

# Introduction to Geographic Information Analysis

SERGIO REY

**GPH 483/598**

**Geographic Information Analysis**

School of Geographical Sciences and Urban Planning  
Arizona State University  
Fall 2010

# Outline

## 1 Course Introduction

- Objectives
- Content and Structure

## 2 Logistics

- Grading
- Readings
- Software

## 3 GIS and Spatial Analysis

- Big Picture
- What is Spatial Analysis?

## 4 EDA and ESDA

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

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# Course Objectives

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

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## Four Sections

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

# Part I: Introduction

Month	Date	Topic/Readings	Out	Due
Jan	20 27	Introduction to Geographic Information Analysis GIA 1, GA 1 Spatial Data GIA 2,3, GA 2,4	Exercise 1	

## Part II: Point Patterns

Month	Date	Topic/Readings	Out	Due
Feb	3	Point Pattern Basics GIA 4	Project	
	10	Point Pattern Processes GIA 5	Exercise 2	Exercise 1
	17	Quadrat and Distance Based Methods GA p 211-221		
	24	Advanced Point Patterns ASD 7	Data Proposals	Exercise 2

# Part III: Lattice Data

Month	Date	Topic/Readings	Out	Due
Mar	3	Lattice Data Basics GIA 7	Exercise 3	
	10	Spatial Weights Anselin and Rey (2010)		Data Approval
	17	Spring Break		
	24	Global Autocorrelation GA p 222-234	Exercise 4	Exercise 3
	31	Local Autocorrelation GIA p 203-208, GA p 234-238		

## Part IV: Geostatistical Data

Month	Date	Topic/Readings	Out	Due
Apr	7	Geostatistics Basics GIA 8	Exercise 5	Exercise 4
	14	Variography GA 6, ASD p 191-208		
	21	Kriging GIA 9, ASD p 208-226		
	28	Future Directions		Exercise 5
May	5			Projects
	12			Presentations

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# Grading

Grading will be assigned on the following scale: A: 90-100, B: 80-89, C:70-79, D: 60-69, F below 60. There will be no curves and no extra credit. I will assign +/- on an individual basis. Points are assigned as follows:

Component	Points	
	Undergraduate	Graduate
Exercises	40	30
Project	40	40
Quizzes	20	20
Presentations		10
<b>TOTAL</b>	<b>100</b>	<b>100</b>

# 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 article synopsis
- present final project

# 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 CoorL 1-18. The first part of each weekly meeting will focus on background and theoretical material related to the particular type of spatial data analysis. Following a short break, the attention will shift to introduce various software packages for the analysis of spatial data.

## Classroom etiquette

To ensure a productive learning environment, all participants are expected to abide by the following rules:

- Because we are meeting in a computer laboratory food is strictly forbidden in the class meetings.
- Use of the classroom computers should only be in support of the course. Extracurricular use (i.e., browsing non-course materials, using social networks, checking email, chat sessions, etc) during class meetings is disruptive for your colleagues and disrespectful. Individuals violating this rule will be asked to leave for that course session.

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# Readings

## Textbooks

Assigned readings are listed in the schedule and are to be done prior to class meeting. The majority of these are taken from the following texts:

- GIA** David O'Sullivan and David J. Unwin (2006) *Geographic Information Analysis*, Wiley: Hoboken
- GA** Michael de Smith, Michael F. Goodchild, and Paul A. Longley (2007) *Geospatial Analysis*, Winchelsea Press: Leicester
- ASD** Roger S. Bivand, Edzer J. Pebesma and Virgilio Gómez-Rubio (2008) *Applied Spatial Data Analysis with R*, Springer: New York.

Additional readings will be assigned by topic.

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# Software

**GeoDa**

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

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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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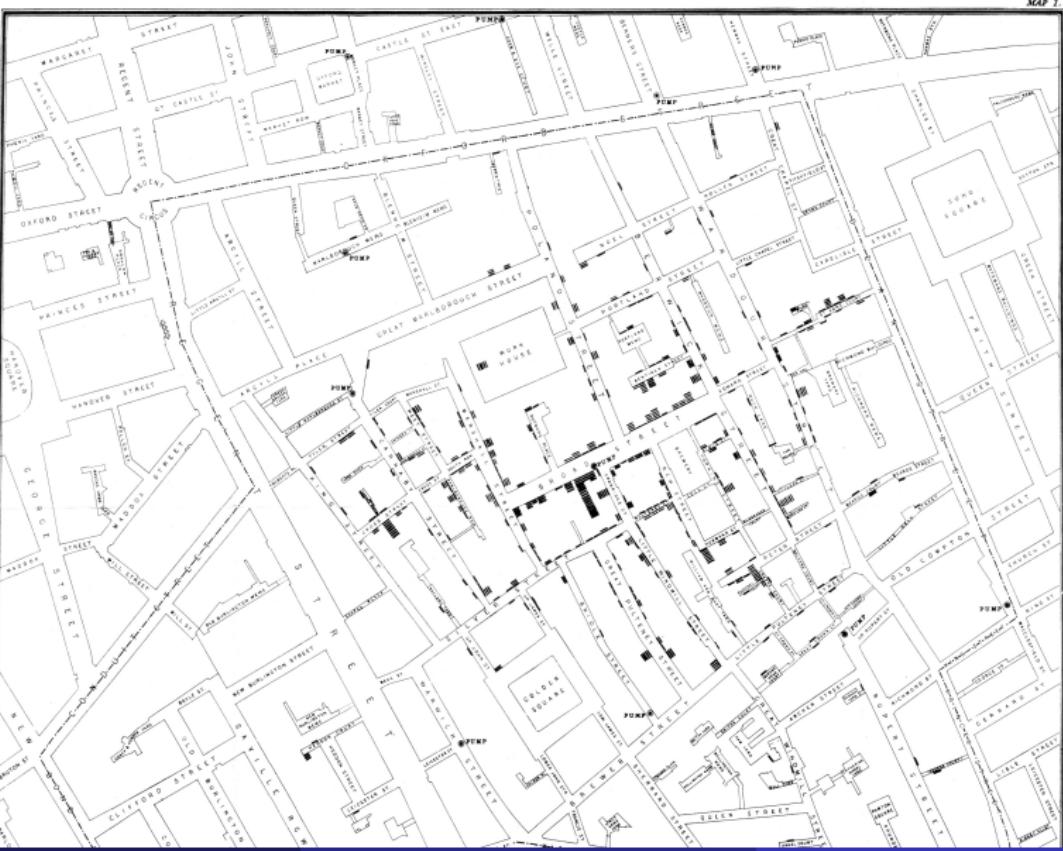
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# GIS Then



# 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

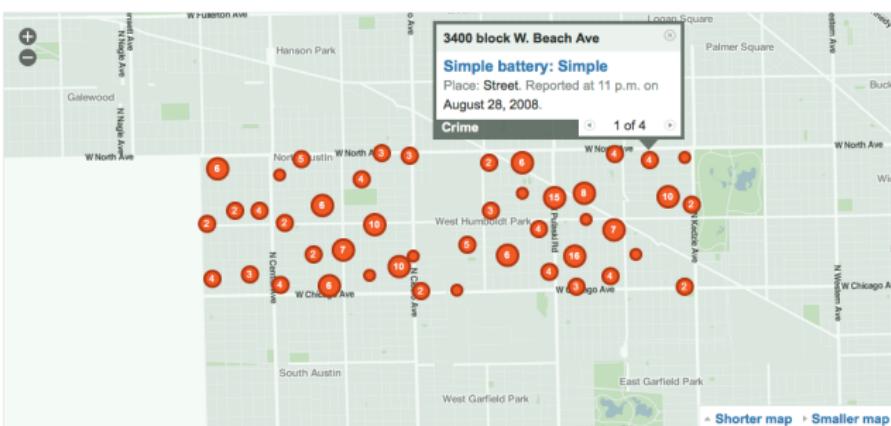
Timeline

By news type

Stay up to date:

Custom RSS feeds

E-mail updates



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**

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# What is Spatial Analysis?

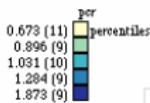
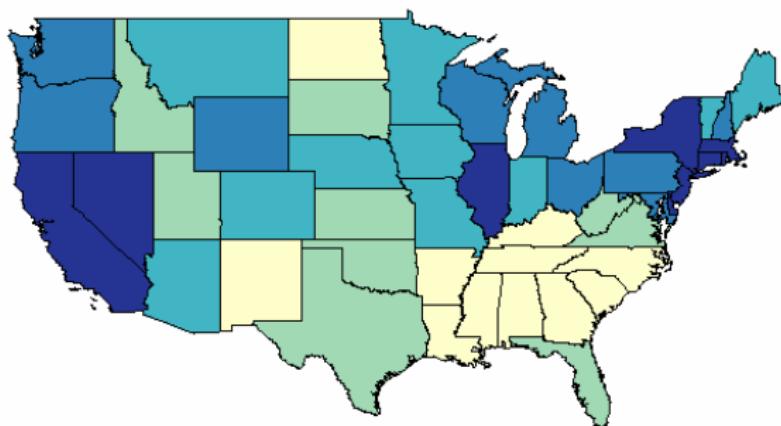
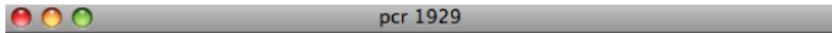
## From Data to Information

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

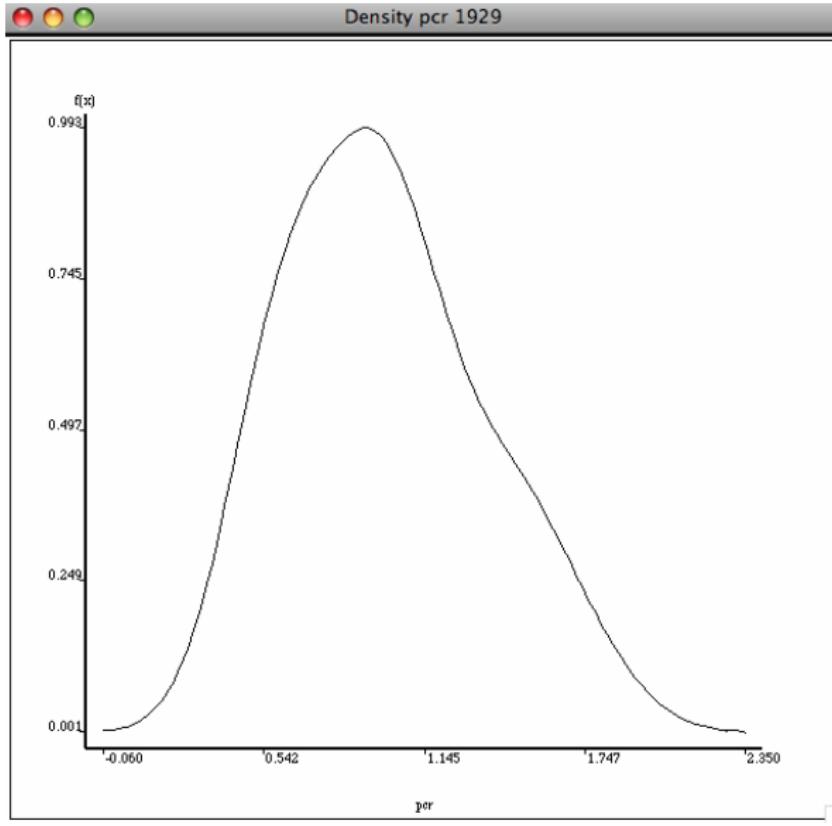
## How Insights Change with location

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

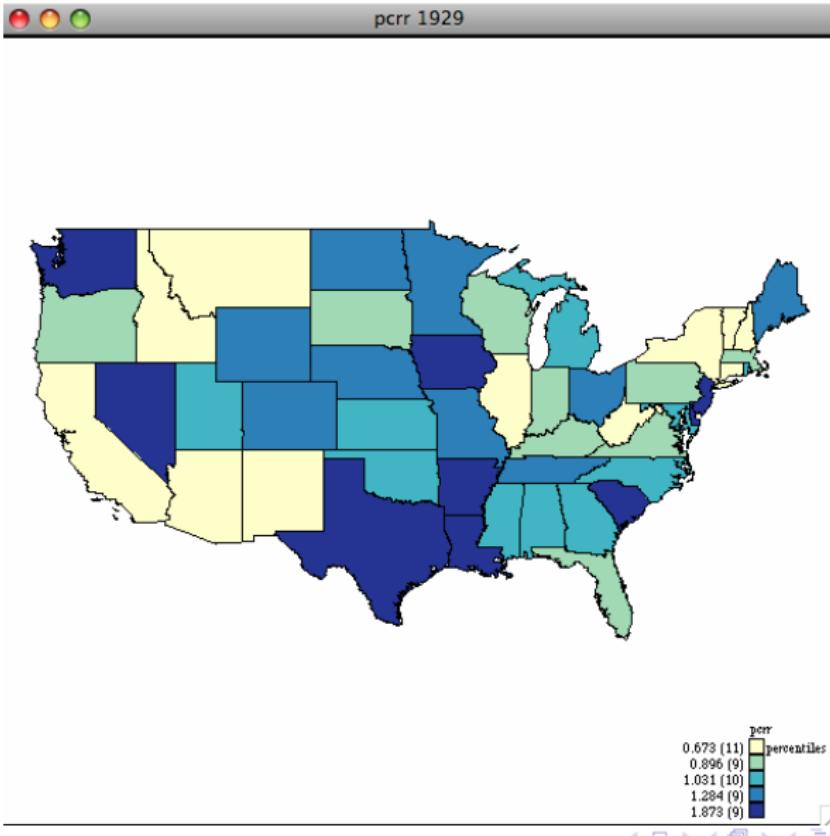
# State Income Distributions 1929



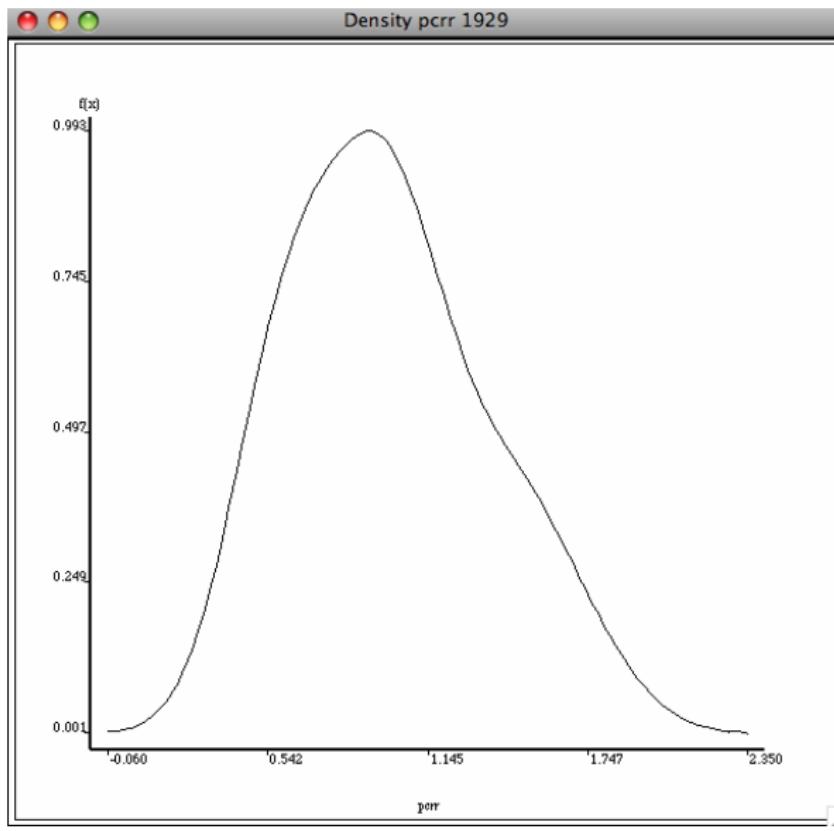
# State Income Distributions 1929



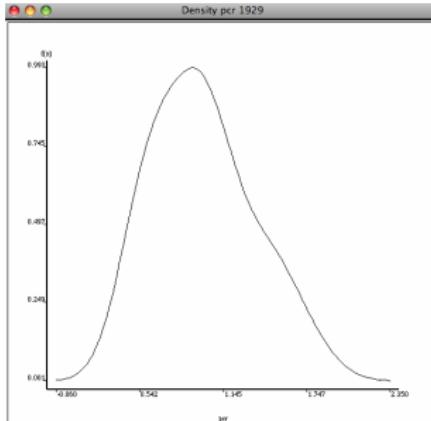
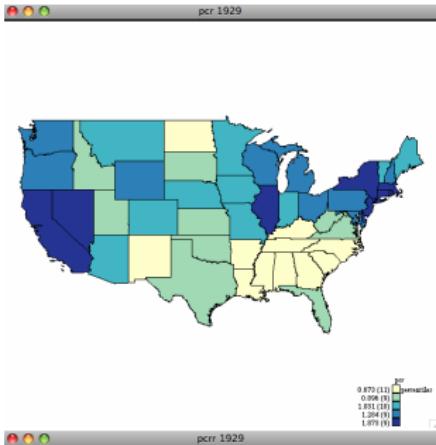
# Randomized Income Distribution 1929



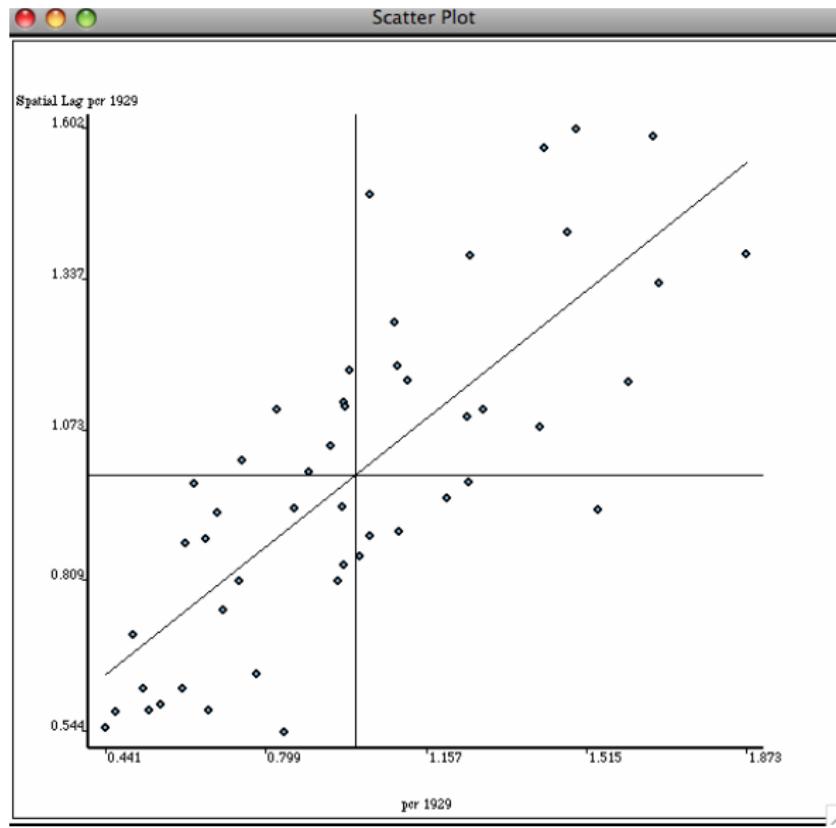
# Randomized Income Density 1929



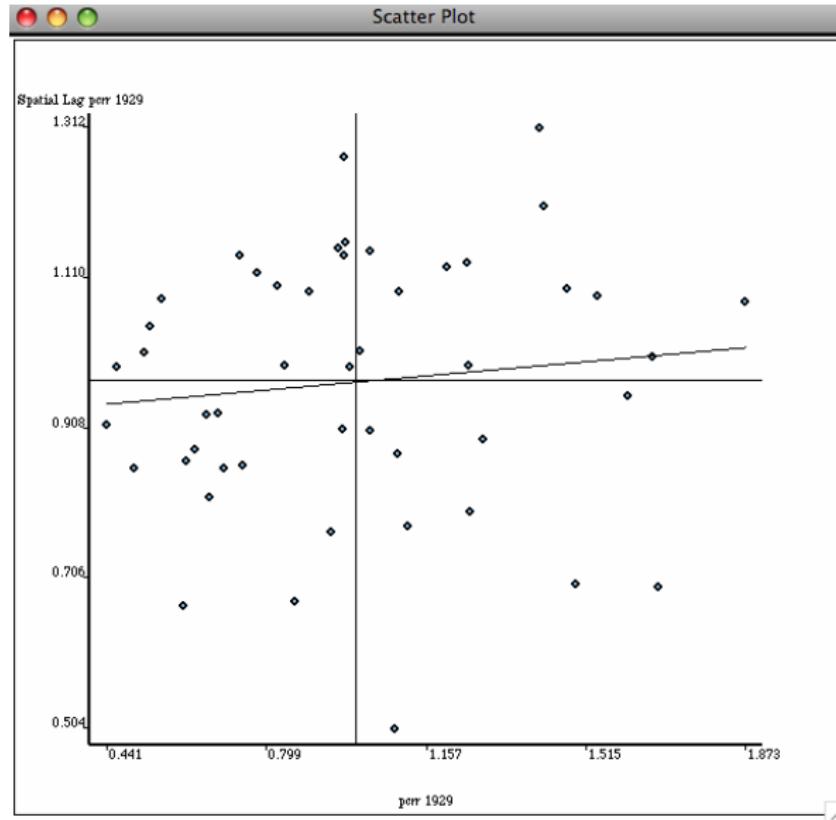
# Locational Invariance



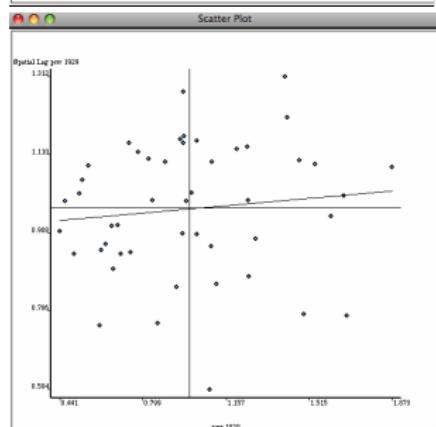
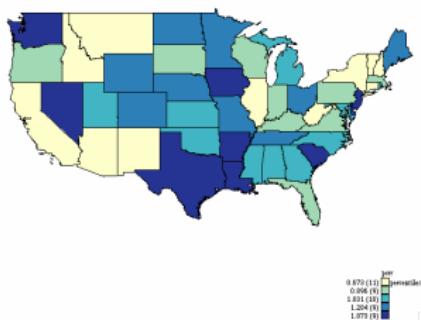
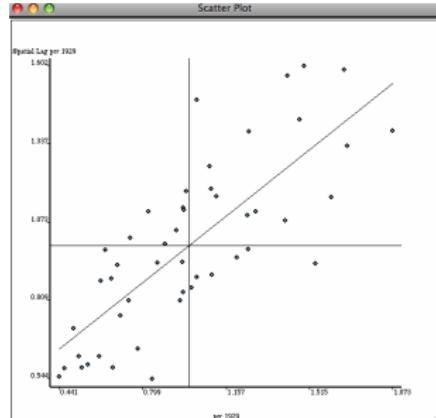
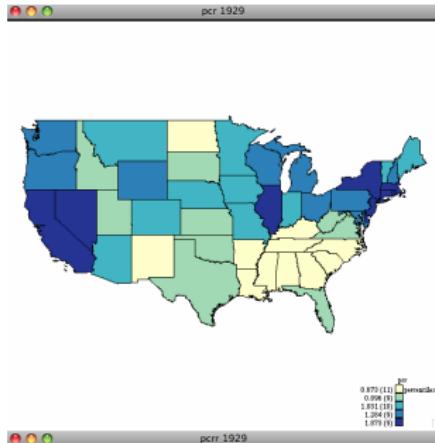
# Spatial Autocorrelation Income 1929



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

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# 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

## 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

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# 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

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## 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
- choro from choros (region) NOT chloro

## Discrete Approximations

- intervals
- continuous shading

# Map Design Issues

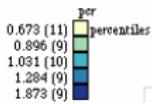
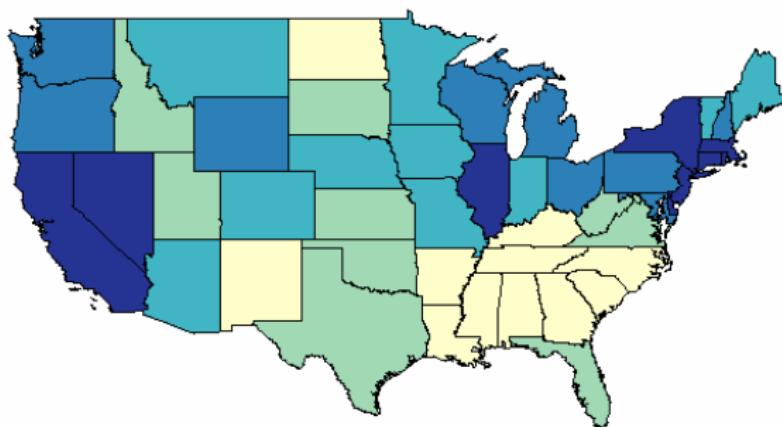
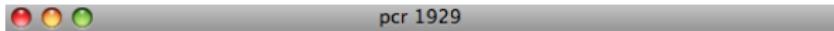
## Choice of Intervals

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

## Choice of Colors

- important for perception of pattern

# Income Quintiles

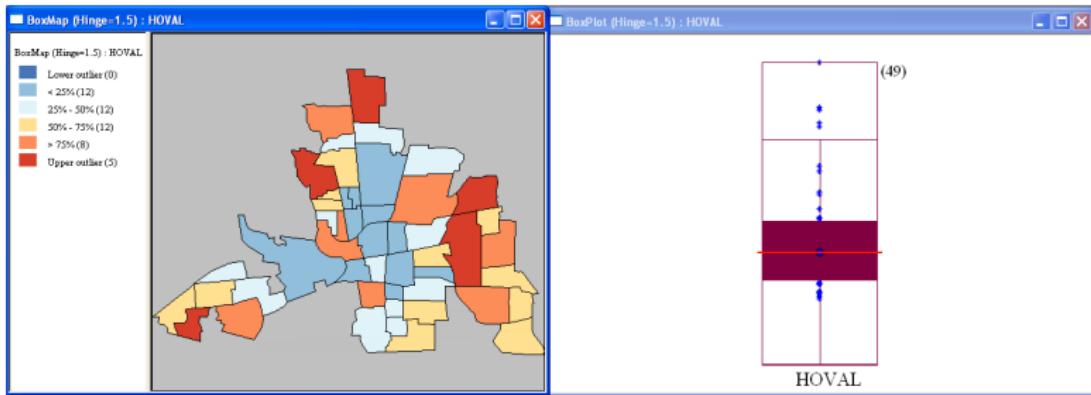


# Outlier Map

## Box Map

- Special Quartile Map
- Outliers Highhlited
  - 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

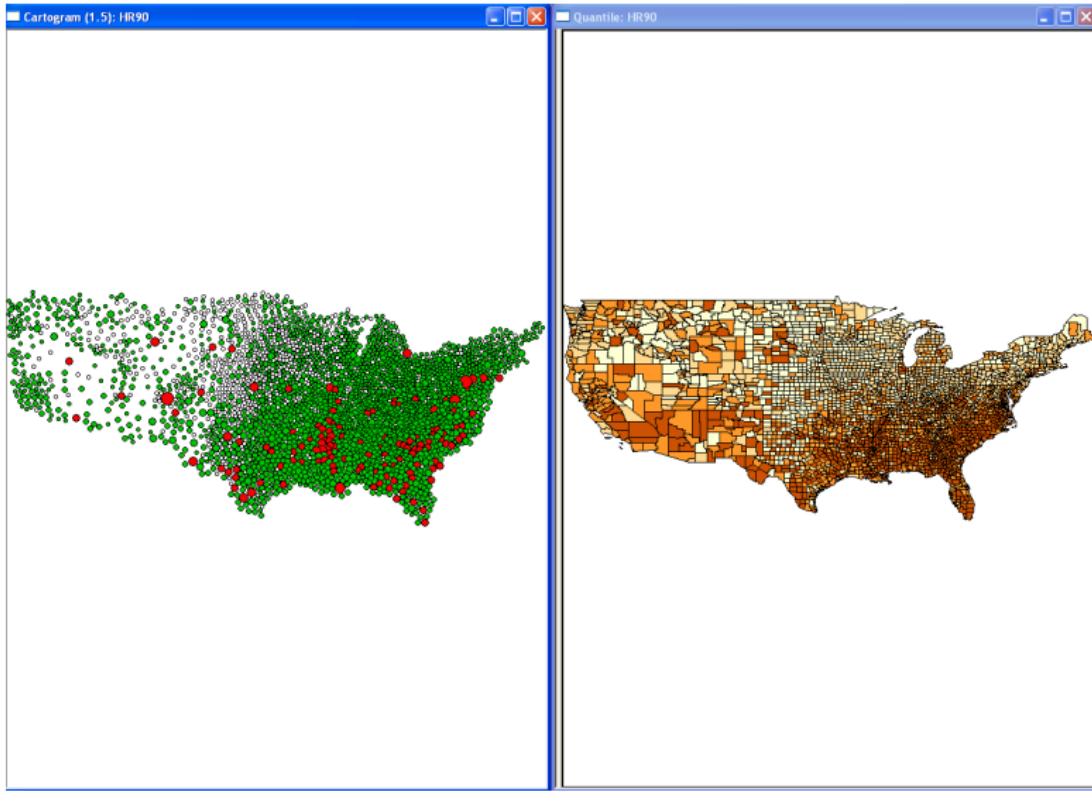
## Objectives

- 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

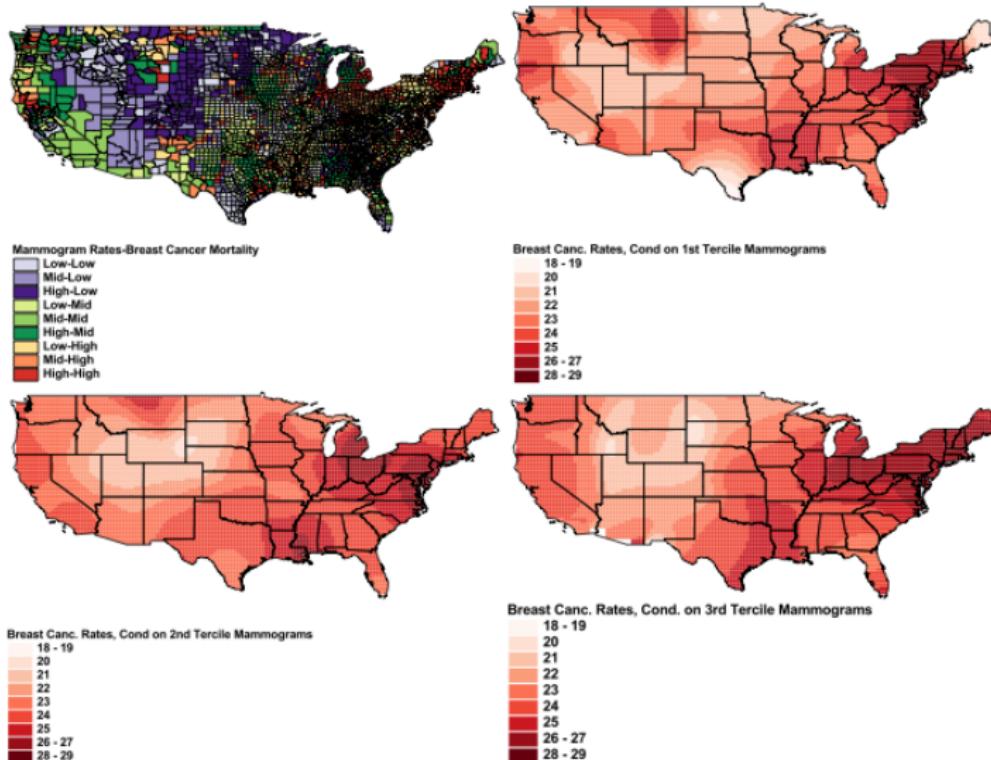
## Conditional Choropleth Map (Carr)

- 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

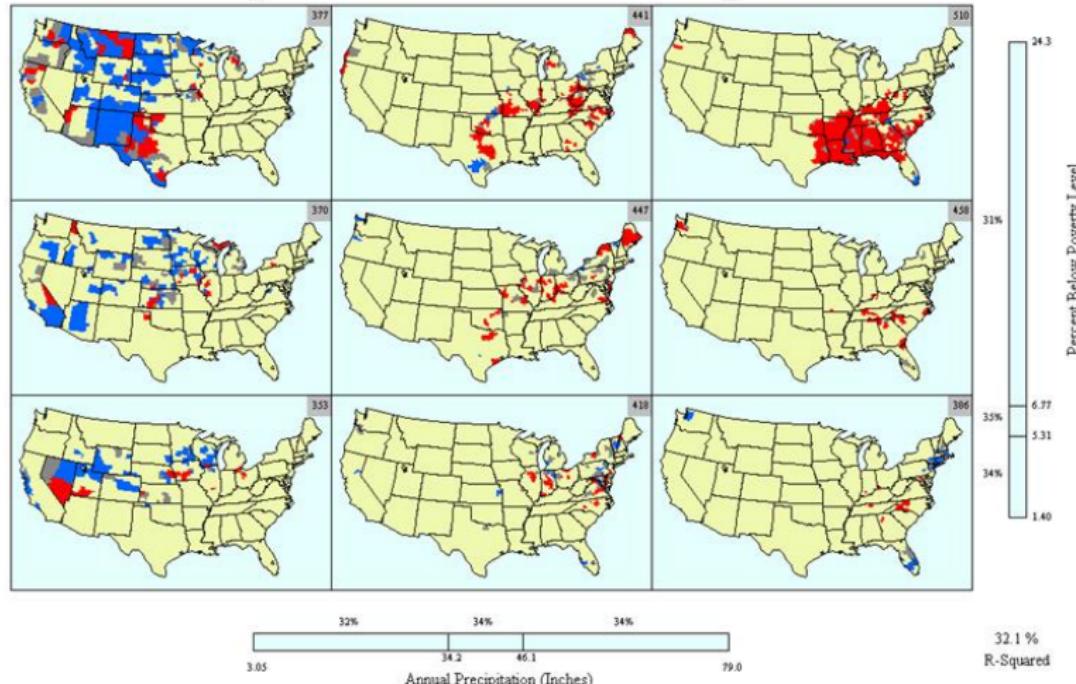
White Males Ages 65-74  
1988-1992  
Regions: Health Service Areas

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

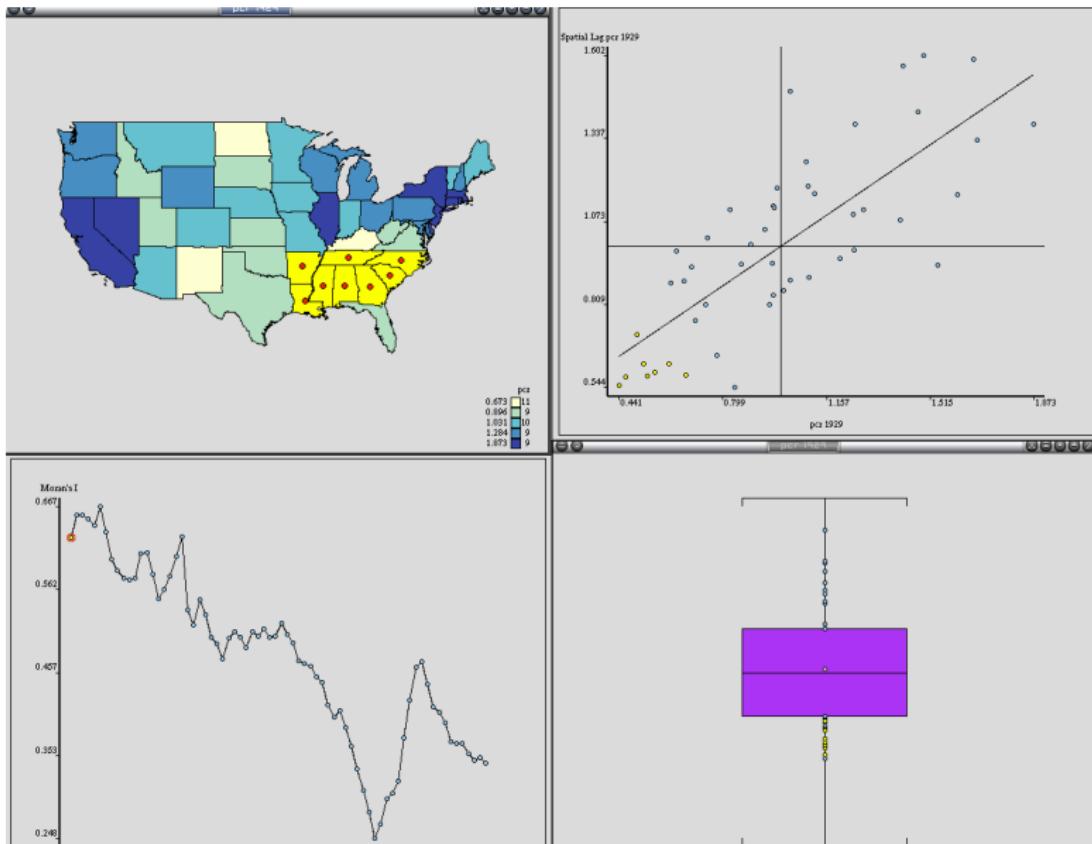
## Linking

- selection in one graph is simultaneously selected in all graphs

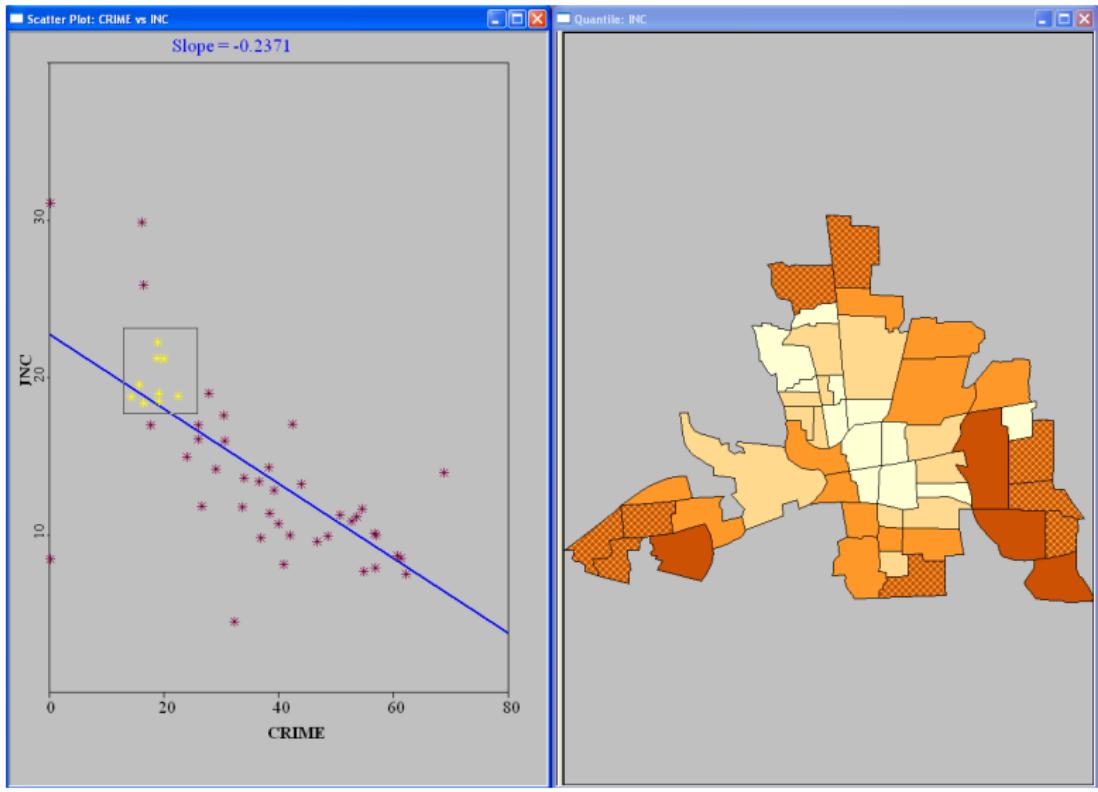
## Brushing

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

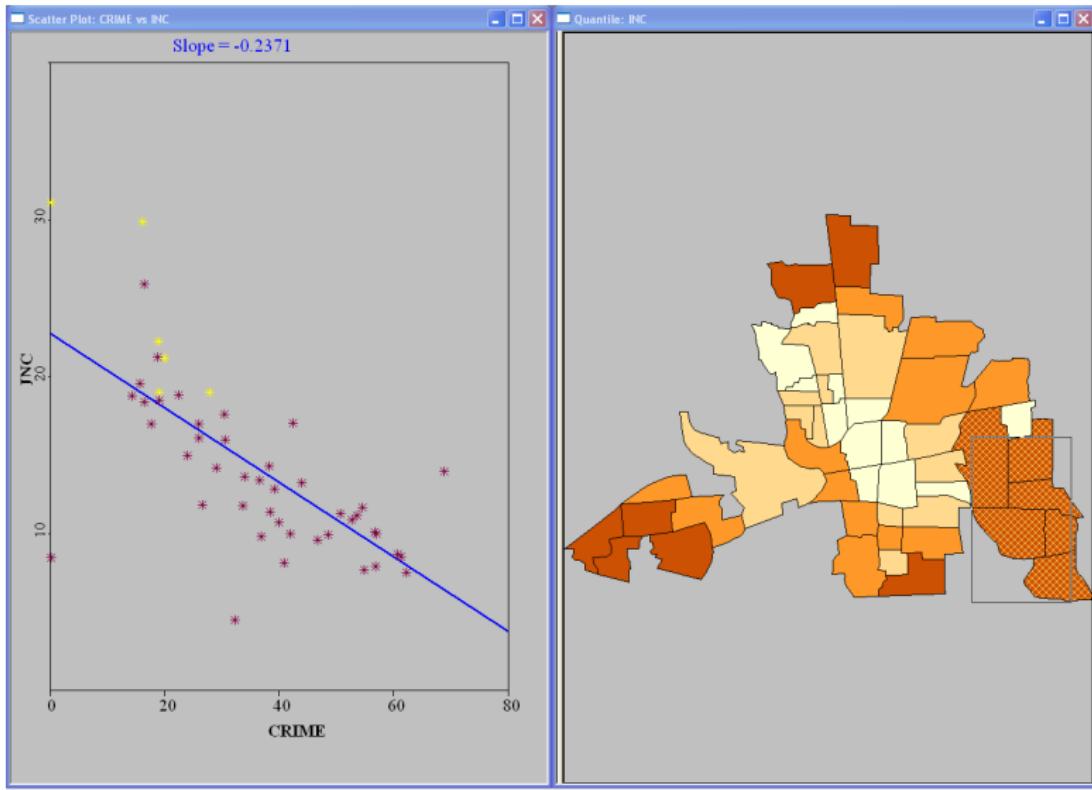
# Linking



# Brushing a Scatter Plot



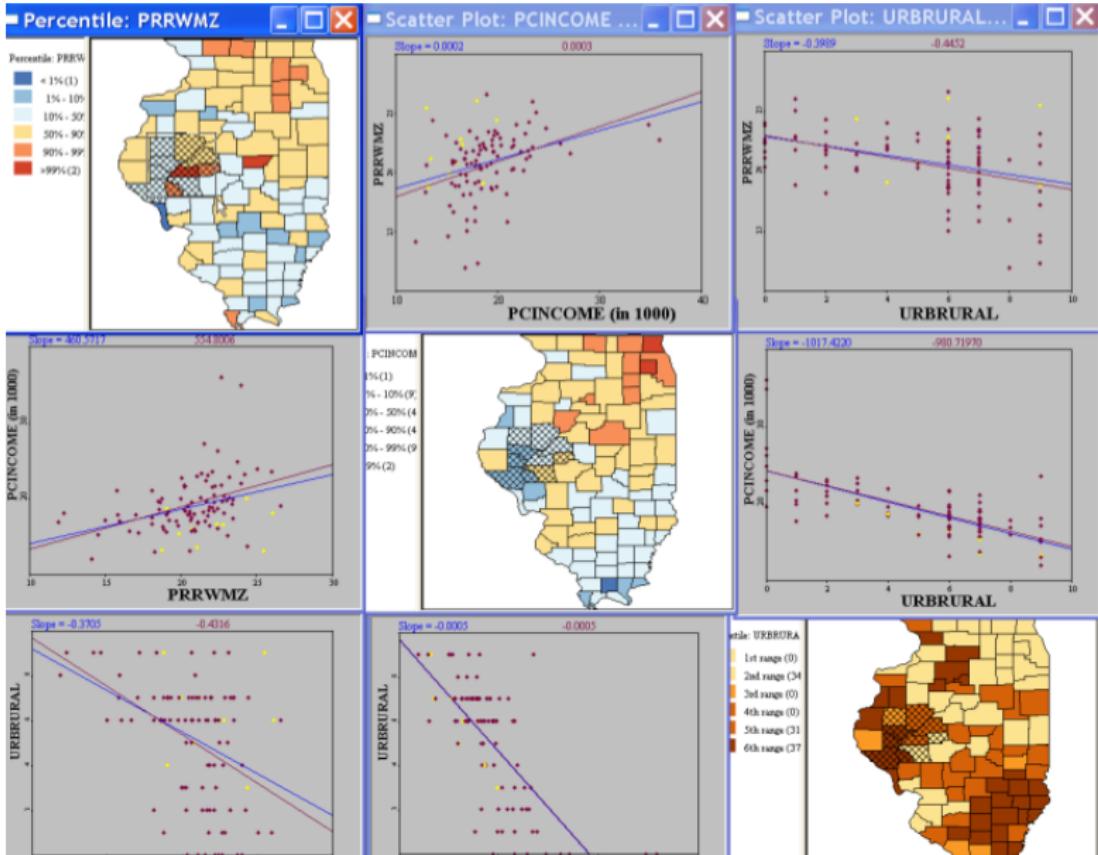
# Brushing a Map



# Multivariate EDA

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

# Scatter Plot Matrix



# Brushing a Parallel Coordinate Plot



# Brushing in 3-D

