Temporal vs. Spatial Data

Temporal

- 1 dimensional
- Units: day, week, month
- Lag: t, t-1, t-2
- Durbin-Watson
- Differencing

Spatial

- 2-3 dimensional
- Units: county, mile, region
- Lag: near neighbor, networks (?)
- Moran's I
- Maps (distortions)

Issues Associated with Spatial Analysis

- Scale
- Zoning
- Dependence
- Heterogeneity
- Boundaries
- Missing Data
- Sampling
- Large Data Sets

Modifiable Areal Unit Problem (MAUP): Scale and Zoning

- Changes in scale change results
- What is the appropriate scale?
- Aggregation and the ecological fallacy

- Changes in zoning change results
- The political redistricting problem
- Appropriate zoning

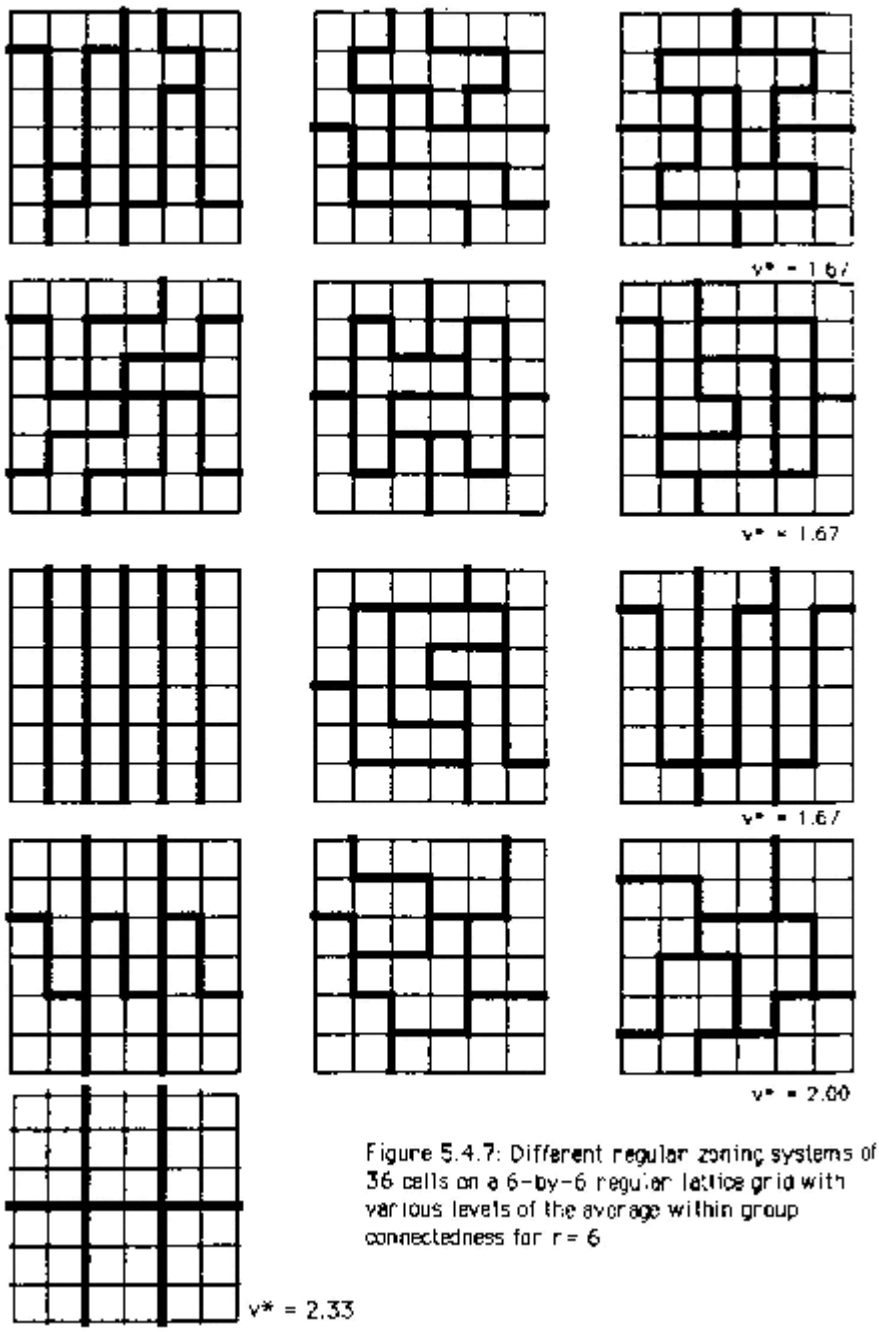


Figure 5.4.7: Different regular zoning systems of 36 cells on a 6-by-6 regular lattice grid with various levels of the average within group connectedness for r = 6

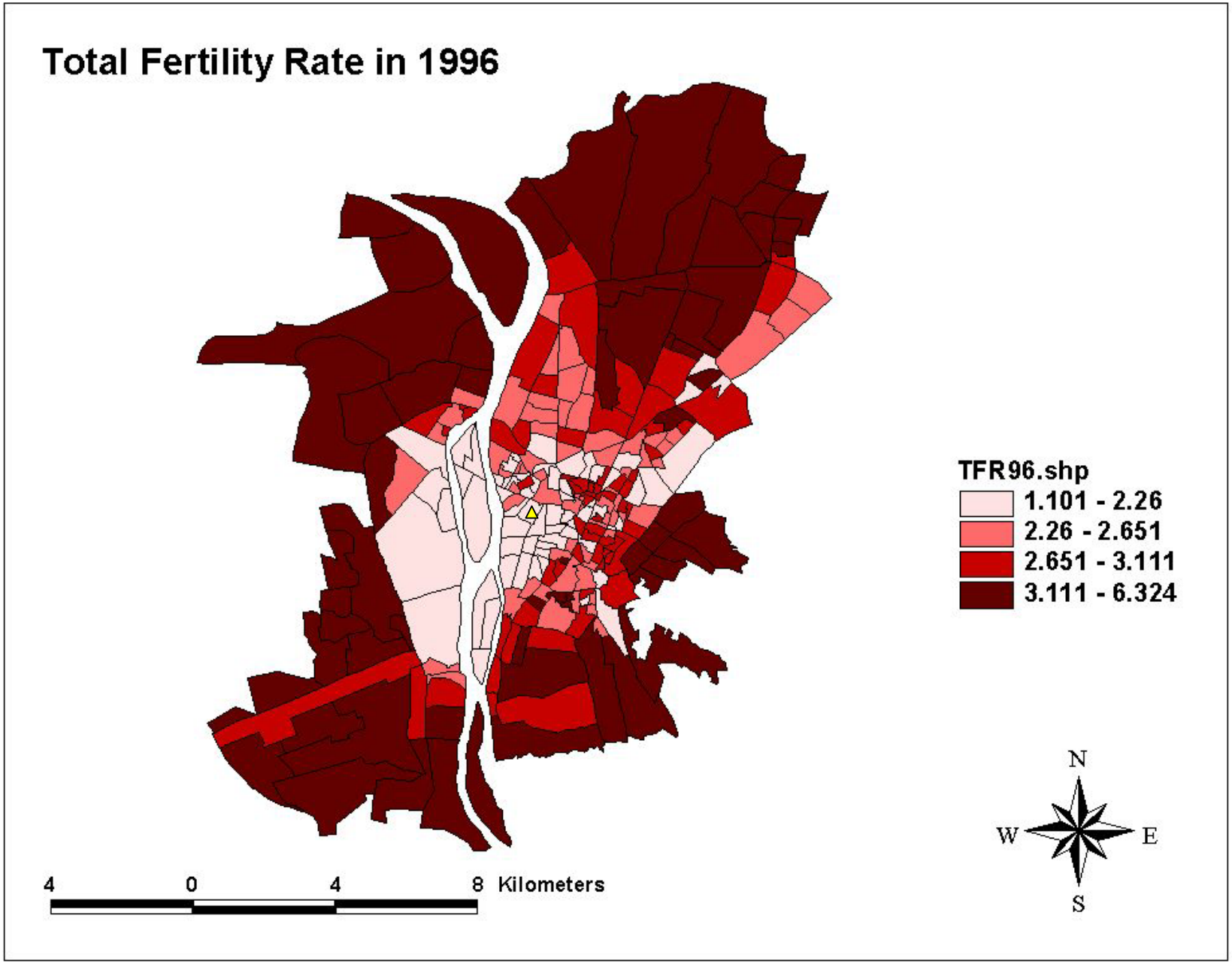
The Iowa Study

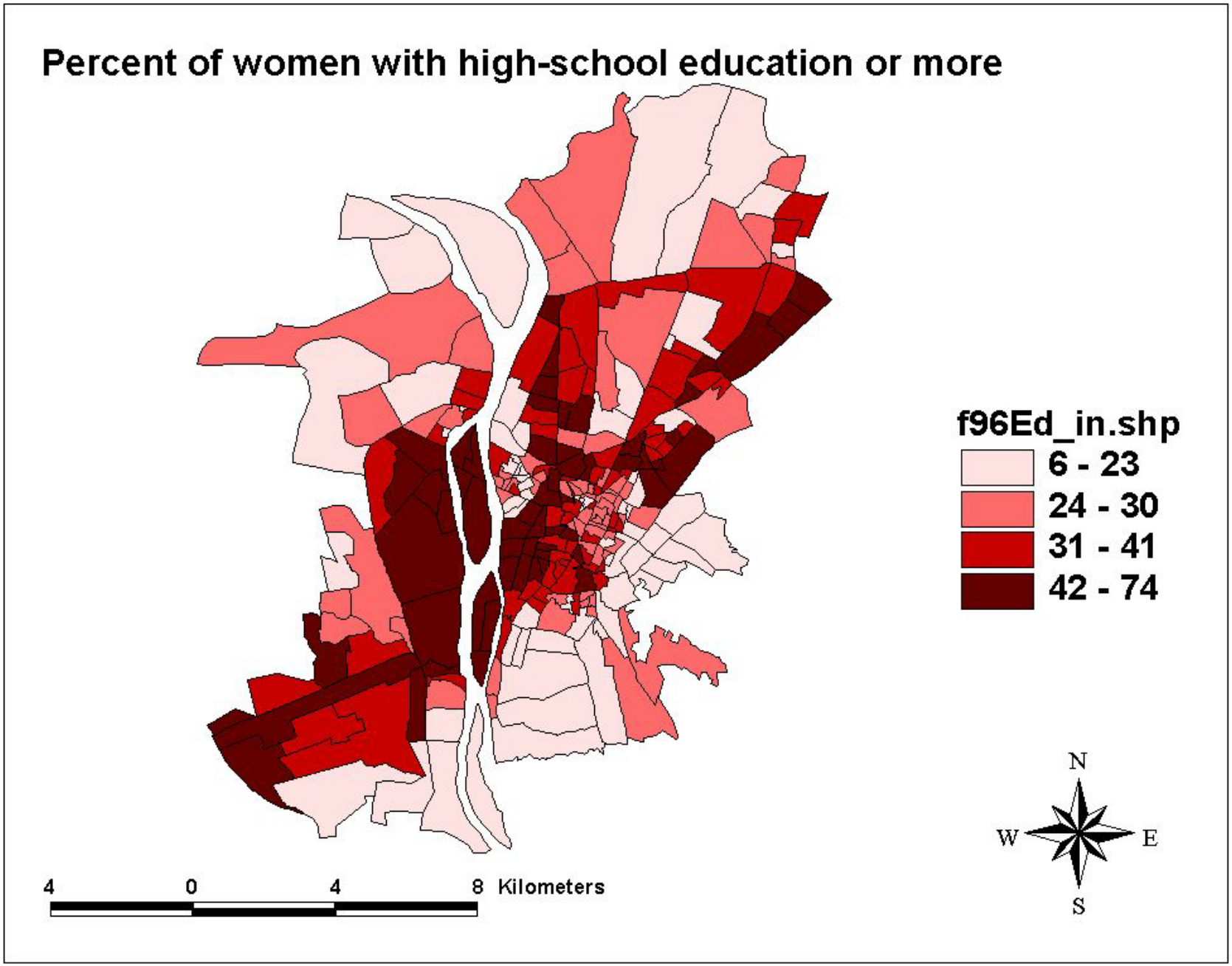
- **Correlation? Elderly and Republican**
  % 65+, % Registered Republican;
  99 Counties.
  r = .35

- **Regrouping into 48 Regions (many times).**
  r ranges between -.55 and +.89
- **Regrouping into 12 Regions (many times).**
  r ranges between -.94 and +.996

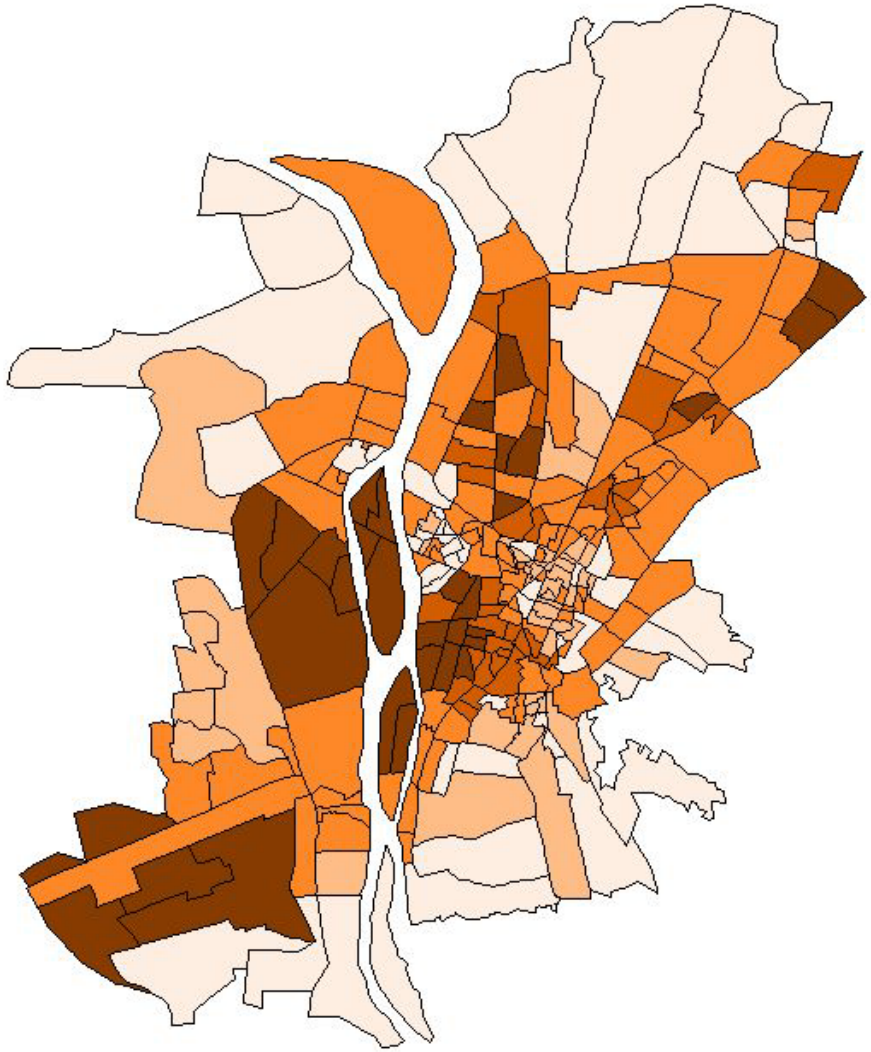
The Dependence Issue

- **Tobler's Law**
- **Independence and the problem of nearness**
- **The *value of an observation* problem**
- **Too many observations**
- **Spillovers/bisection**


Total Fertility Rate in 1996
TFR96.shp
1.101 - 2.26
2.26 - 2.651
2.651 - 3.111
3.111 - 6.324
N
W
E
S
4
0
4
8 Kilometers


Percent of women with high-school education or more
f96Ed_in.shp
6 - 23
24 - 30
31 - 41
42 - 74
4 0 4 8 Kilometers
N
W
E
S

Spatial Component of Percent of Female with High-school Education or more

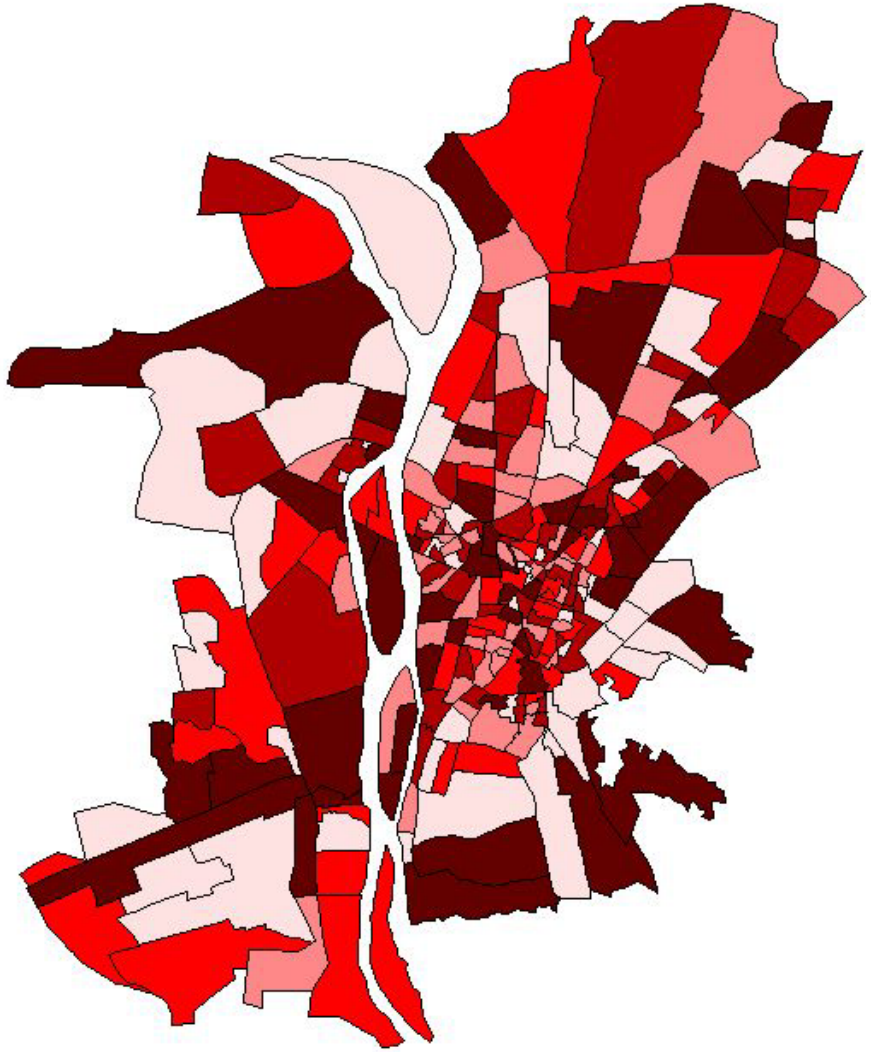


Spa_Ed.shp
-38.164 - -7.807
-7.807 - -2.287
-2.287 - 0
0 - 12.857
12.857 - 32.965

N
W
E
S

4 0 4 8 Kilometers

Non-Spatial Component of Percent of Female with High-school Education or more



Nsp_Ed.shp
- 6.112 - 26.729
- 26.729 - 30.834
- 30.834 - 33.698
- 33.698 - 38.591
- 38.591 - 65.255

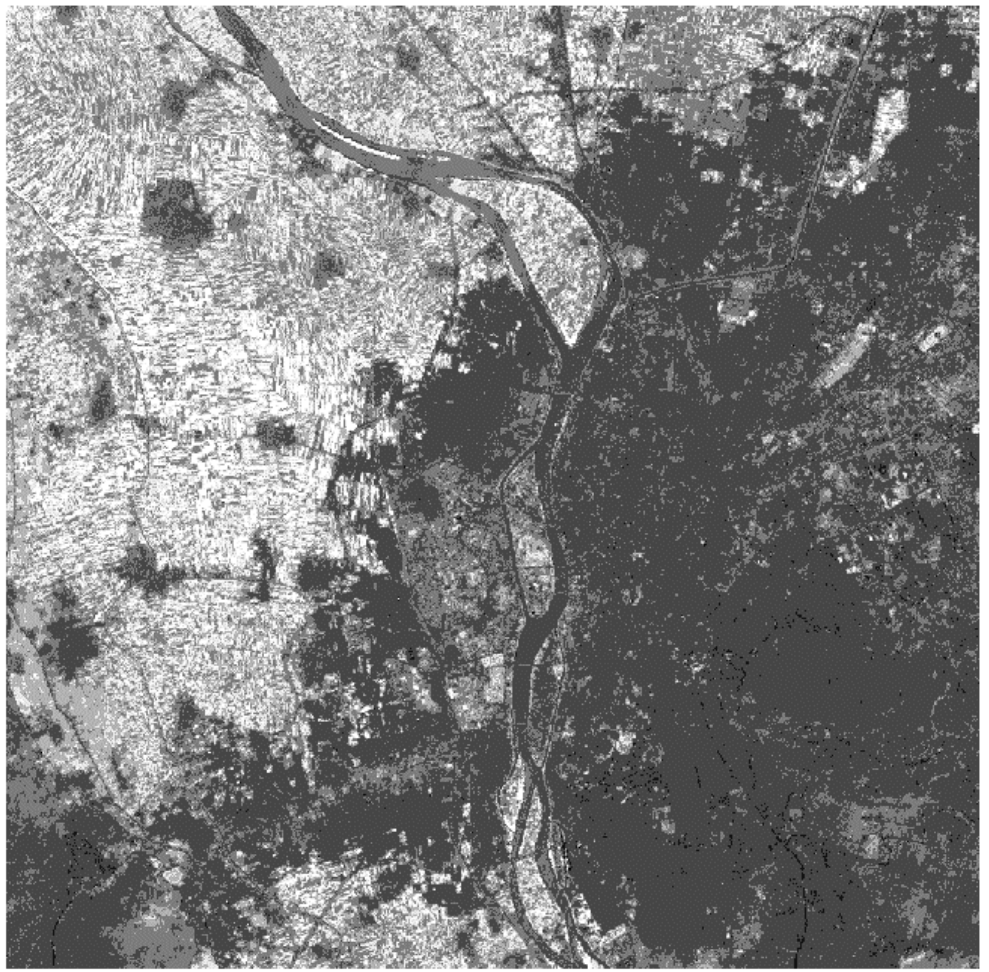
N
W E
S

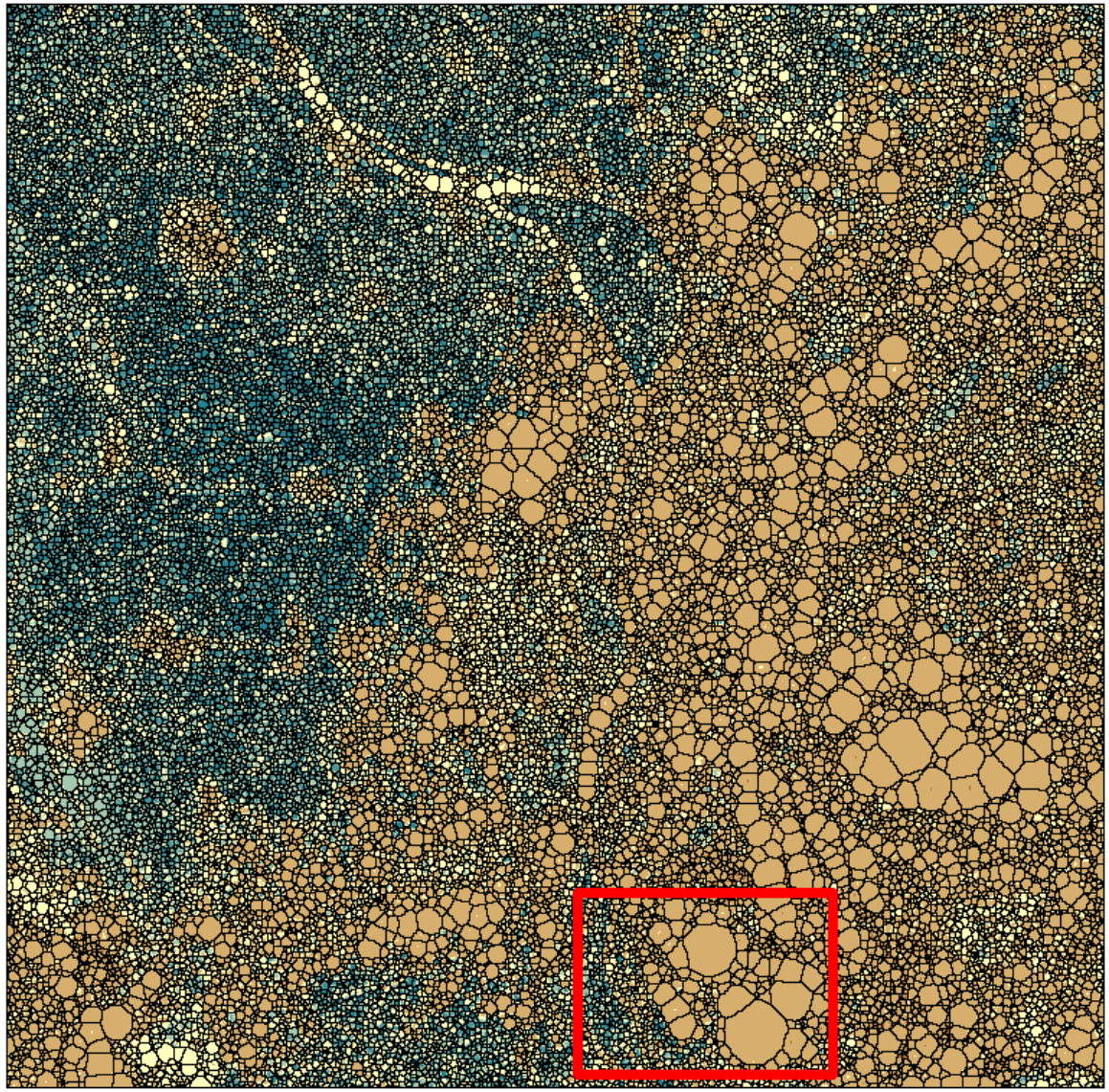
4 0 4 8 Kilometers

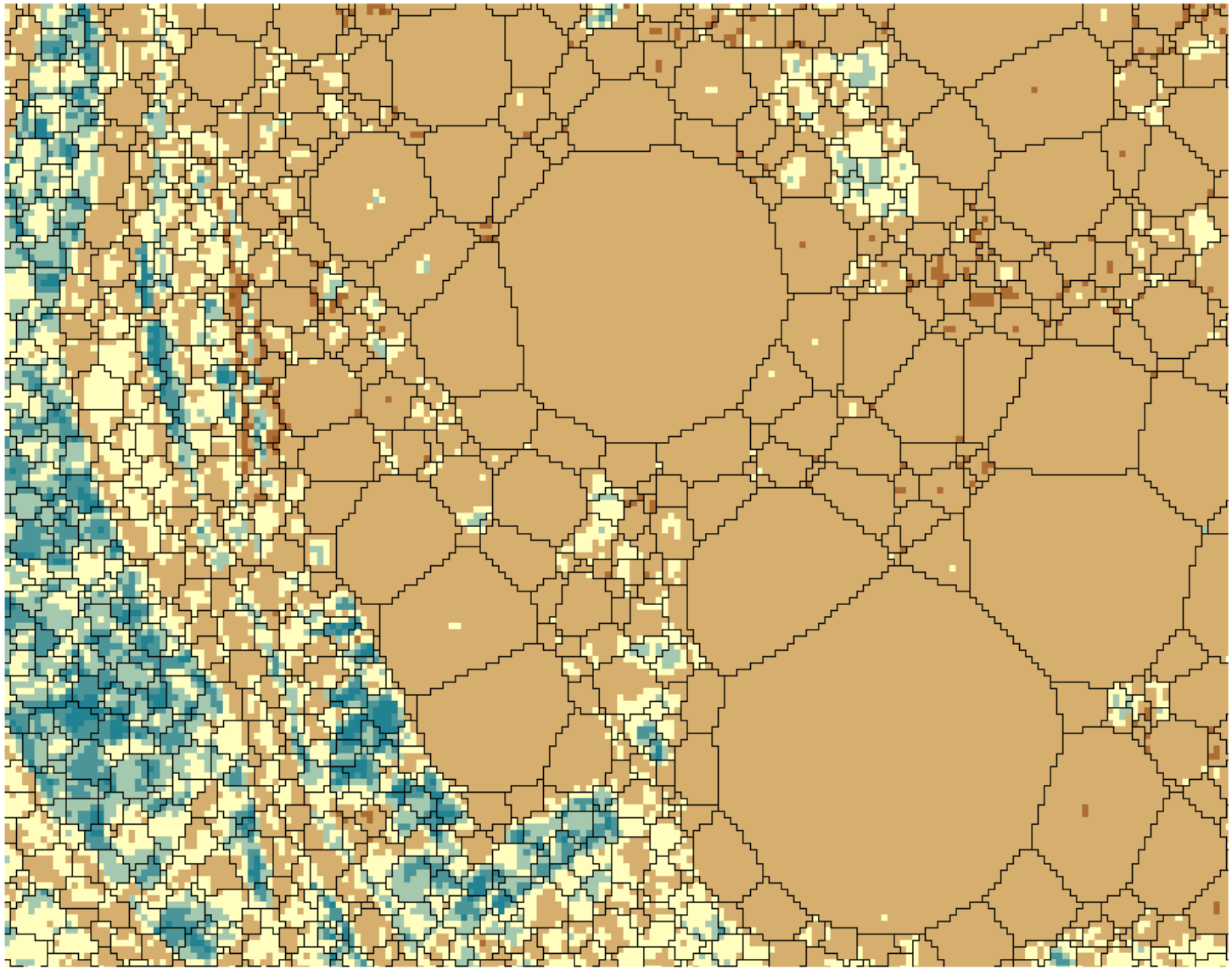
The Heterogeneity Issue

- Uneven spatial distributions
- Heterogeneity can affect our results
- Stationarity assumption
- Drift and its effect on analysis

Original Data







Missing Data Issue

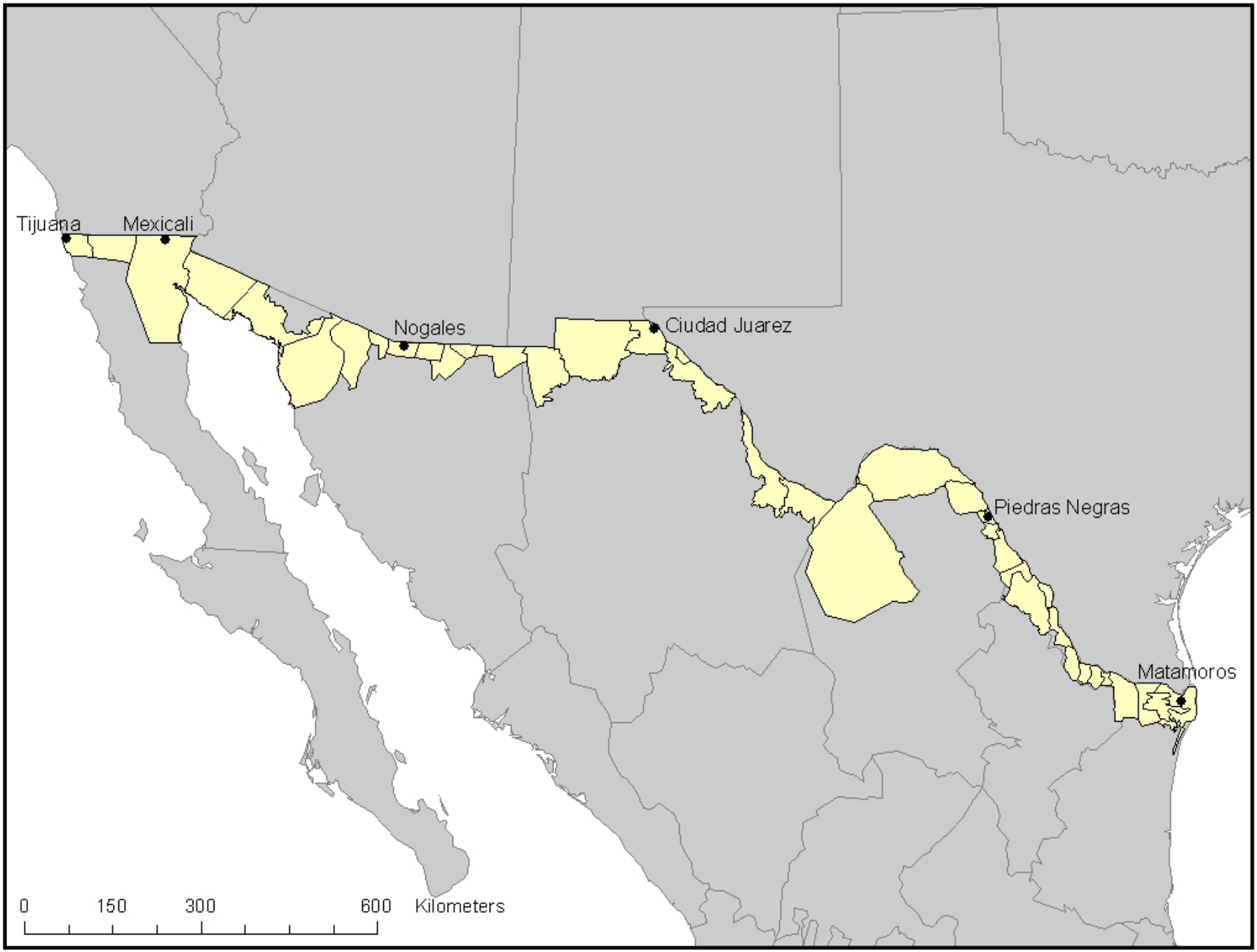
- Empty areas, continuous distributions
- Census restrictions, Privacy
- Algorithms and common sense solutions
- Geostatistics

Spatial Sampling

- **How does one take a random spatial sample? How does one stratify spatially?**

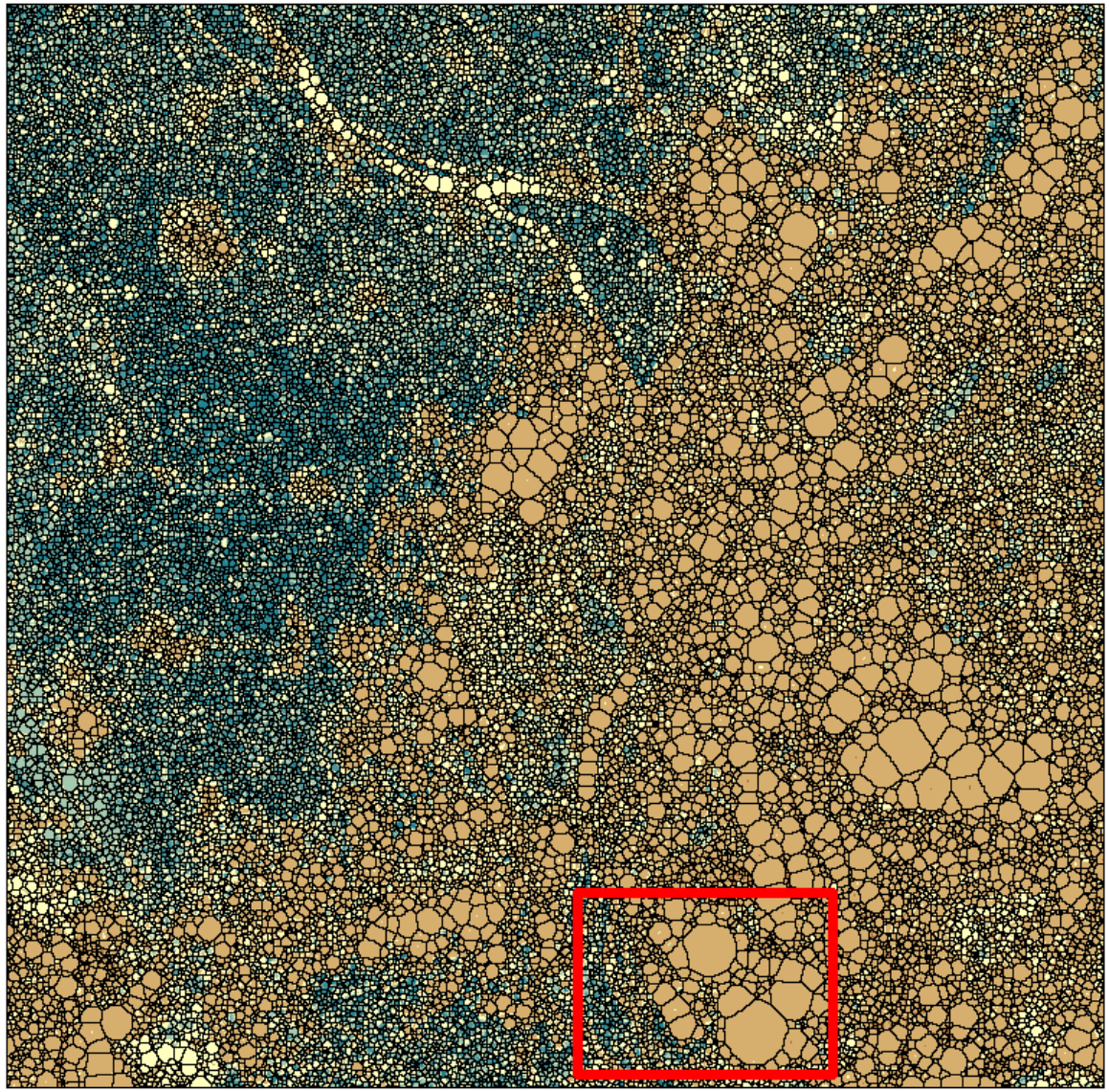
The Boundaries Issue

- What effect do boundaries have on results?
- How do we take them into account?
- Sampling problems associated with boundaries


Tijuana
Mexicali
Nogales
Ciudad Juarez
Piedras Negras
Matamoros
0
150
300
600
Kilometers

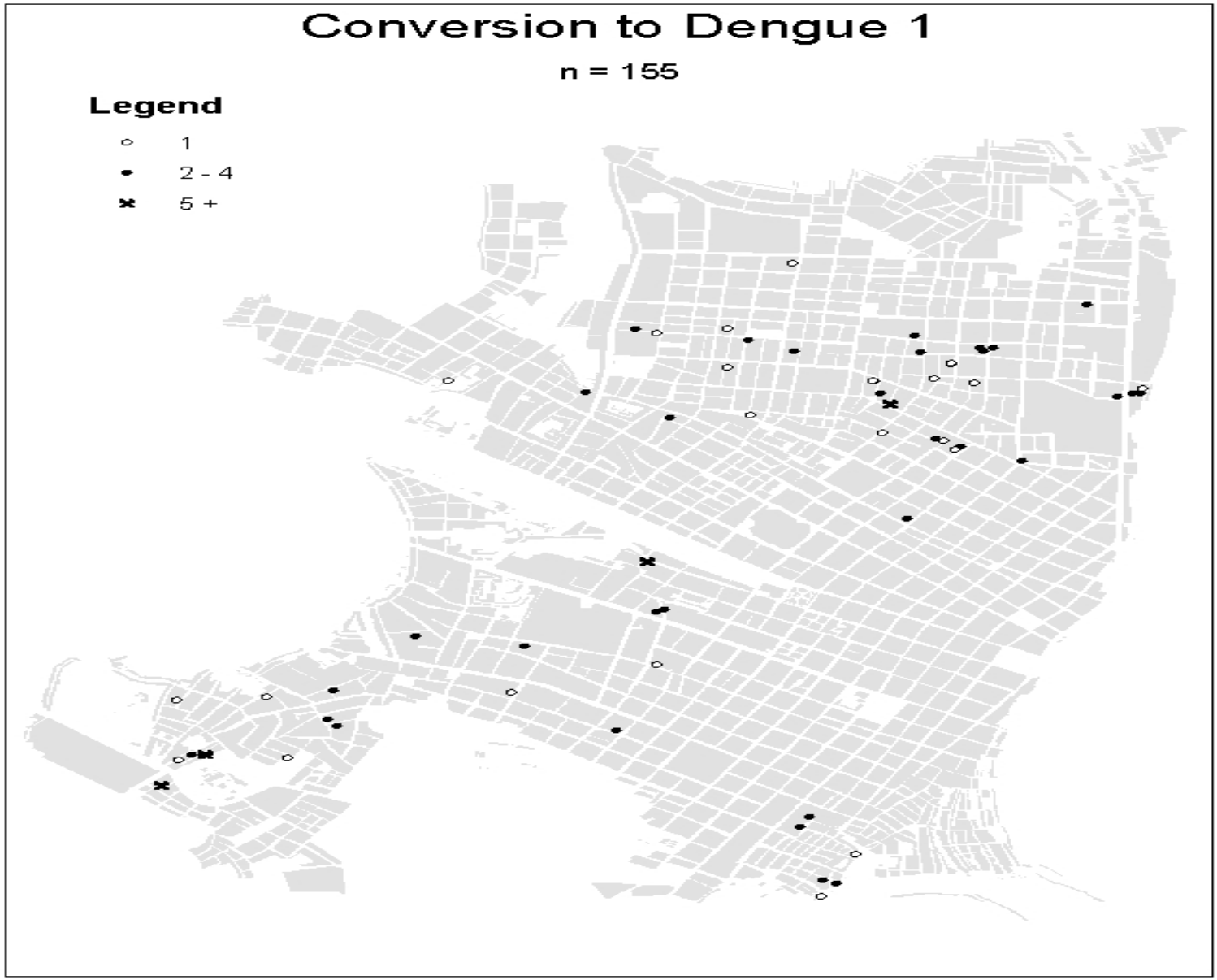
The Large Data Set Issue

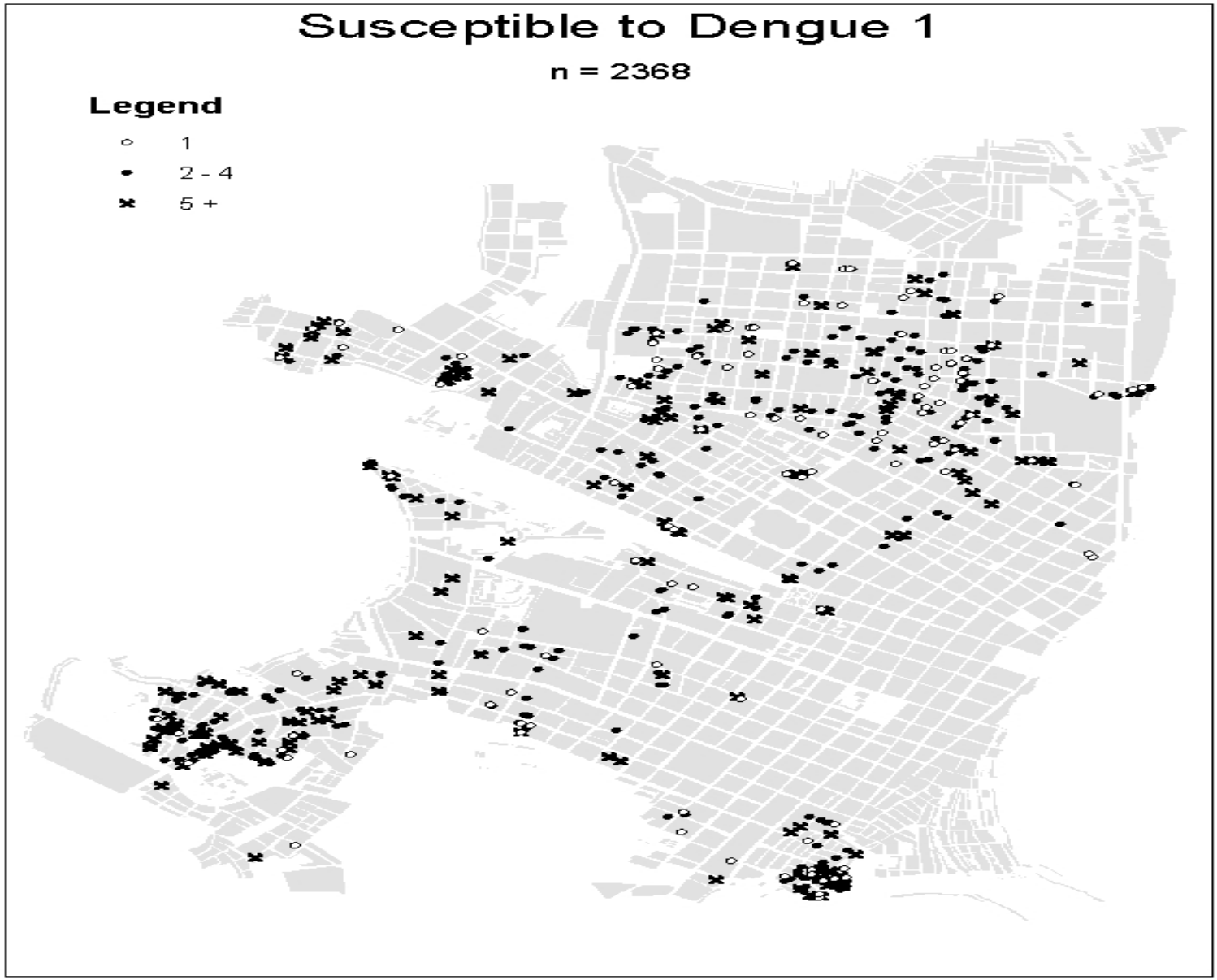
- Censuses
- Remotely sensed data
- Dependence and heterogeneity
- Data mining, partitioning and filtering, principal components analysis



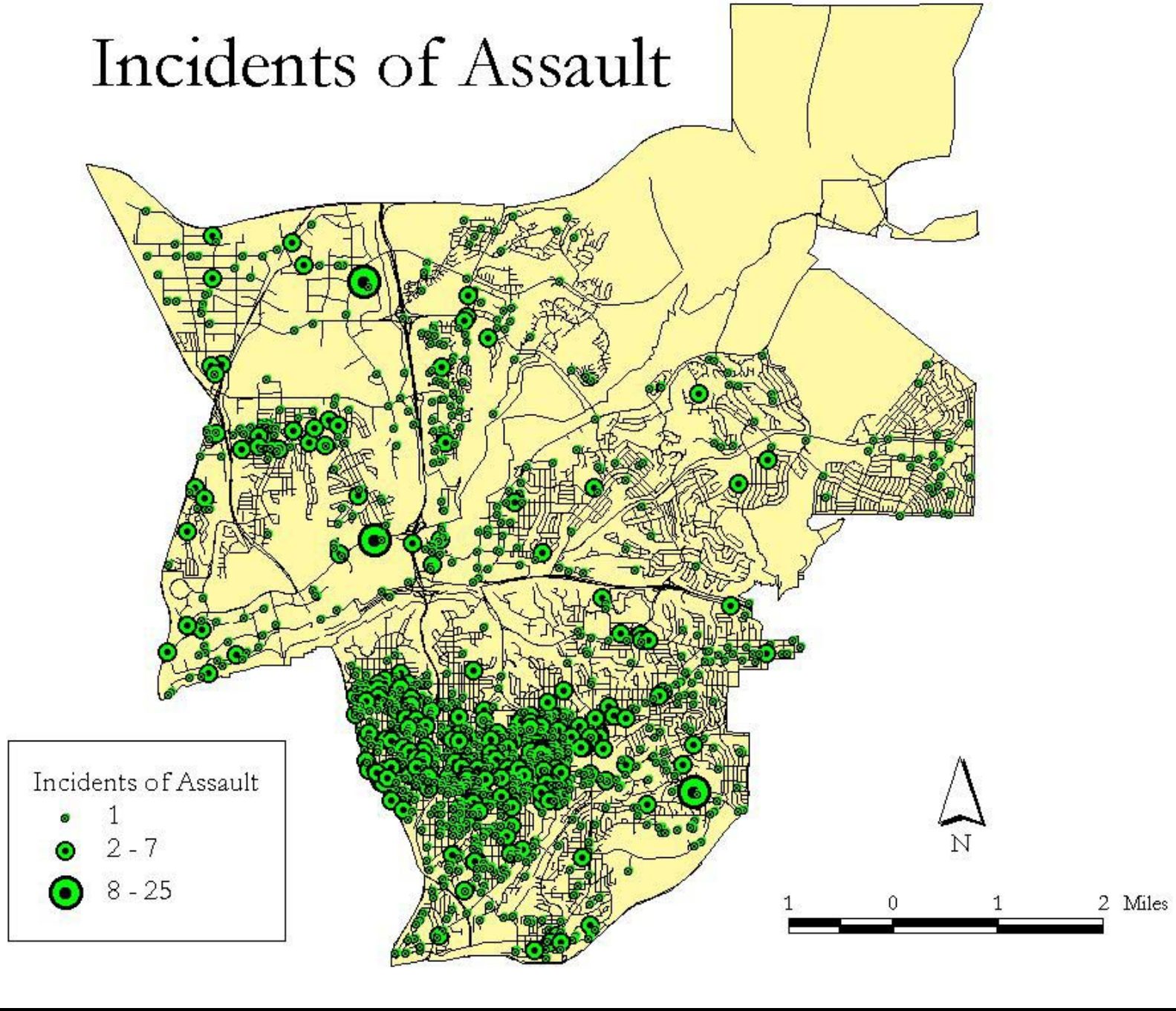
Misapplication

- **Data quality**
- **Availability of data**
- **Data standards**
- **Data suitability**
- **Interpretation**


Conversion to Dengue 1
n = 155
Legend
1
2 - 4
5 +


Susceptible to Dengue 1
n = 2368
Legend
1
2 - 4
5 +

Incidents of Assault



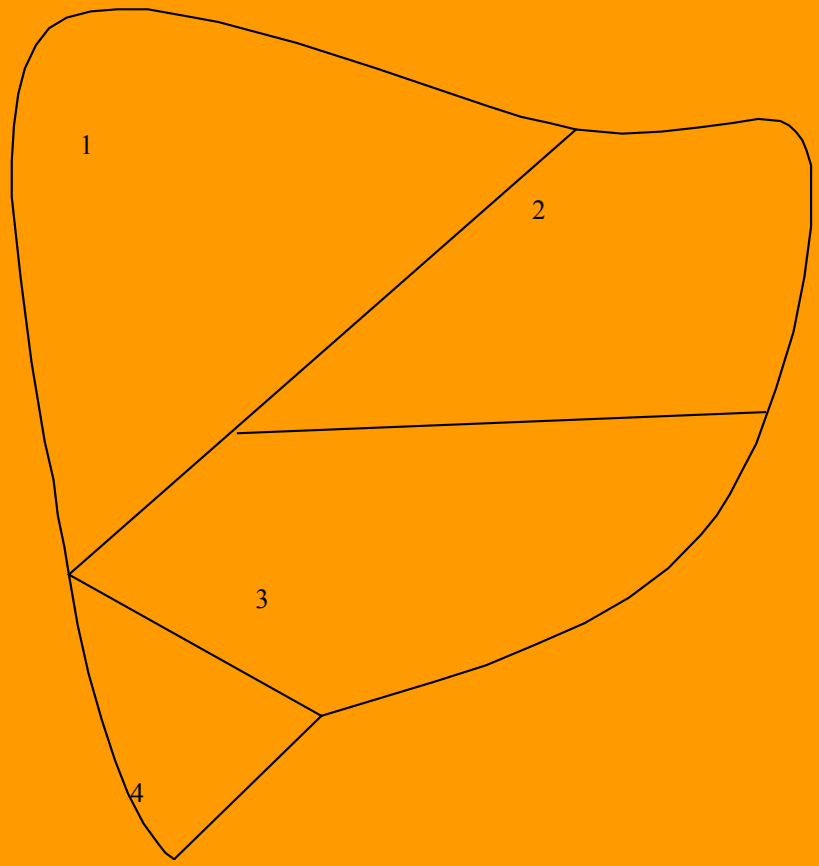
Matrix Representation: WY

- W
- The Spatial Weights Matrix
- The Spatial Association of All Sites to All Other Sites
- $d, d^2, 1/0, 1/d$

- Y
- The Attribute Association Matrix
- The Association of the Attributes at Each Site to the Attributes at All Other Sites
- t , / x

The Spatial Weights Matrix

W is the formal expression of the spatial association between objects



0	1	1	0
1	0	1	0
1	1	0	1
0	0	1	0

Typical W

- Spatially contiguous neighbors (rook, queen: one/zero)
- Inverse distances raised to a power: ($1/d$, $1/d^2$, $1/d^5$)
- Geostatistics functions (spherical, gaussian, exponential)
- Lengths of shared borders (perimeters)
- All centroids within distance *d*
- n^{th} nearest neighbor distance
- Links (number of)

The Attribute Matrix

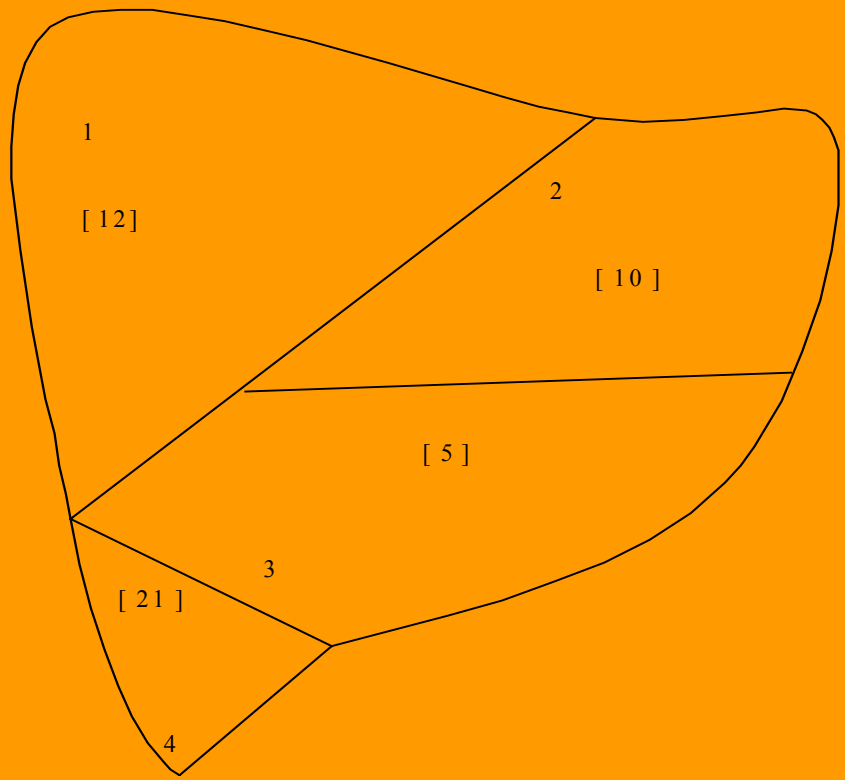
Y

The variable under study. One variable at a time. Interval scale (other scales under special conditions).

For examples:

Residuals from regression,

A socio-economic variable (number of crimes, household income, number of artifacts, etc.).



0	2	7	- 9
-2	0	5	-11
-7	-5	0	-16
9	11	16	0

Attribute Relationships

Y

- **Types of Relationships**

Additive association (clustering): $(Y_i + Y_j)$

Multiplicative association (product): (Y_iY_j)

Covariation (correlation): $(Y_i - Ybar)(Y_j - Ybar)$

Differences (homogeneity/heterogeneity): $(Y_i - Y_j)$

Inverse (relativity): (Y_i/Y_j)

- **All Relationships Subject to Mathematical Manipulation (power, logs, abs, etc.)**

WY: Covariance

- **Set W to preferred spatial weights matrix**
- **(rooks, queens, distance decline, etc.)**
- **Set Y to** $(x_i - \mu)(x_j - \mu)$
- **Set scale to** $n/W \sum (x_i - \mu)^2$
- **I =** $n \sum\sum W_{ij} (x_i - \mu)(x_j - \mu) / W \sum (x_i - \mu)^2$

where W is sum of all W_{ij} ***and*** $i \neq j$

This is Morans's I.

WY: Additive

- Set W to 1/0 spatial weights matrix
- 1 within *d*; 0 outside of *d*
- Set Y to $(x_i + x_j)$
- Set scale to $\sum W_{ij}(d) / \sum (x_i)$
- $G(d) = \sum W_{ij}(d) (x_i + x_j) / \sum (x_i)$ and $i \neq j$

This is Getis and Ord's G.

WY: Difference

- **Set W to preferred spatial weights matrix**
- **Set Y to $(x_i - x_j)^2$**
- **Set scale to $(n-1)/2W\square(x_i - \mu)^2$**
- **$c = (n - 1)\ \square\ \square\ W_{ij}\ (x_i - y_i)^2 / 2W\square(x_i - \mu)^2$**

where W is sum of all W_{ij} and $i \neq j$

This is Geary's c.

WY: Difference

- **Set W to 1/0 weights matrix; 1 within *ah* and 0 otherwise; *a* is an integer; *h* is a constant distance**
- **Set Y to $(x_i - x_j)^2$**
- **Set scale to *1/2***
- **$\chi(ah) = 1/2 \square \square W_{ij} (x_i - x_{j)})^2$**

This is the semi-variogram.

Spatial Information Systems

- **The relationships between individuals, groups, and the environment**

- **Expressed in terms of:**

1) **separation information**
2) **interaction information**
3) **separation and interaction information taken together**

Developing a Curriculum

- **Conceptualization of Space**
- **Data Acquisition and Manipulation**
- **Visualization and Communication**
- **Spatial and Spatial-Temporal Analysis**