

# Introduction to Spatial Analysis

SERGIO REY

**GPH 483/598**  
**Geographic Information Analysis**  
School of Geographical Sciences  
Arizona State University  
Fall 2010

## 1 GIS and Spatial Analysis

- Big Picture
- What is Spatial Analysis?

## 2 EDA and ESDA

- Exploratory Data Analysis (EDA)
- Exploratory Spatial Data Analysis (ESDA)
- Geovisualization

# Course Objectives

- Introduction to fundamentals of ESDA
- Conceptual background
- Hands-on

## Four Sections

- Introduction and Background
- Point Patterns
- Geostatistics
- Spatial Autocorrelation

# Introduction and Background

Session	Topic
Jan 20	Introduction
22	GIS and Spatial Analysis
27	Spatial Data Taxonomy
29	<i>Lab: Introduction to GeoDa</i>

# Point Patterns

Session	Topic
Feb 3	Point Pattern Analysis Basics
5	<i>Lab: Descriptive Point Pattern Analysis</i>
10	Point Pattern Processes
12	<i>Lab: Point Pattern Analysis in R</i>
17	Clustering and Clusters
19	Lab: Scan Statistics in StatScan
24	Second Order Analysis and Point Pattern Process Modeling
26	<i>Lab: Second Order Analysis and Point Processes in R</i>

# Geostatistics

Session	Topic
Mar 3	Geostatistics Basics
5	<i>Lab: Variography in ArcGIS Geostatistical Analyst and R</i>
10	Spring Break
12	Spring Break
17	Kriging
19	<i>Lab: Kriging Prediction in R and Geostatistical Analyst</i>
24	AAG
26	AAG

# Spatial Autocorrelation

Session	Topic
Mar 31	Spatial Autocorrelation Basics
Apr 2	Spatial Weights
7	Advanced Weights
9	<i>Lab: Spatial Weights</i>
14	Global Autocorrelation
16	<i>Lab: Global Autocorrelation</i>
21	Local Autocorrelation
23	<i>Lab: Local Autocorrelation</i>
28	Exploratory Space-Time Analysis
30	<i>Lab: STARS</i>

# Presentations

Session	Topic
May 5	Presentations
12	Presentations (12:10-2:00)

# Grading

## Components

- 50% Graded Assignments
- 50% Final Project

## Assignments

- 3: Point Patterns, Geostatistics, Spatial Autocorrelation
- Highest two grades used
- Can resubmit (up to 2 weeks after original submission)

# Grading 483 vs. 598

## Undergraduate

For your project you can either:

- select your own data
- use data I give you

## Graduate

- you must select your own data for your project
- present assignment or supplementary reading
- 50=40 (assignments) + 10 (presentation)

All students will present their final projects

# Prerequisites

All participants are expected to have working knowledge of spatial analysis concepts and to be familiar with multivariate statistics. No extensive GIS background beyond ArcGIS basics is needed.

# Course Organization

The course will meet in the GIS Laboratory in 316 Schwada for both lectures and labs. The class time will be complemented with a virtual classroom supported by the *moodle* software. This is a continued experiment but I hope you will appreciate the added opportunity for virtual office hours and easy access to materials. As this is an evolving project, any feedback on the design and features of the site is welcome. The course site will be announced in class.

# Readings

There is no required textbook for the course. Supplementary readings will be taken from journals and the following two textbooks:

- O'Sullivan, D.O. and D.J. Unwin (2003) *Geographic Information Analysis*. John Wiley: New York.
- de Smith, M.J., M.F. Goodchild and P.A. Longley (2008) *Geospatial Analysis*. Available at  
<http://www.spatialanalysisonline.com/>.

Reading lists for each topic will be given out in class and made available on the moodle class web site.

## GeoDa

<http://geodacenter.asu.edu/software/downloads>

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## CrimeStat

<http://www.icpsr.umich.edu/CRIMESTAT/download.html>

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## SatScan

<http://www.satscan.org/>

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## R

<http://cran.r-project.org/>

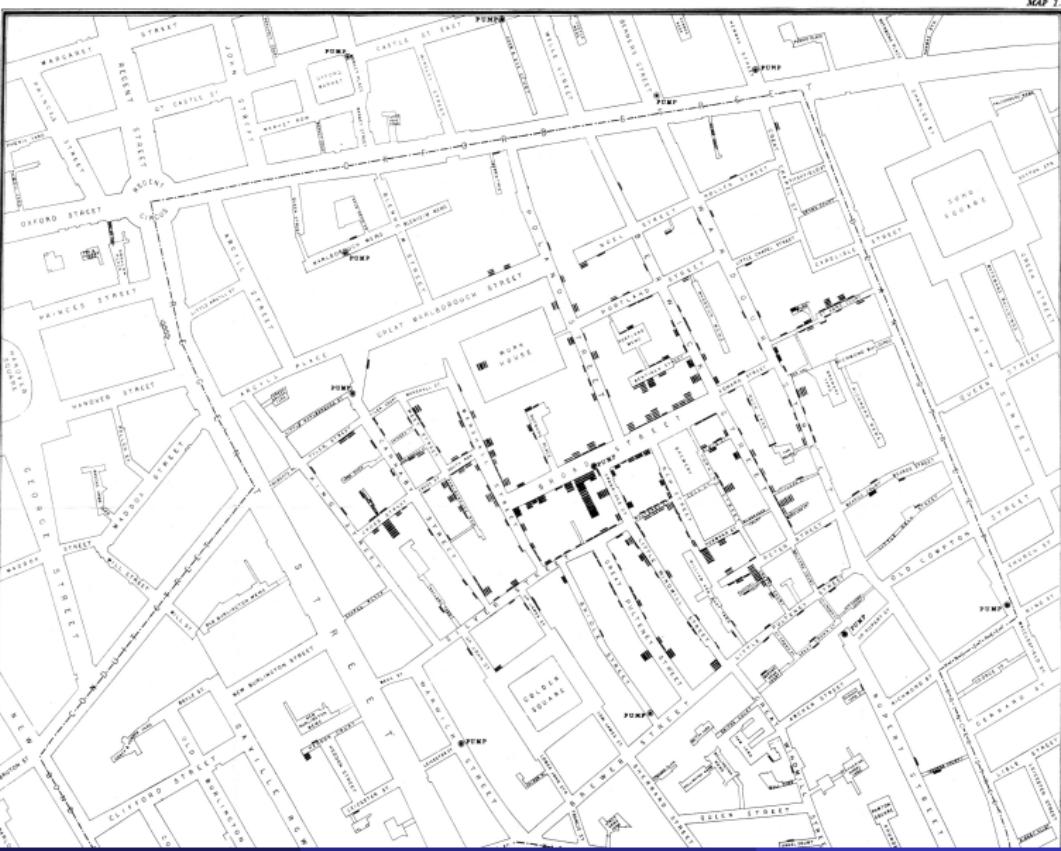
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## STARS

<http://regionalanalysislab.org/index.php/Main/STARS>

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## GIS Then



# GIS Then





ZIP codes

60651

Nearby: • North Austin • South Austin • West Humboldt Park • Ward 30 • Ward 37

- Categories**
- Latest news**
- Bike rack installations
- Building permits
- Business licenses
- Business reviews
- City press releases
- Crimes
- Filming
- Liquor license applications
- Lost and found postings
- News articles
- Photos
- Property transfers

## Latest news in 60651

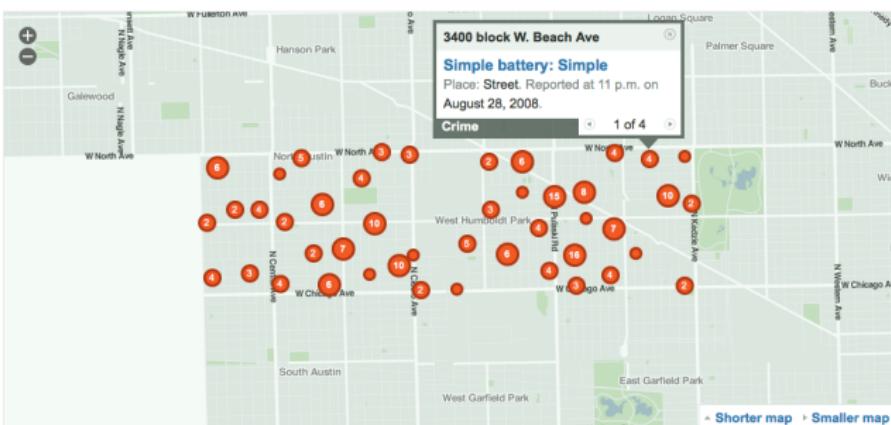
Timeline

By news type

Stay up to date:

Custom RSS feeds

E-mail updates



[Shorter map](#) [Smaller map](#)

NEW ON EVERYBLOCK YESTERDAY

DECEMBER 1, 2008

1 news article

Survivors talk about Our Lady of Angels fire

About

Avers and Iowa

Have you found  
any news nearby  
that we don't know  
about? Please

## Anselin-Getis (1992) Taxonomy

- Input
- Storage
- **Analysis**
- Output

Many other taxonomies

## Goodchild (1992)

- cross-disciplinary
- **central** role for spatial analysis
- scientific **glue**

# What is Spatial Analysis?

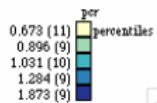
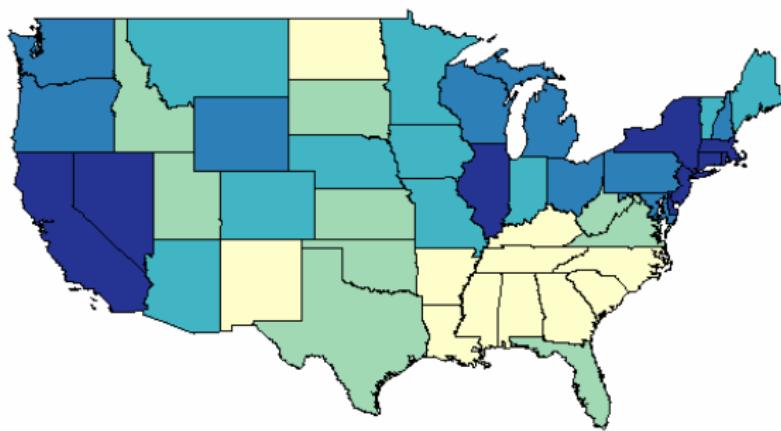
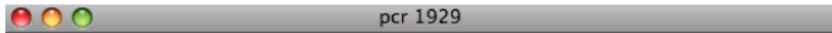
## From Data to Information

- Beyond mapping
- added value
- transformations, manipulations and application of analytical methods to spatial (geographic data)

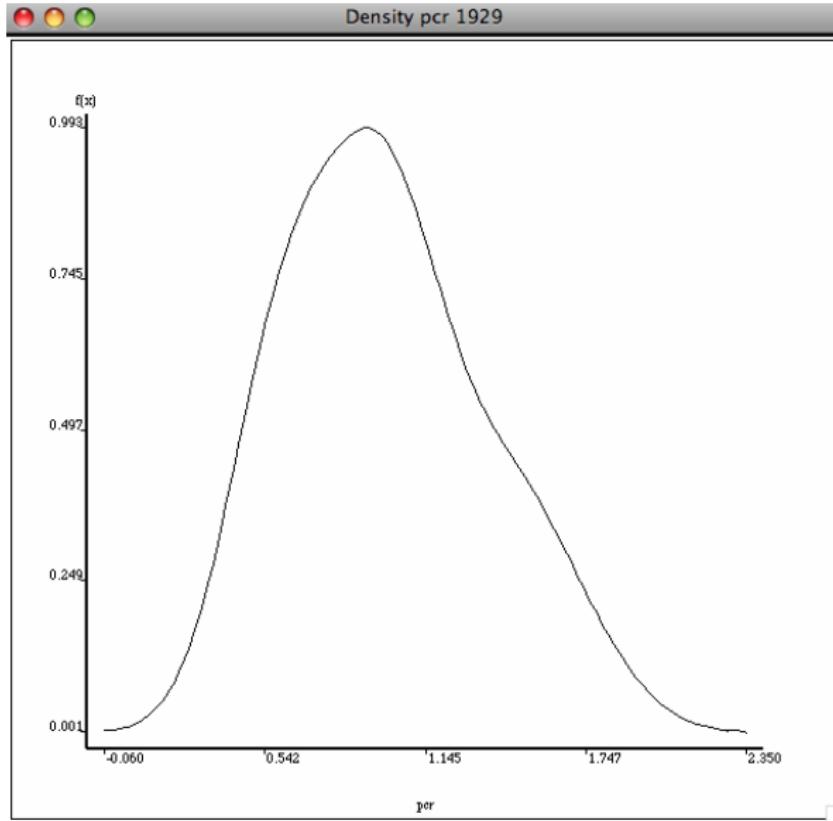
## How Insights Change with location

- spatial analysis is **not** locationally invariant
- the results change when the locations of the study objects change
- **where** matters

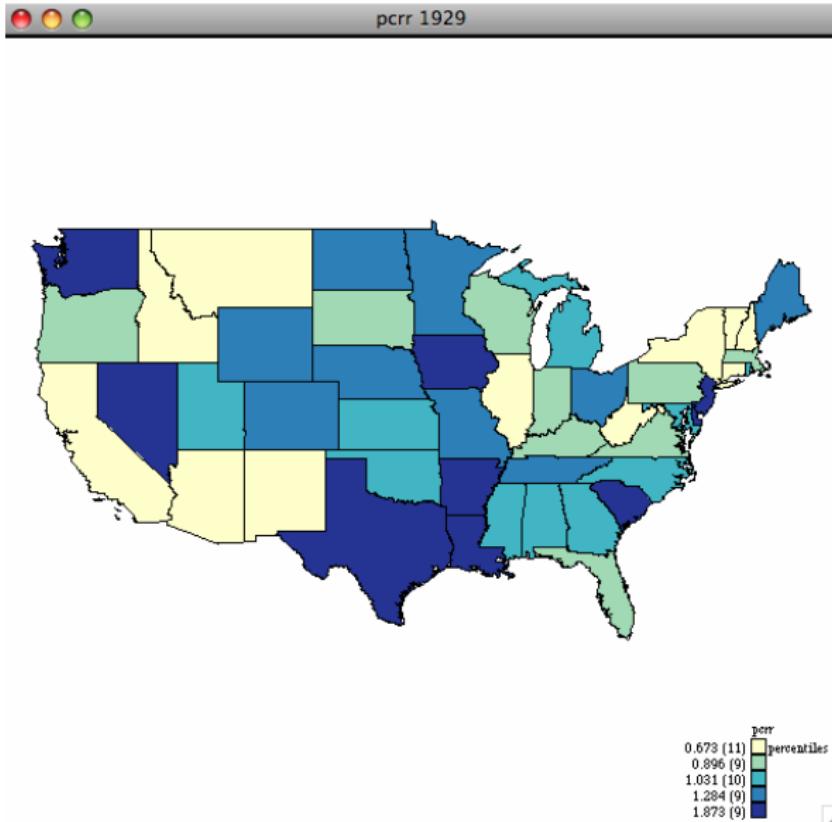
# State Income Distributions 1929



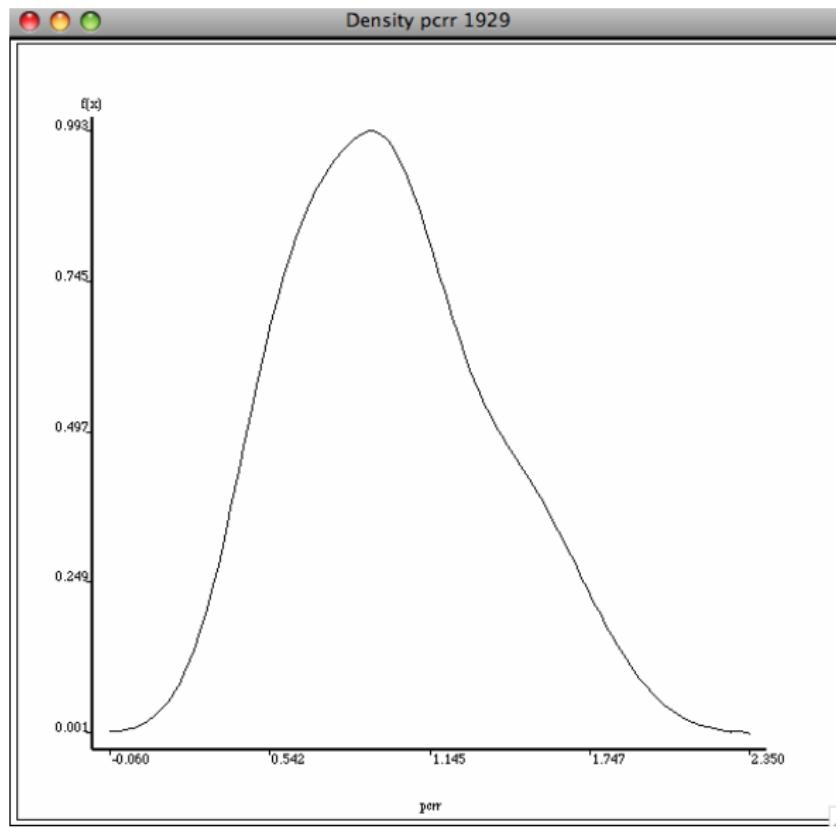
# State Income Distributions 1929



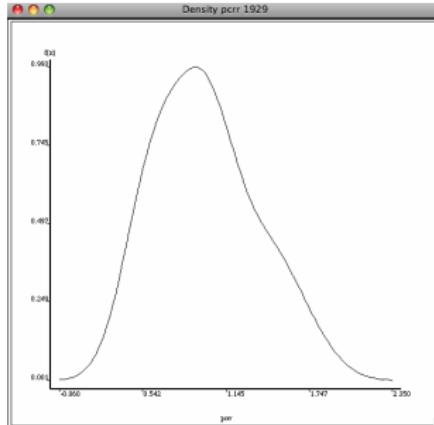
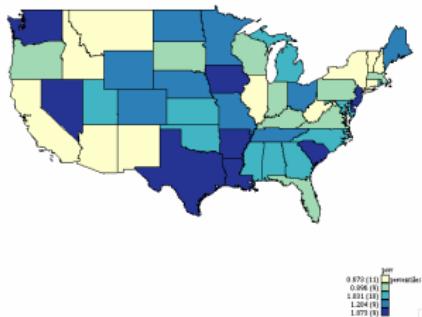
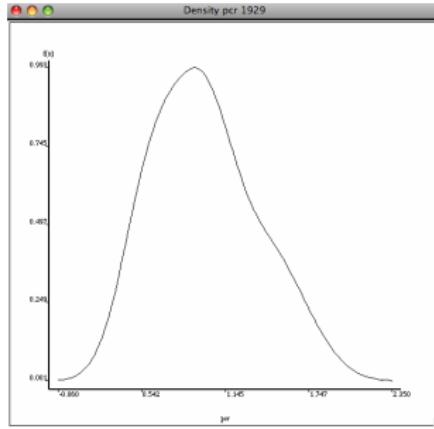
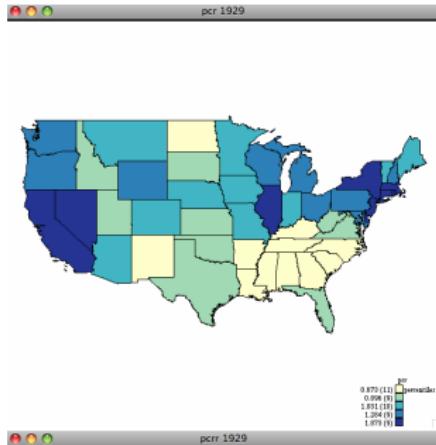
# Randomized Income Distribution 1929



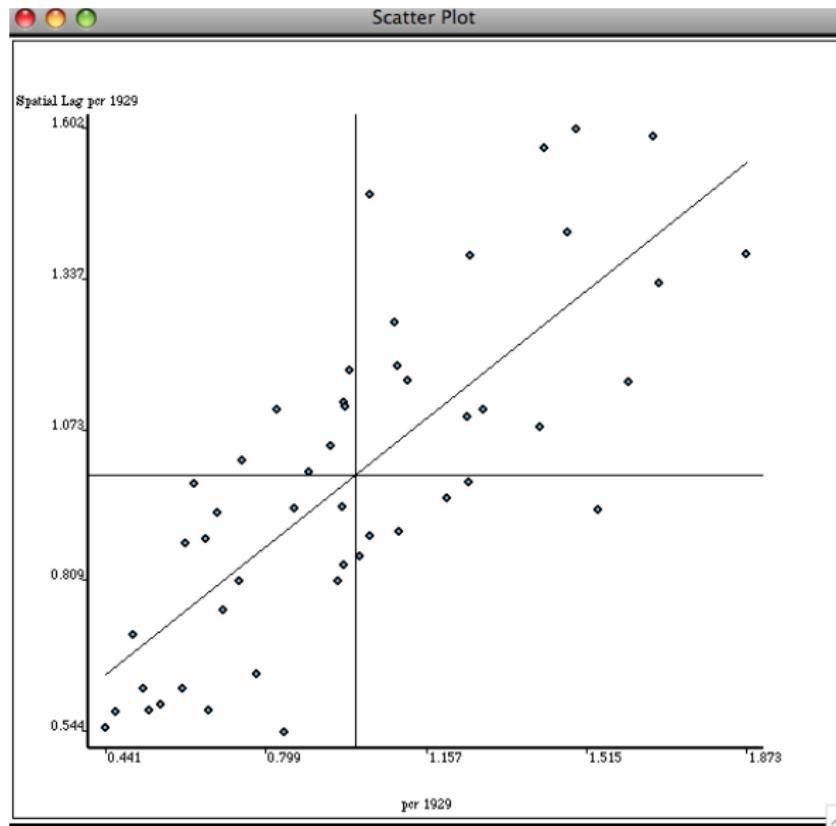
# Randomized Income Density 1929



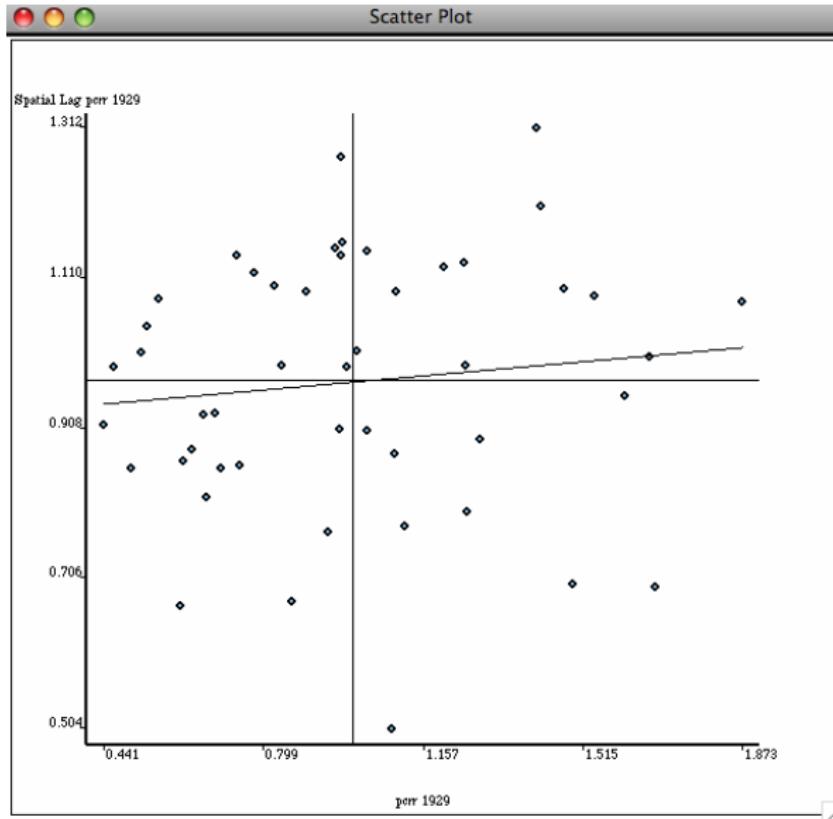
# Locational Invariance



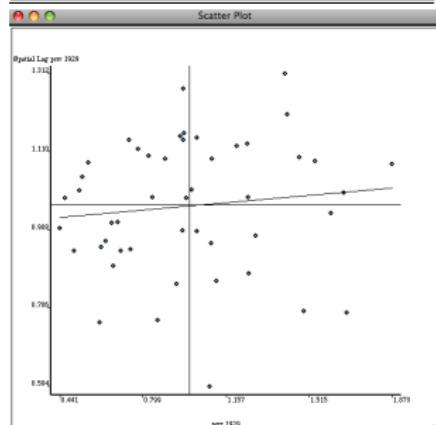
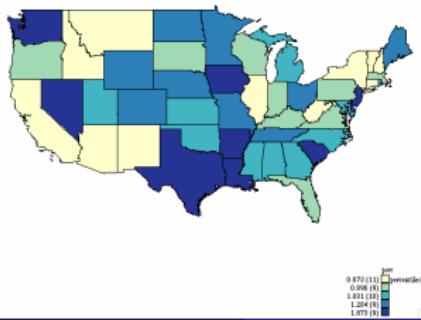
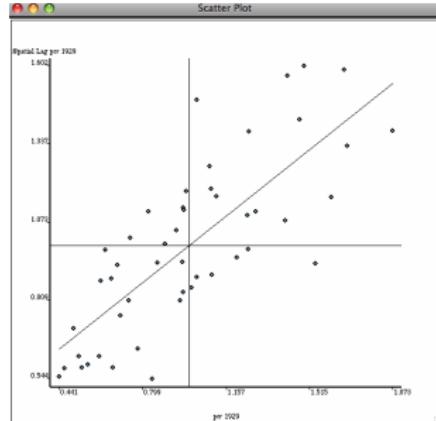
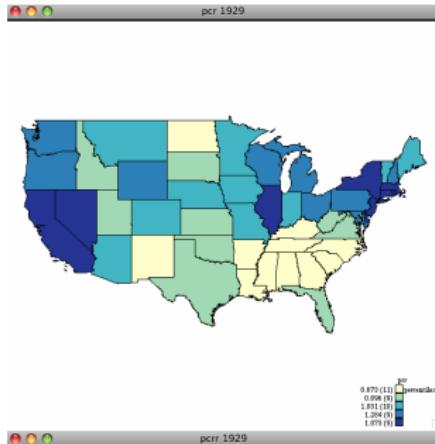
# Spatial Autocorrelation Income 1929



# Spatial Autocorrelation Randomized Income 1929



# Locational Invariance



# Components of Spatial Analysis

Mapping and Geovisualization

**showing** interesting patterns

Exploratory Spatial Data Analysis

**discovering** interesting patterns

Spatial Modeling

**explaining** interesting patterns

# Summary: Spatial Analysis

Beyond Mapping

Central role for **analysis**

Distinguished by Locational Variance

**Location** matters

Components

Showing, discovering, explaining

# What is EDA?

## Philosophy

EDA is an approach, not simply a set of techniques, but an attitude/philosophy about how a data analysis should be carried out. Postpones the usual assumptions about what kind of model the data follow

## Origins

Tukey, J. (1977) *Exploratory Data Analysis*. Addison, Wesely

# Components

## Set of techniques to

- maximize insight into a data set
- uncover underlying structures
- extract important variables
- detect outliers and anomalies
- test underlying assumptions
- suggest hypotheses
- develop parsimonious models

## Statistical Graphics

- EDA relies heavily on statistical graphics
- EDA is not identical to statistical graphics
- Graphics support pattern recognition and open-minded exploration
- Interactive graphics push this even further

## Quantitative Methods

Although heavily graphic in orientation, there are also a number of numerical techniques in EDA.

# EDA Versus Confirmatory Analysis

Confirmatory Analysis (e.g. regression)

Problem → Theory → Model → Data → Conclusion

Exploratory Analysis

Problem → Data → Analysis → Model

# What is ESDA?

## Definitions

- Type of EDA
- Extended to include spatial attributes of the data

## Crossfertilization

- Applying classic EDA to spatial data
- Developing new EDA methods for spatial data
- Interactions between EDA and ESDA

# How does ESDA fit in spatial analysis?

## Spatial Modeling?

- Modeling based on assumptions
- ESDA largely model free
- Matter of degree (e.g., clustering)

## Mapping?

- Maps play a critical role in ESDA
- Does a map = ESDA?
- No. ESDA = map, manipulation + visualization

## Beyond Mapping

- Combing map and scientific visualization methods
- Exploit human pattern recognition capabilities

## Statistical Maps

- innovative map devices

## How to Lie with Maps

- Monmonnier (1996)
- many design issues
- projects
- human perception can be tricked

## The Science of Analytical Reasoning Facilitated by Interactive Visual Interfaces

- NVAC 2005
- science of analytical reasoning
- visual representation and interaction
- data representation and transformations
- production, presentation and dissemination

## Tools

- synthesize information
- derive insights
- detect the expected and discover the unexpected
- understandable assessments
- communicate effectively
- focused on policy actions

# Visual Explanations

Tufte (1997)

Reasoning about Evidence and Design of Graphics

- documenting sources (metadata)
- appropriate comparisons
- quantify and show cause and effect
- multivariate nature of analytic problems
- evaluate alternative explanations

# Choropleth Map

## Map Counterpart of Histogram

- values for discrete spatial units
- choros from choros (region) NOT chloro

## Discrete Approximations

- intervals
- continuous shading

# Map Design Issues

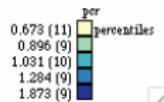
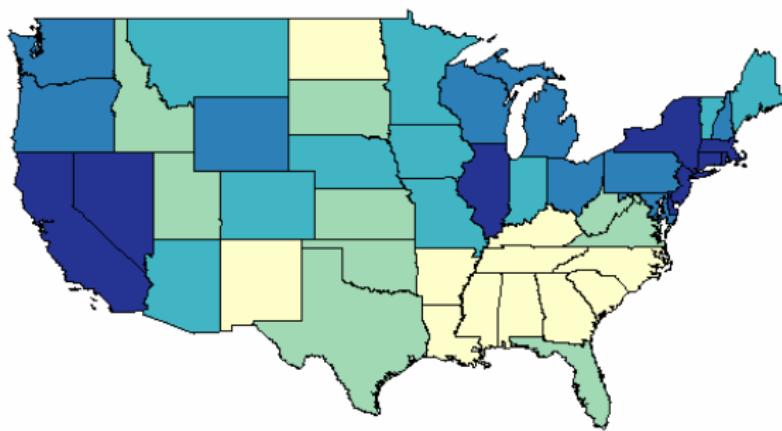
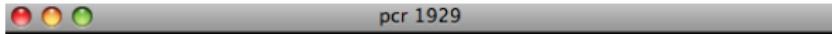
## Choice of Intervals

- cut points: equal interval, natural breaks
- statistical criteria: equal area (quantile)

## Choice of Colors

- important for perception of pattern

# Income Quintiles

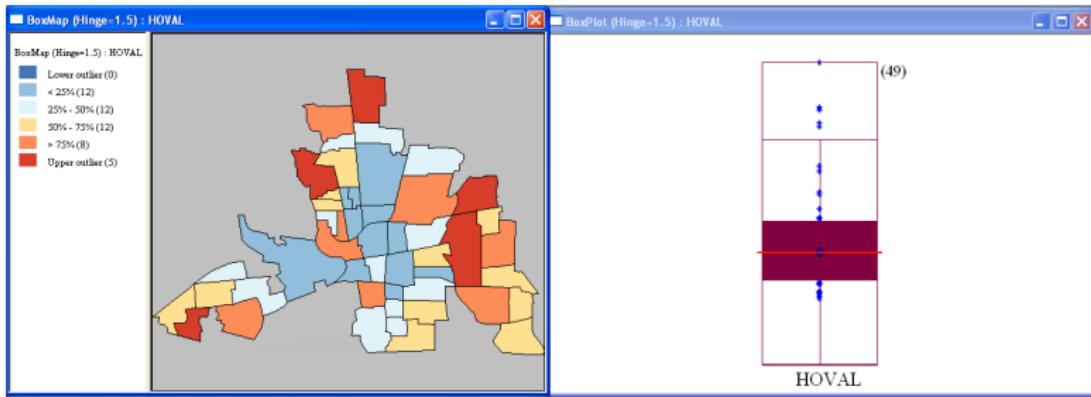


# Outlier Map

## Box Map

- Special Quartile Map
- Outliers Highighlited
  - same criteria as a box plot
  - outliers added as extra categories
  - six instead of four categories
- Both Magnitude and Location

# Box Map



# Special Maps

- Cartogram
- Conditional Maps
- Map Animation

# Cartogram

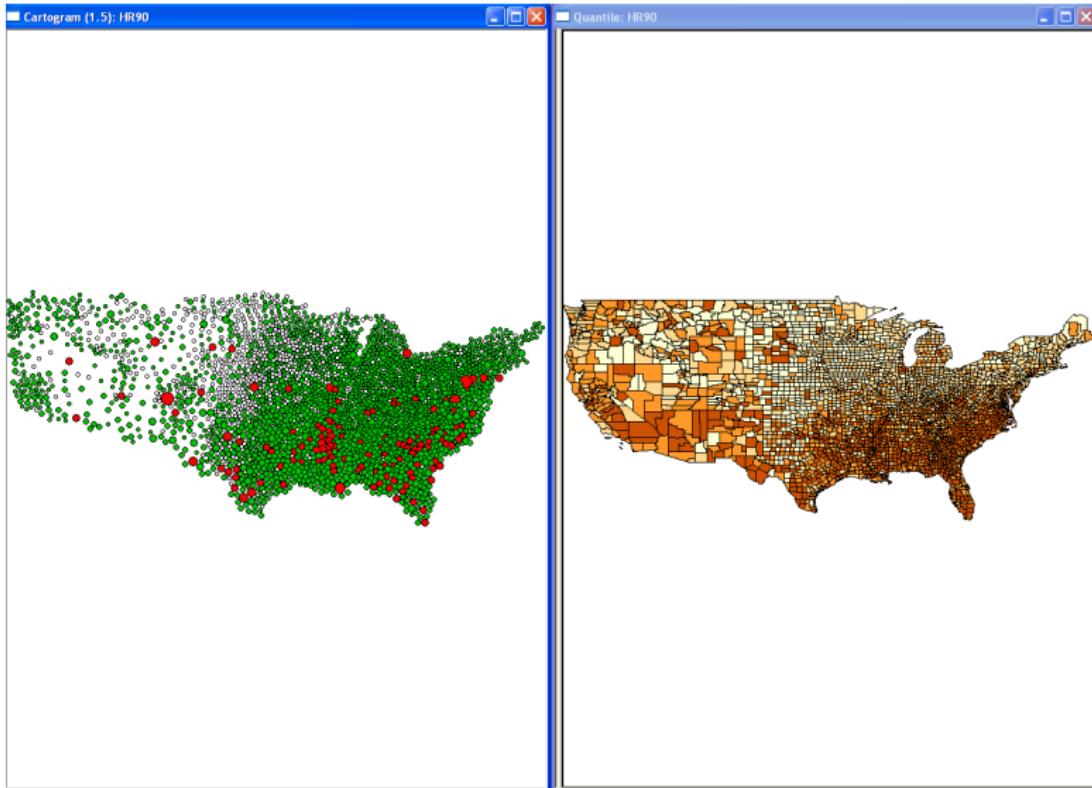
## Objectives

- Correct for misleading effect of area
  - larger area units draw attention
  - change layout to reflect size other than area
- Respect topology

## Circular Cartogram

- variable maps to area/radius of circle

# Cartogram



# Conditional Maps

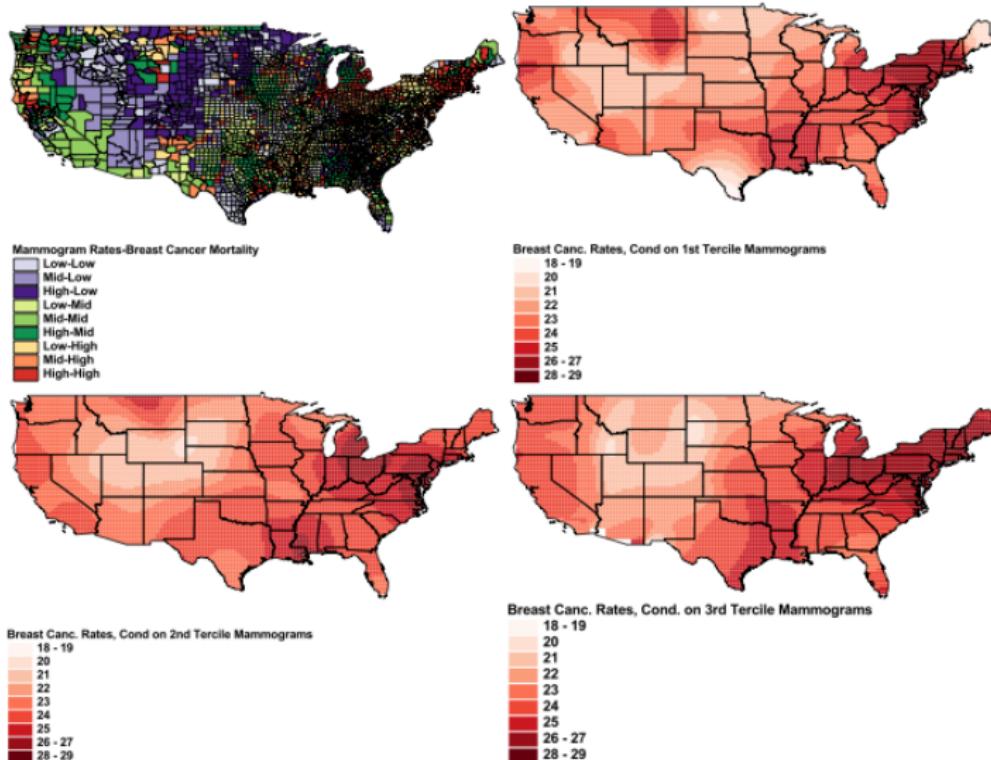
## Conditional Choropleth Map (Carr)

- Special case of conditional plots
- trellis graphs

## Conditioning

- along two dimensions (variables)
- micromap matrix
- choropleth map on dependent variable

# Conditional Choropleth: Univariate Conditioning



# Conditional Choropleth: Bivariate Conditioning

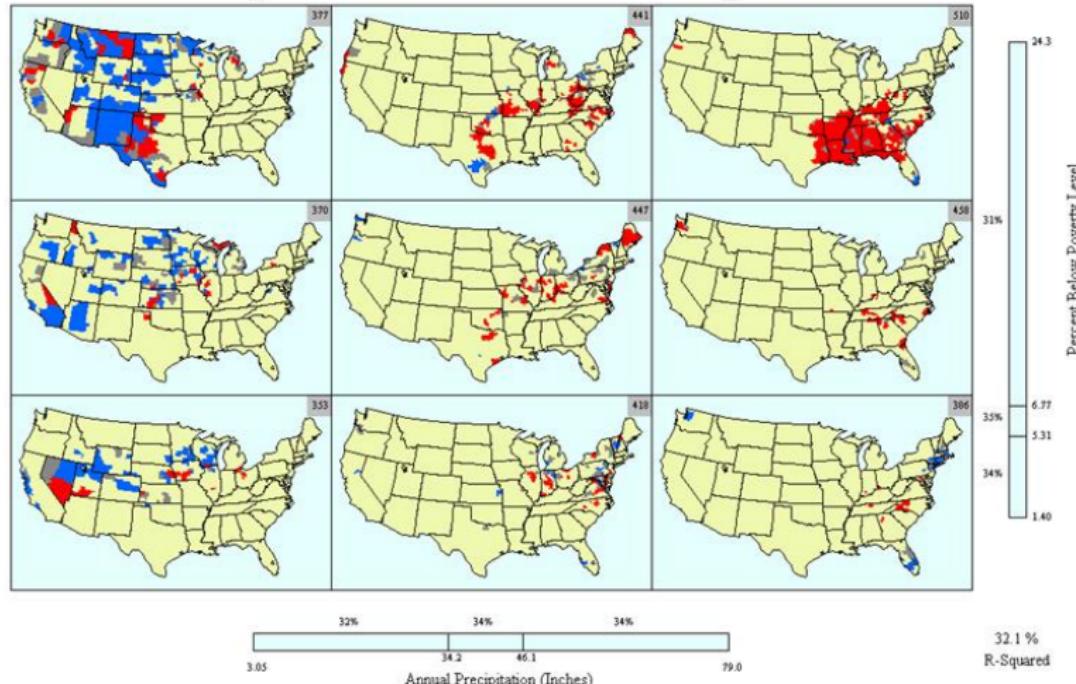
White Males Ages 65-74  
1988-1992  
Regions: Health Service Areas

Lung Cancer Mortality Rate (Deaths Per 100,000)

34% 32% 34%

63.7 375 443 893

Weight: Population  
Statist. Med. 2000;19:2521-2538  
Contact Dan Carr: dcarr@gmu.edu



# Map Animation

## Map Movie

- location highlighted in turn
- from low value to high value

## Looking for pattern

- spatial heterogeneity
- systematic movements/locations

# Map Animation

Demo

## Interactive View Manipulation

- the analyst interacts with the data
- dynamic graphics
- no longer passive

# Linking and Brushing

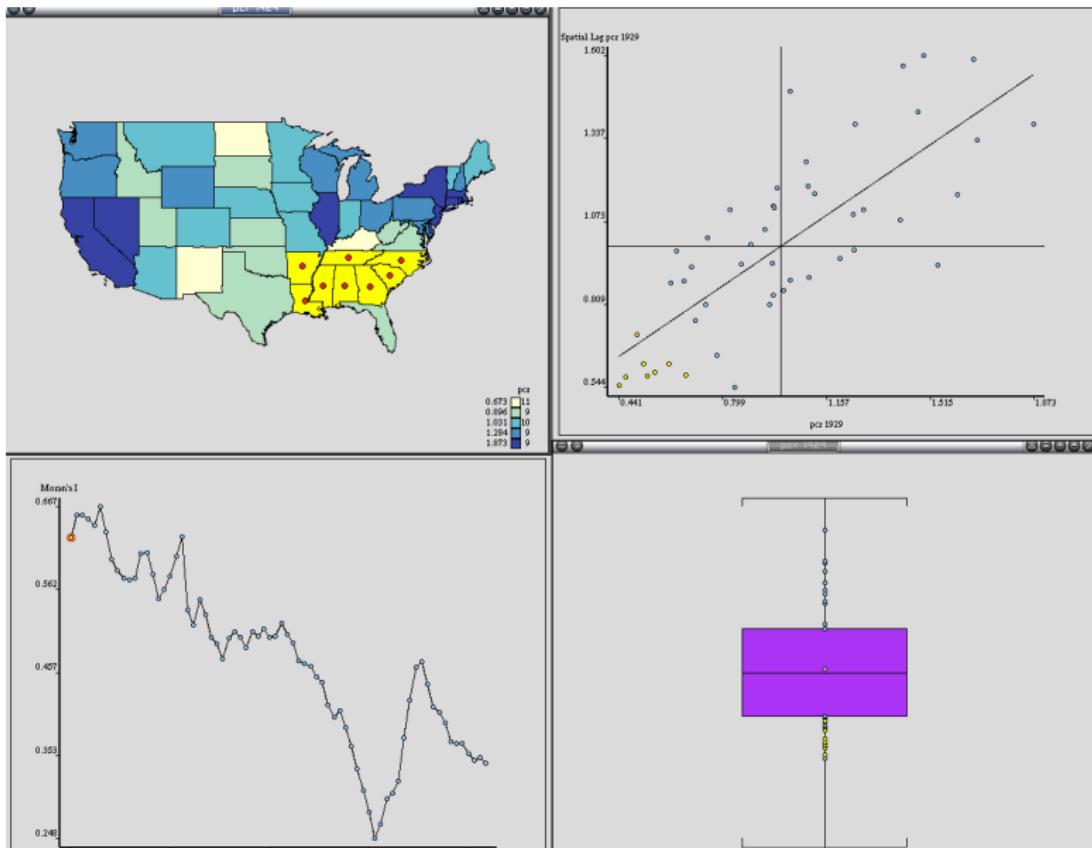
## Linking

- selection in one graph is simultaneously selected in all graphs

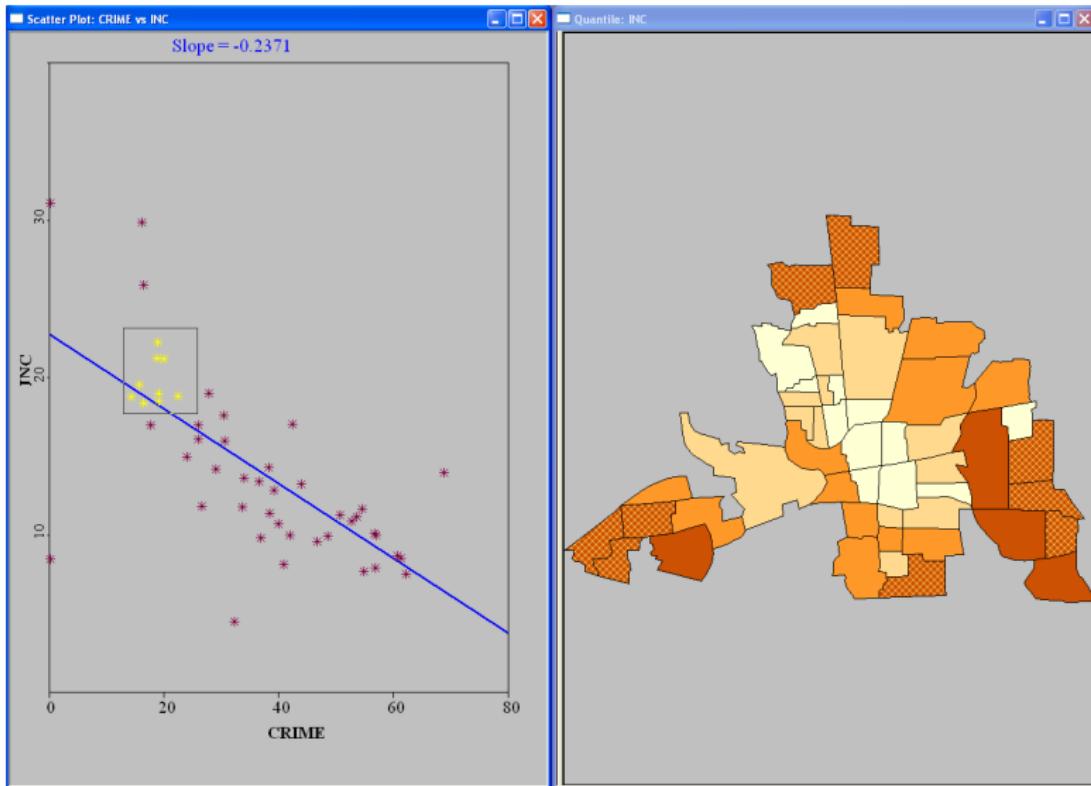
## Brushing

- changing the selection set is dynamically updated in all graphs and maps

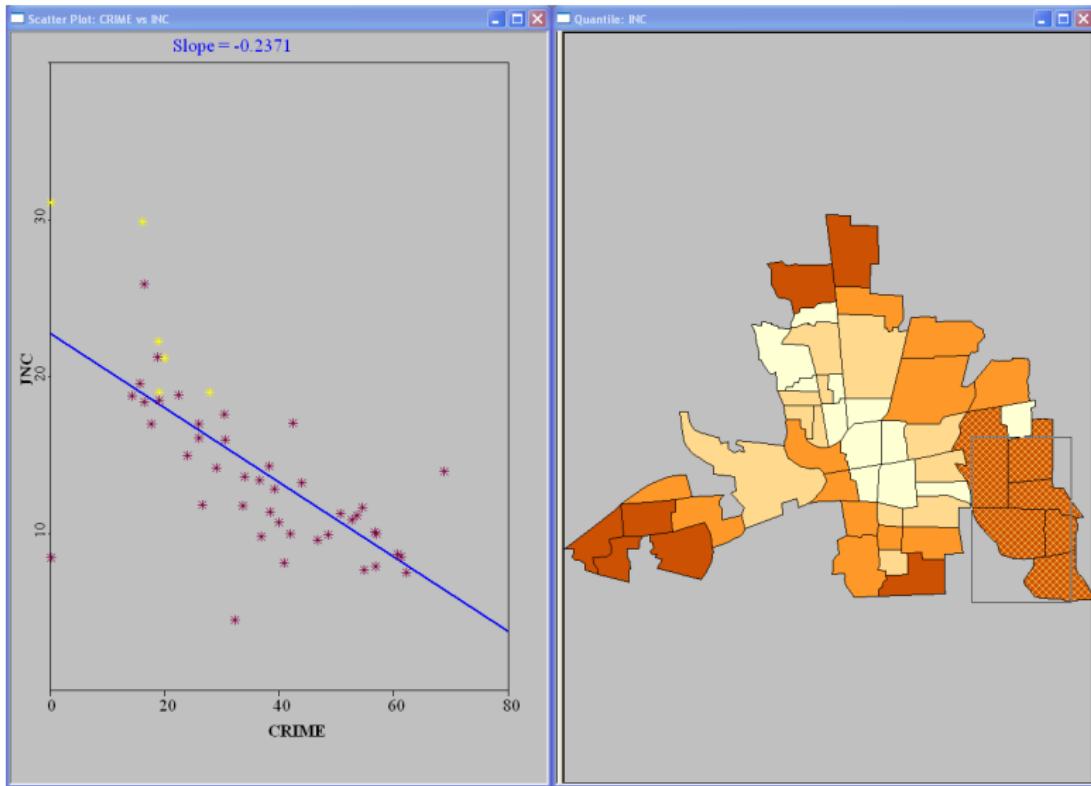
# Linking



# Brushing a Scatter Plot



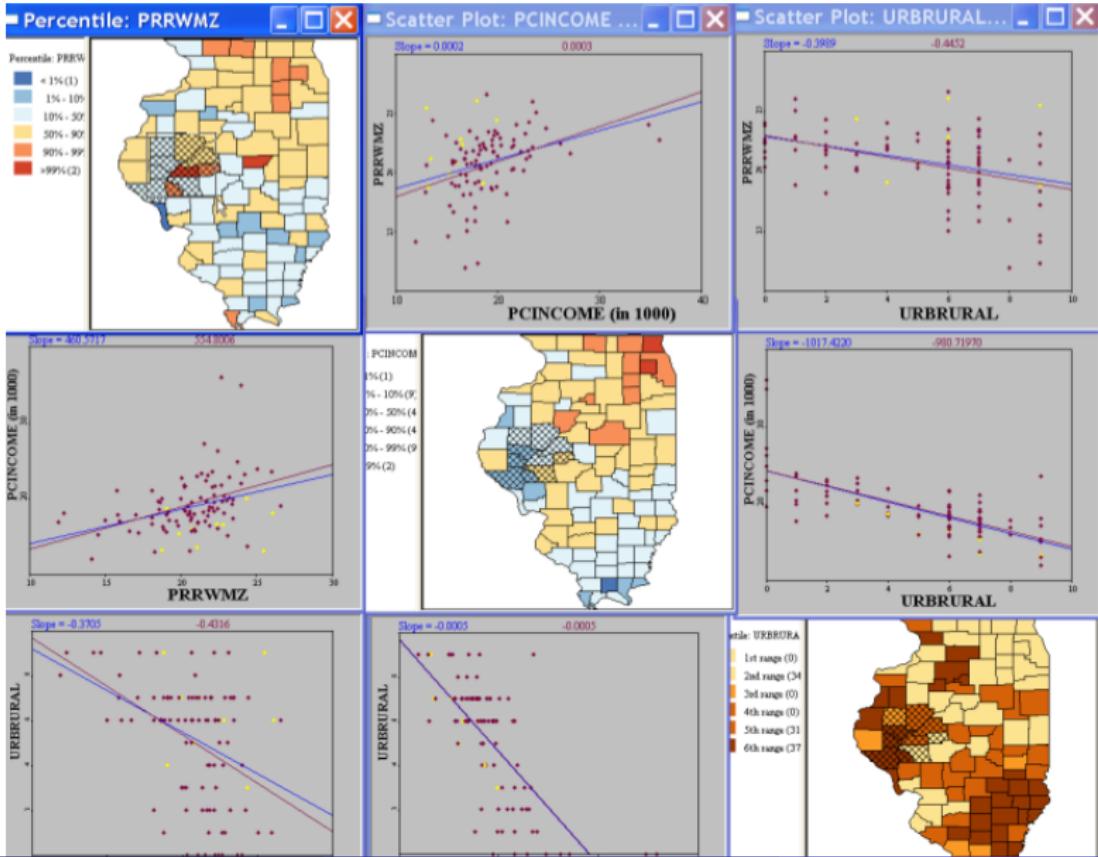
# Brushing a Map



# Multivariate EDA

- Scatter Plot Matrix
- Parallel Coordinate Plot
- 3-D Scatter Plot

# Scatter Plot Matrix



# Brushing a Parallel Coordinate Plot



# Brushing in 3-D

