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San Diego, California

Technical Workshops | July 24, 2012

Spatial Pattern Analysis: Mapping Trends and Clusters

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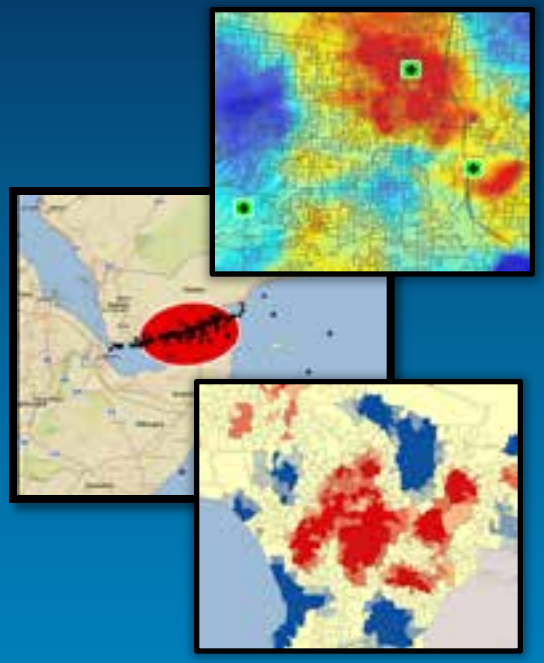
Presentation Outline

- Spatial problem solving
- Spatial statistics overview
- Describing spatial patterns
- Quantifying spatial patterns
- Mapping spatial clusters
  - Hot and cold spots
  - Spatial outliers
  - Similar features



DEMO

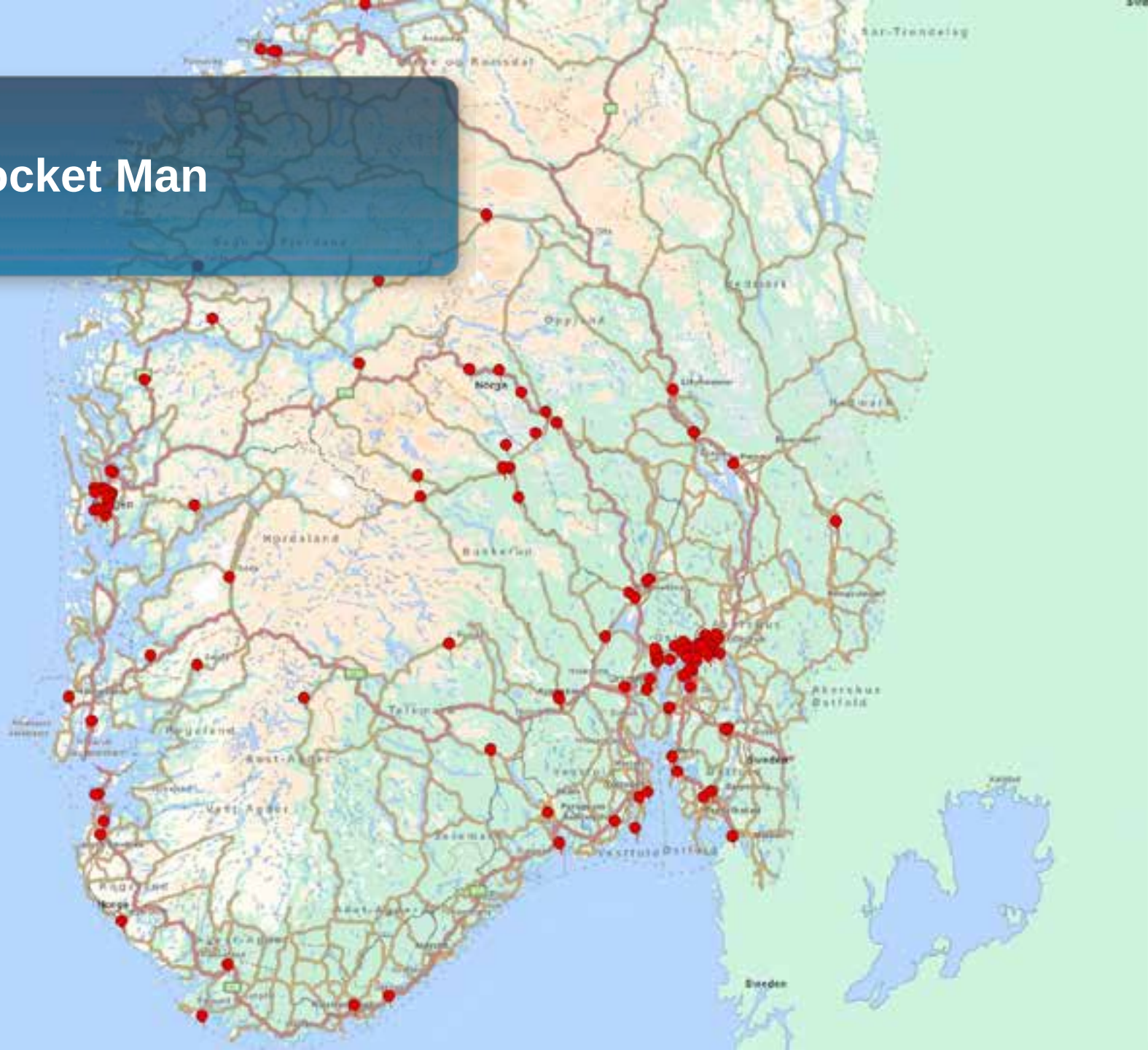
- Exploring regional variations in health care.

Kindly cmplete a course evaluation: *www.esri.com/ucsessionsurveys*

Norway March 30, 2008

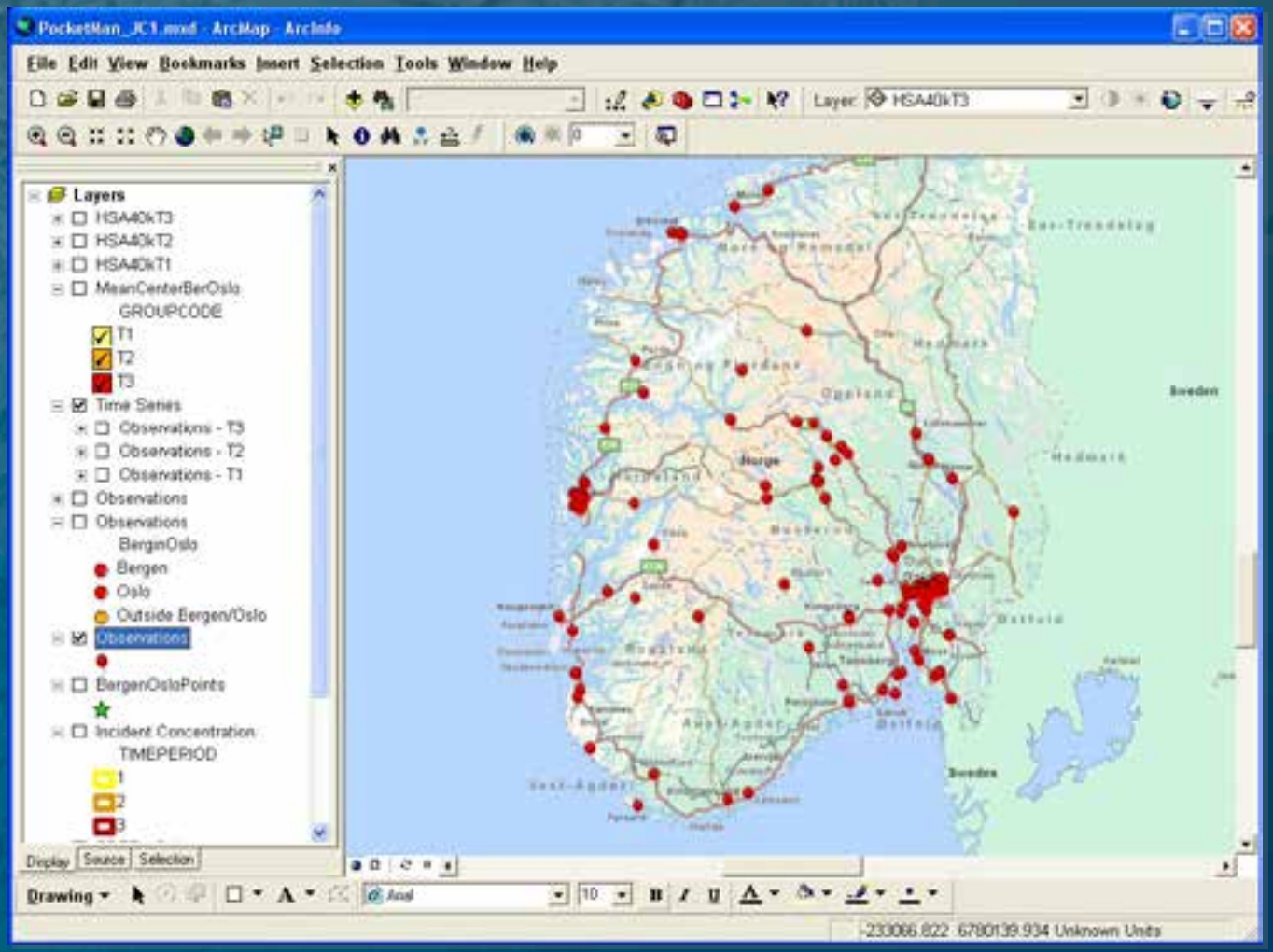
The Pocket Man

The Pocket Man



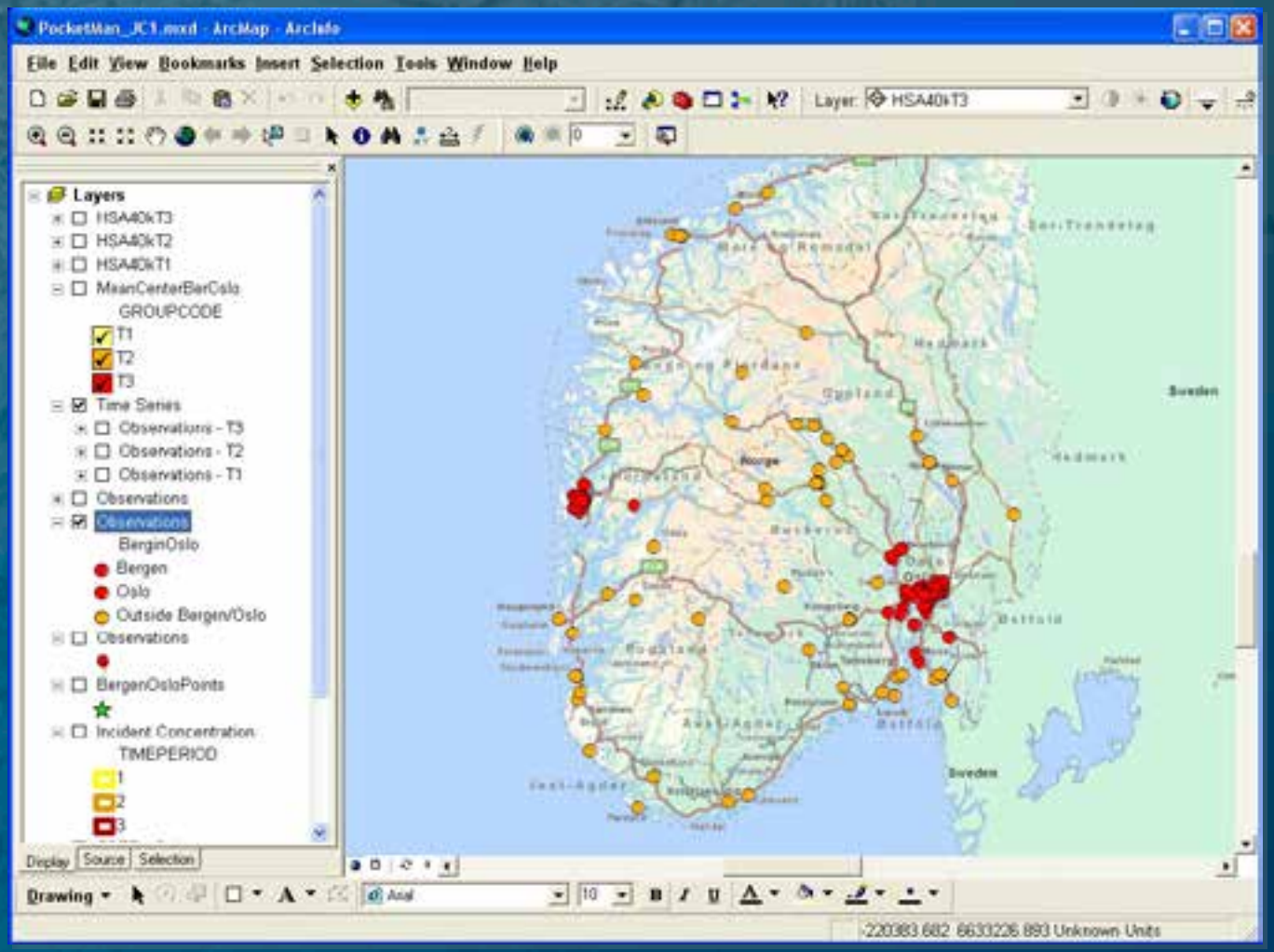
The Pocket Man

All Incidents



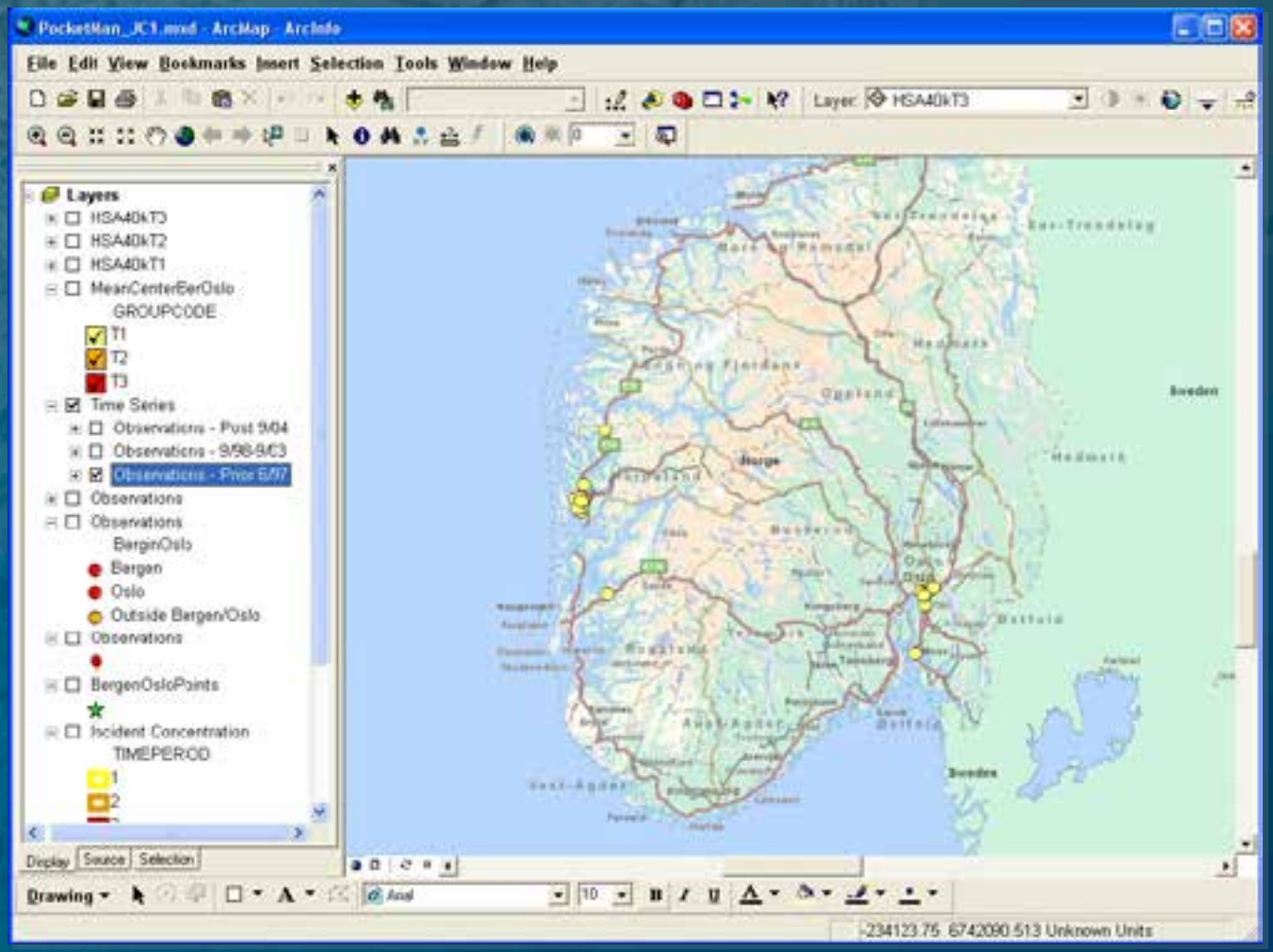
The Pocket Man

Spatial Clusters



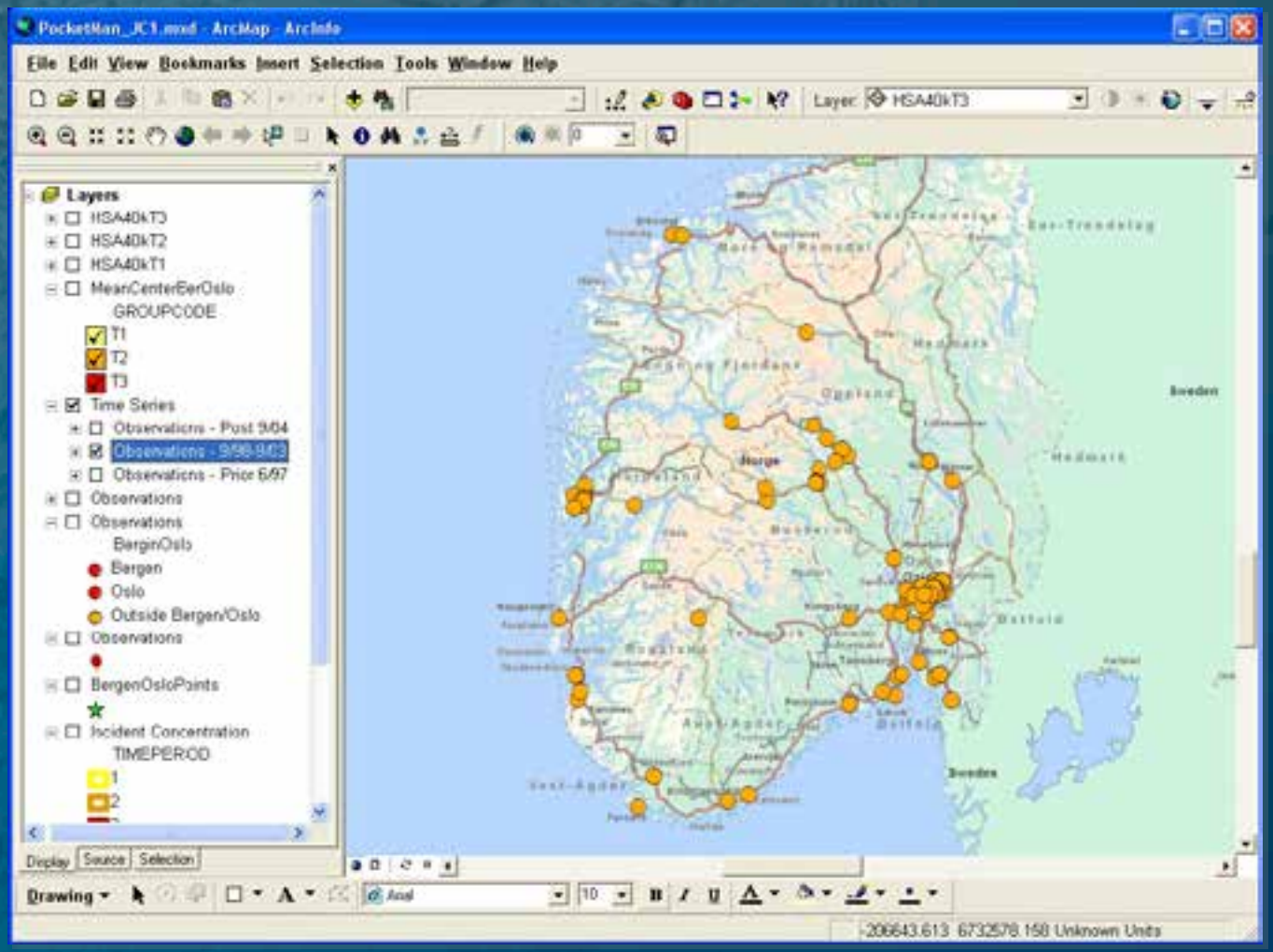
The Pocket Man

Time (early events)



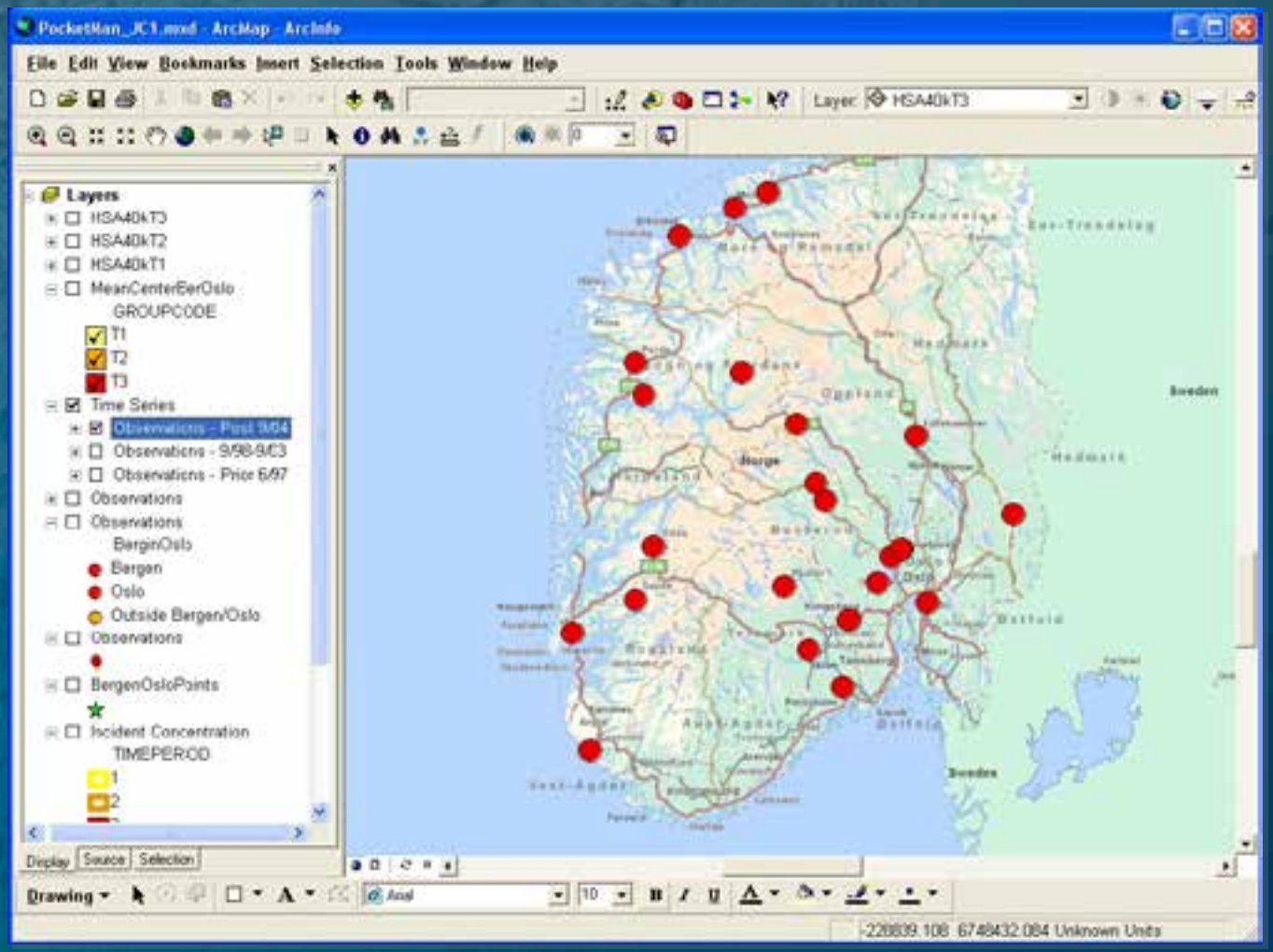
The Pocket Man

Time (mid events)



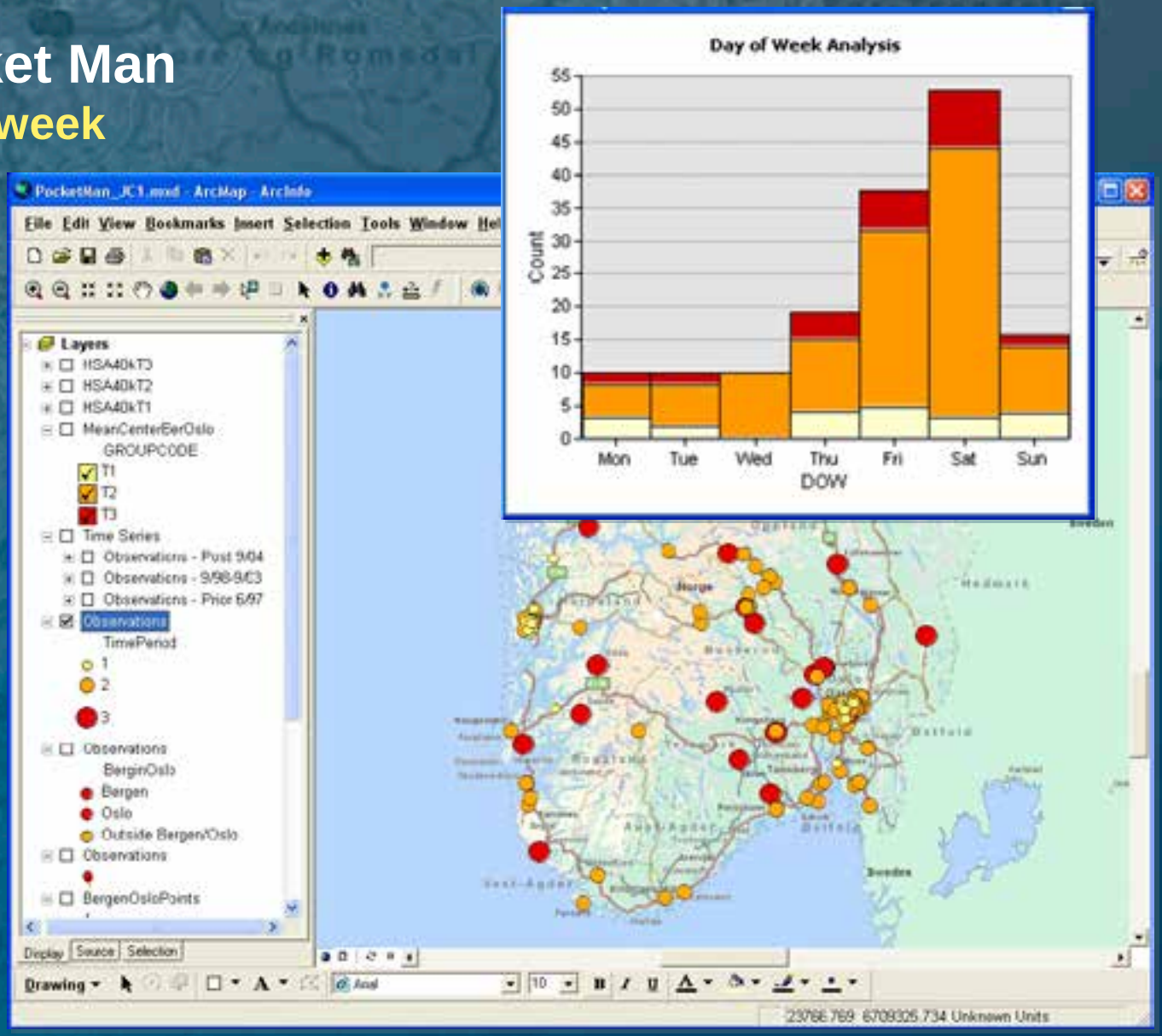
The Pocket Man

Time (late events)



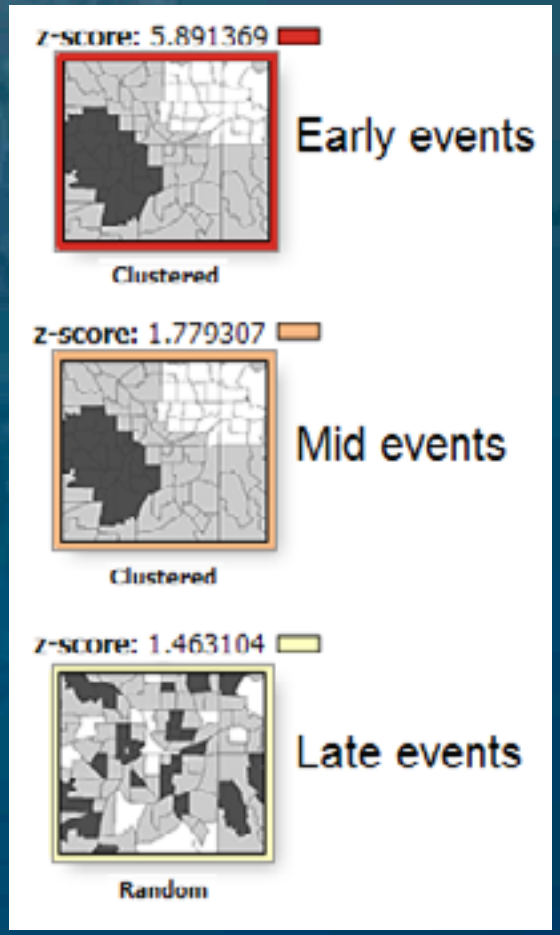
The Pocket Man

Day of the week



The Pocket Man

Spatial Statistics



The Pocket Man

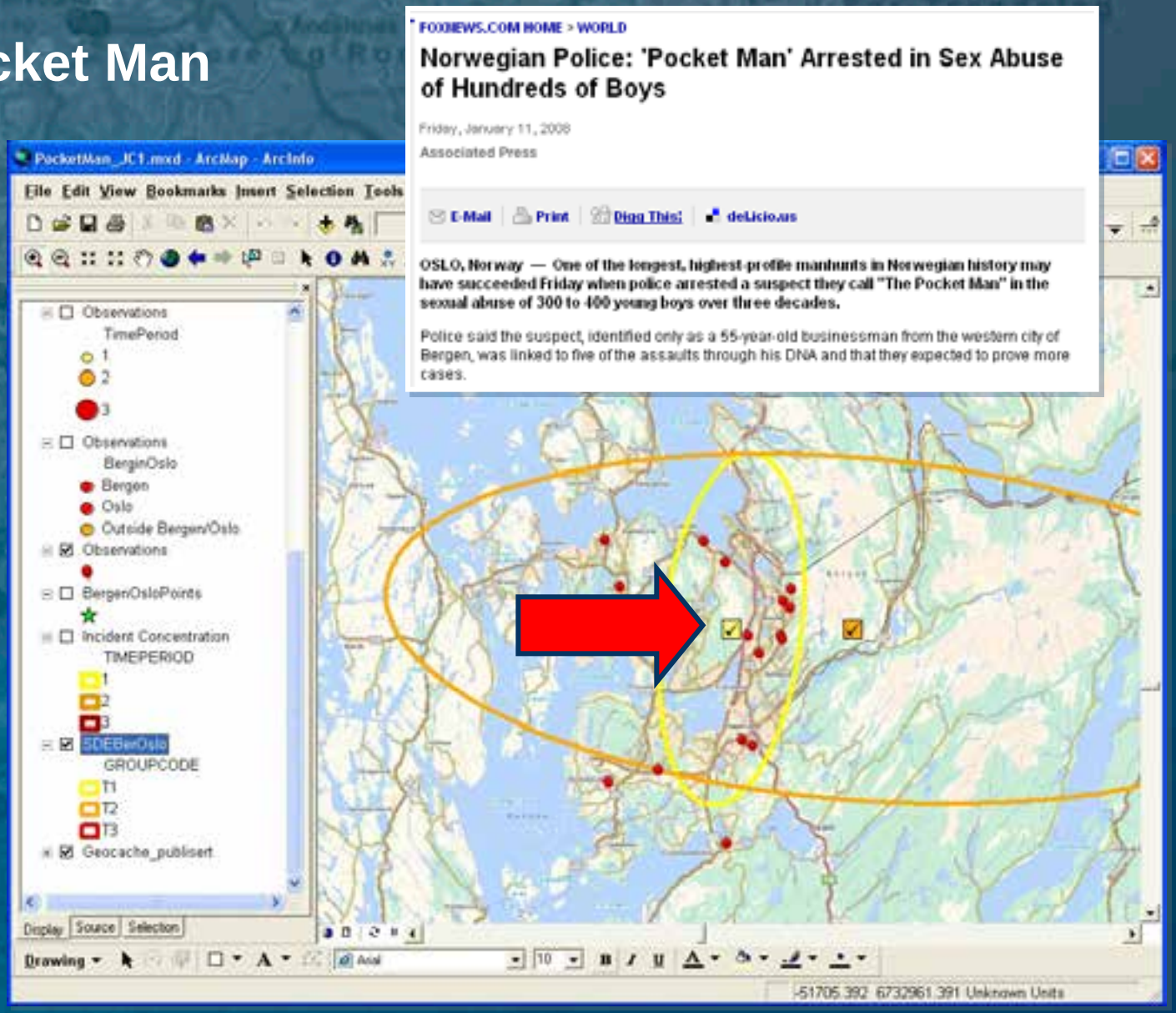
Hot Spot Analysis

Bergen Hot Spot

Oslo Hot Spot

Oslo Cold Spot

The Pocket Man
Caught



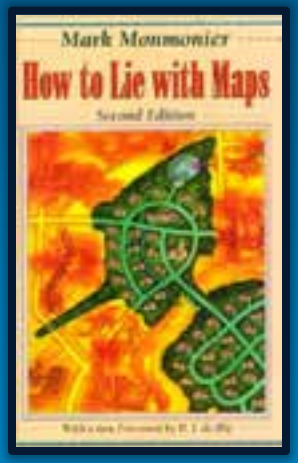
What are Spatial Statistics in ArcGIS?

- **A set of exploratory methods and techniques**
- **Specifically developed for use with geographic data**
  - They incorporate space (area, length, proximity, orientation) directly into their mathematics
- **They describe and model:**
  - Spatial Distributions
  - Spatial Patterns
  - Spatial Processes
  - Spatial Relationships

Spatial statistics extend what the eyes and mind do intuitively to assess spatial patterns, trends and relationships.

Why use spatial statistics?

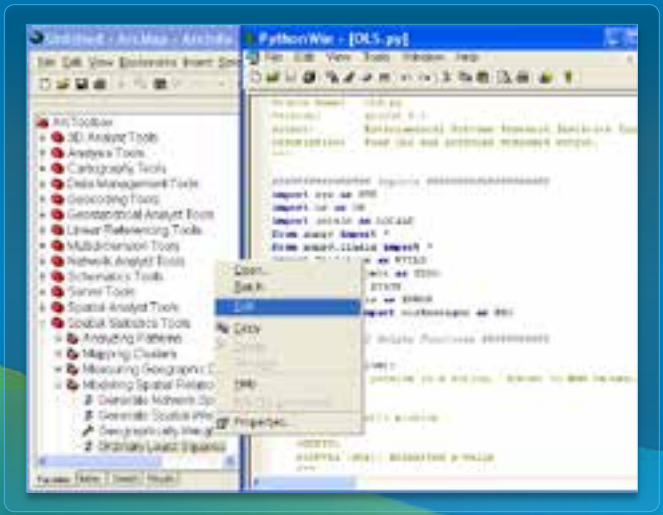
- Spatial Statistics help us assess:
  - Patterns
  - Relationships
  - Trends

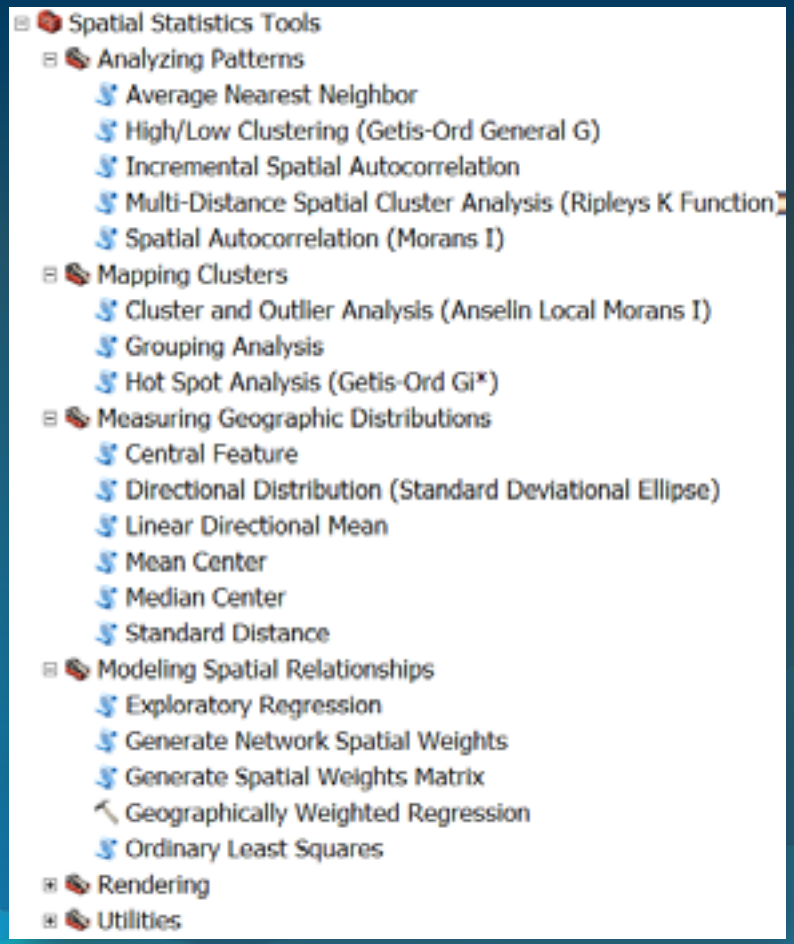


How we present our results (colors, class breaks, symbols…) can either enhance or obscure communication.

Spatial Statistics Toolbox in ArcGIS

- **Core functionality with ArcGIS (not an extension).**
- **Most tools delivered with their source code.**
- **Most tools available at all license levels.**

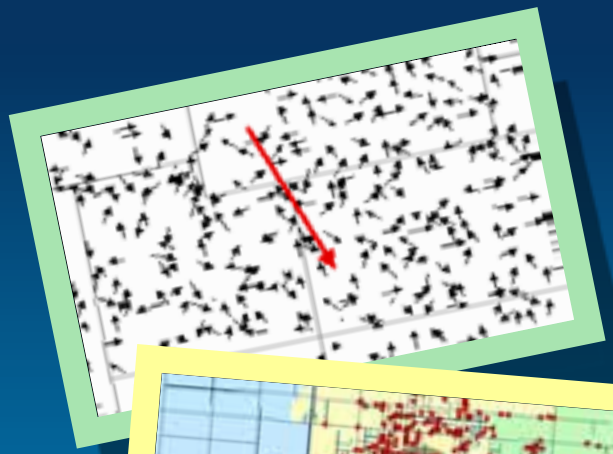




Describing Spatial Data

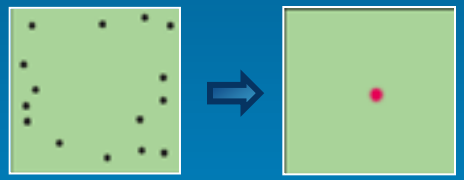
- Measuring Geographic Distributions
  - Central Feature
  - Directional Distribution (Standard Deviational Ellipse)
  - Linear Directional Mean
  - Mean Center
  - Median Center
  - Standard Distance

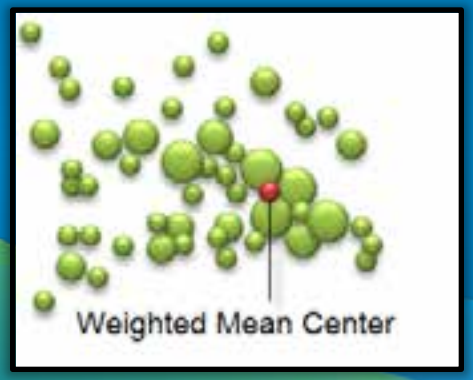
- **Questions**
  - Which site is most accessible?
  - What is the primary wind direction in the winter months?
  - Where is the population center and how it is changing over time?
  - Which species has the broadest spatial distribution? Which are the most spatially integrated?

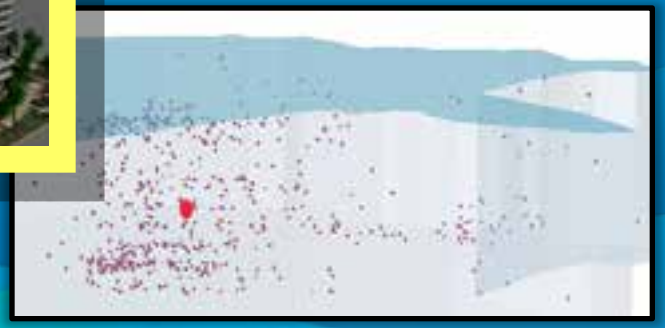


Finding the center

- The Mean Center tool computes the average x and y coordinate, based on all features in the study area.





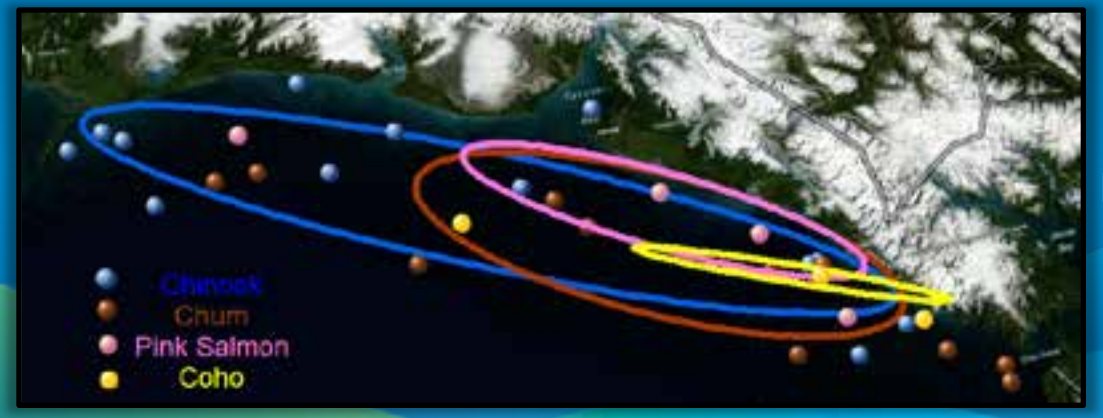


Distribution and Direction

(Standard Deviational Ellipse)

- **Abstracting spatial and temporal trends in a distribution of features**

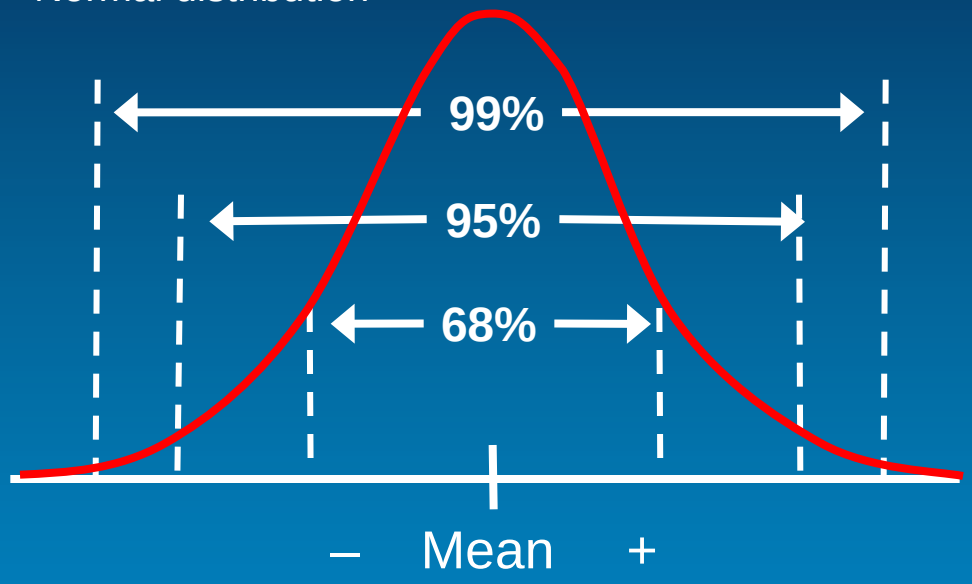
Dengue Fever Outbreak

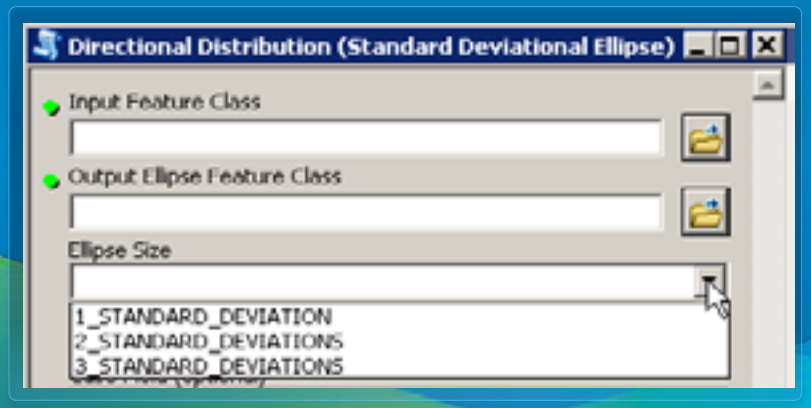


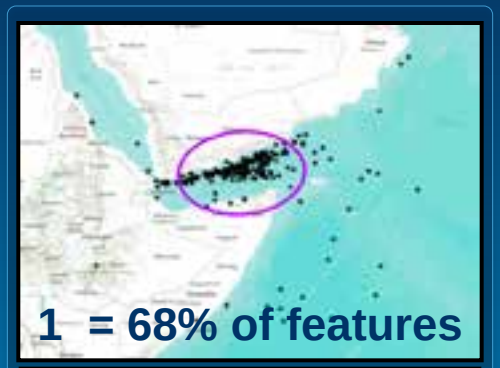
Salmon Distributions

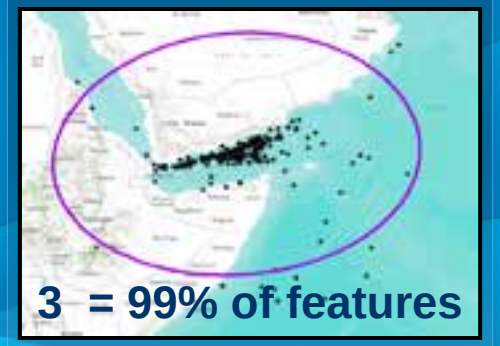
Ellipse size

Normal distribution





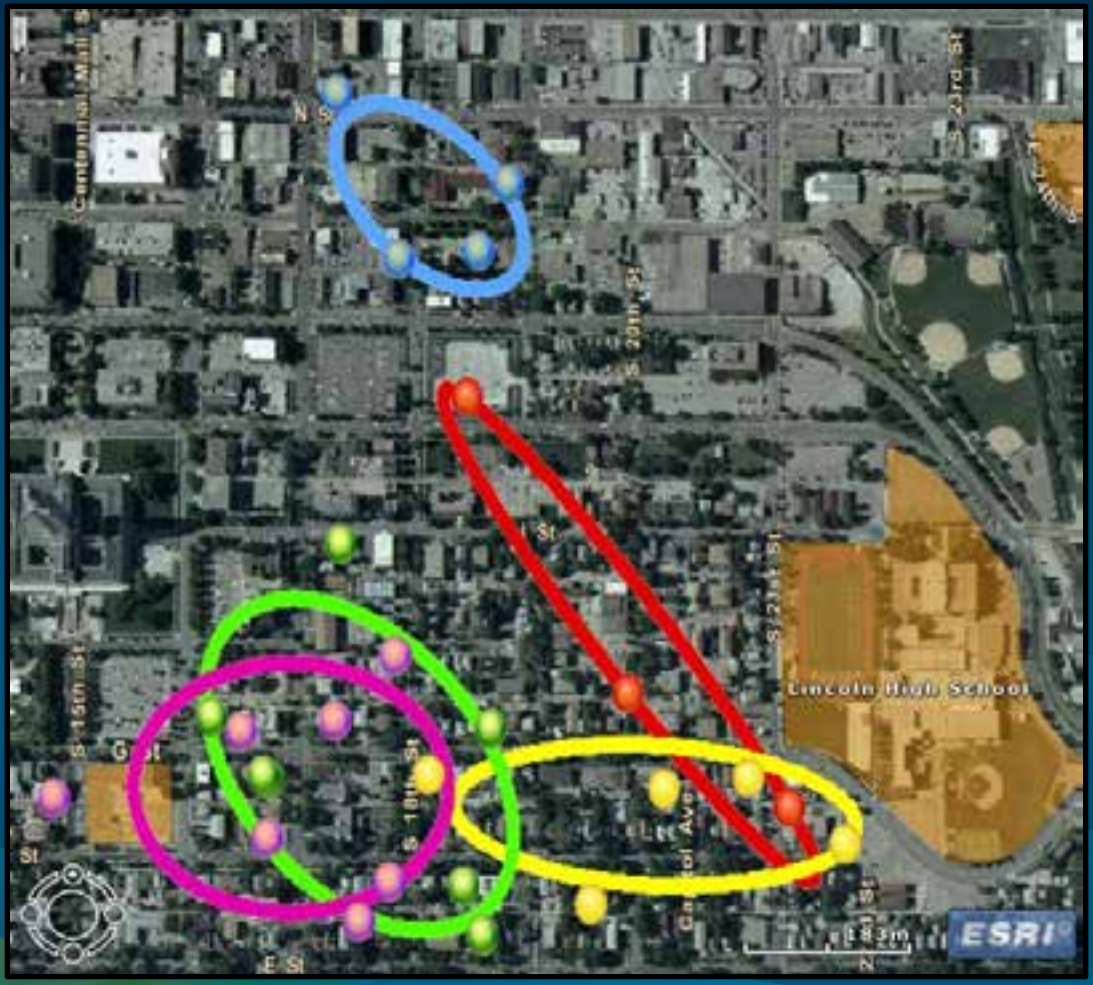




Analyzing territories

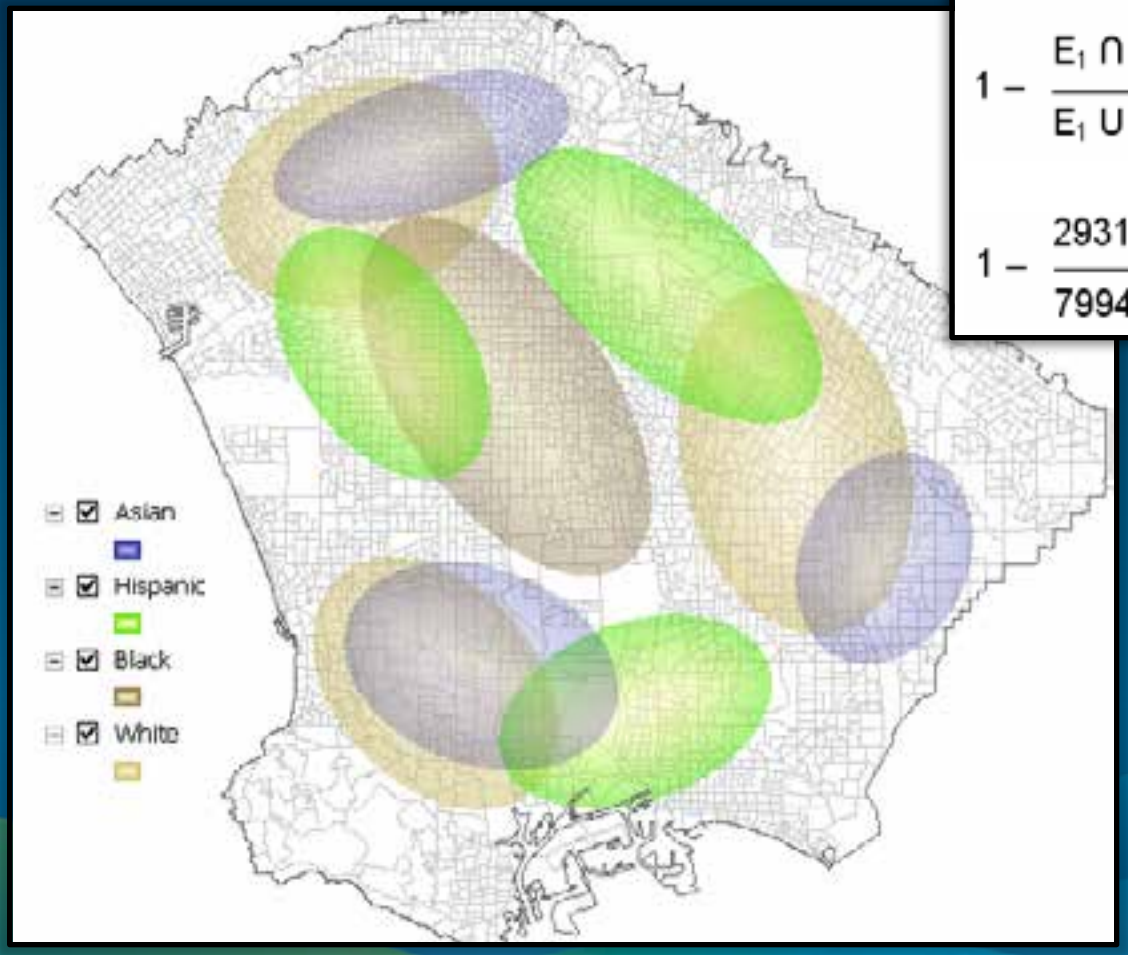
(Standard Deviational Ellipse)

- Center
- Dispersion
- Orientation



Measuring segregation and integration

(Standard Deviational Ellipse)



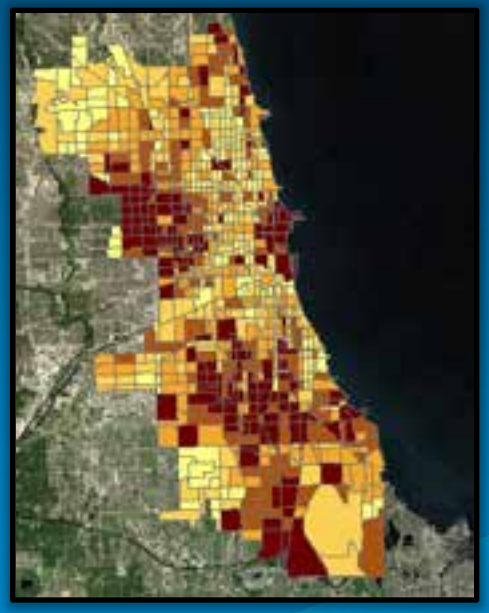
Segregation Index =

$$1 - \frac{E_1 \cap E_2 \cap E_3 \cap \ldots E_n}{E_1 \cup E_2 \cup E_3 \cup \ldots E_n} =$$

$$1 - \frac{2931680545.83}{7994760004.92} = 0.63$$

Quantifying Spatial Patterns

Which pattern is most clustered?

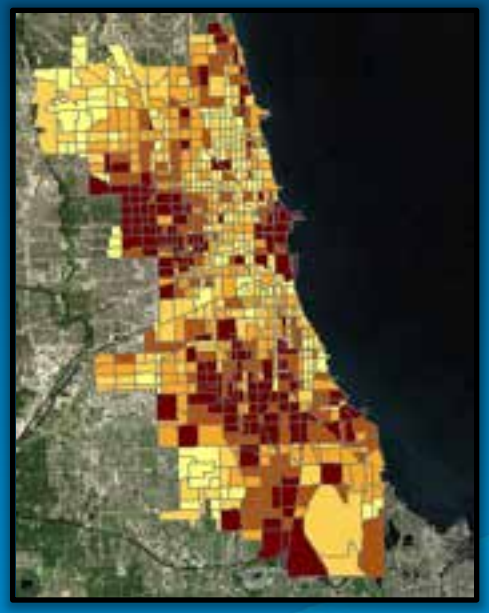


Quantifying Spatial Patterns

Which pattern is most clustered?

Natural Breaks

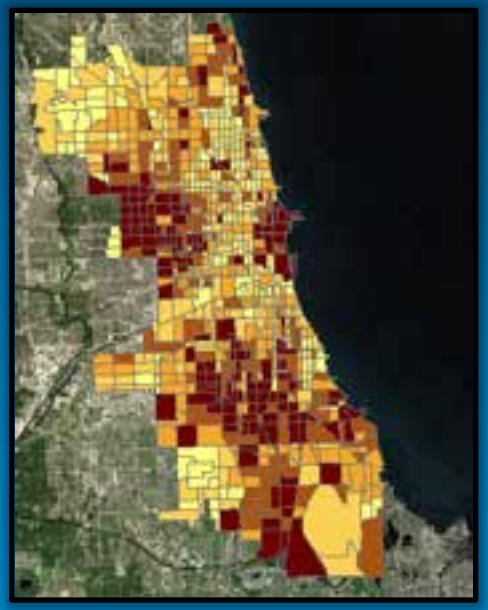
Equal Interval



Quantile

Quantifying Spatial Patterns

You say it's clustered

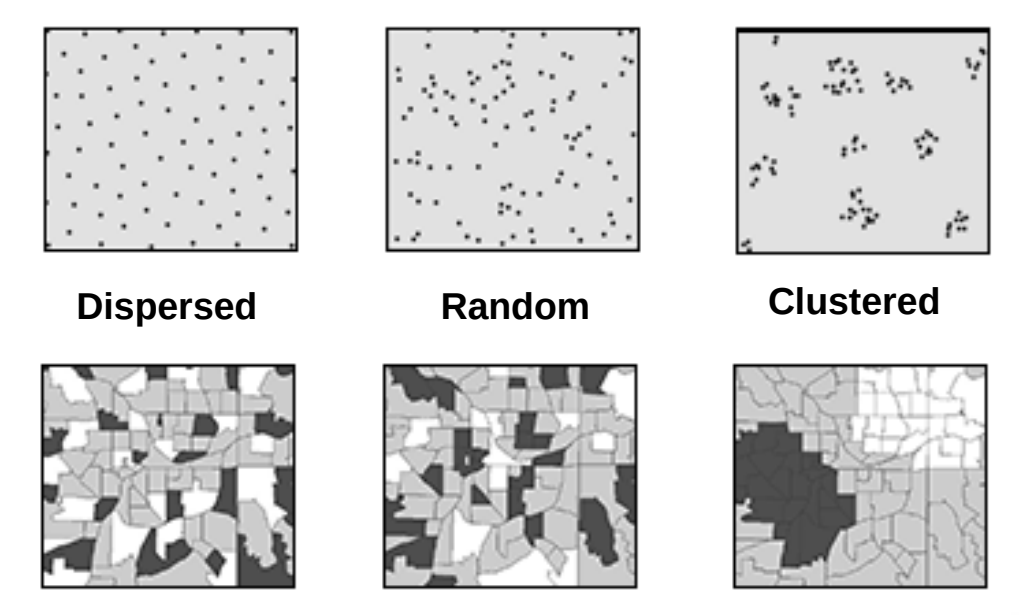


- Compared to what?
- Says who?

Compared to what?

Complete Spatial Randomness

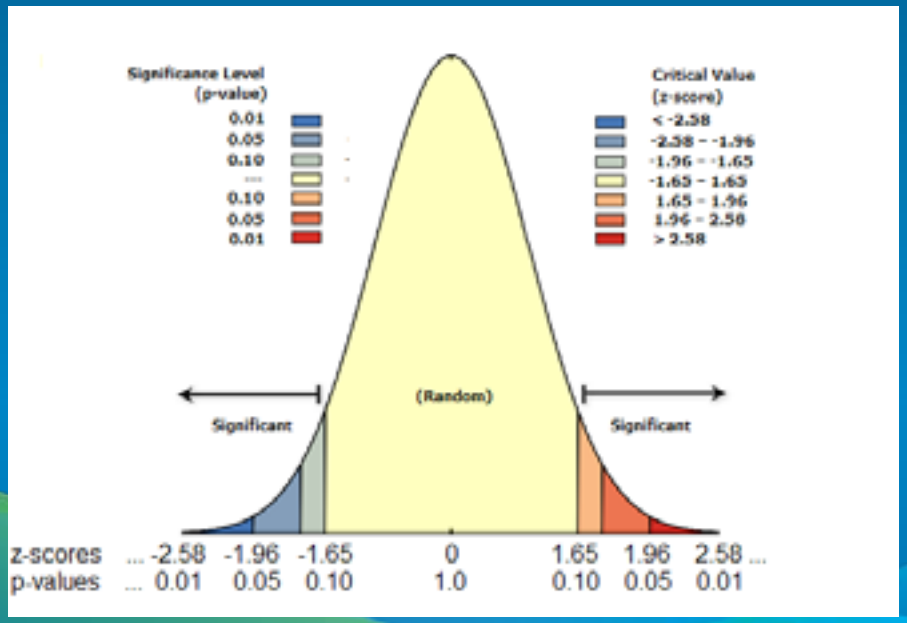
- Inferential statistics start with a null hypothesis
  - Random distribution of features
  - Random distribution of values within fixed features



Says who?

Probability theory

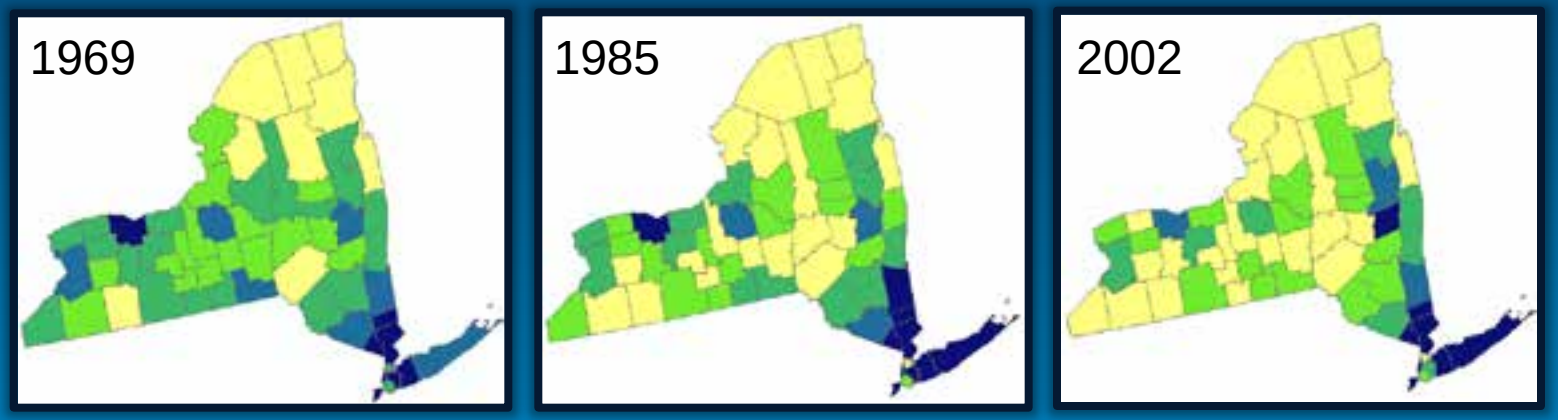
- **Inferential statistics report a p-value and z-score**
  - **z-scores are standard deviations**
  - **p-values are probabilities**



- **z-scores can be mapped to specific p-values**
  - **p-value 0.01 = z-score +/- 2.58**
  - **p-value 0.05 = z-score +/-1.96**
  - **p-value 0.10 = z-score +/-1.65**

Quantifying spatial patterns over time

Spatial Autocorrelation (Global Moran's I)

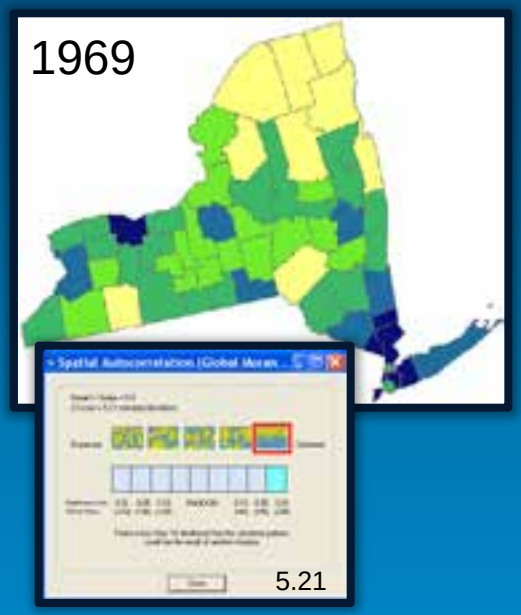


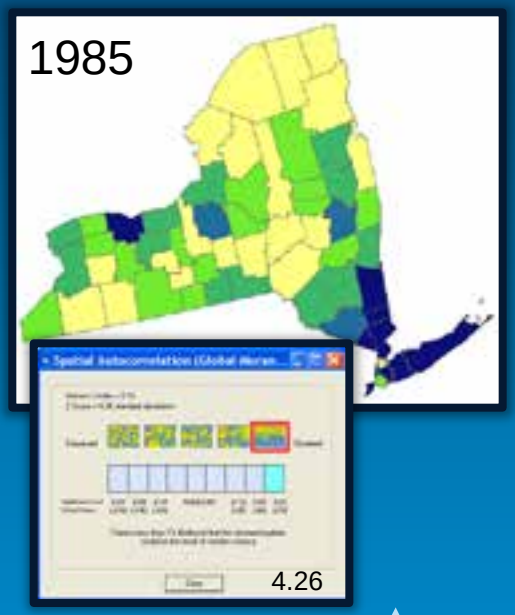
Thematic maps showing relative per capita Income for New York by county, 1969 to 2002

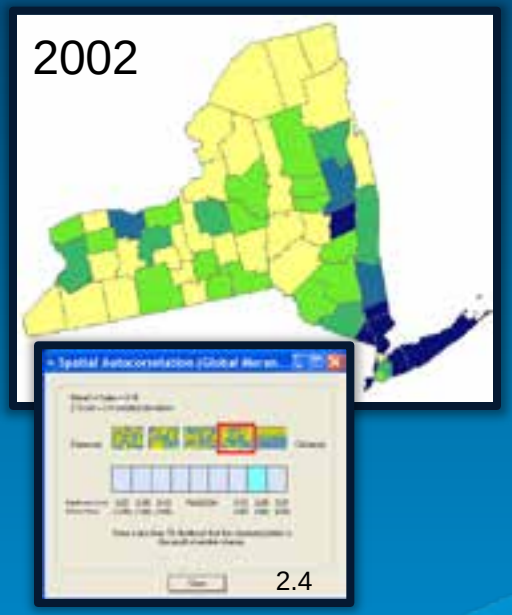
Is the spatial "gap" between rich and poor increasing or dissipating?

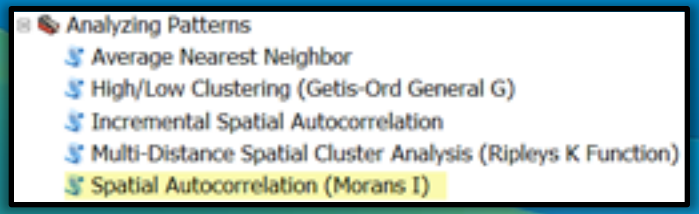
Quantifying spatial patterns over time

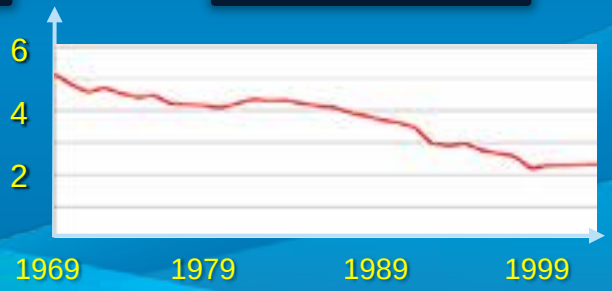
Spatial Autocorrelation (Global Moran's I)





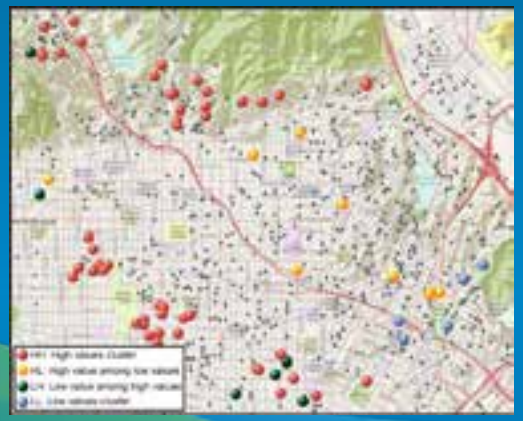






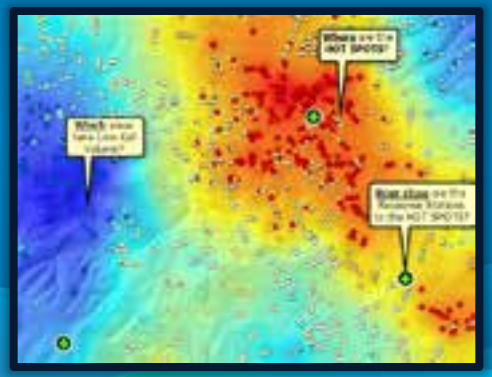
Mapping Spatial Clusters

- **Some of the questions you can answer:**
  - Where do we find anomalous spending patterns?
  - Where do we see unexpectedly high rates of suicide?
  - Do burglaries committed during the day have the same spatial pattern as those occurring at night?
  - Which disease incidents are likely part of the same outbreak?

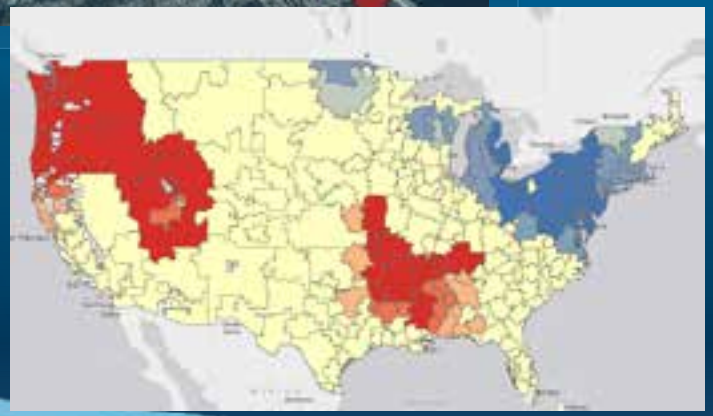


Which homes sold for more than expected?

Where are the 911 call hot spots?



Which countries face similar challenges?

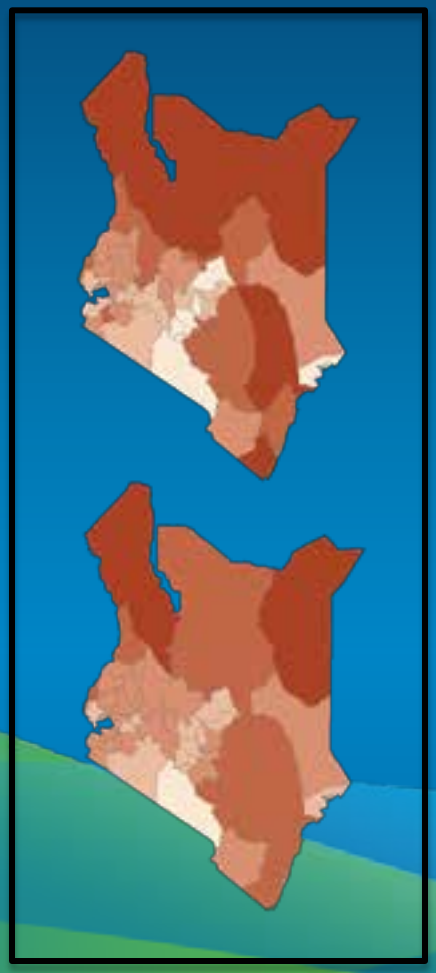


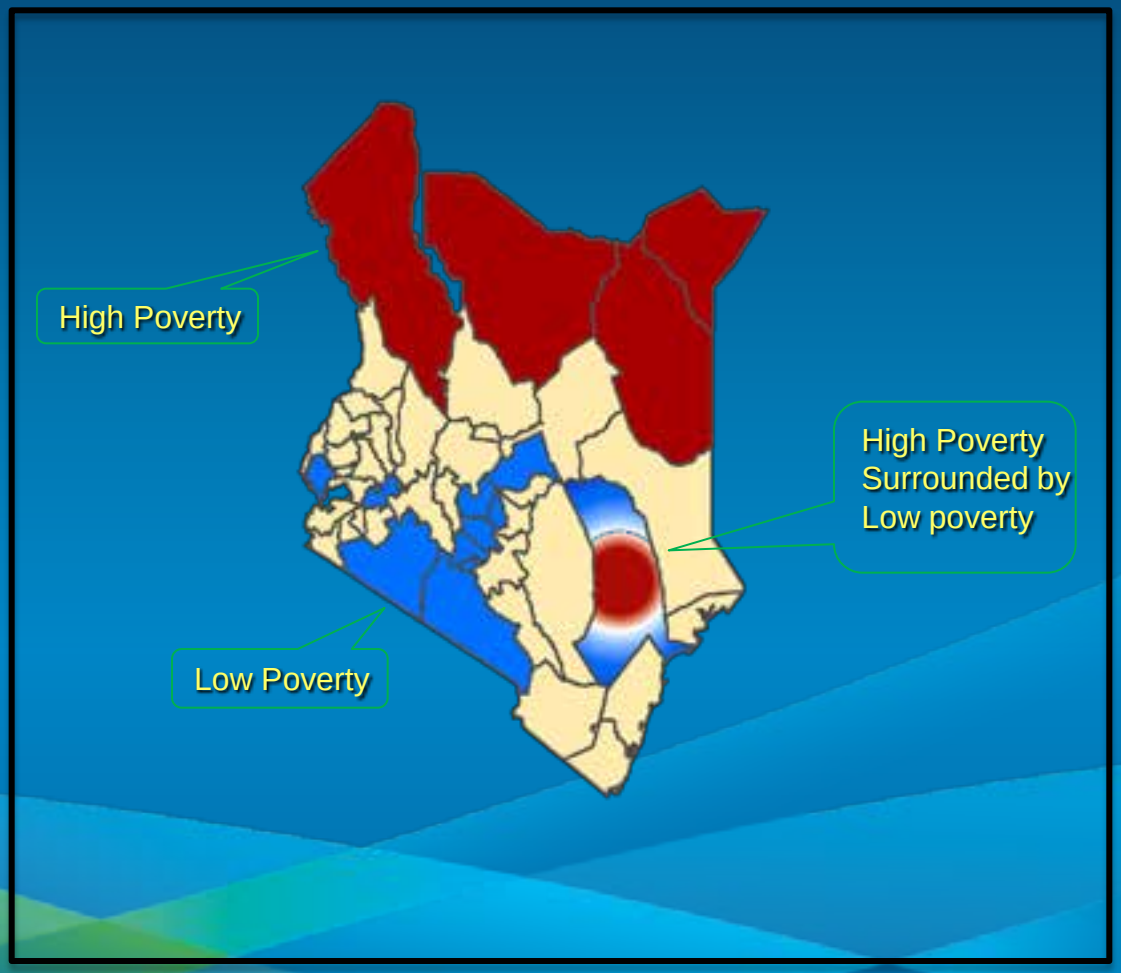
Exploring regional variations in health care

Lauren Rosenshein Bennett, MS

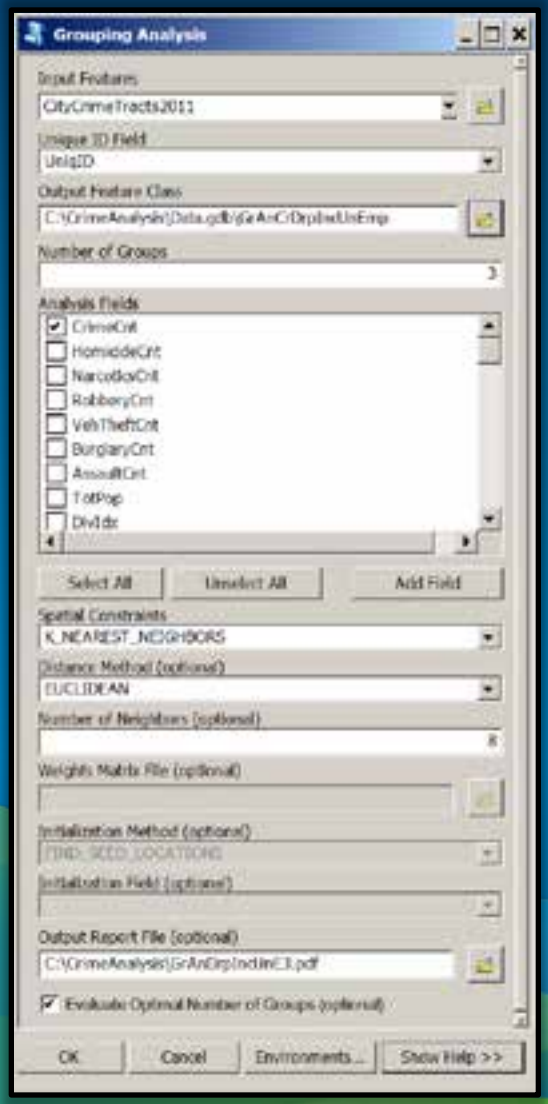
Examining the spatial pattern of poverty in Kenya

(Cluster and Outlier Analysis: Anselin Local Moran's I)



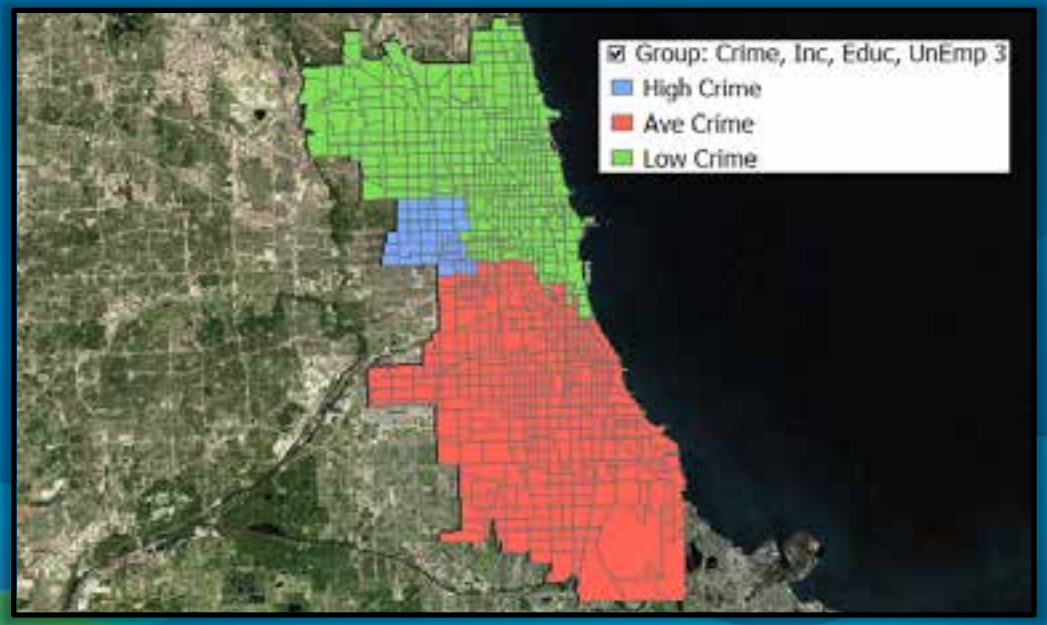


Grouping Analysis

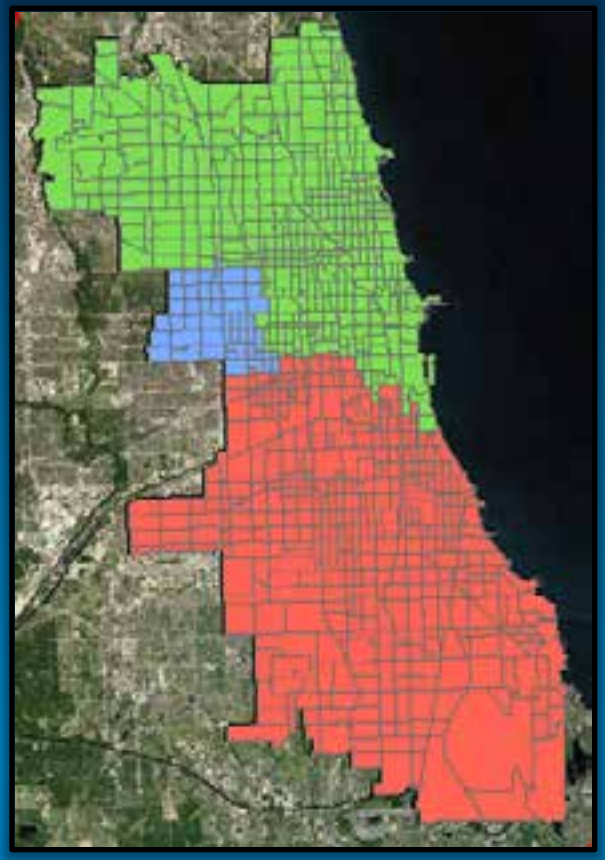


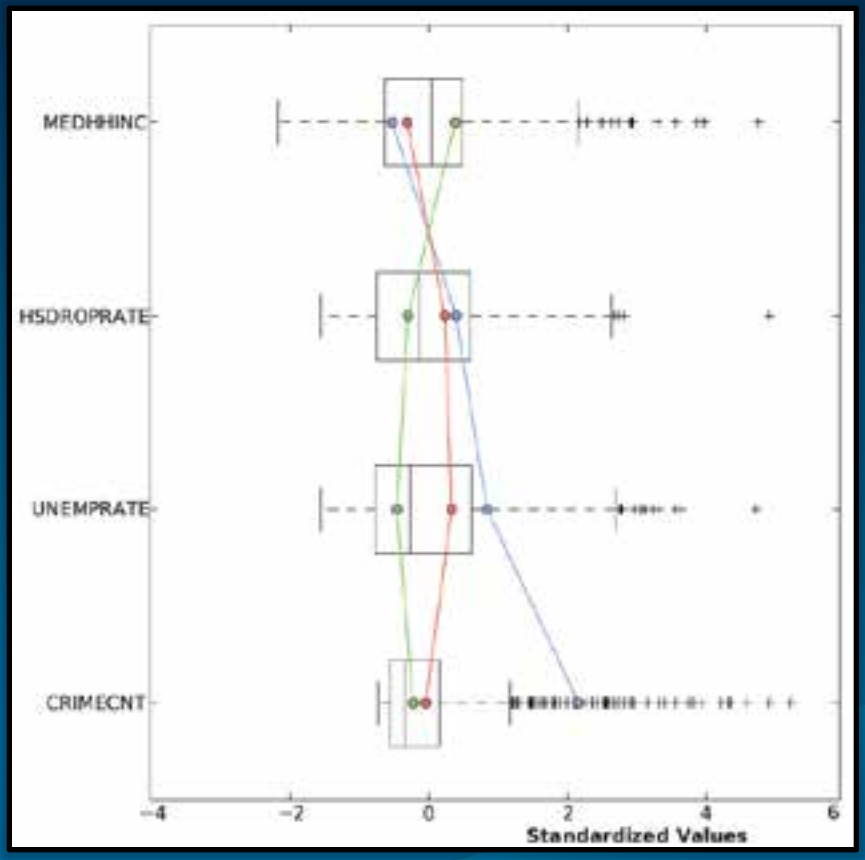
Provide:

- Number of groups
- Variables to use for grouping
- Spatial-temporal constrains (if any)
- Option to evaluate optimal number of groups



Grouping Analysis





Group 1: low income, low education, high unemployment, high crime

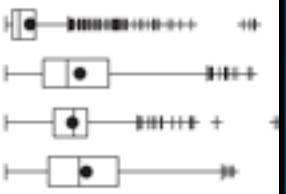
Group 2: middle values for all variables

Group 3: higher income and education, lower unemployment and crime

Grouping Analysis Reports

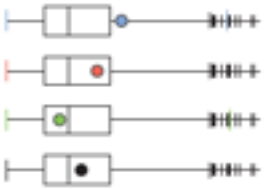
Overall Variable Statistics

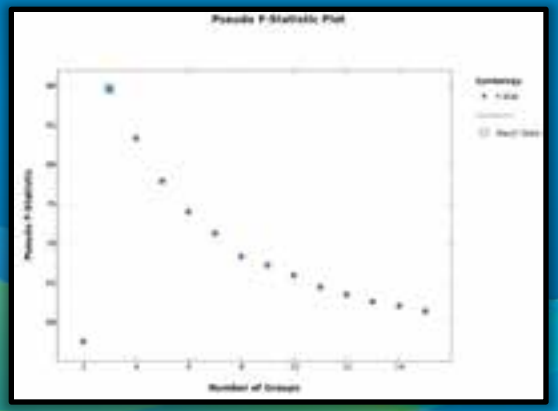
Variable	Mean	Std. Dev.	Min	Max	R2
CRIMECNT	42.4021	59.1462	0.0000	593.0000	0.2852
UNEMPRATE	0.1982	0.1273	0.0000	0.8000	0.1887
MEDHHINC	49379.4271	22747.1008	0.0000	225000.0000	0.1296
HSDROPRATE	0.2393	0.1547	0.0000	1.0000	0.0762

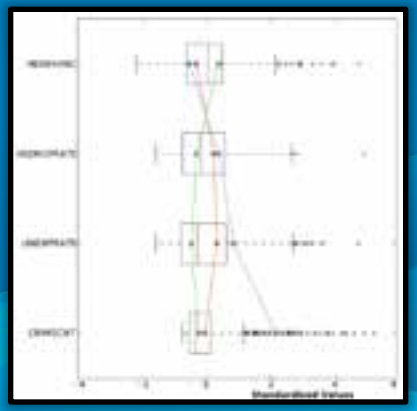


UNEMPRATE: R2 = 0.19

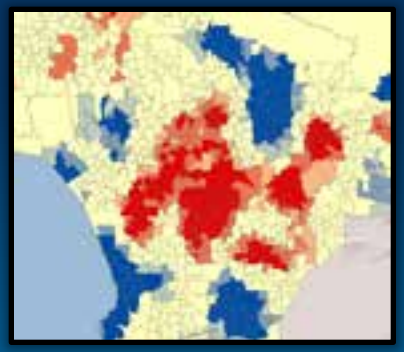
Group	Mean	Std. Dev.	Min	Max	Share
1	0.3057	0.1298	0.0000	0.5883	0.7354
2	0.2407	0.1287	0.0000	0.8000	1.0000
3	0.1403	0.0954	0.0000	0.5962	0.7452
Total	0.1982	0.1273	0.0000	0.8000	1.0000



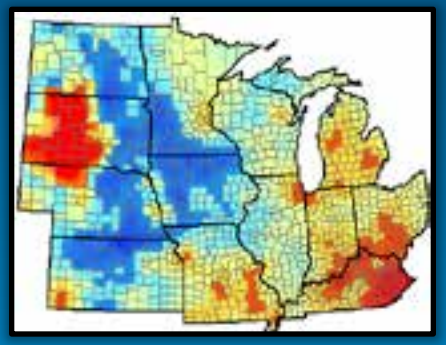


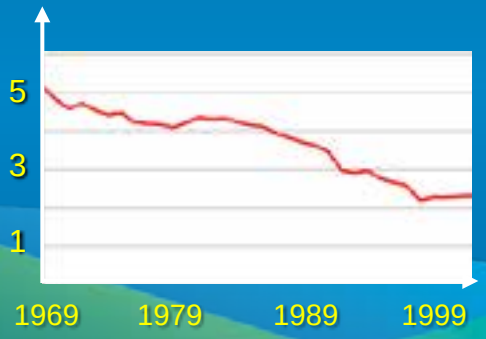


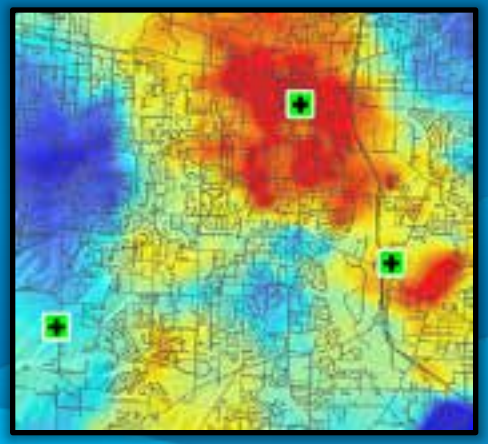
Is CSR useful?



- **Raising the bar:**
  - Normalize the analysis field to create a rate
  - Analyze average values
  - Compare *z*-score magnitudes
    - Across space
    - Over time
    - Among control spatial distributions







Resources for learning more…

During the conference

Technical Workshops	Room 5A/B
Modeling Spatial Relationships Using Regression	T 10:15
What's New in Spatial Statistics	T 3:15
Spatial Pattern Analysis	W 1:30
Modeling Spatial Relationships Using Regression	W 3:15
Spatial Statistics Best Practices	Th 1:30

Demos	
Hot Spot Maps: Minimizing Subjectivity Geoprocessing and Analysis Demo Theater	W 5:30
Crime Mapping: Using Spatial Statistics Public Safety Showcase Demo Theater	Th 11:00

- Integrating open-source statistical packages Rm 1A 12:00
- Working with Temporal Data Rm 28D Th 10:15AM

Resources for learning more…

After the conference

QUESTIONS?

- **www.esriurl.com/spatialstats**
- Short videos
- Articles and blogs
- Online documentation
- Supplementary model and script tools
- Hot Spot, Regression, and ModelBuilder tutorials

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Esri.com/ucsessionsurveys

Session ID: 117/594

Esri International User Conference
San Diego, California

Technical Workshops | July 25, 2012

Spatial Pattern Analysis: Mapping Trends and Clusters

Lauren M. Scott, PhD

Lauren Rosenshein Bennett, MS

Resources for learning more…

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- **resources.arcgis.com**

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Session ID: 117/739