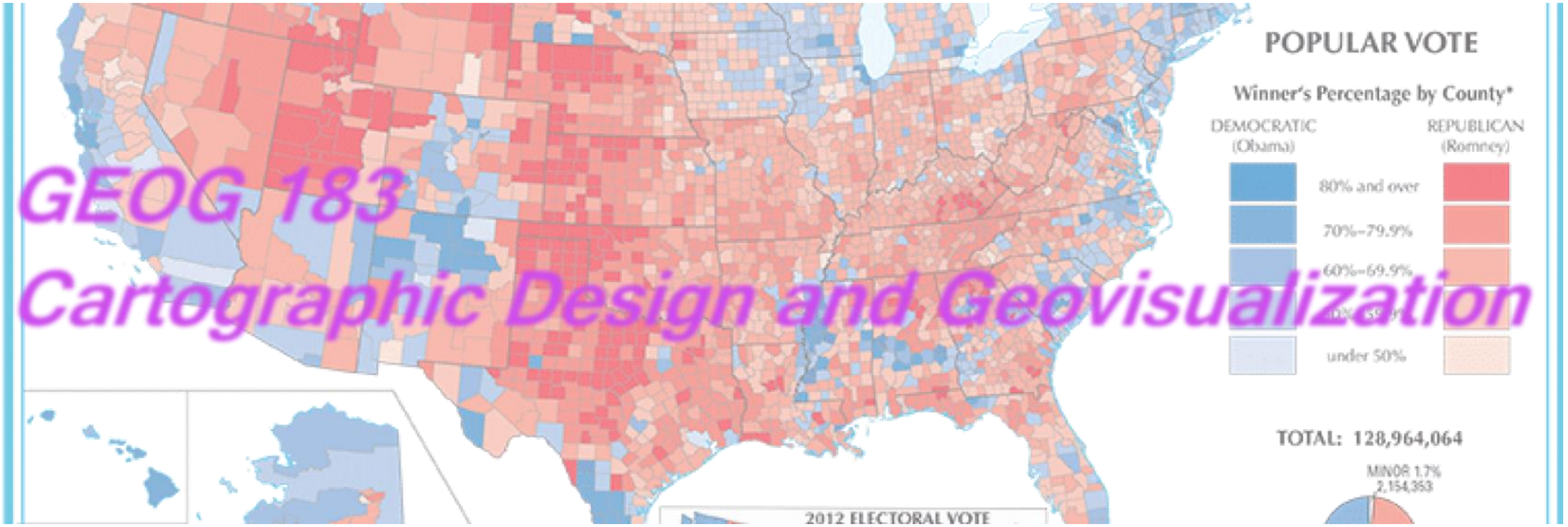
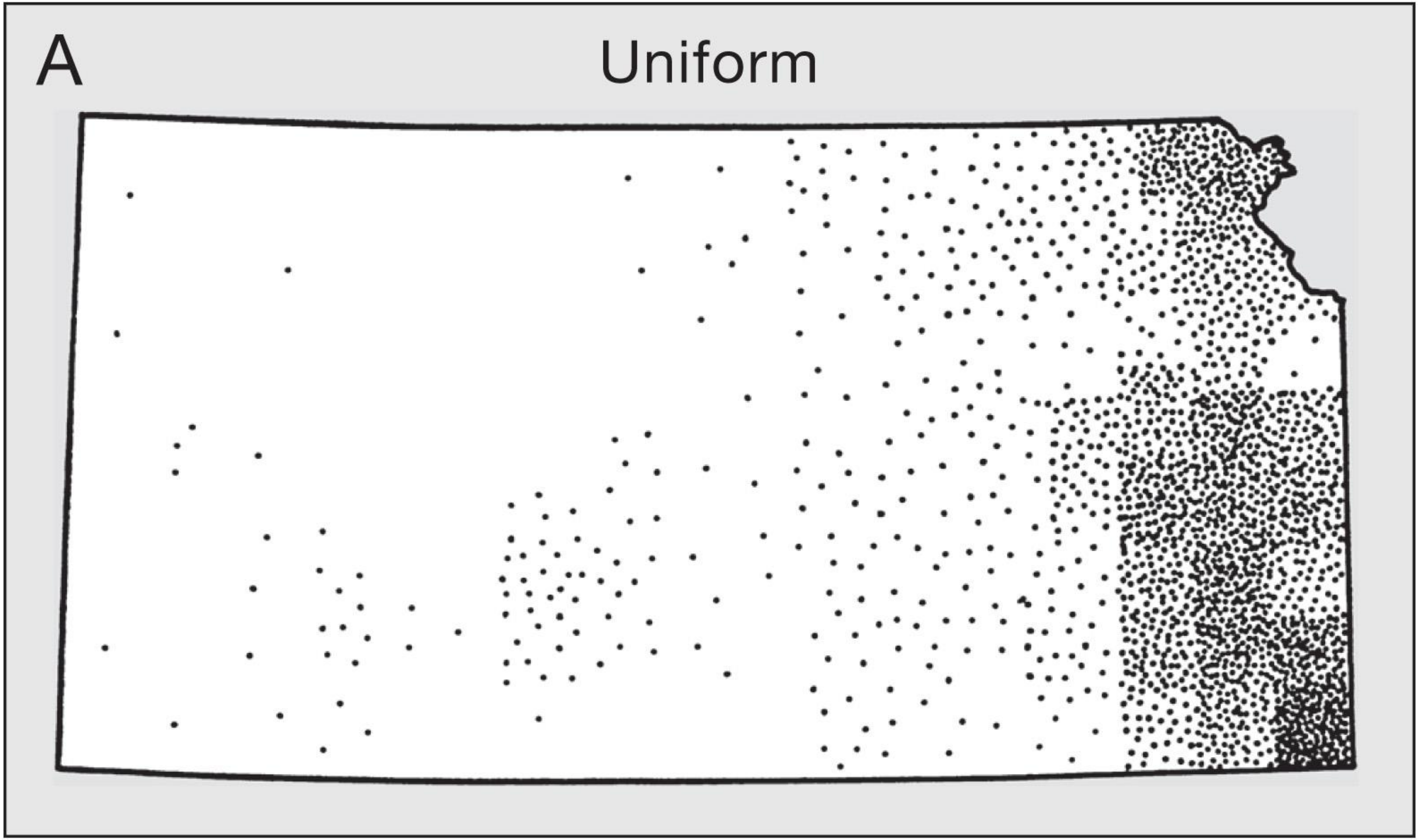


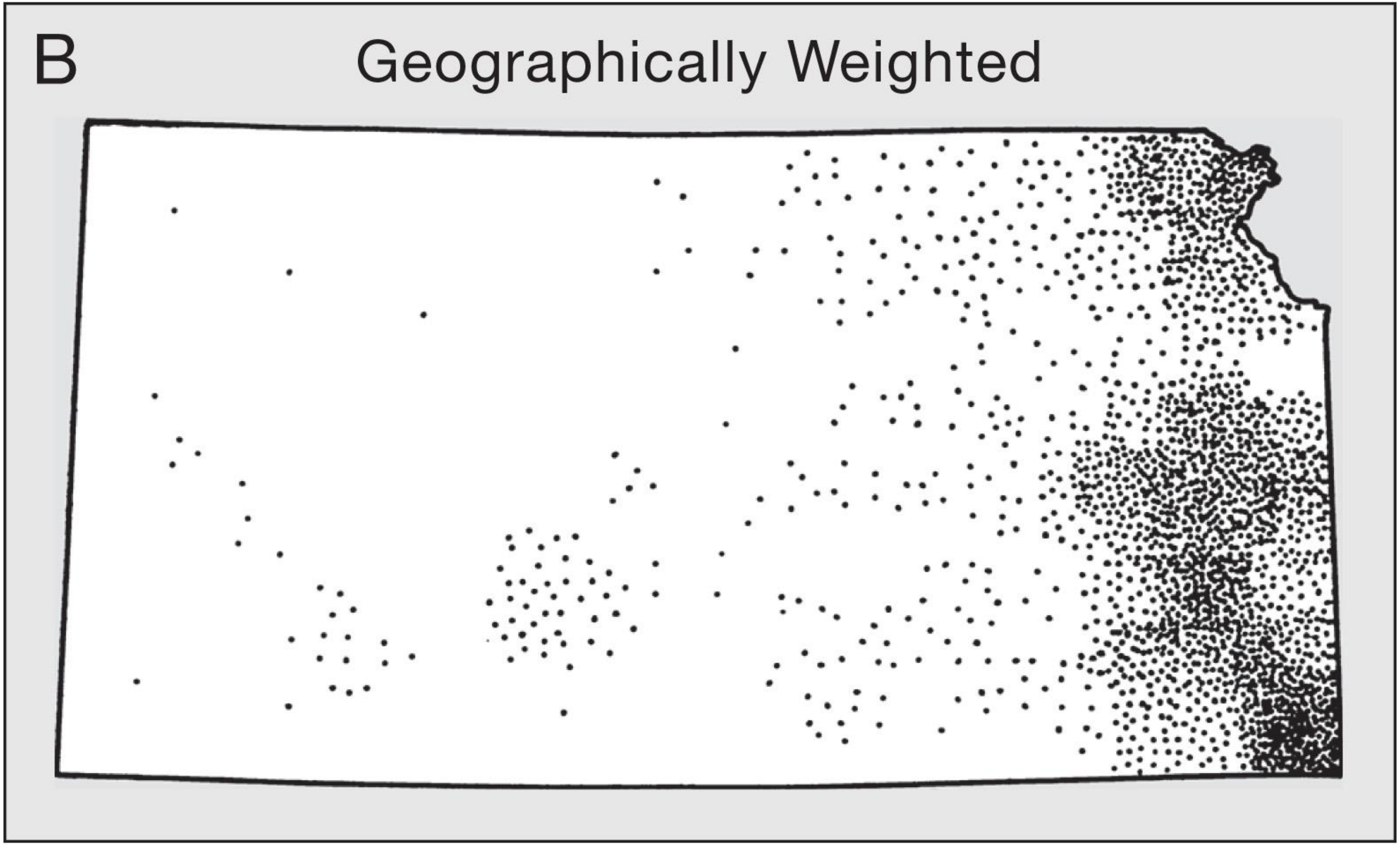

Geog183: Cartographic Design and Geovisualization Spring Quarter 2020

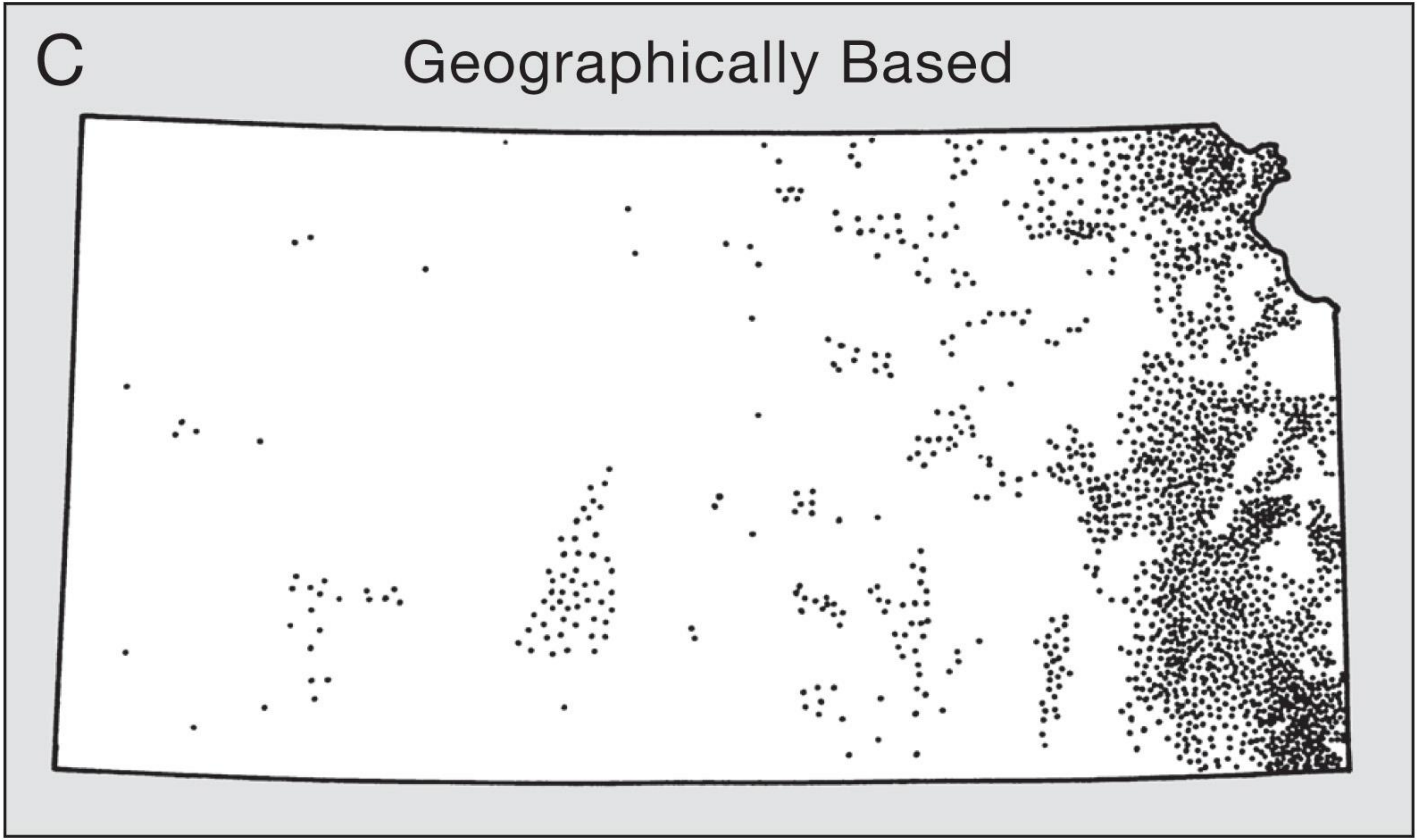
# Lecture 11: Dasymetric and isarithmic mapping

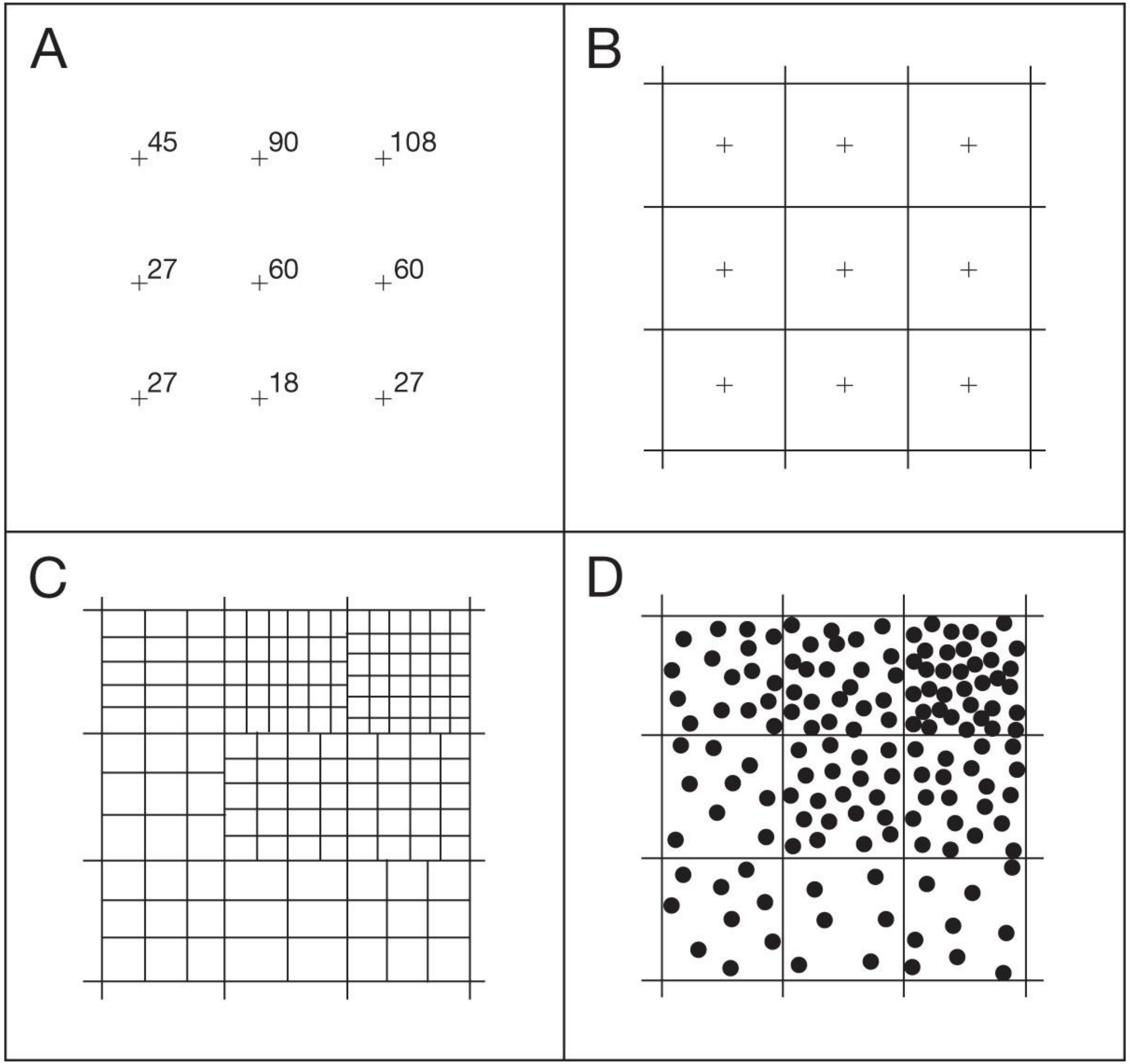
# Discrete vs. continuous revisited

- Choropleth suited to discrete areal, but suffers from MAUP unless standardized
- Dots can work for discrete points, but can be ineffective
- Dasymetric mapping allows discrete data to be supplemented with additional information about distributions
- Isarithmic methods work for continuous field variables, and are mostly derived from terrain mapping
- Isarithmic mapping often abused, on web commonly called “heat mapping”

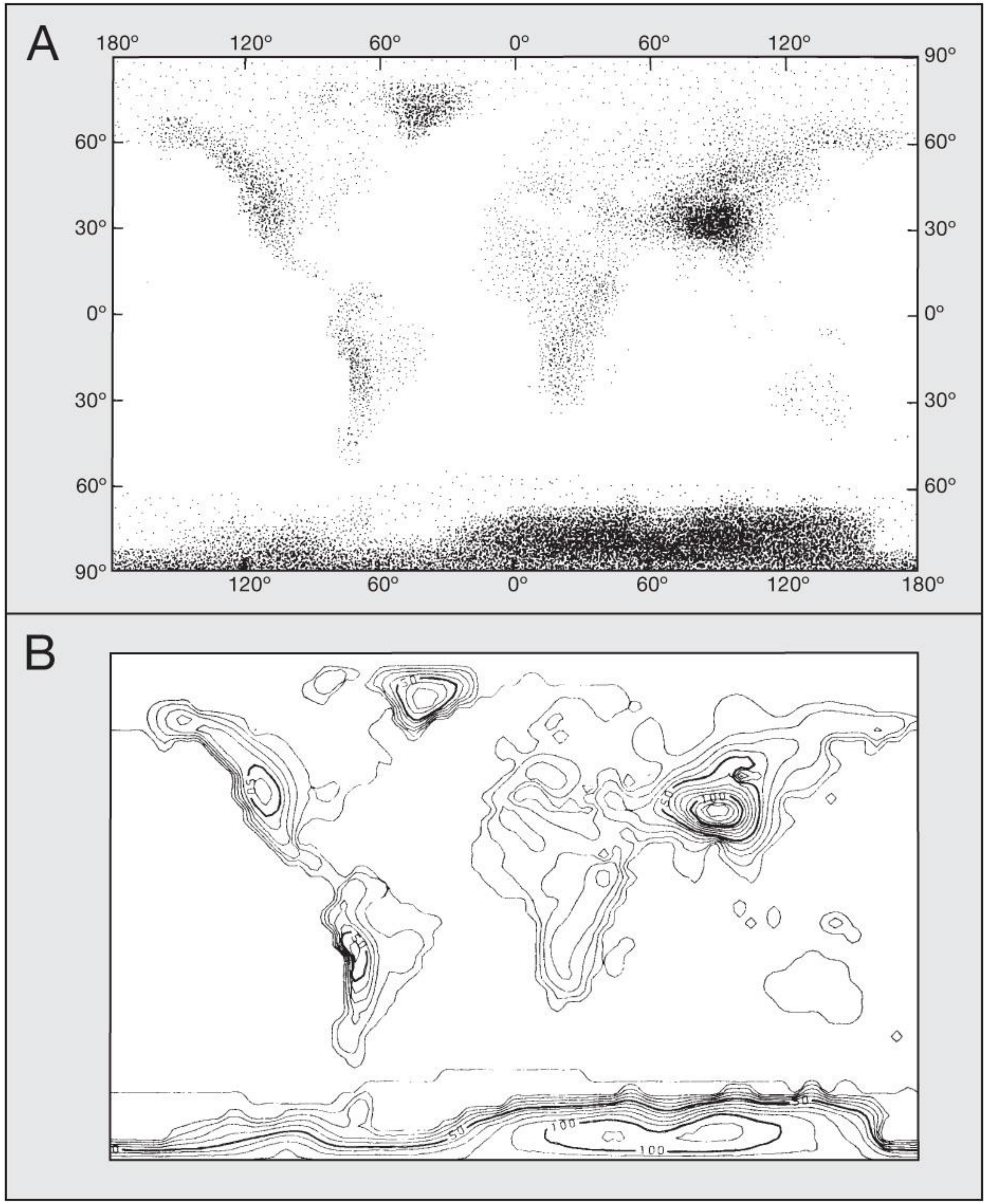

A
Uniform


B
Geographically Weighted

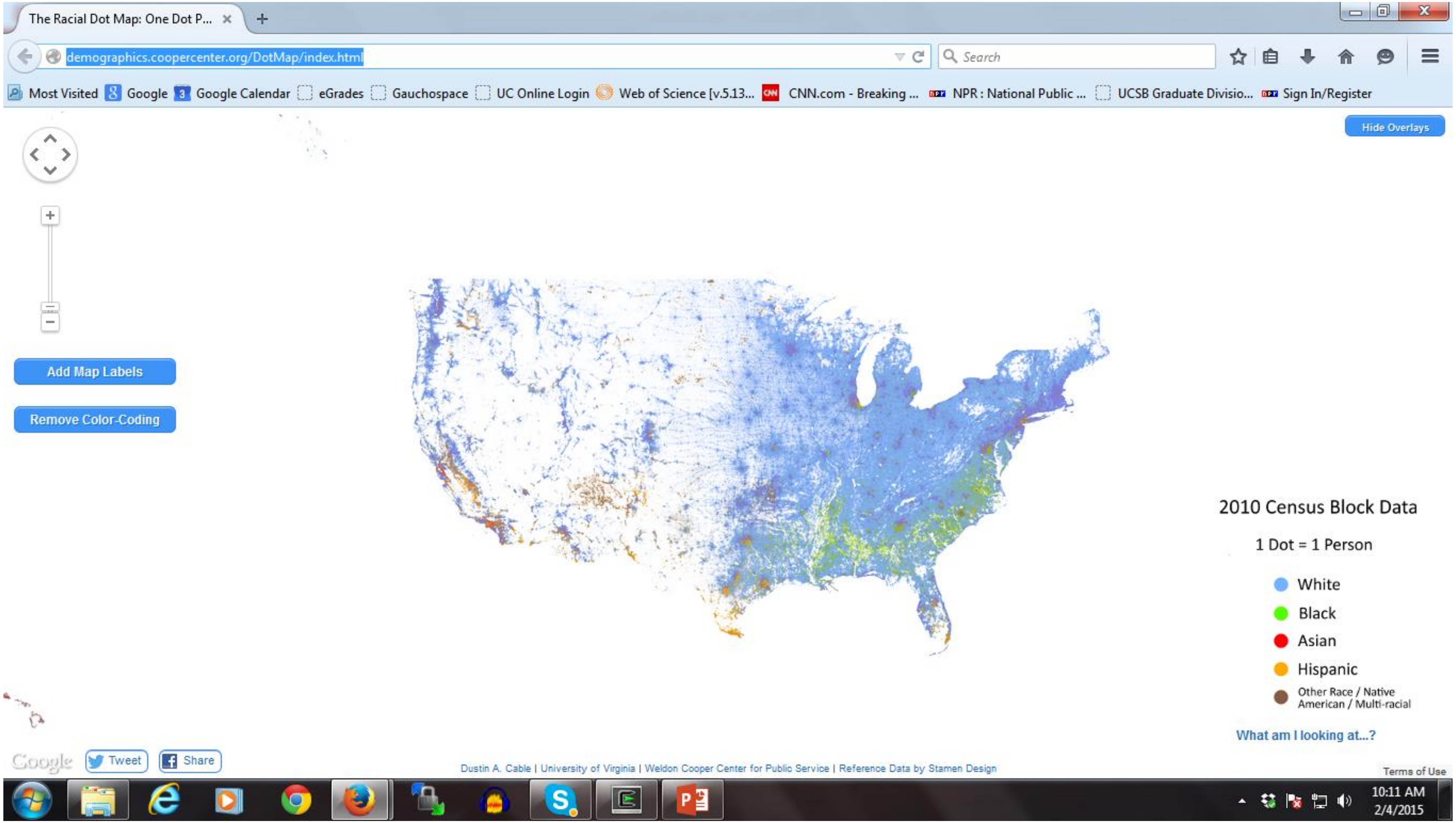

C
Geographically Based

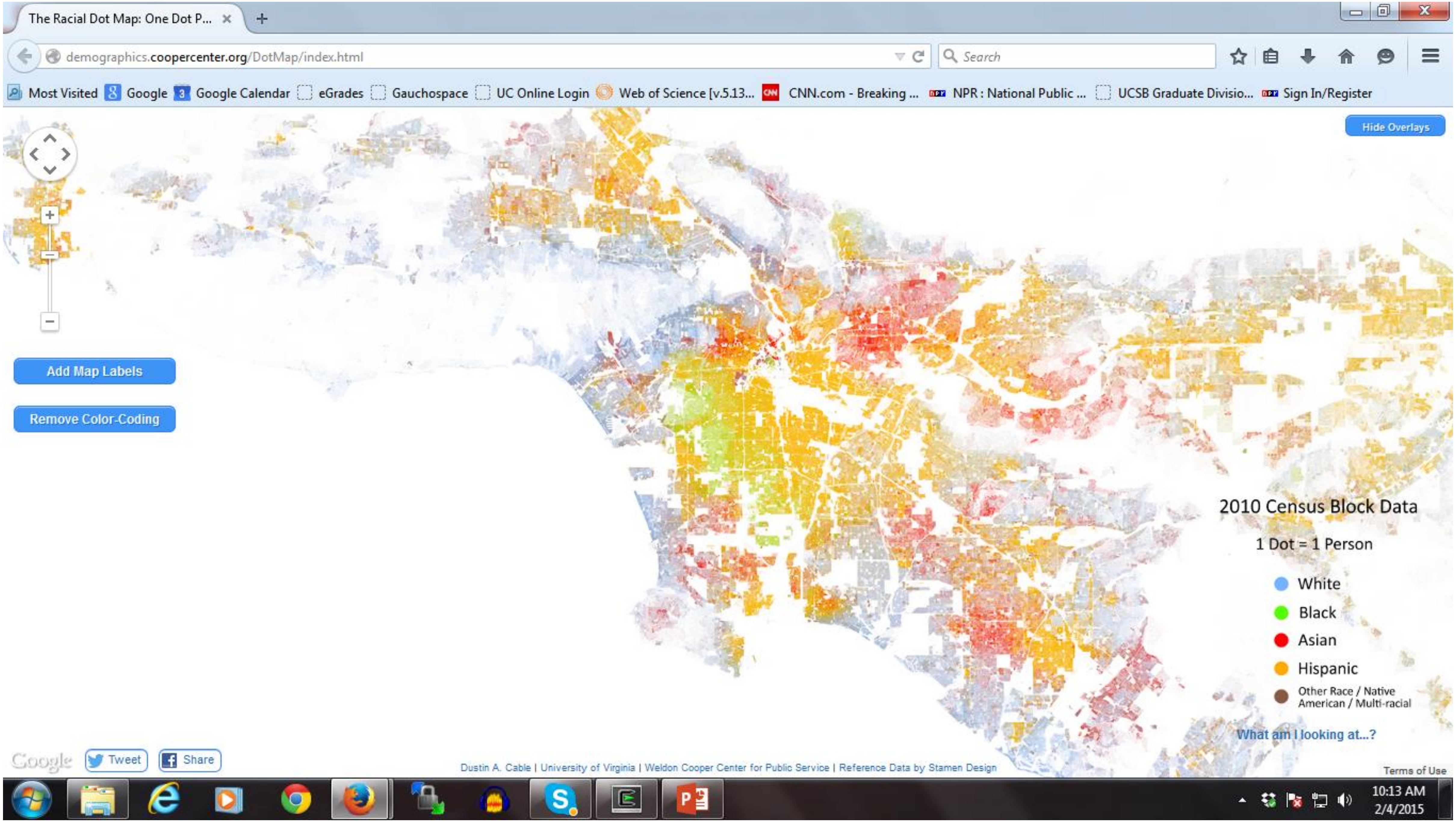

A
45
90
108
27
60
60
27
18
27
B
C
D




A
180°
120°
60°
0°
60°
120°
90°
60°
30°
0°
30°
60°
90°
120°
60°
0°
60°
120°
180°
B
100
50
100

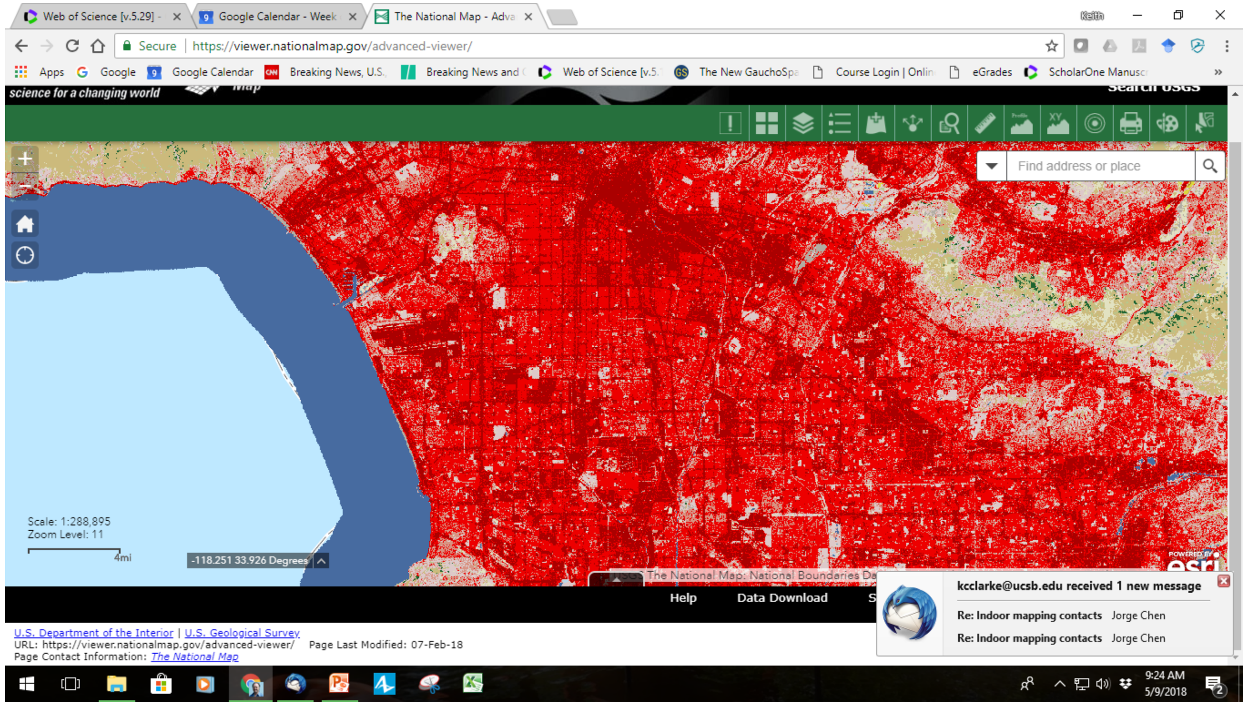
http://demographics.coopercenter.org/DotMap/index.html

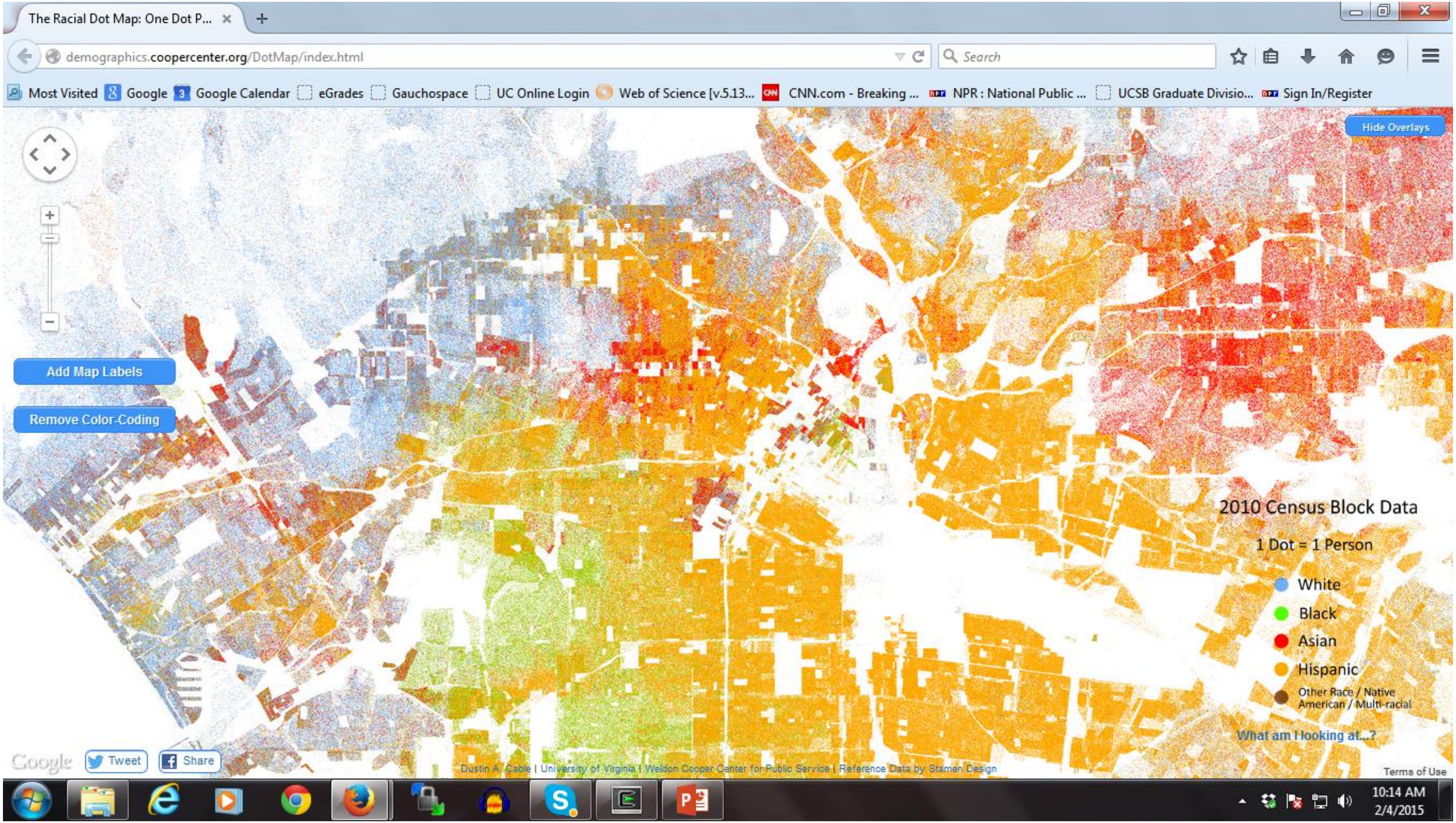



The Racial Dot Map: One Dot P...
demographics.coopercenter.org/DotMap/index.html
Search
Most Visited
Google
Google Calendar
eGrades
Gauchospace
UC Online Login
Web of Science [v.5.13...
CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Sign In/Register
Hide Overlays
Add Map Labels
Remove Color-Coding
2010 Census Block Data
1 Dot = 1 Person
White
Black
Asian
Hispanic
Other Race / Native American / Multi-racial
What am I looking at...?
Google
Tweet
Share
Dustin A. Cable | University of Virginia | Weldon Cooper Center for Public Service | Reference Data by Stamen Design
Terms of Use
10:13 AM
2/4/2015

# Dasymetric: Note the blank areas

- Overlay land use and other data
- Move dots to where they are most likely to reside
- Can compute quantities from proportions in overlay
- Example of data fusion




The Racial Dot Map: One Dot P...
demographics.coopercenter.org/DotMap/index.html
Search
Most Visited
Google
Google Calendar
eGrades
Gauchospace
UC Online Login
Web of Science [v.5.13...
CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Sign In/Register
Hide Overlays
Add Map Labels
Remove Color-Coding
2010 Census Block Data
1 Dot = 1 Person
White
Black
Asian
Hispanic
Other Race / Native American / Multi-racial
What am I looking at...?
Tweet
Share
Dustin A. Cable | University of Virginia | Weldon Cooper Center for Public Service | Reference Data by Stamen Design
Terms of Use
10:14 AM
2/4/2015

# Dasymetric

- Method of thematic mapping, which uses areal symbols to spatially classify volumetric data
- Developed and named in 1911 by Benjamin Petrovich Semenov-Tyan-Shansky
- Popularized by J.K. Wright in a 1936 map of Cape Cod
- Cartographers use dasymetric mapping for population density over other methods because of its ability to realistically place data over geography
- Now possible to use land use, imagery, many other information sources

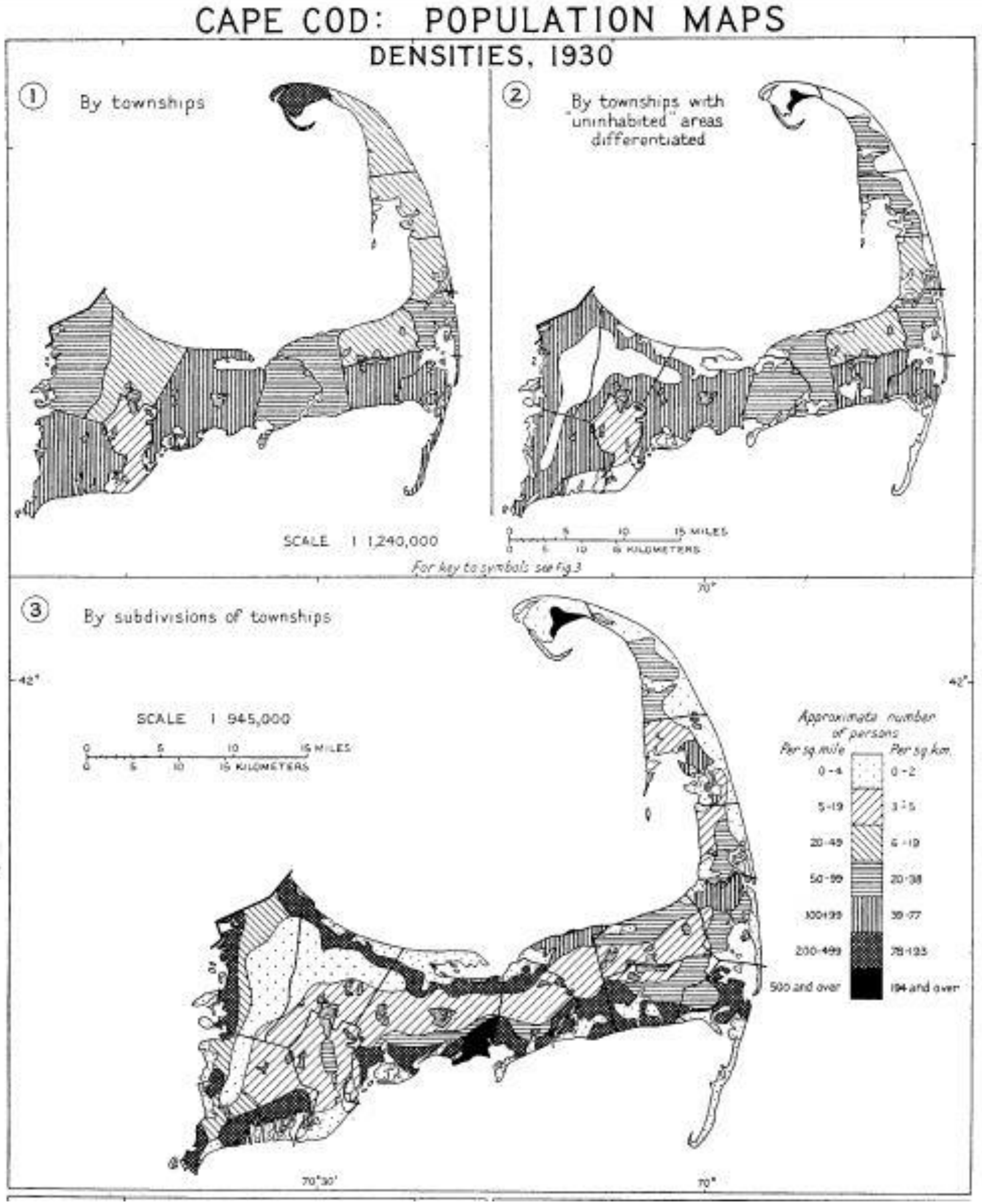
# J. K. Wright *Geographical Review* 1936

## A METHOD OF MAPPING DENSITIES OF POPULATION

### WITH CAPE COD AS AN EXAMPLE

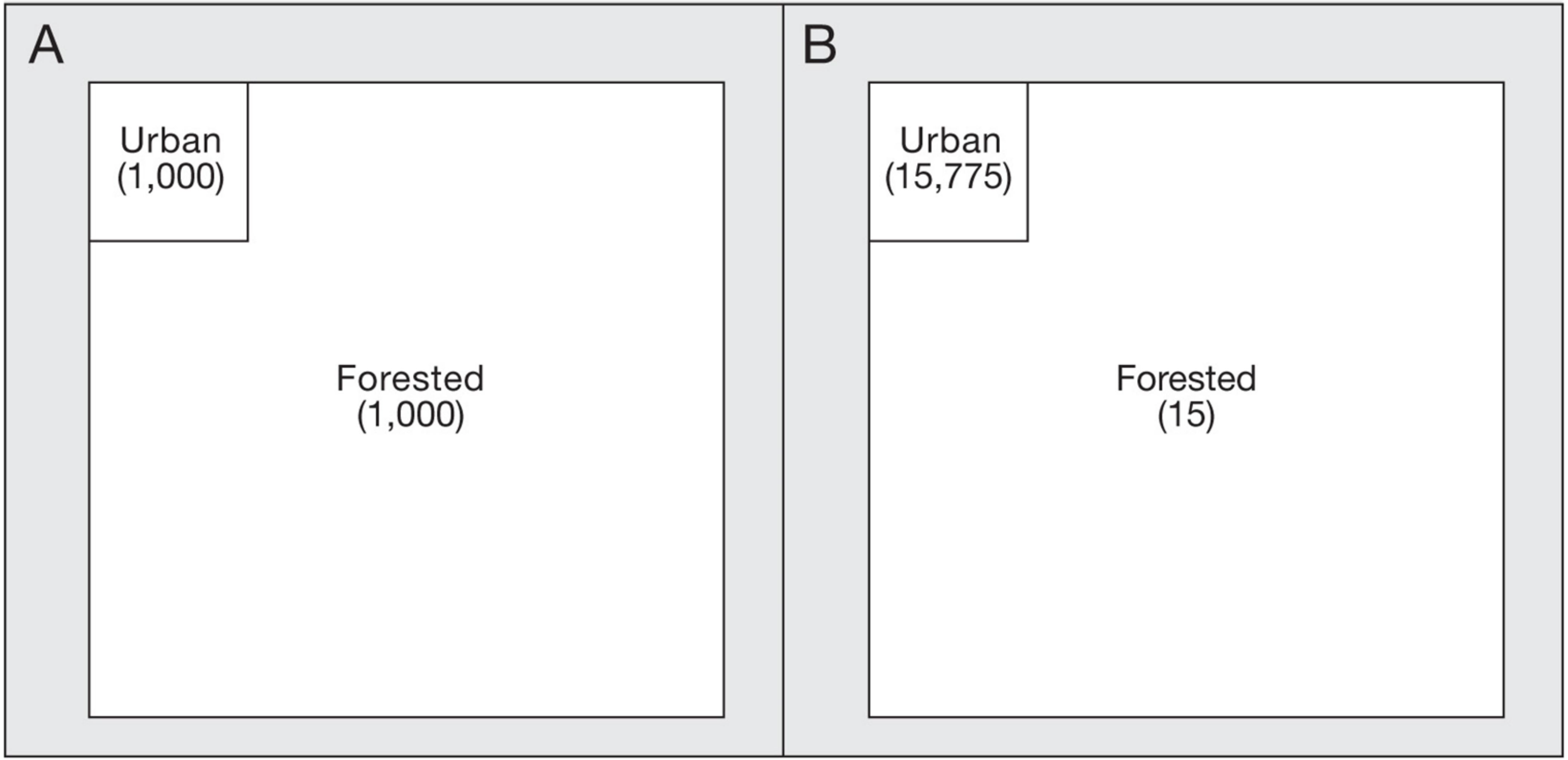
John K. Wright

THE first of the maps presented on page 105 is a conventional population map of Cape Cod in which a symbol for the density covers the whole area of each township. The map is not particularly realistic. Anyone who has visited the region knows that large parts of it are uninhabited. Terminal-moraine ridges run parallel to the north and east shores of the Cape's "upper arm"—to use a term implying comparison of the Cape to an arm shaking its fist at the Atlantic. These moraines are wildernesses of burnt-over land covered with scrub oak and stunted pine. Fringing Nantucket Sound is a string of villages, but elsewhere the sandy outwash plains that intervene between the moraines and the sound are thinly peopled, and one often drives for several miles without seeing a house. At the tip end of the Cape the map shows a density of 200 to 500 to the square mile in the "fist." As a matter of fact, nearly all the people here live in the compact village of Provincetown along the harbor, and the greater

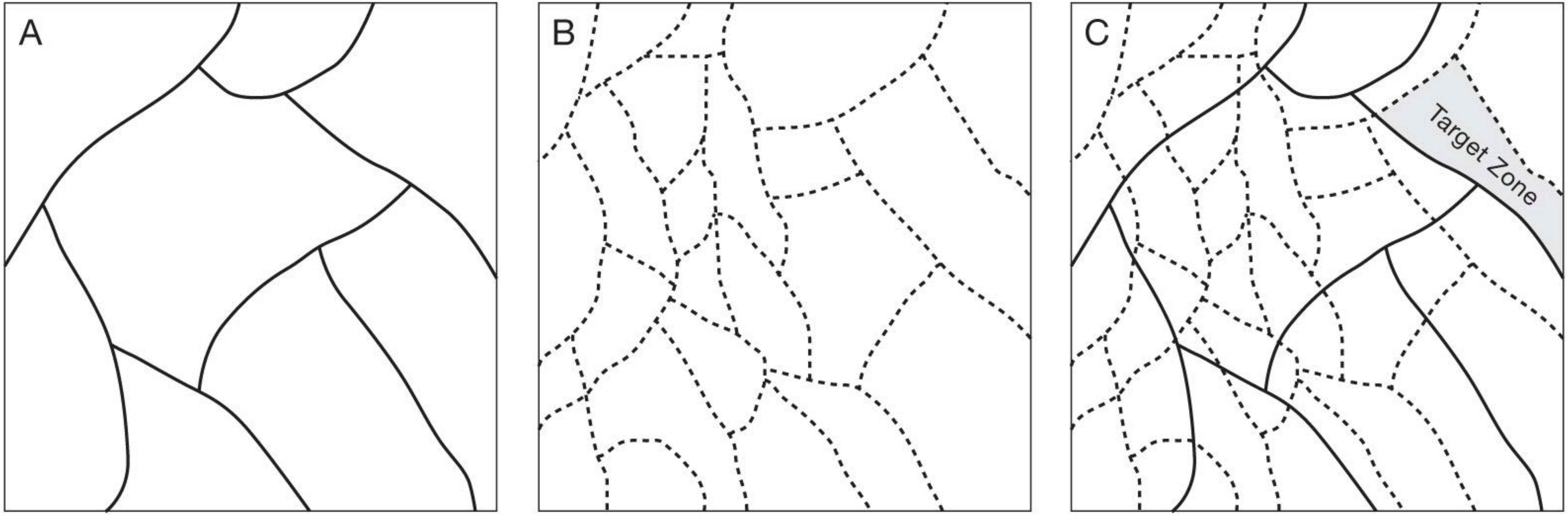



- Start with the counts for the choropleth map
- Adjust each area using land use to exclude areas that are uninhabited
- Adjust the remaining area and recompute the density
- Remap densities within each land use class, e.g. urban, rural

# Adjustments to density



# Overlapping zones

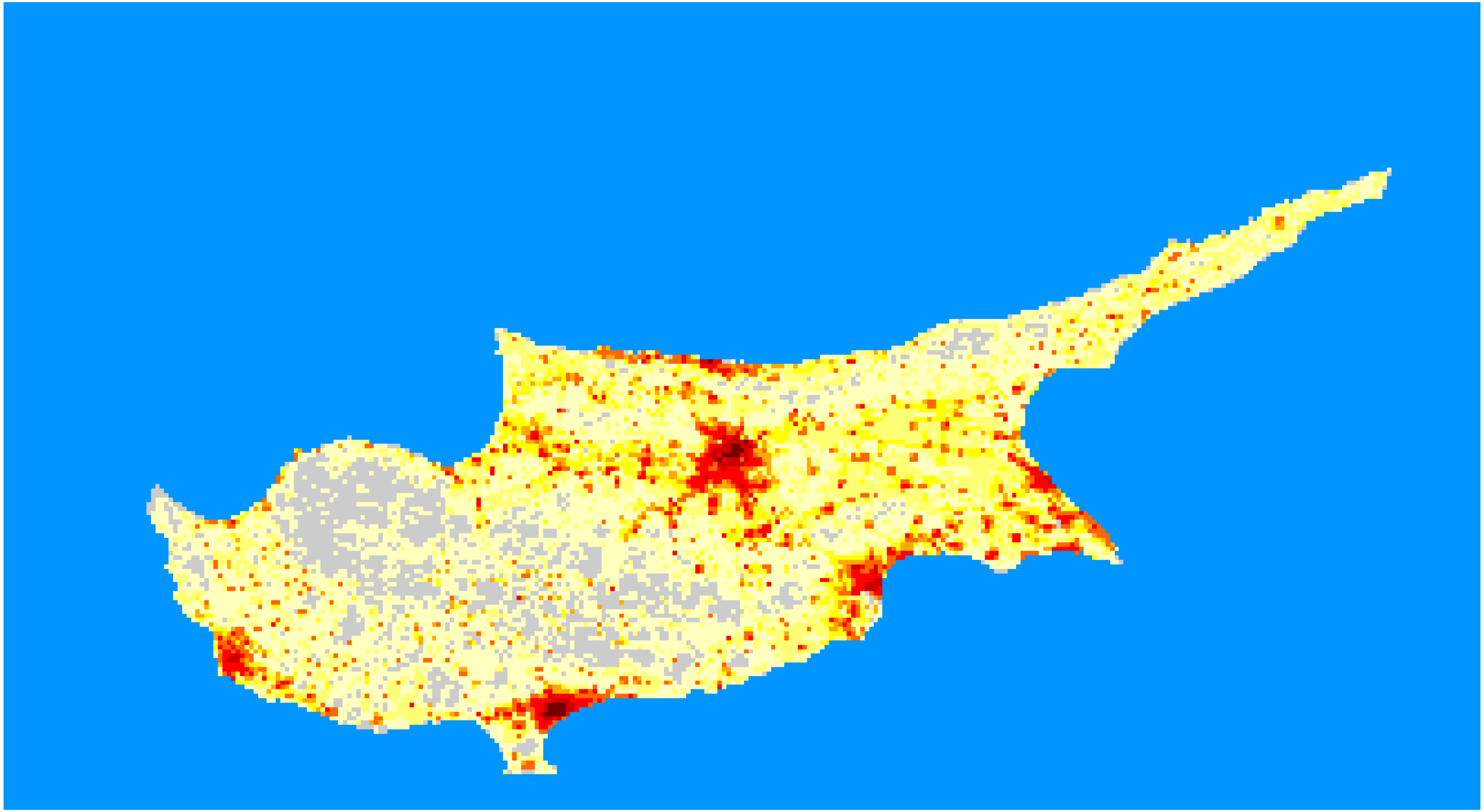


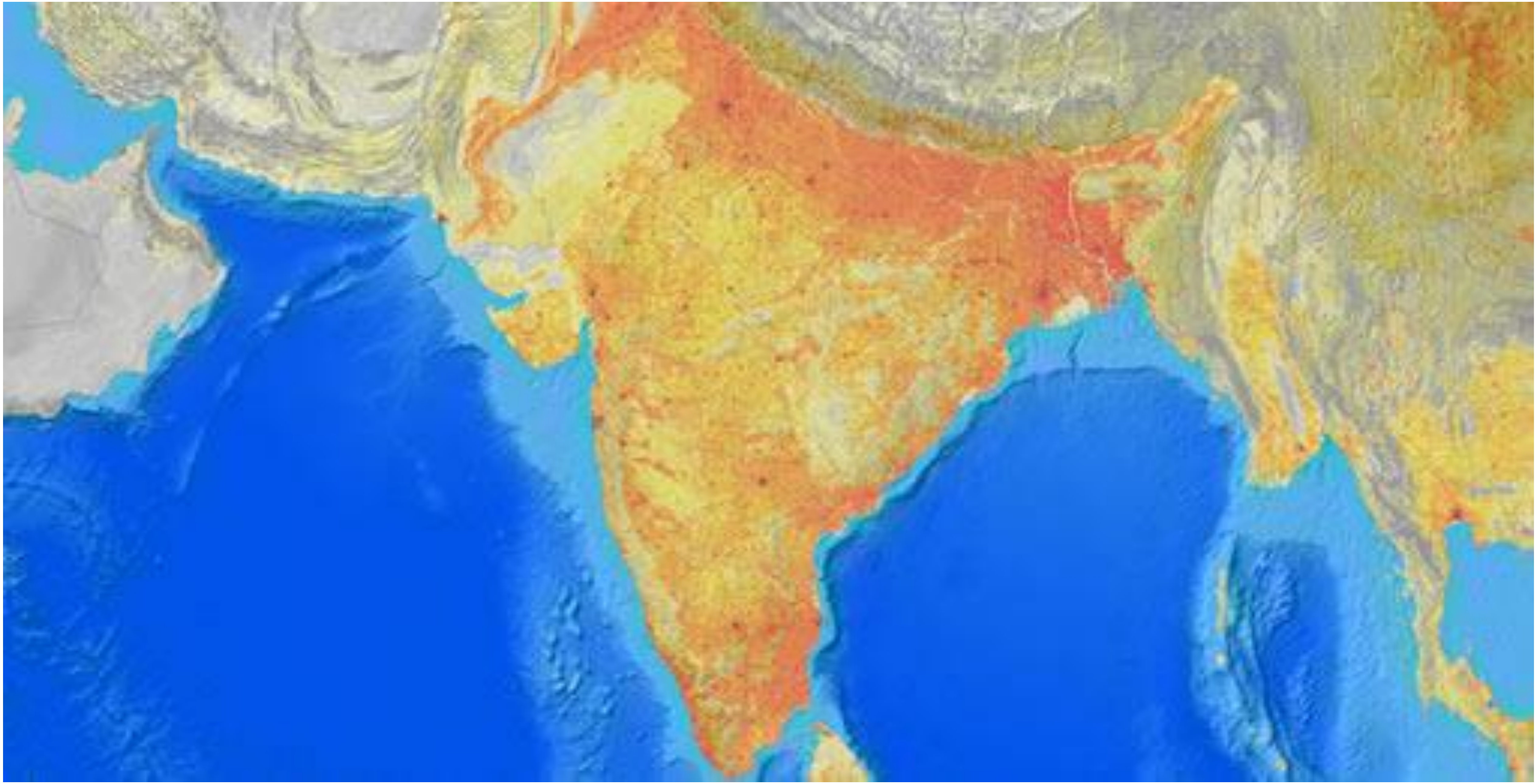

Source Zones

Ancillary Zones

Overlay of Zones

# Landscan: Global Population (Eastview)

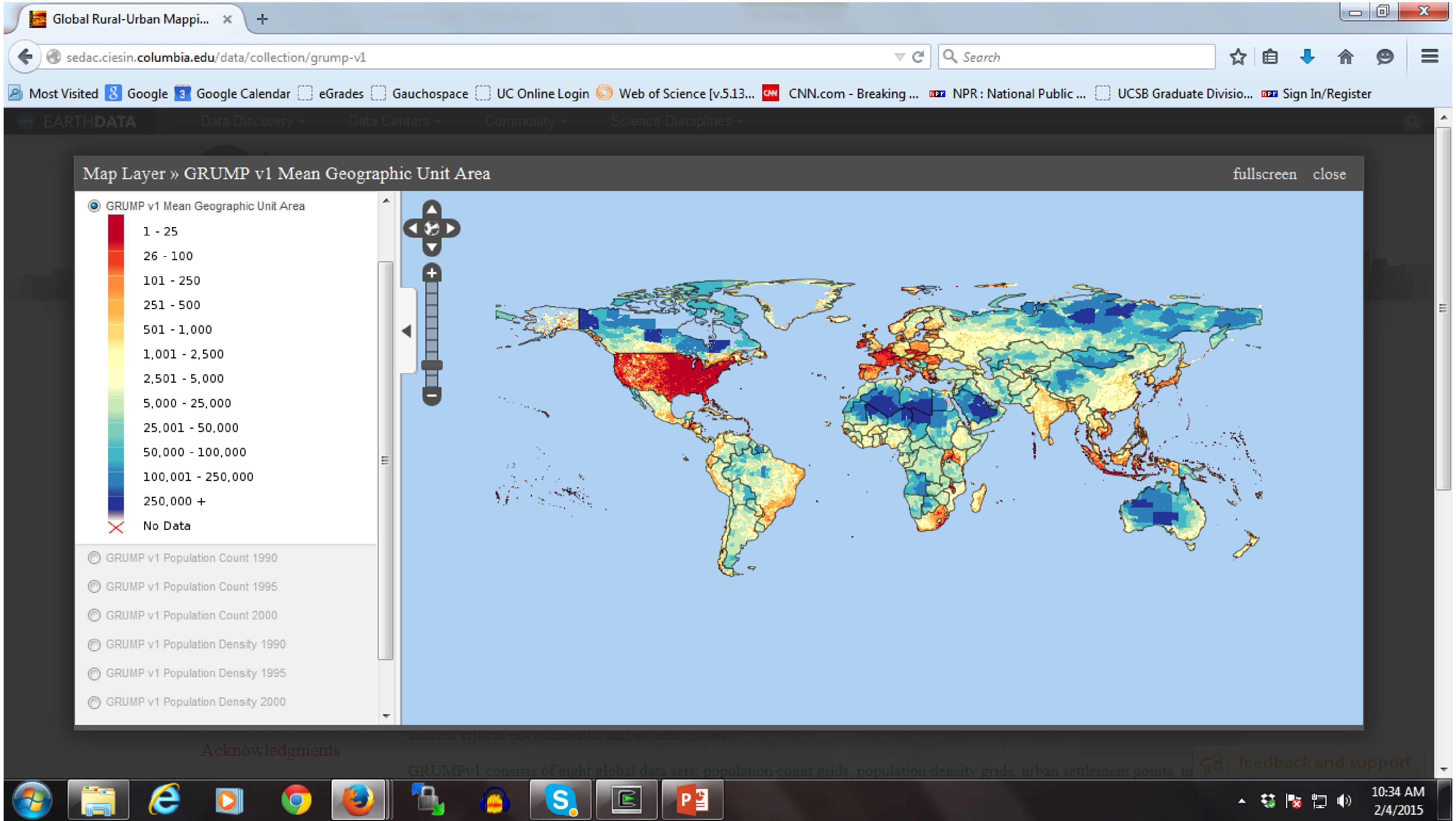


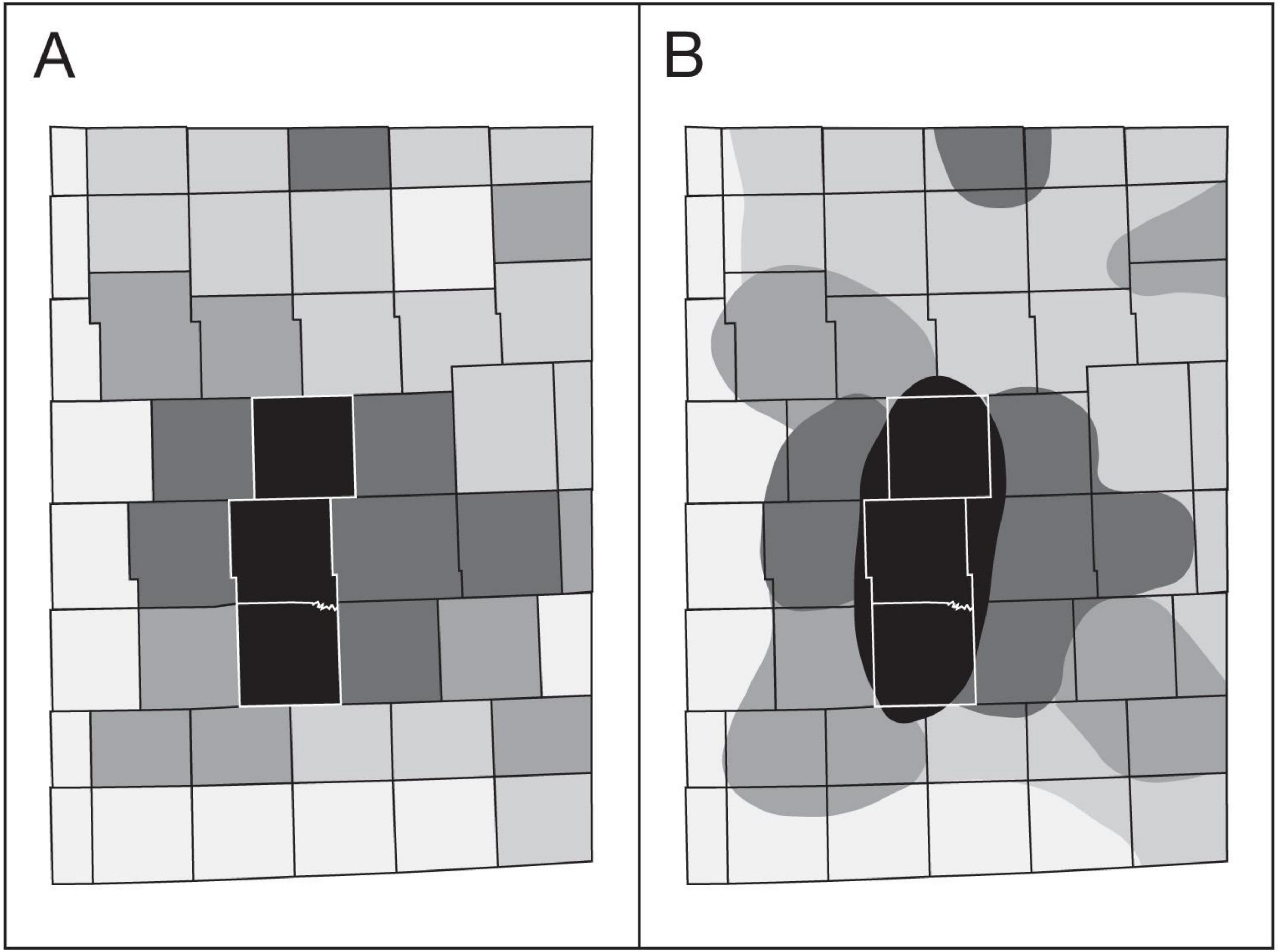


# Landscan Data Sources

- Census
- Administrative boundaries
- Land cover
- Elevation and slope
- Coastlines
- Imagery
- Nighttime lights

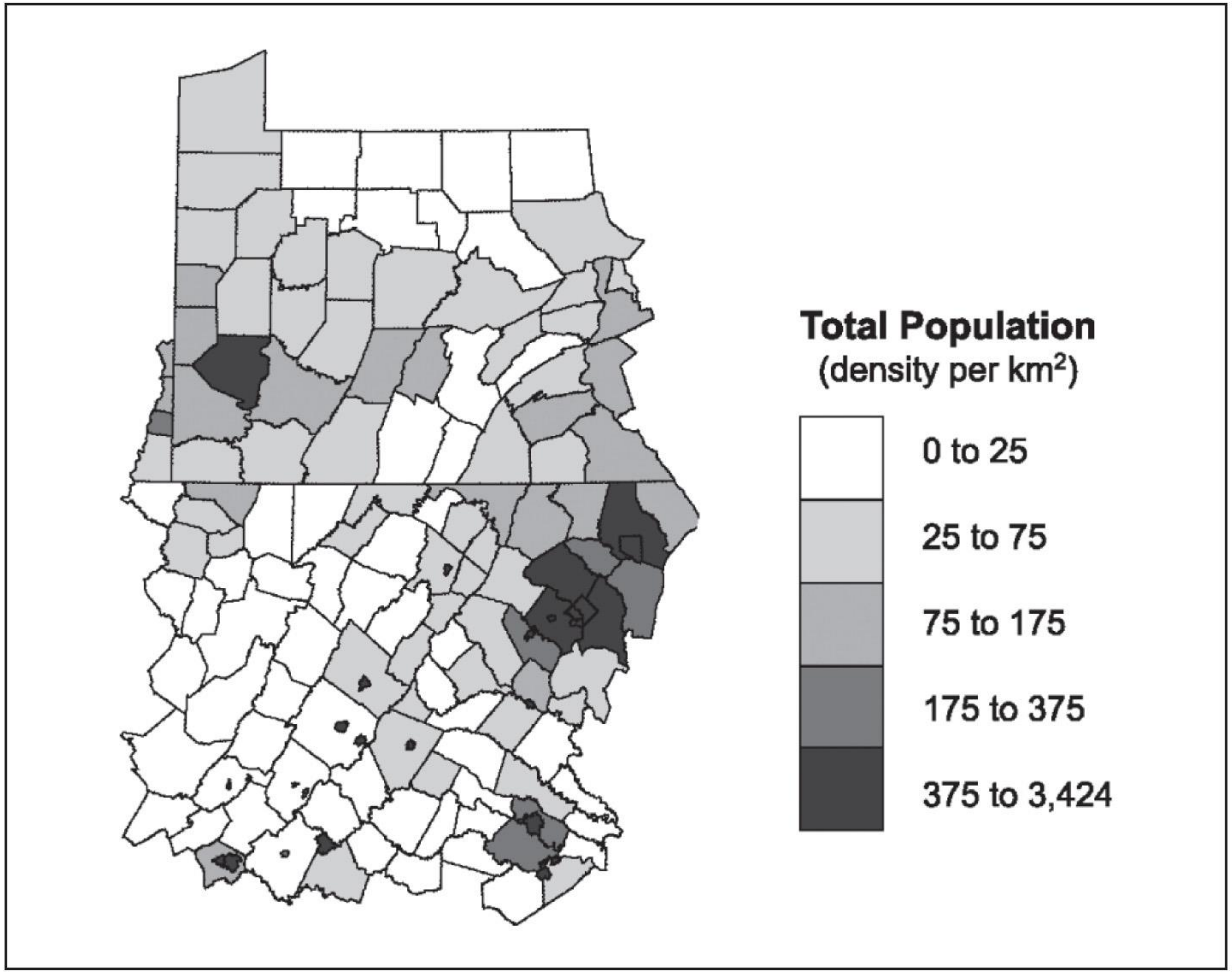
# NASA: Global Rural-Urban Mapping Project Distributed via CEISIN: http://sedac.ciesin.columbia.edu/data/collection/grump-v1

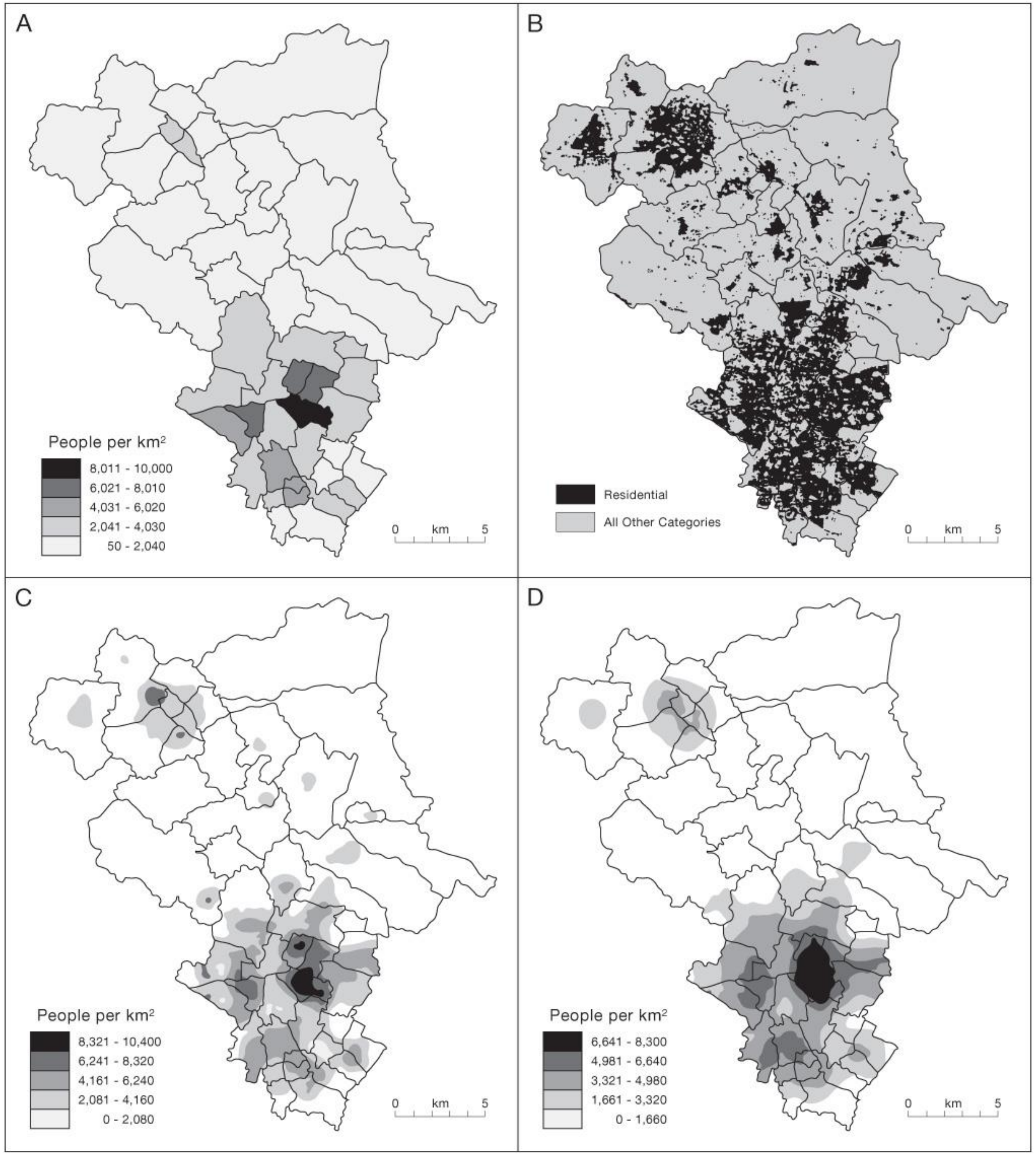



A
B


Erie
PENNSYLVANIA
Pittsburgh
Harrisburg
York
MARYLAND
Baltimore
Washington
WEST VIRGINIA
VIRGINIA
Charlottesville
Richmond
Roanoke




Total Population
(density per km²)
0 to 25
25 to 75
75 to 175
175 to 375
375 to 3,424

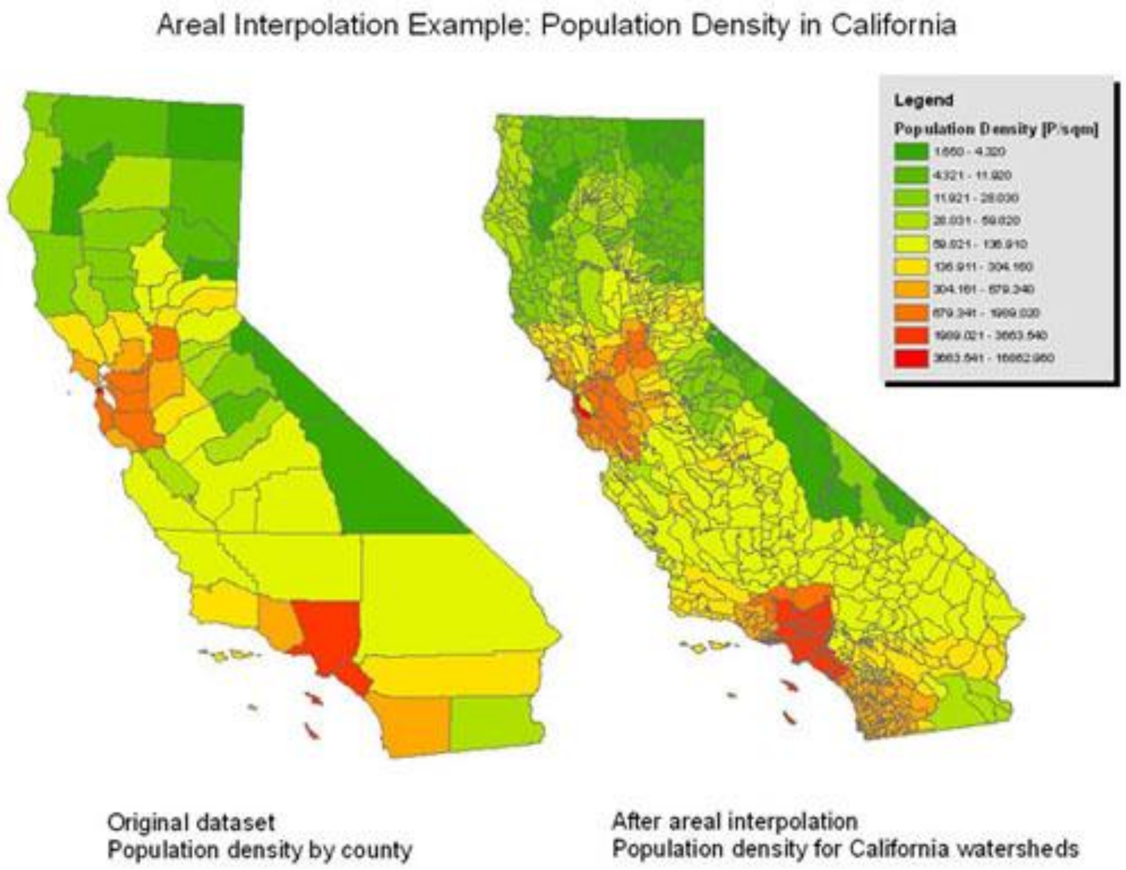





Langford, M. and Unwin, D. (1994) “Generating and mapping population density surfaces within a geographical information system”. *The Cartographic Journal*. 31, 21-26.

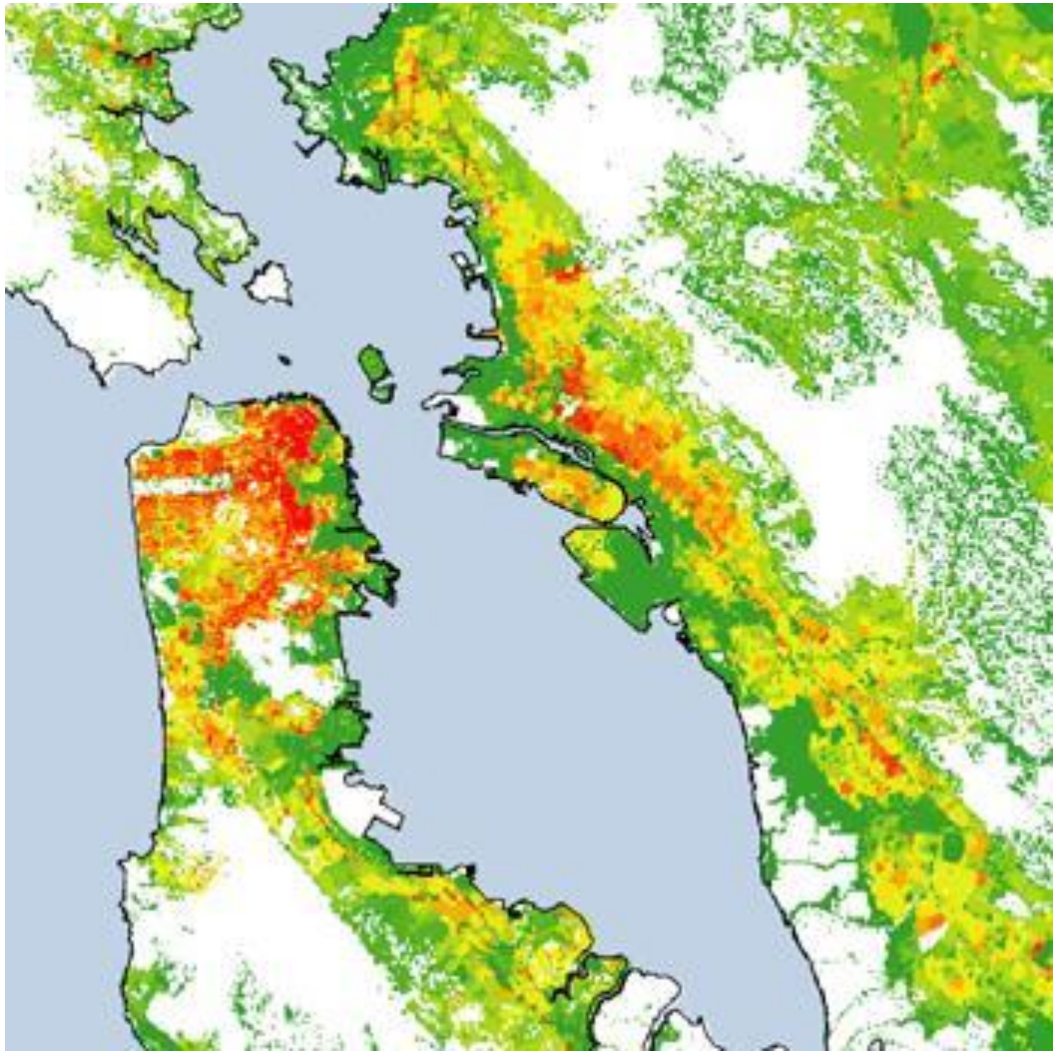
# Software

- Use standard map overlay, e.g. in ArcGIS
- Using imagery: eCognition
- Schneider’s code in R at UCSB
- Mashups



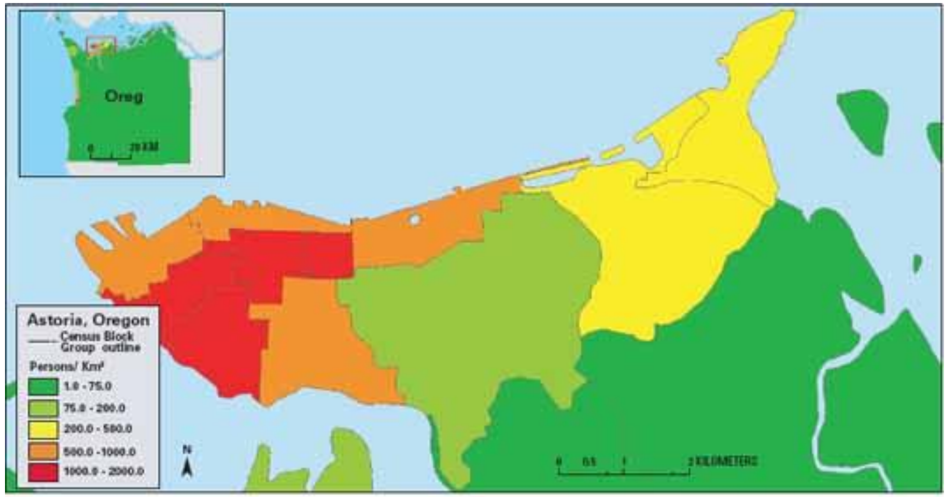
# USGS Western Mapping Center

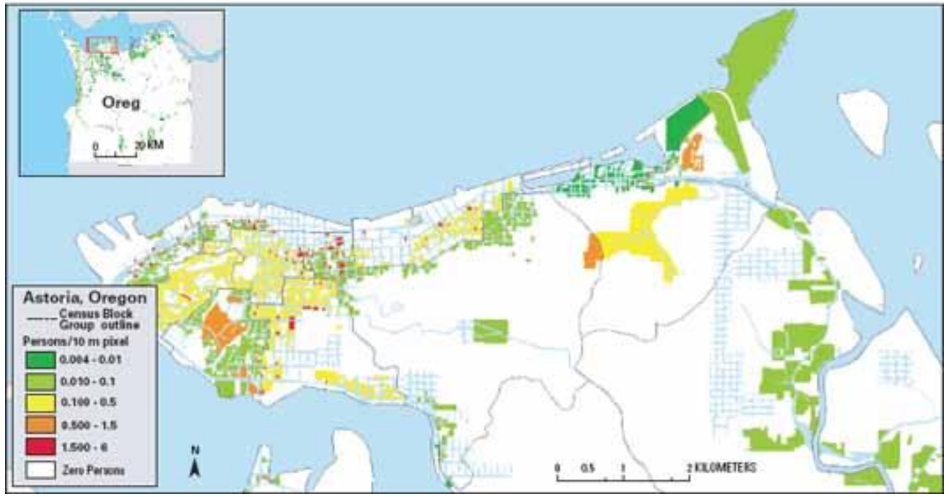
http://geography.wr.usgs.gov/science/dasymetric/ "Plans to update tool for ArcGIS 10"



# Astoria, Oregon

Rachel Sleeter and Michael Gould http://pubs.usgs.gov/tm/tm11c2/

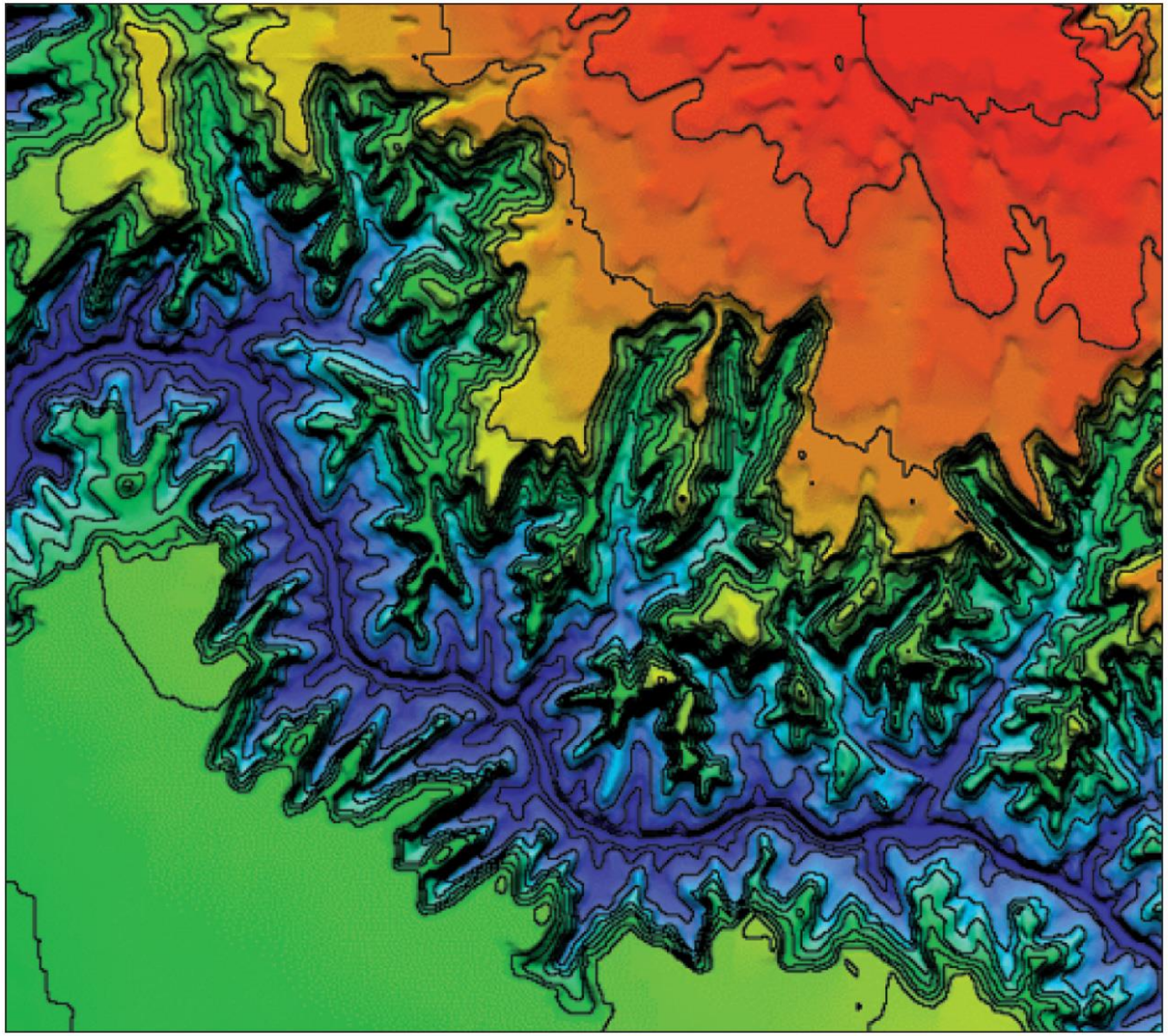


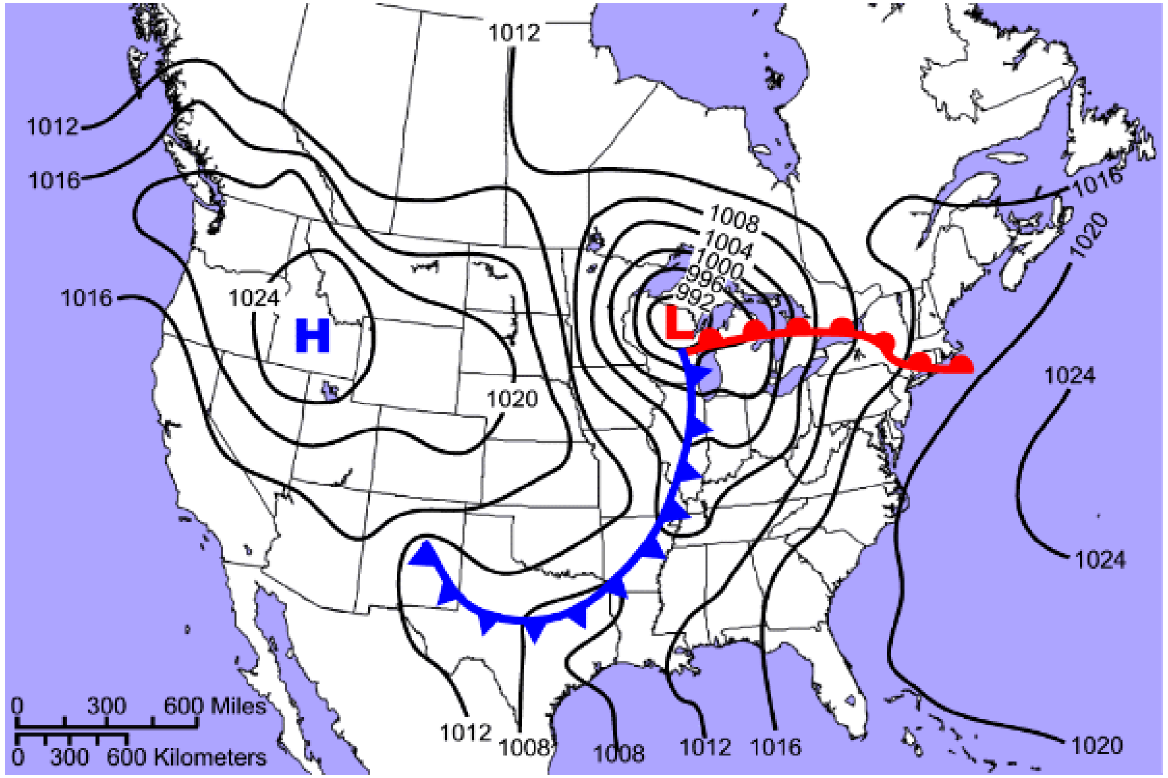
# Isarithmic mapping

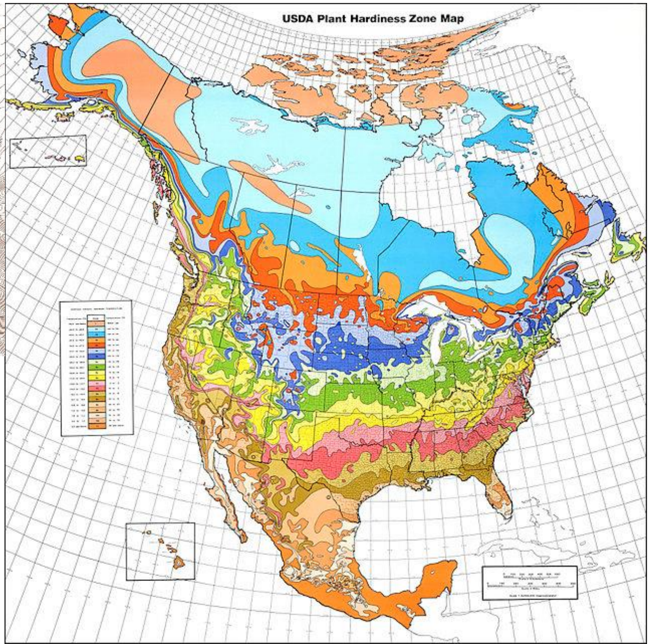
- Includes contour maps
- Any map showing lines joining points of equal value
- Can shade or use colors for areas between lines
- Can use many terrain-based methods, such as shading
- Based on assumption of continuity
- When data at points (or area centroids) are used, need to use interpolation
- Interpolation methods and models are many
- Longley et al. Contrast interpolation and kernel density function
- Can use optimal interpolation, e.g. kriging

# Isarithmic maps using isopleths







# Planar Map Transformations on Points - Centroids

- Multiple point or line or area to be transformed to single point
- Point can be "real" or representative
- Can use weightings or populations
- Mean center simple to compute but may fall outside point cluster or polygon
- Can use point-in-polygon to test for inclusion

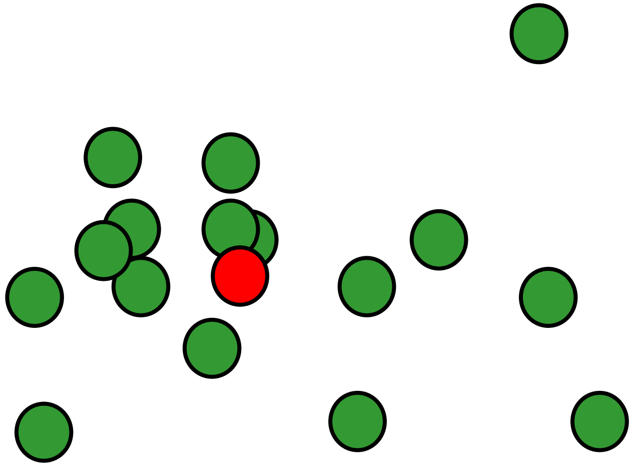
$$\bar{x} = \frac{\sum_{i=1}^{npts} P_i x_i}{\sum_{i=1}^{npts} P_i} \qquad \bar{y} = \frac{\sum_{i=1}^{npts} P_i y_i}{\sum_{i=1}^{npts} P_i}$$

## Mean Center of Population for the United States: 1790 to 2000

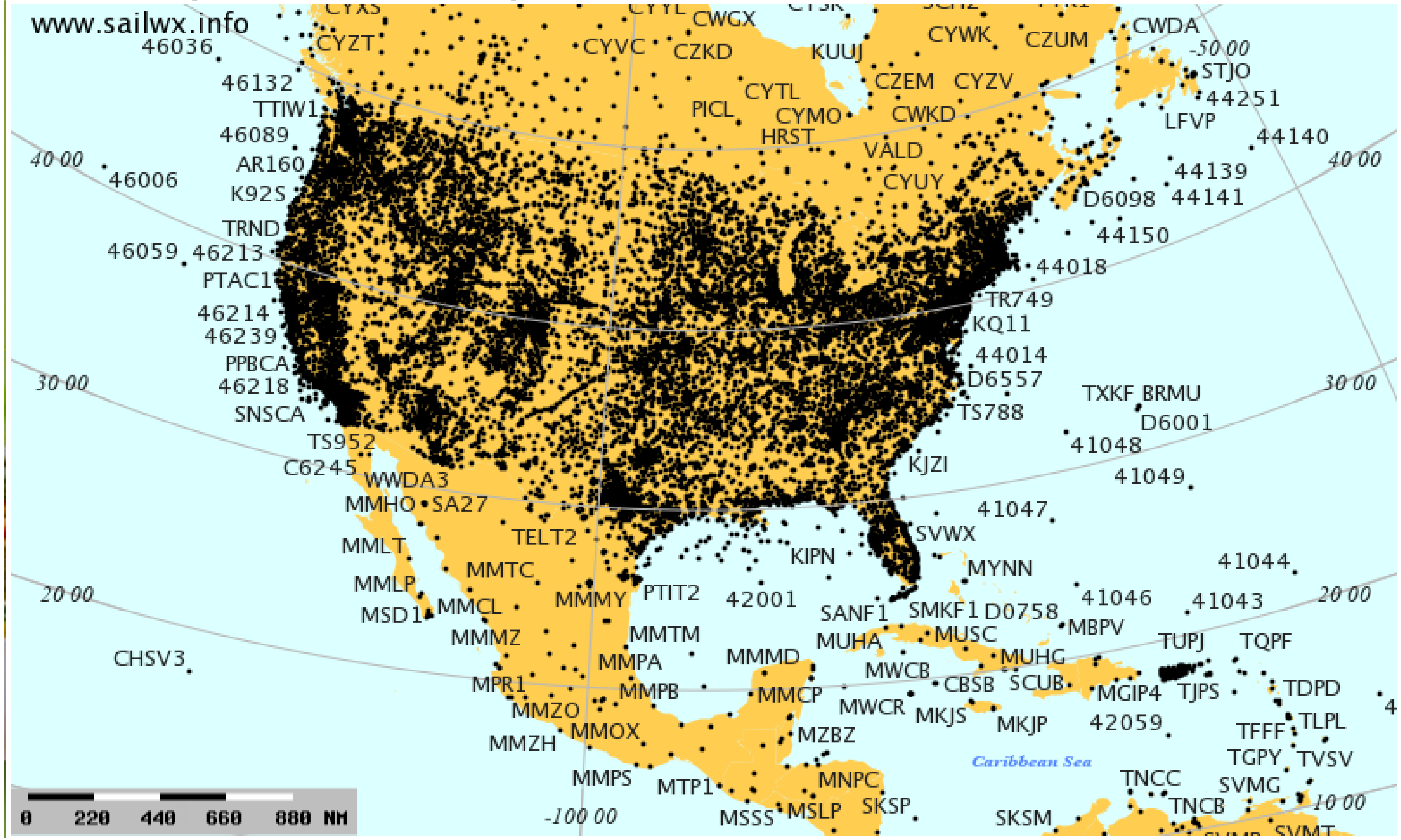

U.S. Department of Commerce Economics and Statistics Administration U.S. Census Bureau

Prepared by the Geography Division

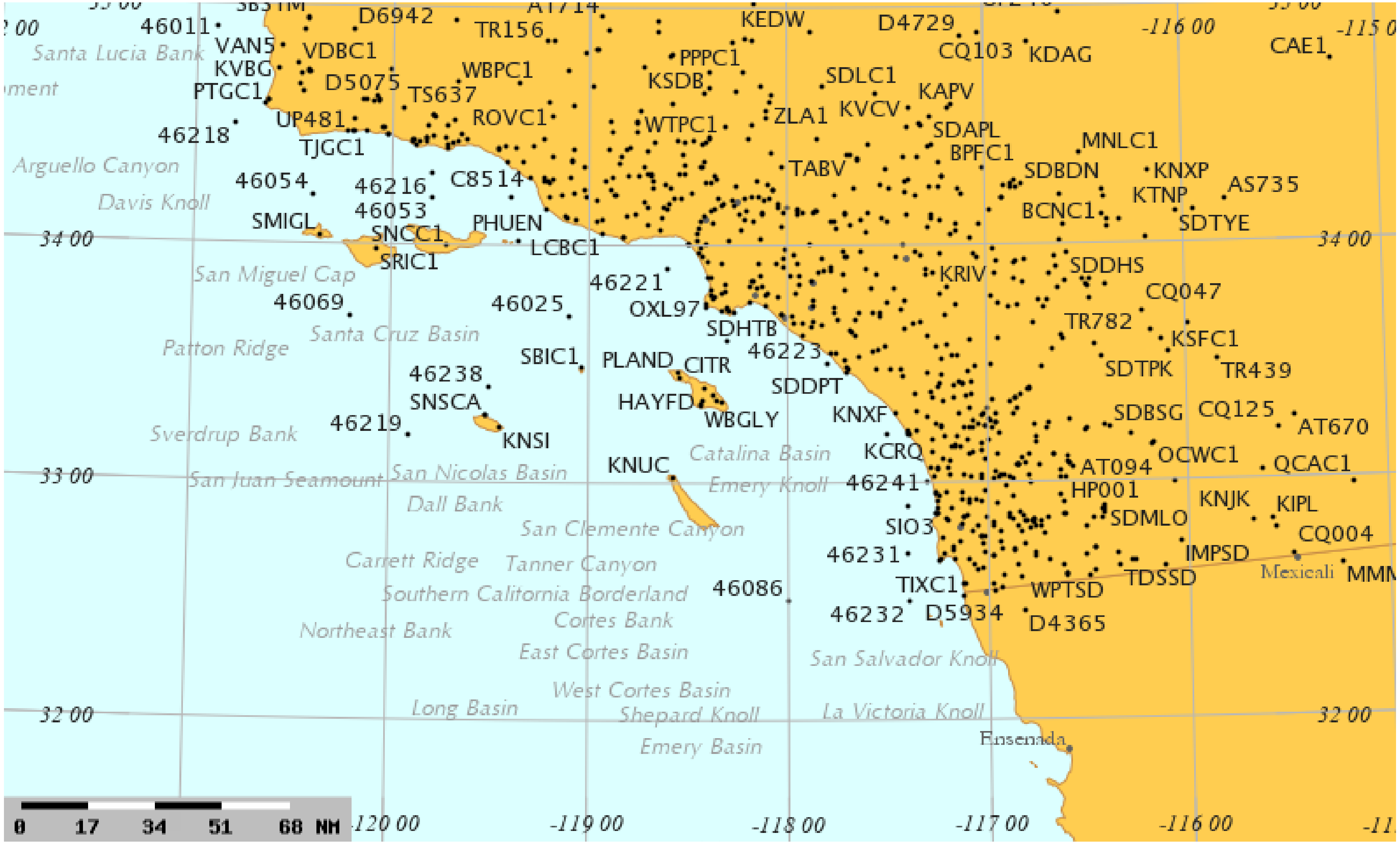
# Mean point vs. centroid



# The interpolation problem



# Southern California

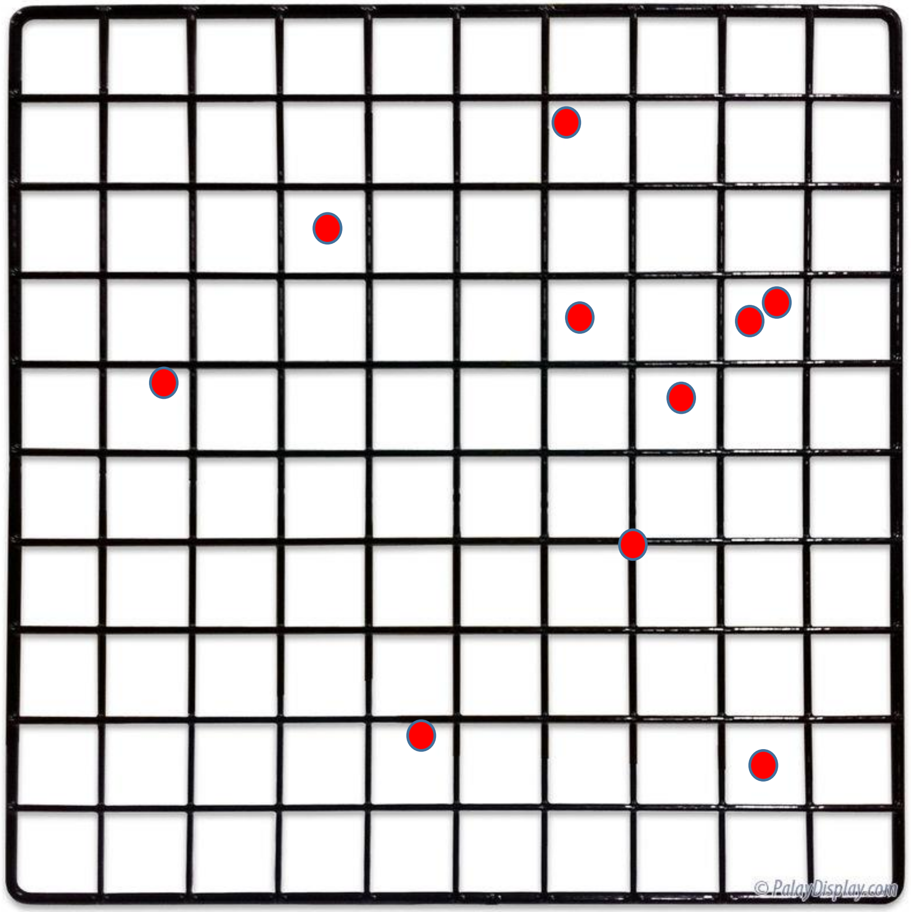


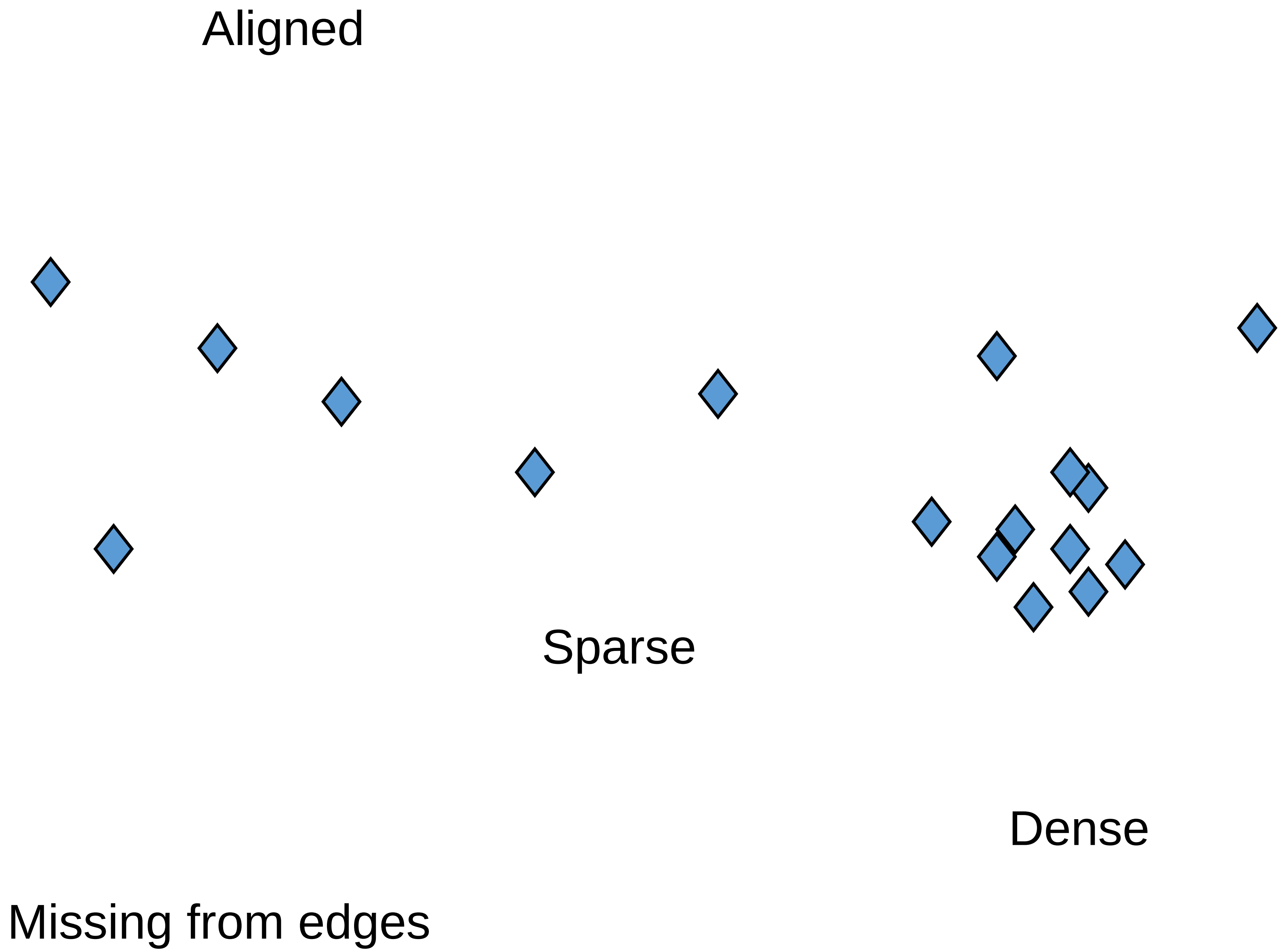
# Interpolation to a Grid

- Given a set of point elevations (x, y, z) generate a new set of points at the nodes of a regular grid so that the interpolated surface is a reasonable representation of the surface sampled by the points.
- Imposes a model of the true surface on the sample
- "Model" is a mathematical model of the neighborhood relationship
- Influence of a single point = f(1/d)
- Can be constrained to fit all points
- Should contain *z* extremes, and local extrema
- Most models are algorithmic local operators
- Work cell-to-cell. Operative cell = kernel

# Smooth and Abrupt landscapes: Surface derivative

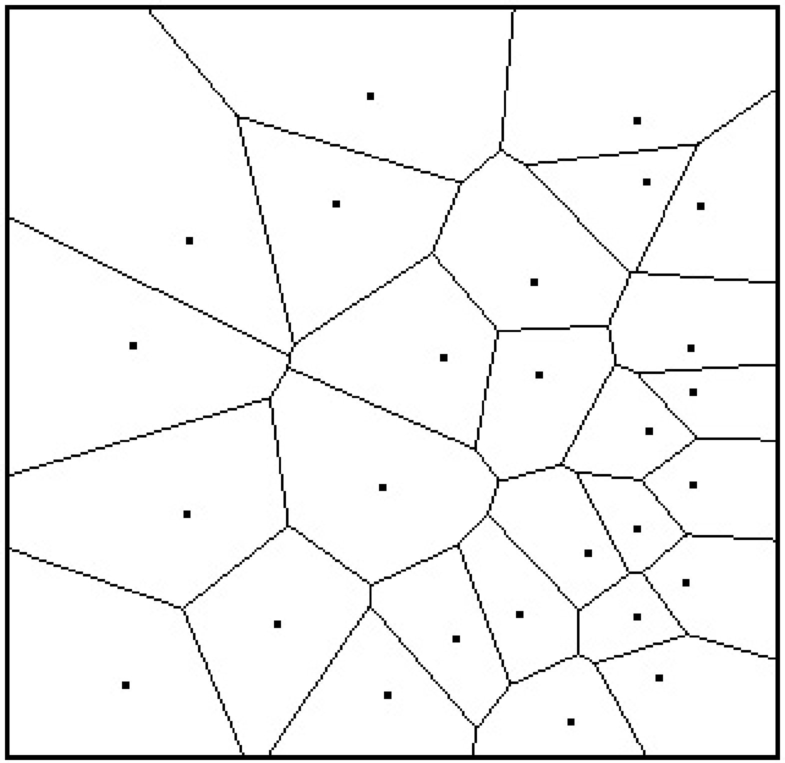
# Regular vs. Irregular Point Distribution

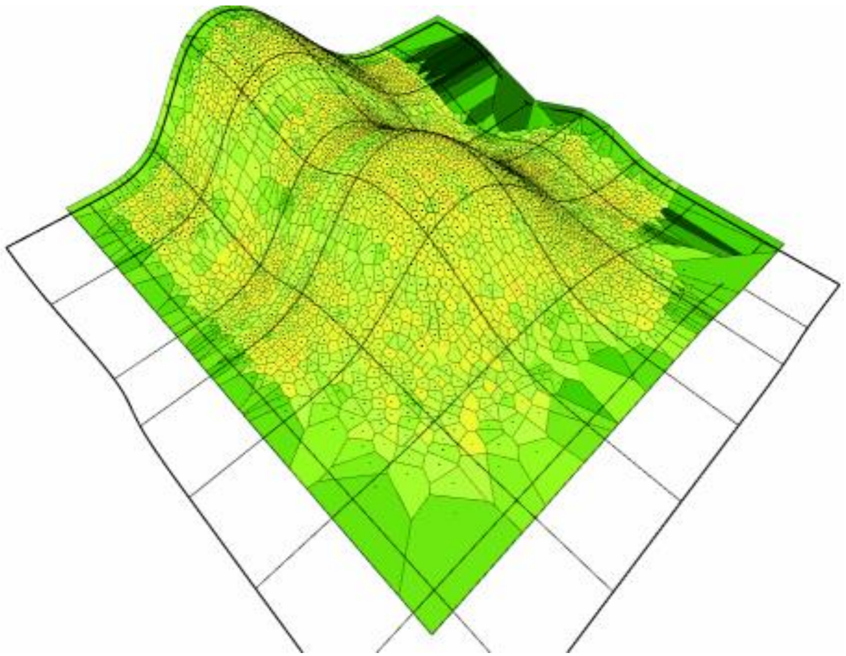



Aligned
Sparse
Dense
Missing from edges

# Planar Map Transformations Based on Areas
# - Theissen Polygons

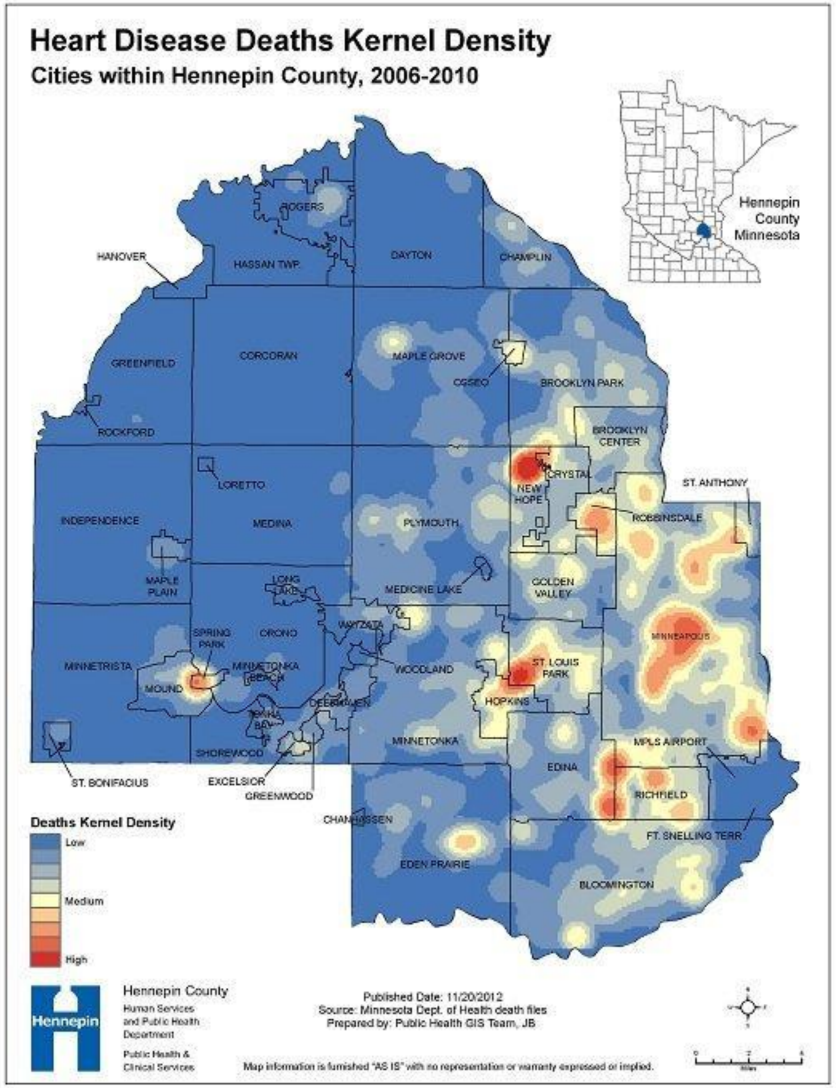
- Often called proximal regions or Voronoi diagrams
- Often used for contouring terrain, climate, interpolation, etc

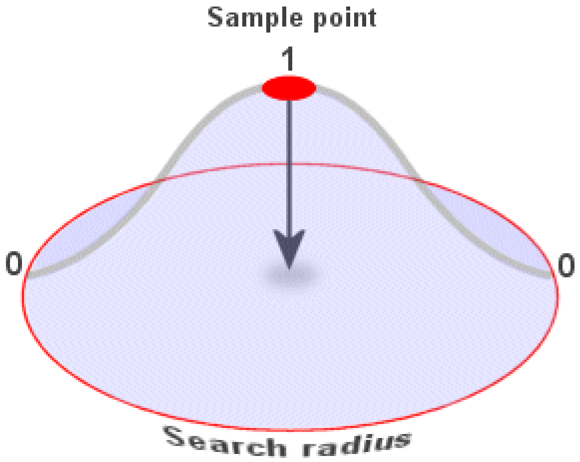




http://en.wiki.mcneel.com/default.aspx/McNeel/PointsetReconstruction.html

# Kernel density maps



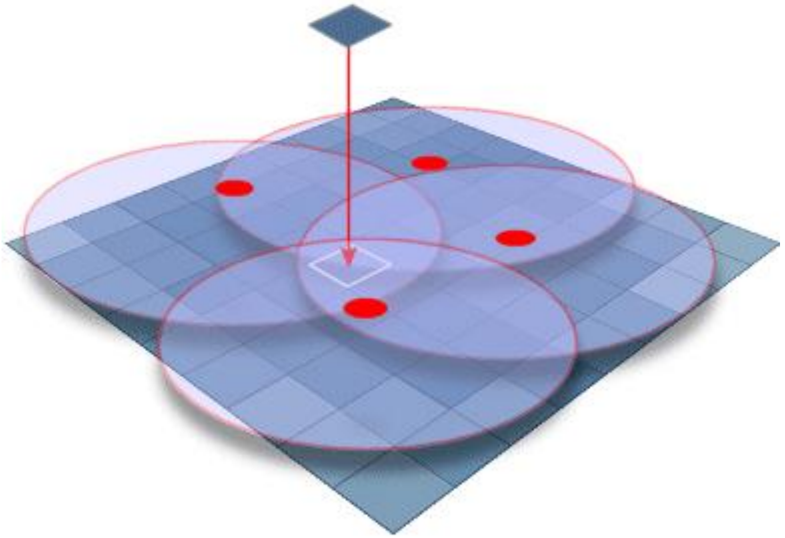



Image source: Jochen Albrecht

# Weighting Methods

- Impose z = f (1/d^n)
- Computationally rather intensive
- e.g. 200 x 200 cells 1000 points = 40 x 10^6 distance calculations
- If all points are used and sorted by distance, called "brute force" method
- Possible to use sorted search and tiling (Hodgson, ERDAS)
- Distance can be weighted and powered by n = friction of distance
- Can be refined with break lines
- Use cos (angle) to prevent shadowing

# Inverse Distance Weighting

$$Z_{i,j} = \frac{\sum_{p=1}^{R} z_p d_p^{-n}}{\sum_{p=1}^{R} d_p^{-n}}$$

Z=height

D=distance

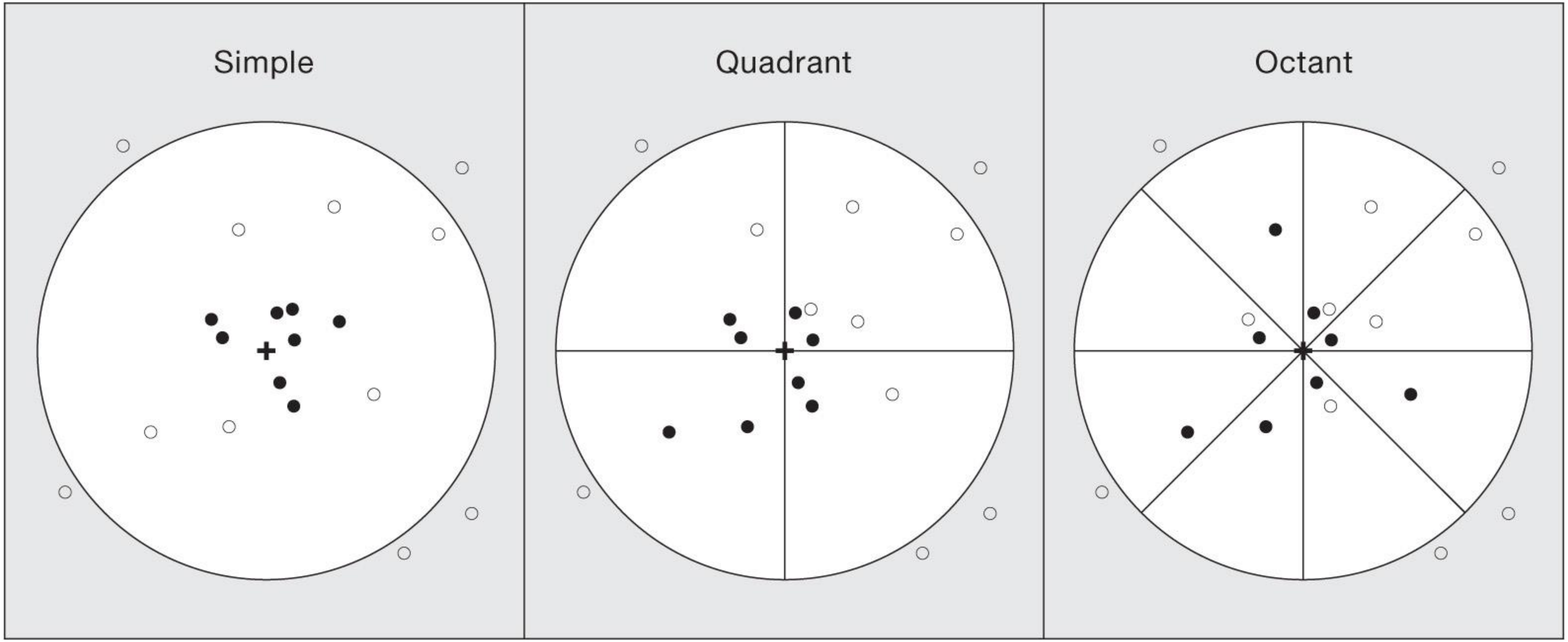
P=1….R

n= ?

# Search Patterns

- Many possible ways to define interpolated "region" R
- Can use # points or distance
- Problems in
  - Sparse areas
  - Dense areas
  - Edges
- Bias can be reduced by changing search strategy

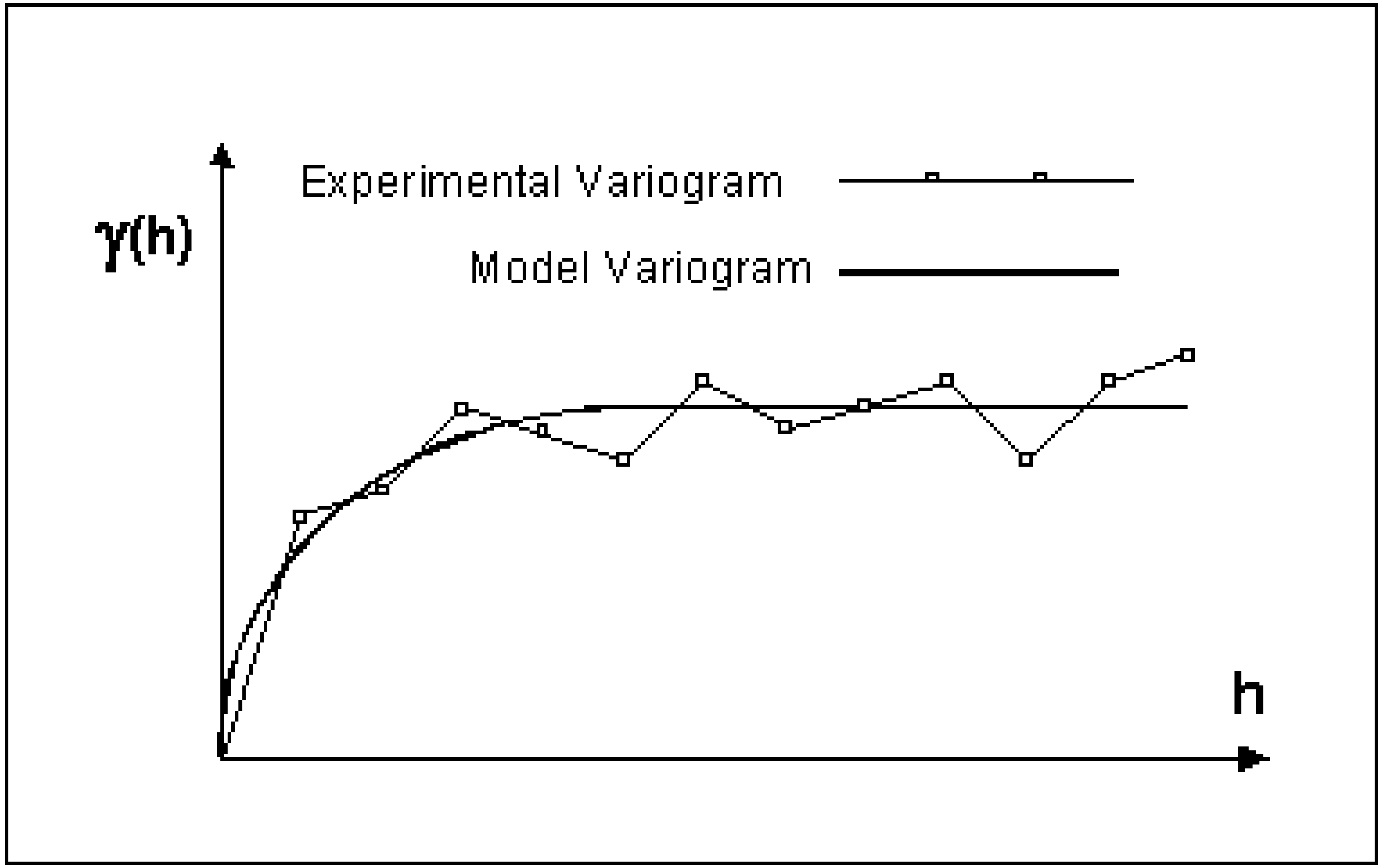
# Search patterns



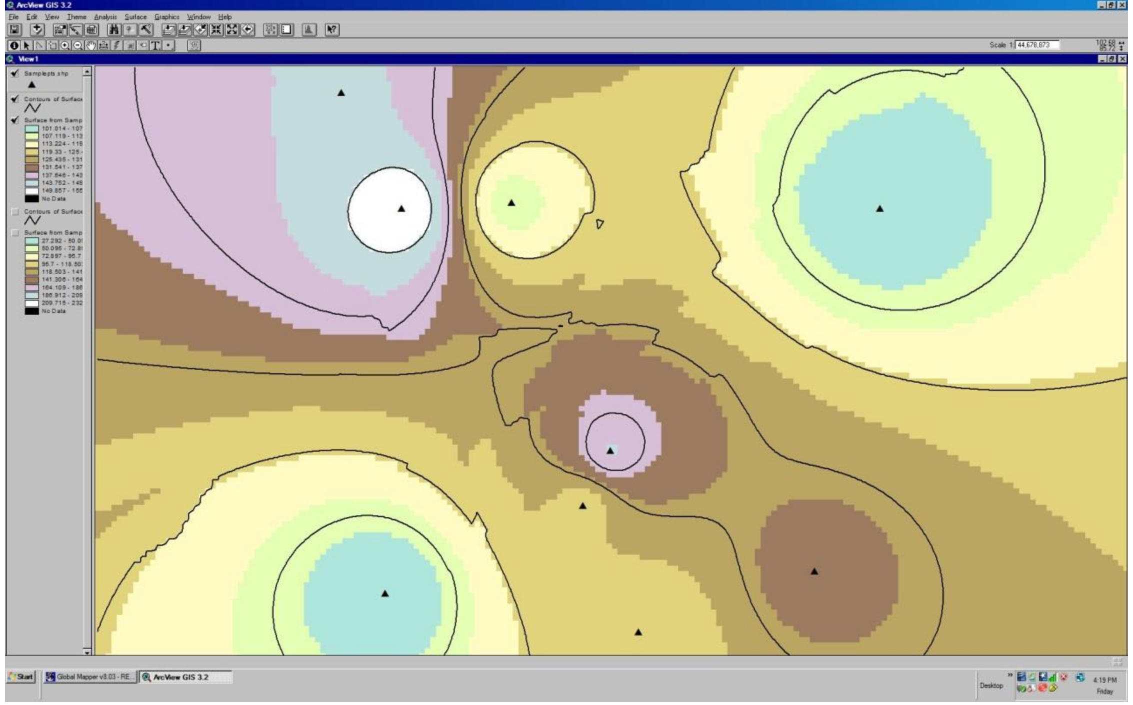
# Kriging

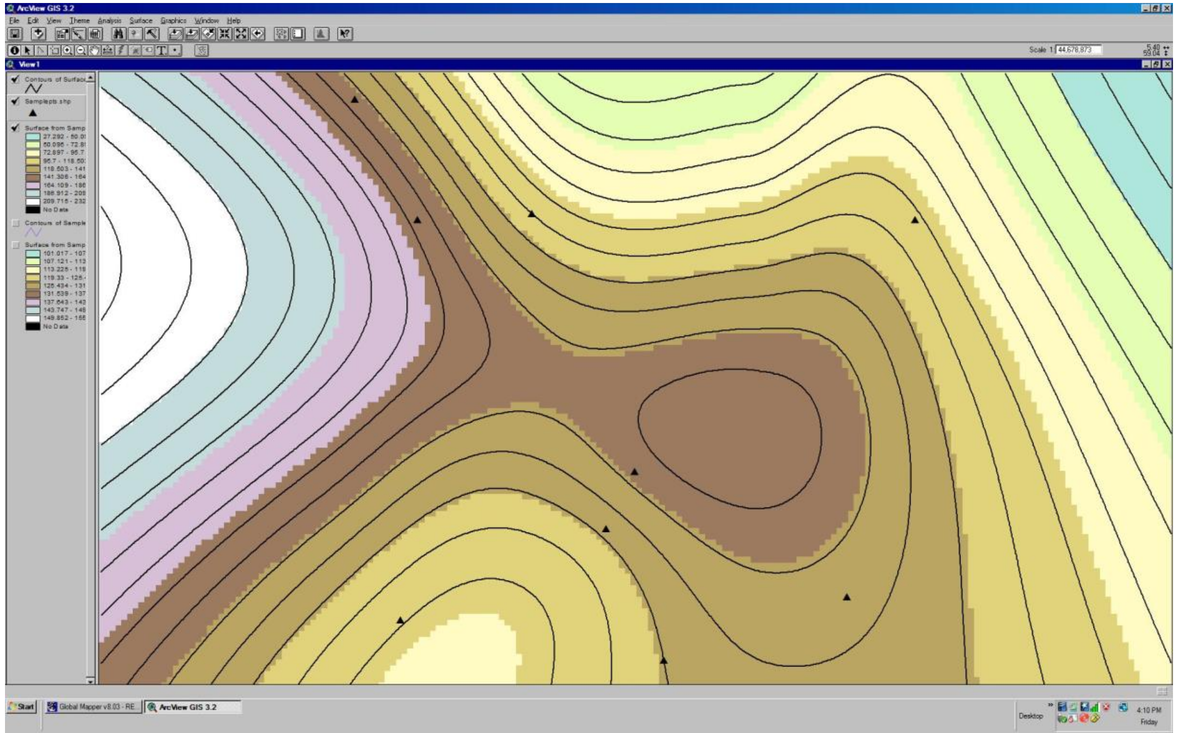
- "Optimal interpolation method" by D.G. Krige
- Origin in geology (geostatistics, gold mining)
- Spatial variation = f(drift, random-correlated, random noise)
- To use Kriging
  - Model and extract drift
  - Compute variogram
  - Model variogram
  - Compute expected variance at d, and so best estimate of local mean
- Several alternative methods
- Universal Kriging best when local trends are well defined
- Kriging produces best estimate and estimate of variance at all places on map

# Variogram

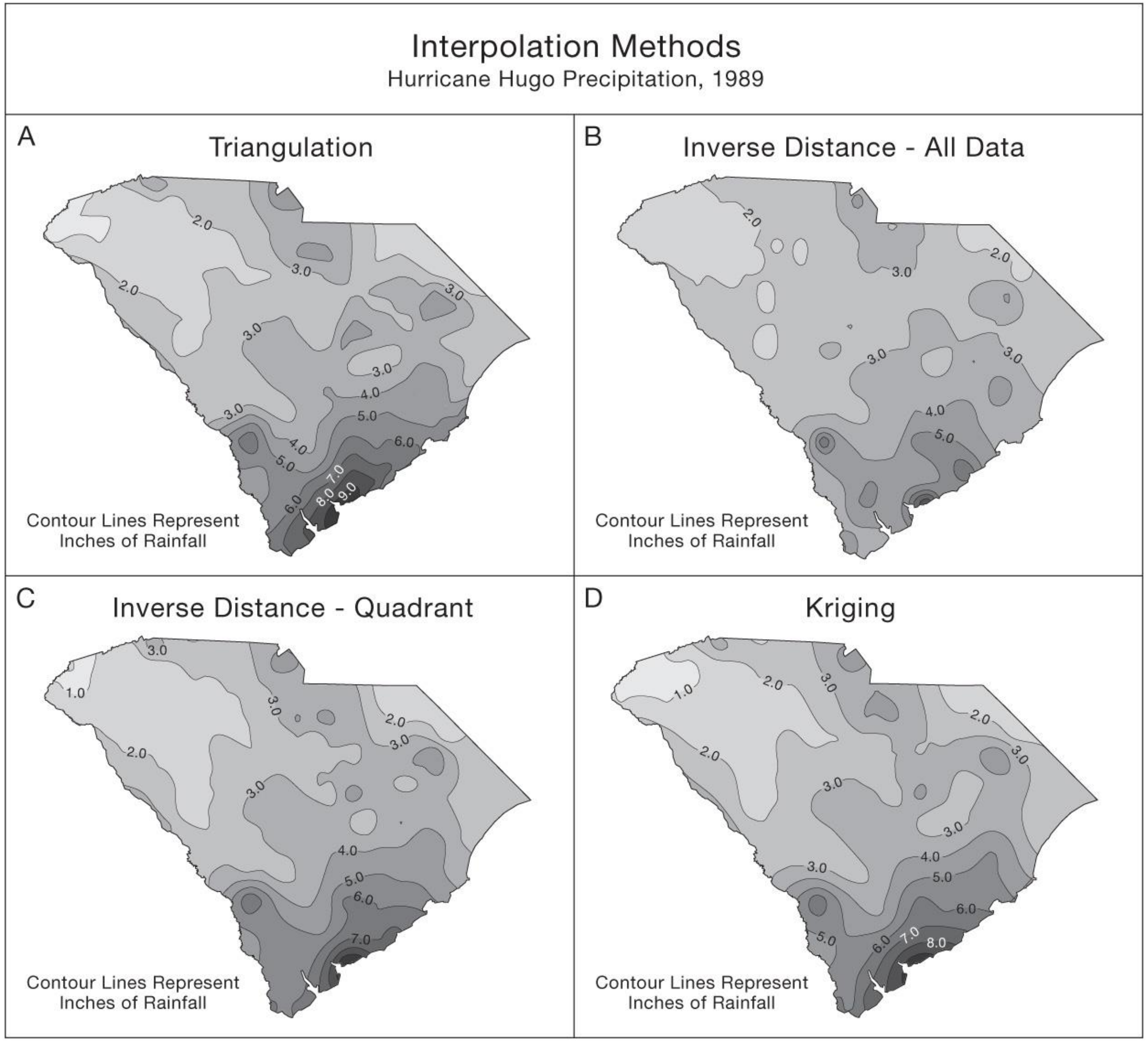


# Algorithm matters: IDW (5) vs. Splines (12, 0.1)





# Interpolation methods



# Summary

- Discrete vs. continuous (Choropleth, Dasymetric, Isarithmic)
- Dots useful, but aggregate
- Dasymetric mapping effective, good data not so good software
- Isarithmic maps; many symbolization methods to choose among
- Conversion to surface an issue: points, density, model
- Interpolation a problem: heuristics vs optimal methods
- Must assume surface model, search pattern, neighborhood and method