0])

  Problems: **Subjectivity** and imprecision since **area** of land use class **not considered** (small urbans still get 70%)
- Implementation as **vector** and **grid** methods

Dasymetric Mapping Methods

- **Limiting Variable** Method (P)

  areal weighting to assign data to inhabitable polygons in each county

  three inhabitable classes with **equal pop densities** (water = 0)

  max density thresholds for individual land use classes

  adjustments to the data within each county (if polygon exceeds threshold - **max threshold** assigned, remaining data **distributed evenly** over the other zones)

  search for **max densities** for forest and agr difficult…

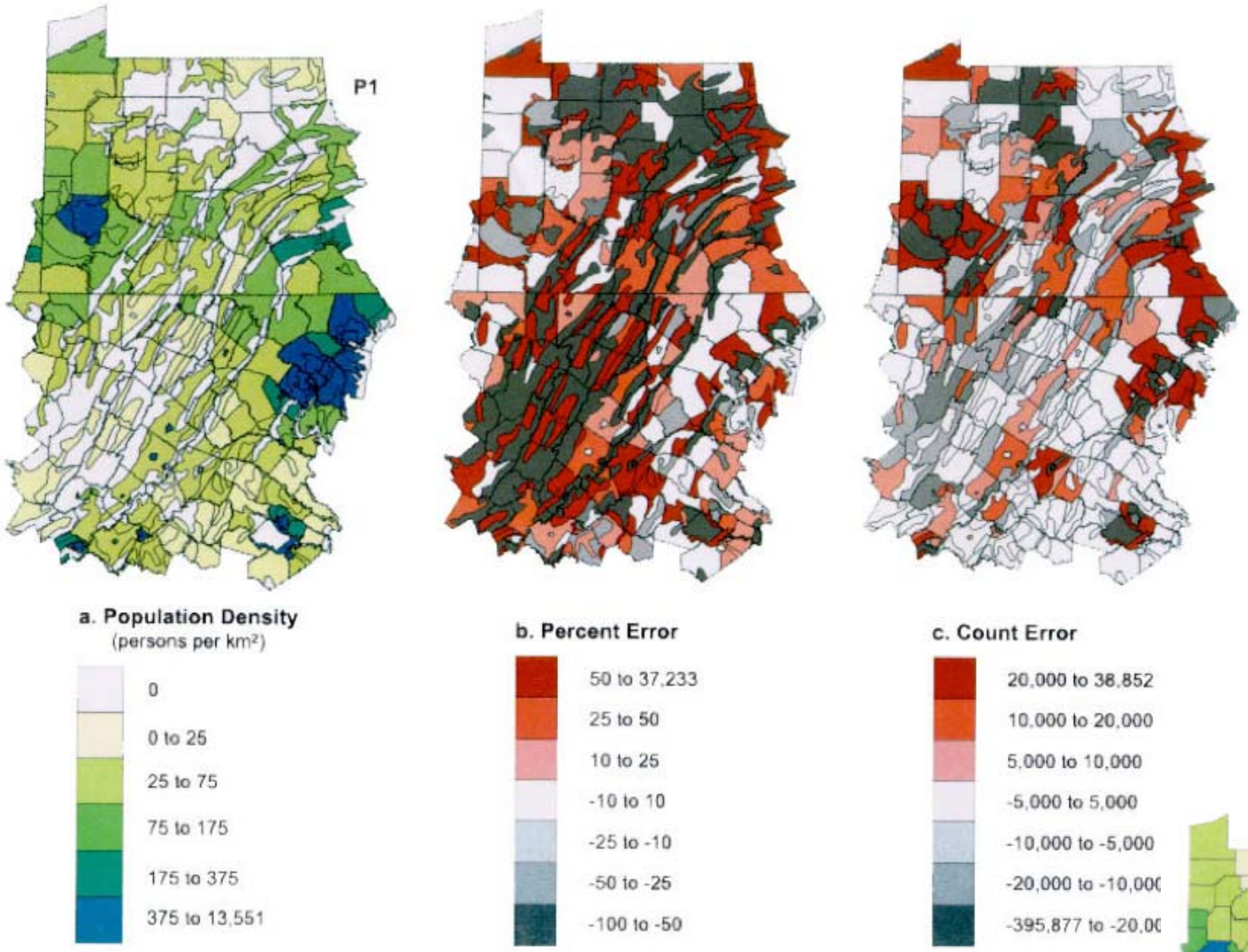
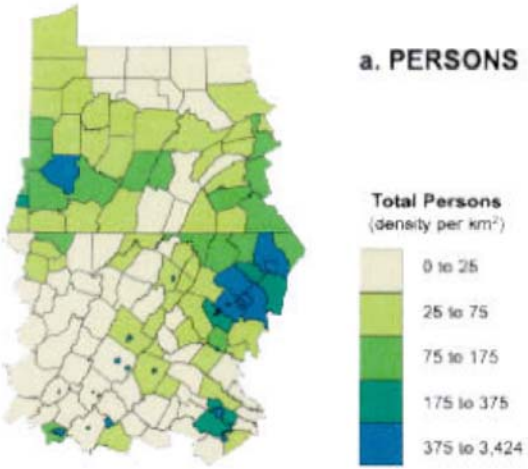


Figure 4. Maps for binary method (P1): a. dasymetric population density map; b. percent error; and c. count error in number of persons.



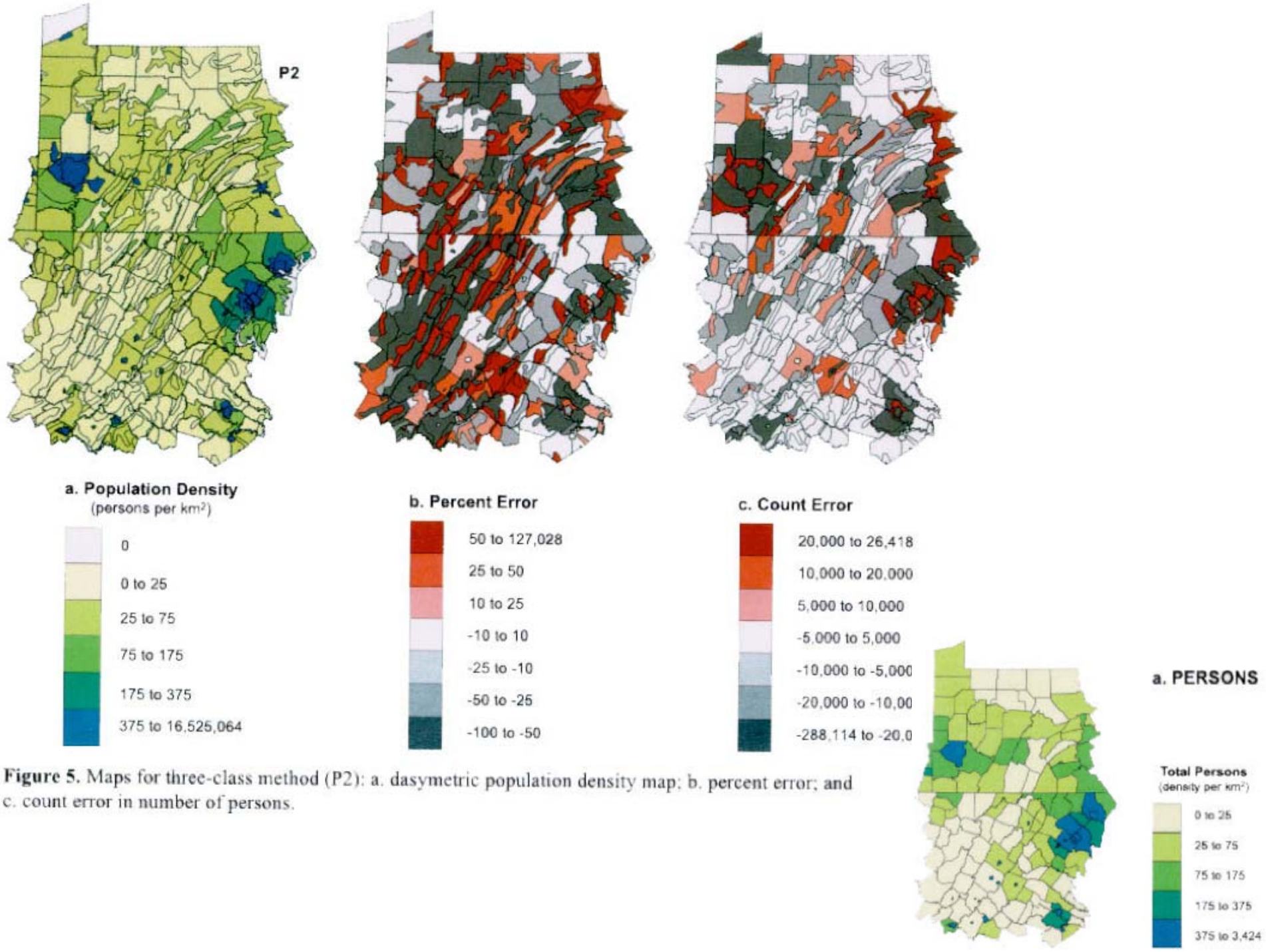


Figure 5. Maps for three-class method (P2): a. dasymetric population density map; b. percent error; and c. count error in number of persons.

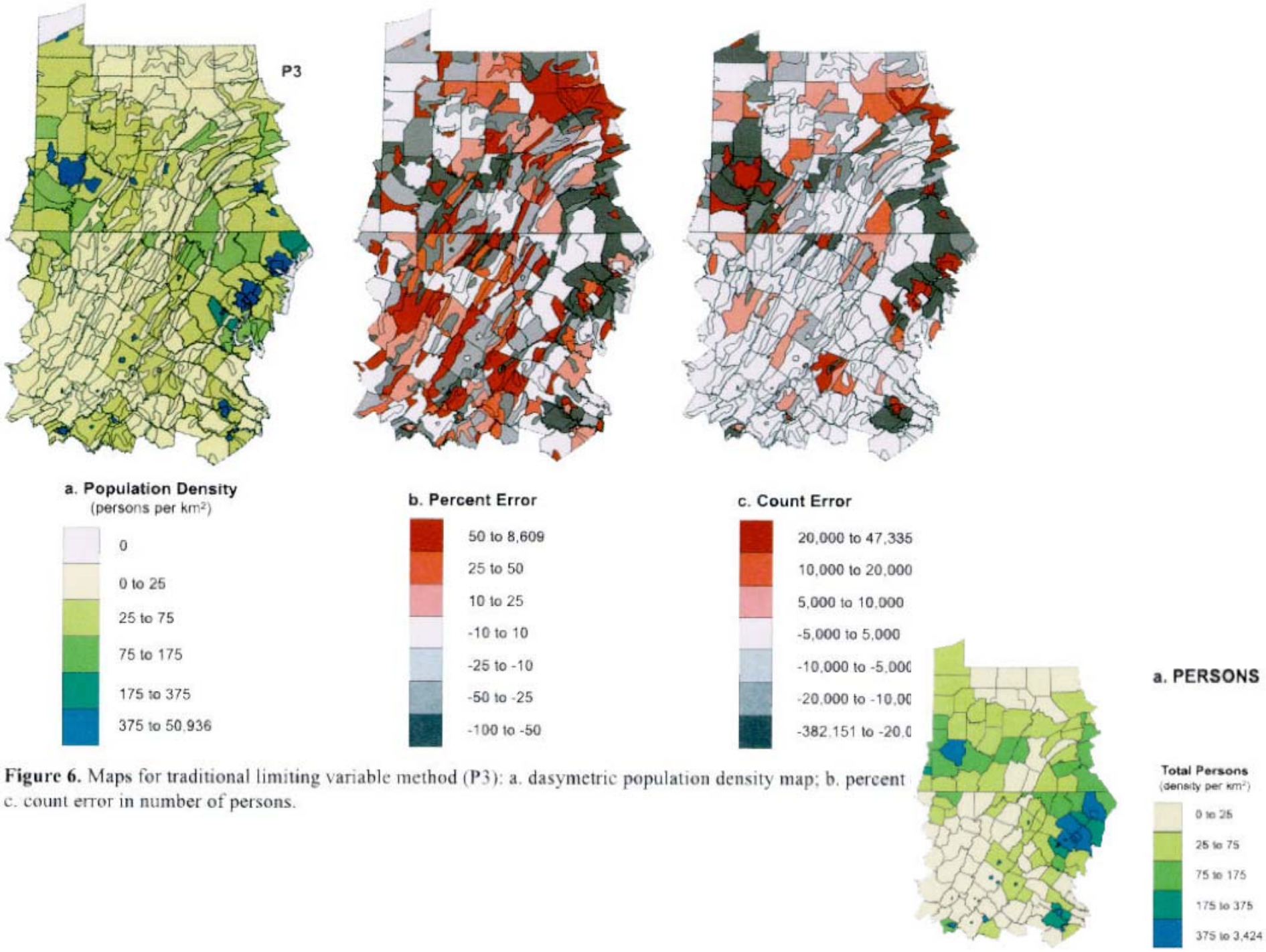
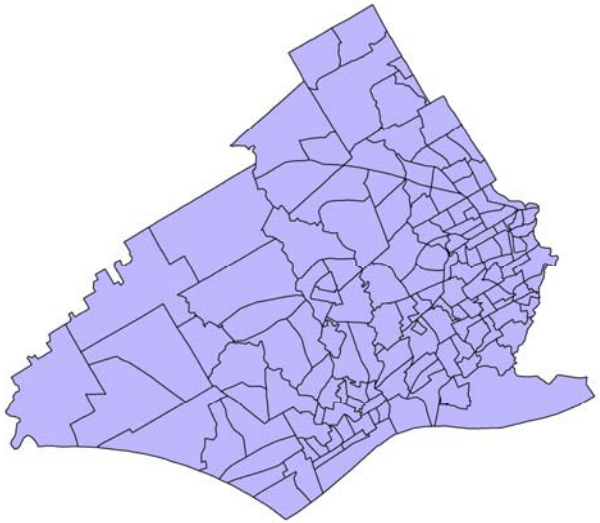
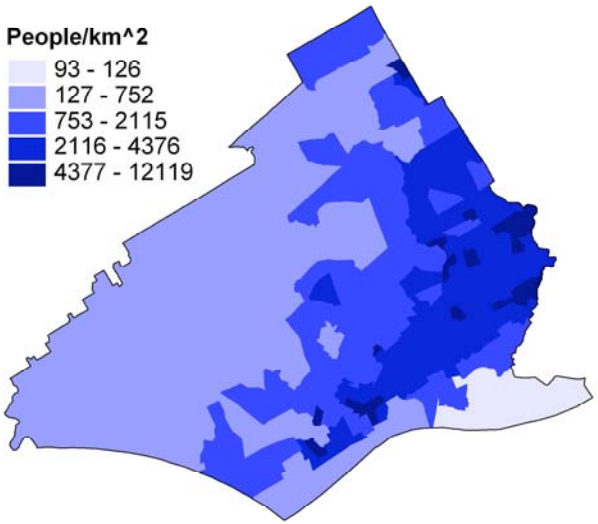


Figure 6. Maps for traditional limiting variable method (P3): a. dasymetric population density map; b. percent c. count error in number of persons.

An Example - Population Data

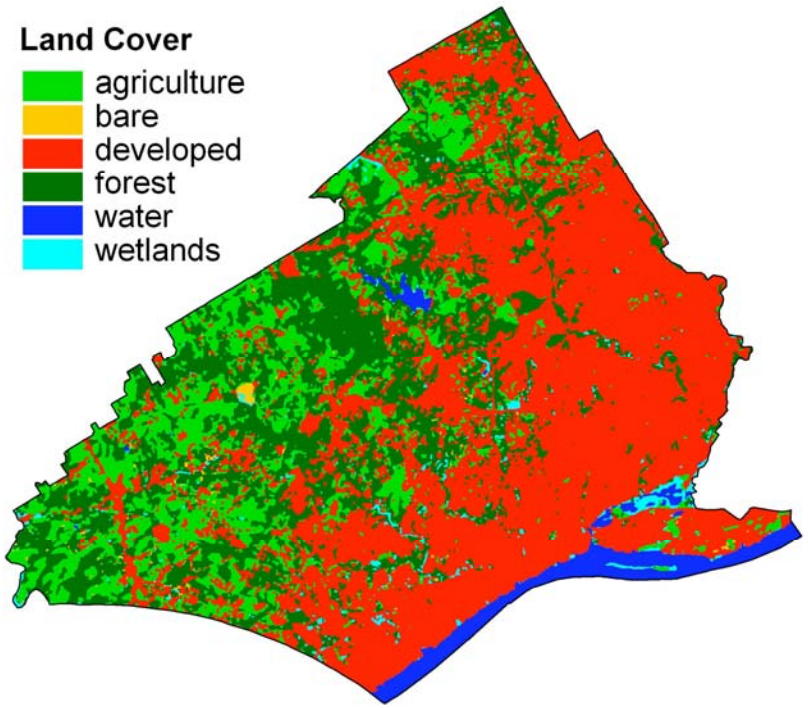
- From Mennis (2003)
- Population data for Delaware County, PA, are dasymmetrically mapped using RS land cover data
- Census tracts data (2000): 148 tracts with different population densities given





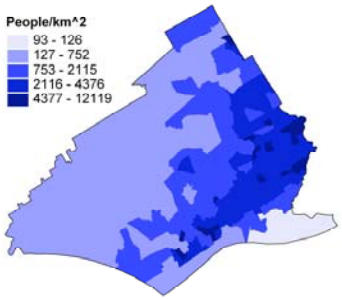
Ancillary Data

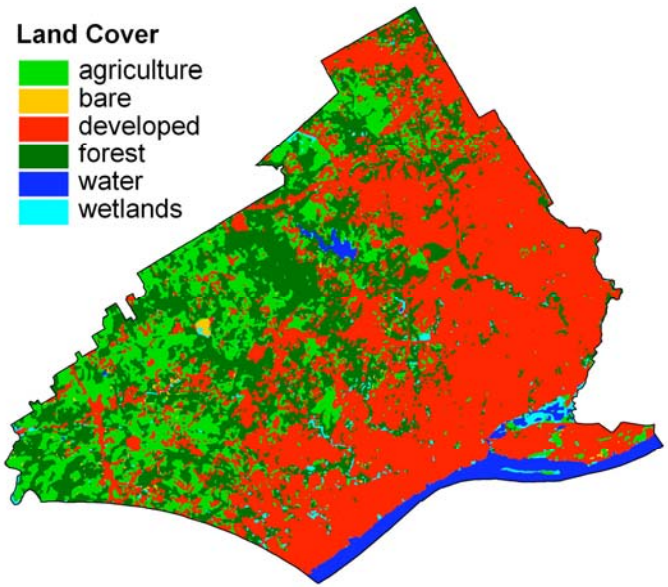
- Land cover data (NLCD, 2001) converted to a smoothed vector data layer (polygons)
- Max population densities for each of the land cover classes defined…
- Three-class method of Eicher & Brewer 2001, but improved due to weaknesses
- (1) empirical sampling to determine appropriate %-assignment values of population for each land use class (subjectivity reduced)
- (2) area-based weighting to address area fractions of ancillary data (land useclasses) within each unit

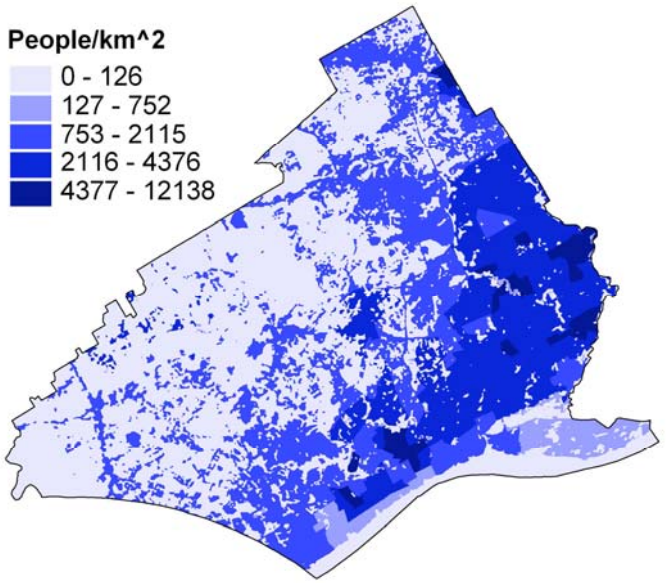


The Dasymetric Map

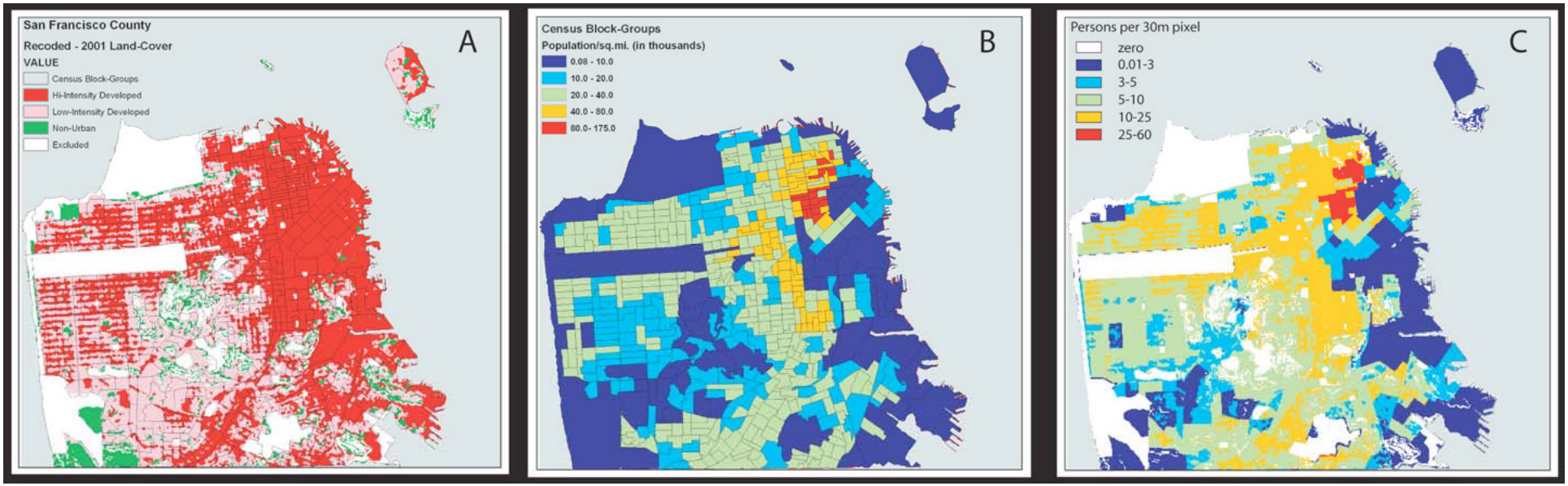
- New vector data layer (polygons) showing population densities in relationship to varying proportions in developed regions and undeveloped regions (forest, agricultural) by implying sets of rules







Another Example



(A) Land-Cover re-code from a collection of input sources (land-cover, slope, open space); **(B)** Block-group population density; **(C)** Dasymetric map output after interpolation

from http://geography.wr.usgs.gov/science/dasymetric/methods.htm

Summary I

- **Dasymetric mapping** as one interesting alternative to improve estimations of our mapped variable (often population or density measures)
- **Refining** the **original** spatial unit (**enumeration** unit) using **ancillary data** (**mapping unit**) and the **relationships** between these variables
- Using **categorical** data as **ancillary data** to improve **ratio-scaled** distributions of a variable
- **Limiting** and **related** variables
- Different **methods**…

Summary II

- Disaggregating of aggregated information by using additional information we have based on ancillary data
- If more detail is available about our area/variable of interest - how can we use this information to improve the spatial distribution of the variable of interest

References

- Eicher, C.L. and Brewer, C.A., 2001. Dasymetricmapping and areal interpolation: implementation and evaluation. Cartography and Geographic Information Science, 28(2): 125-138.
- Holloway, S. R., Schumacher, J., and Redmond, R. L. 1997. DasymetricMapping Using Arc/Info. Cartographic Design Using ArcViewand ARC/INFO. High Mountain Press, NM.
- Mennis, J. and Hultgren, T., 2006. Intelligent dasymetric mapping and its application to areal interpolation. Cartography and Geographic Information Science, 33(3): 179-194.
- Mennis, J., 2003. Generating surface models of population using dasymetric mapping. The Professional Geographer, 55(1): 31-42.
- Wright, J. K. 1936. A method of mapping densities of population. The Geographical Review 26: 103-110.