Thinking Spatially in the Social Sciences

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Outline

- Contrasting world views
  - location as an attribute
  - GIS
- Six arguments for the importance of space
- CSISS

Location as attribute

- The data table
  - Census summary table
- What value is location as an explanatory variable?
- Linking the table to a boundary file
  - enabling maps of summary data

Tract	Pop	Location	Shape
1	3786	*x*,*y*	
2	2966	*x*,*y*	
3	5001	*x*,*y*	
4	4983	*x*,*y*	
5	4130	*x*,*y*	
6	3229	*x*,*y*	
7	4086	*x*,*y*	
8	3979	*x*,*y*	

Abstraction of geographic space

- Cartograms

- Invariance under rotation, displacement
- Reconstruction from a distance matrix
- Reconstruction from ranked distances
  - ordered metric data (Coombs)

Space as a matrix

- ***W*** where w_{ij} is some measure of interaction
  - adjacency
  - decreasing function of distance
  - invariant under rotation, displacement
  - readily obtained from a GIS

Applications of the *W* matrix

- Spatial regression
  - add spatially lagged terms weighted by ***W***
  - Anselin's SPACESTAT
- Moran and Geary indices of spatial dependence

$$c = \frac{(n-1)\sum_i \sum_j w_{ij}(x_i - x_j)^2}{2\sum_i \sum_j w_{ij} \sum_i (x_i - a)^2}$$

The location-as-attribute world view

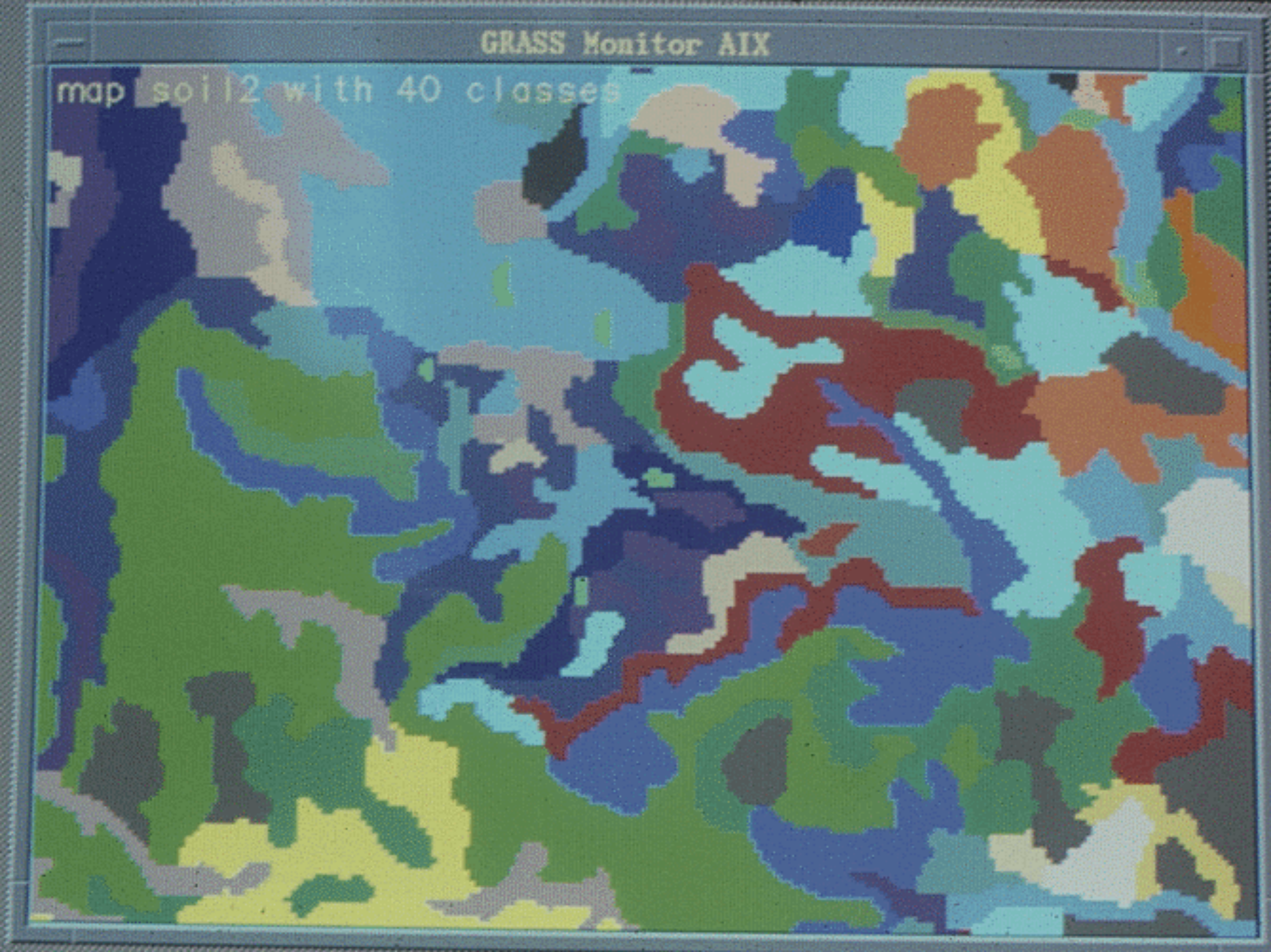
- Objective: scientific explanation, understanding of social processes
  - is location an explanatory factor?
- Relative location as expressed in the ***W*** matrix
  - a surrogate for spatial interaction
  - reflecting costs of transport, probability of interaction and acquaintance, probability of migration or travel, probability of seed dispersal
  - compare social network theory

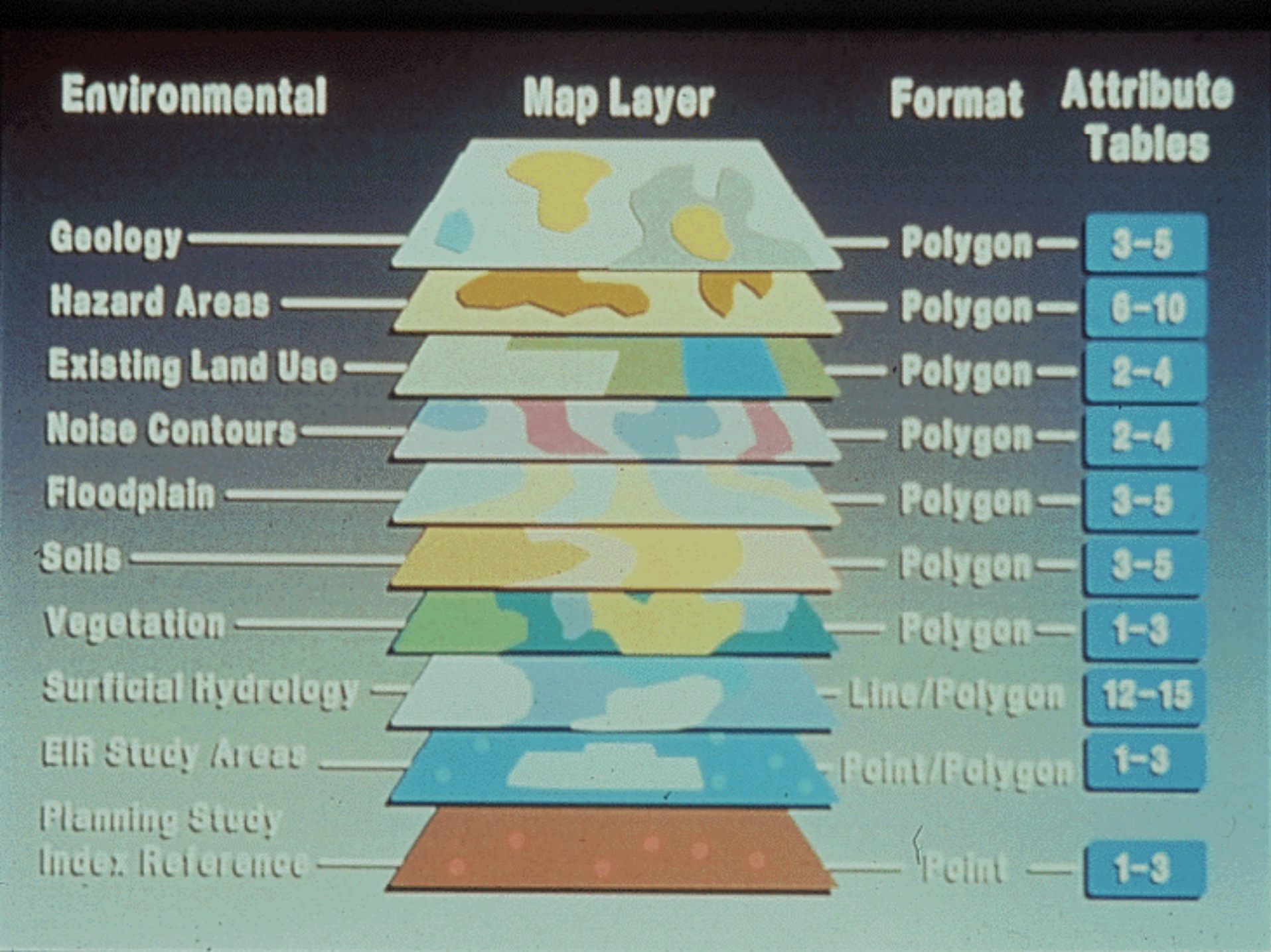
Geographic information systems

- Systems to acquire, store, transform, analyze, display, share, archive geographic information
- Geographic information
  - information about the specific characteristics of places on or near the Earth's surface
  - <***x***,***z***> where ***x*** is a location in space-time and ***z*** is some set of general properties

Origins of GIS

- The Canada Geographic Information System
  - circa 1965
  - support for the Canada Land Inventory
  - $20 million investment by the Government of Canada
  - justified by accurate cost-benefit analysis


GRASS Monitor AIX
map soil2 with 40 classes


Environmental
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Surficial Hydrology
EIR Study Areas
Planning Study Index Reference
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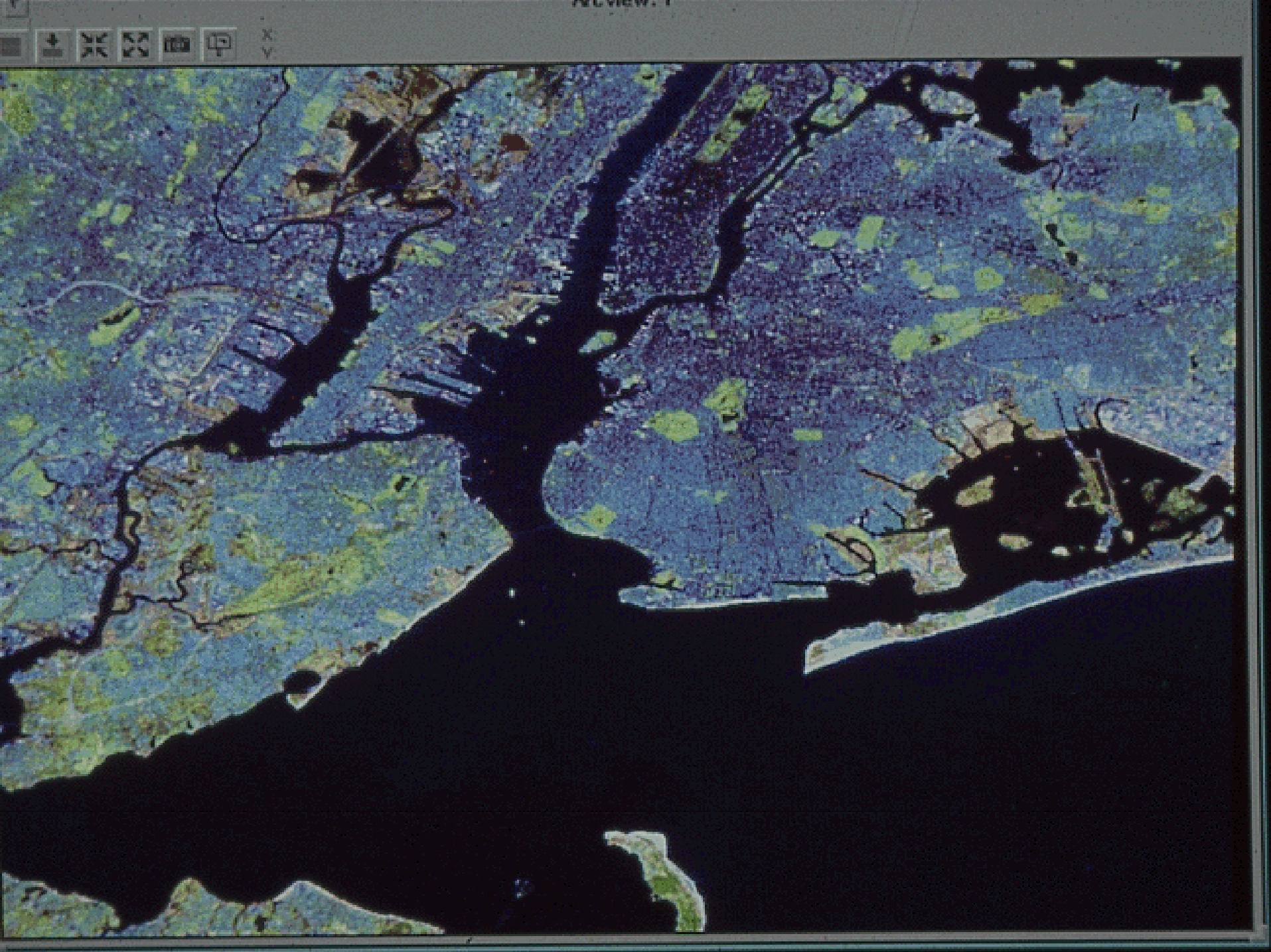
1-3

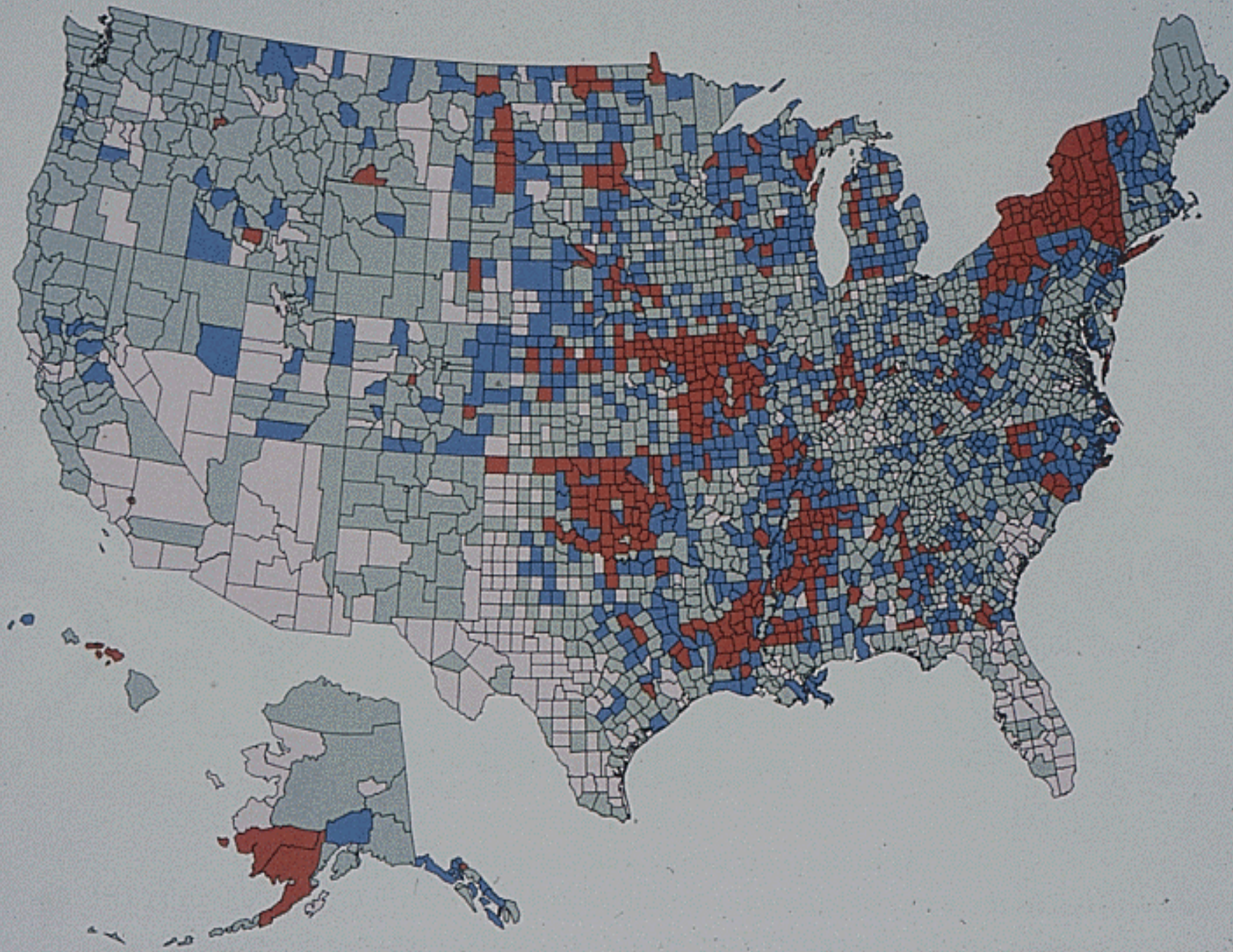
Objectives of GIS

- Mapping and inventory
  - representing the contents of the Earth's surface
  - using space (and time) as the organizing dimensions
- Design
  - formulation, evaluation of future scenarios
- Support for science
  - search for pattern, anomalies, hypotheses, explanation
  - integrating layers of data
  - geographic context

Definitions

- Spatial data
  - information about phenomena organized in a spatial frame
  - the geographic frame
- Spatial analysis
  - methods applied to spatial data that
    - add value
    - reveal patterns and anomalies
    - support decisions





The role of the GIS

- The infrastructure for handling data types
  - to spatial data as Excel is to tables, as S-Plus is to statistical data, as Word is to text
  - spatial data or geographic data?
  - the housekeeper
  - the editor
- The visualization tool

The GIS data types

- Discrete geographic features
  - points, lines, areas
  - the contents of maps
  - with associated attributes
  - countable
  - conceived as tables with associated feature geometry

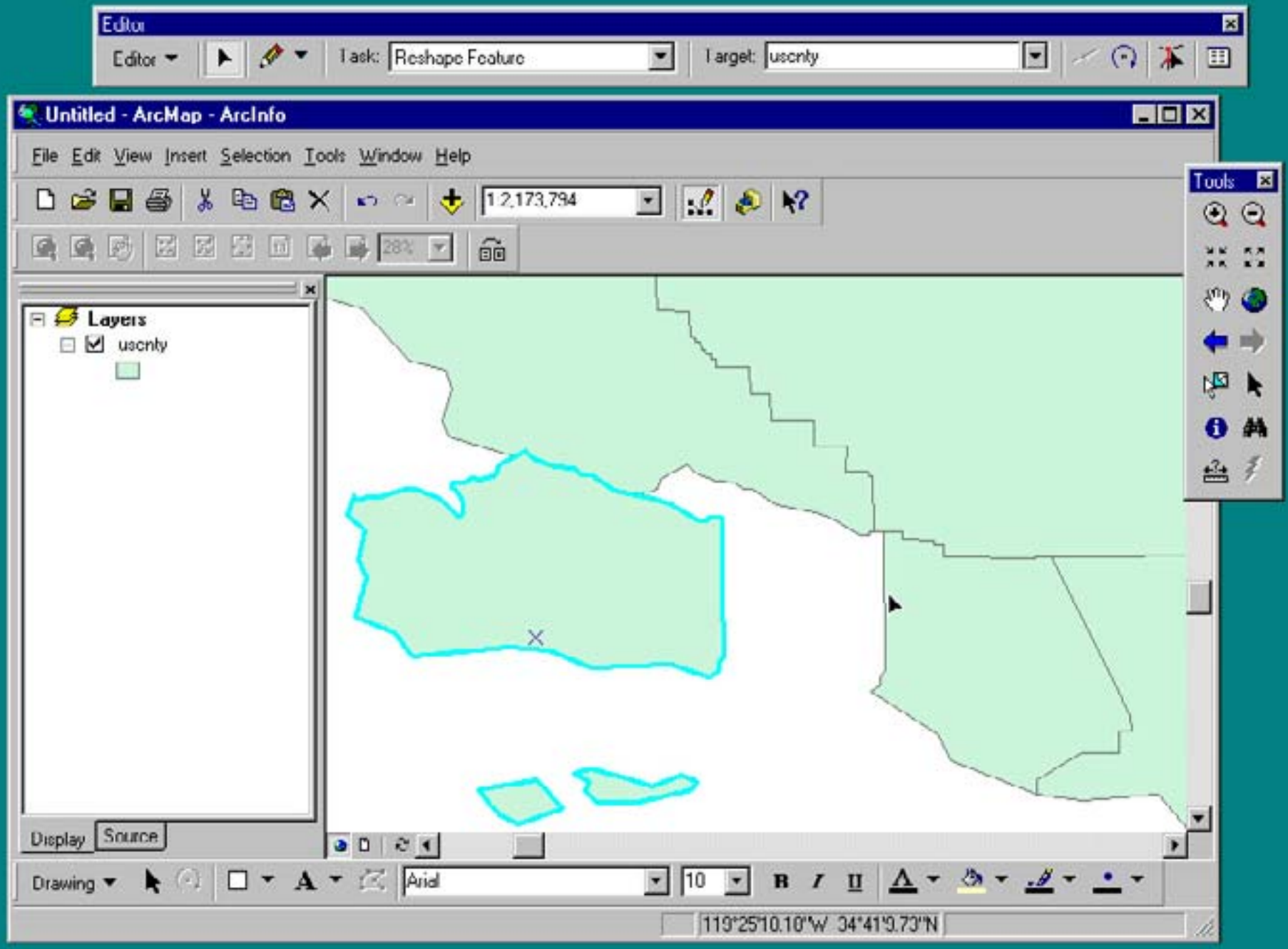
Scottish Munros

1.. Ben Hope
2.. Ben Klibreck
3..Ben More Assynt
4..An Teallach
5..Seana Bhraigh
6..Ben Wyvis
7..Slioch
8..Sgorr Ruadh
9..Moruisg
10..Sgurr na Ruaidhe
11..Bia Bheinn
12..Sgurr na Lapaich
13..Ben Attow
14..The Saddle
15..Creag a' Mhaim
16..Ladhar Bheinn

17..Coireachan
18..Ben Nevis
19..Ben More
20..Ben Starav
21..Braeriach
22..Ben Avon
23..Meall Chuaich
24..Mt Keen
25..Deinn Dearg
26..Glas Maol
27..Driesh
28..Schiehallion
29..Ben Chonzie
30..Ben Lawers
30..Ben Challum
32..Ben Lomond

Fields

- Geography as a collection of continuous variables
  - measured on nominal, ordinal, interval, ratio scales
  - vector fields of direction and magnitude
  - exactly one value per point
  - $z=f(\mathbf{x})$
  - population density, land ownership, zoning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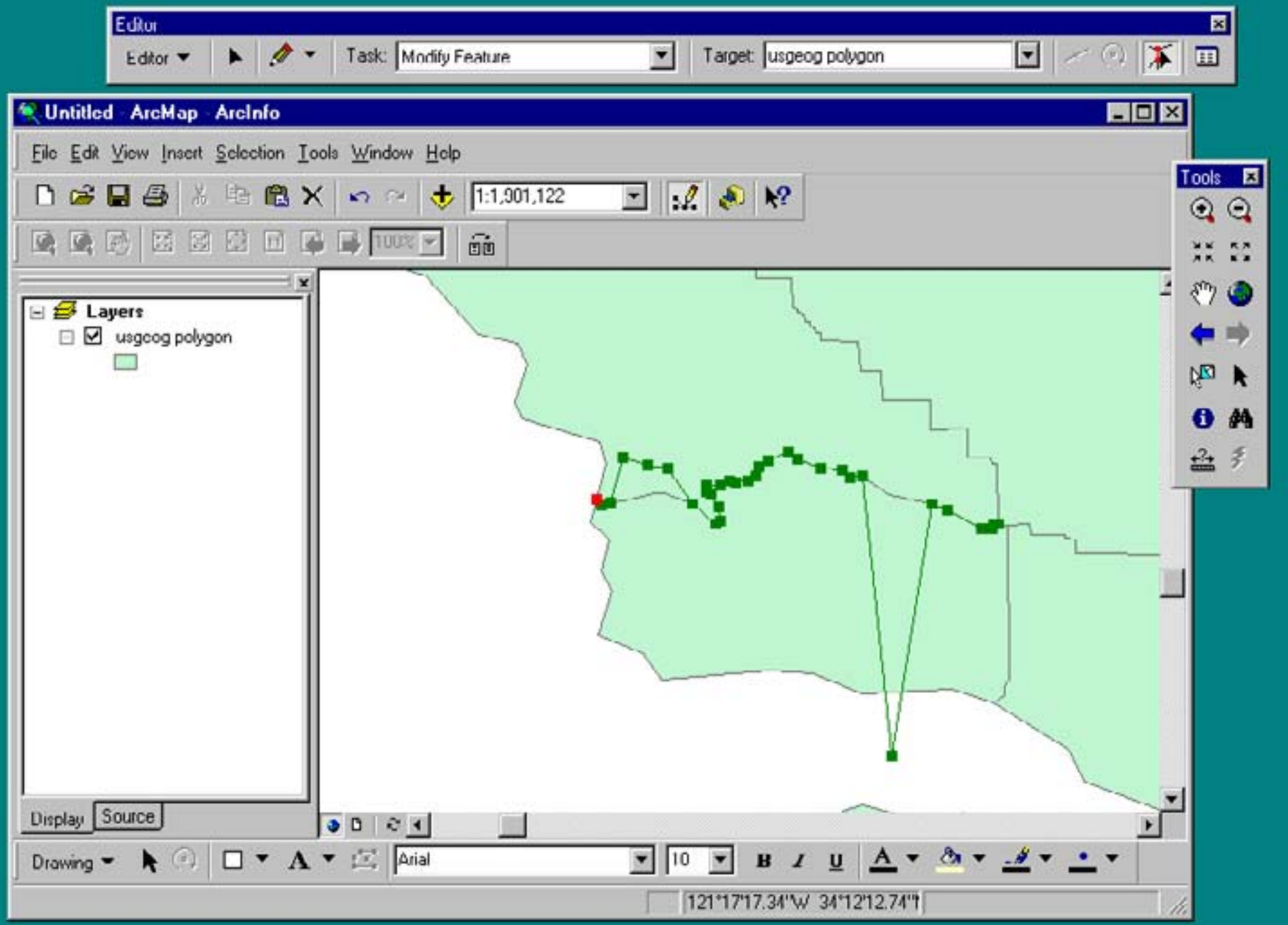
119°25'10.10"W 34°41'0.73"N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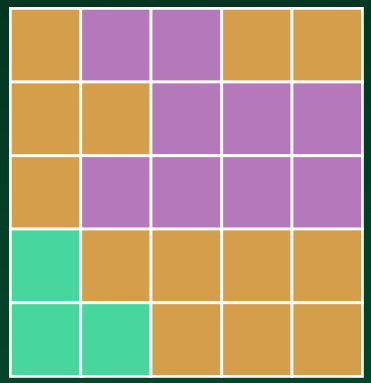
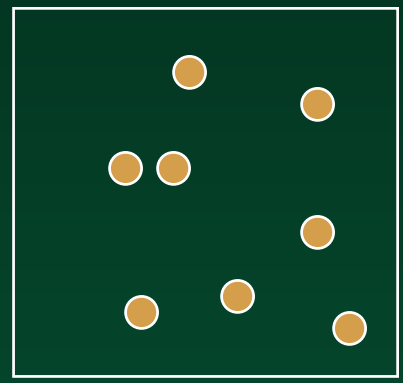
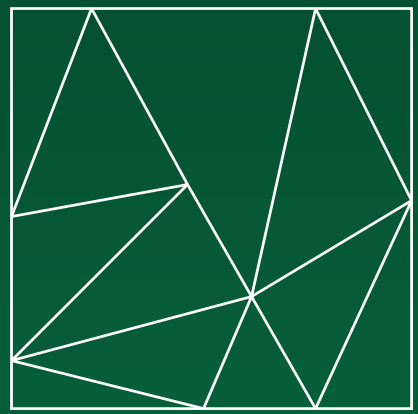
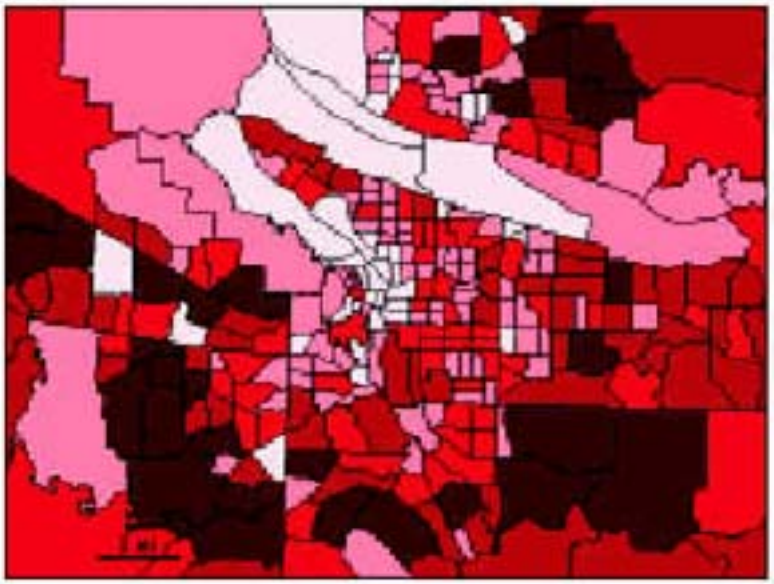
121°17'17.34"W 34°12'12.74"N







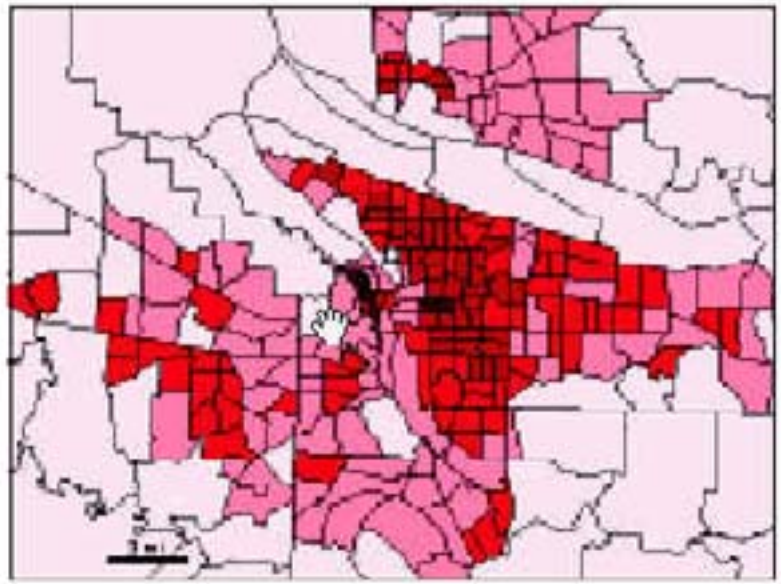
If you want to know approximately how many people each census tract has, map total population.



132 - 2224
2225 - 3900
3901 - 5507
5508 - 7732
7733 - 12611

Census tracts by total population.

If you want to know where most of the people are concentrated. map population density.



8 - 1882
1883 - 4409
4410 - 6906
6907 - 11111
11112 - 21334

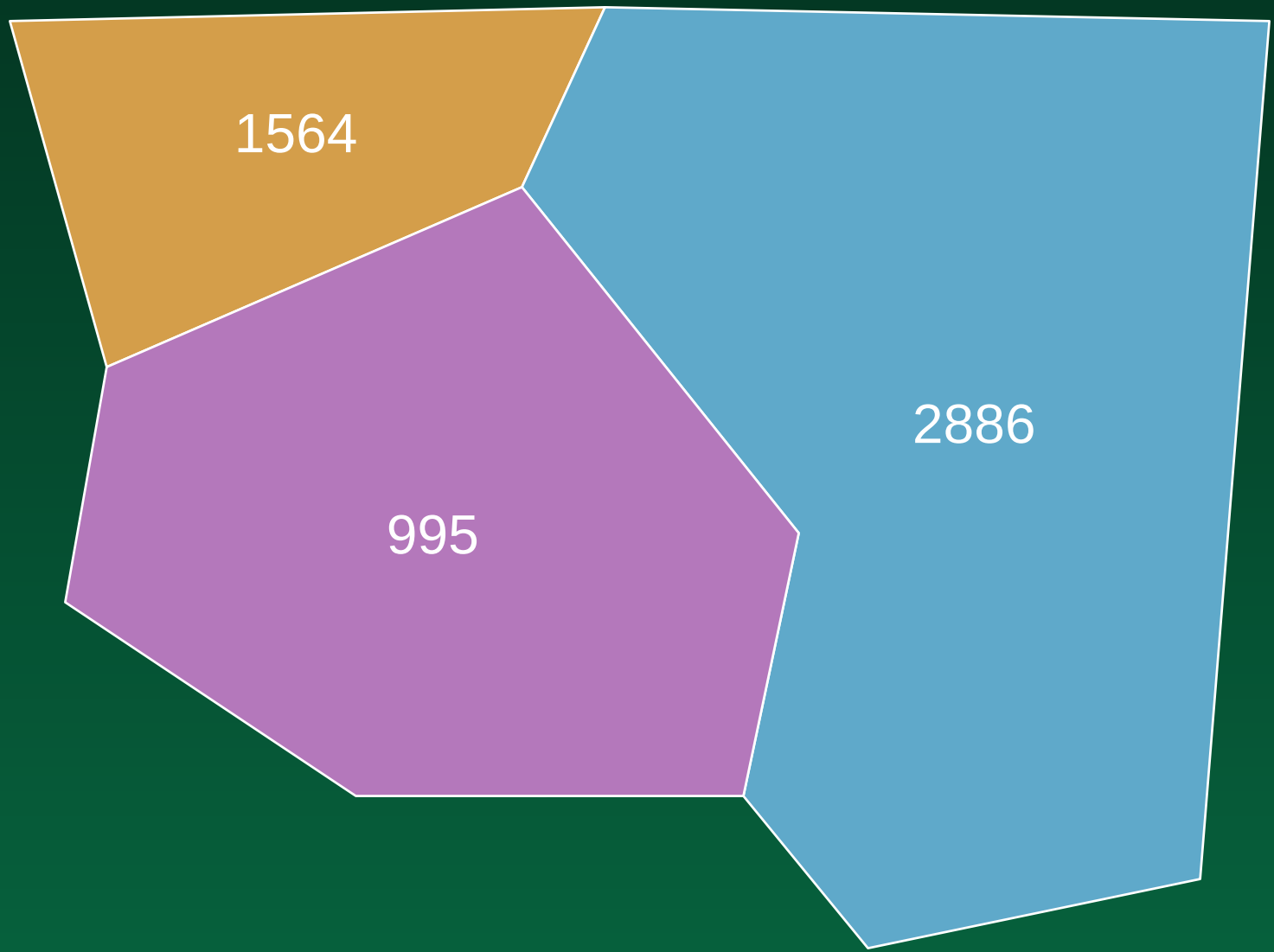
Census tracts by people per square mile.

Taxonomies of spatial analysis

- Thousands of methods
  - every one a command, menu item, icon, …
- Based on data type
  - point pattern analysis
  - area (polygon) analysis
  - analysis of interactions
  - Bailey and Gatrell, Haining, Unwin

A six-way conceptual classification

- Query and reasoning
- Measurement
- Transformation
- Descriptive summary
- Optimization
- Hypothesis testing

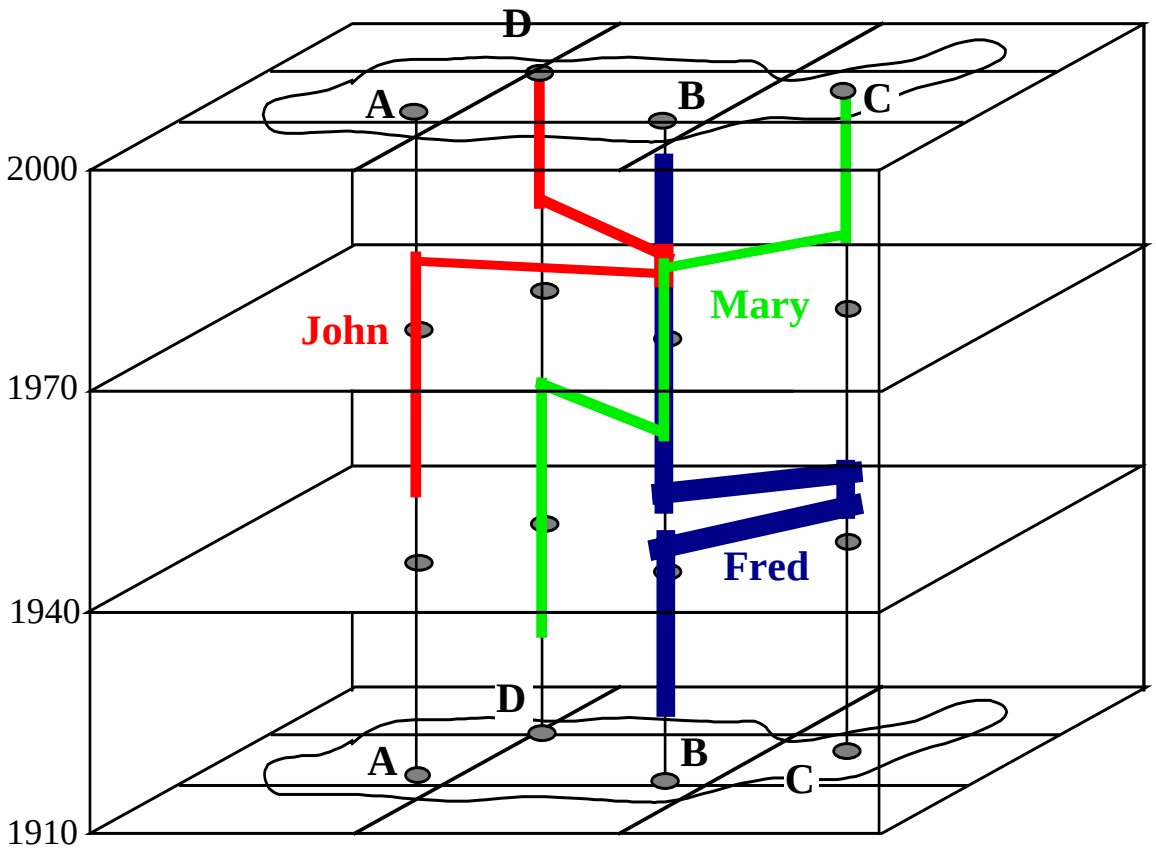

1564
2886
995
1990

Information lost to the representation

- All sub-polygon spatial variation
- All within-decade temporal variation
- All identities
  - instead of <xy, person> we have

  <R, number> and

  <xy, xy, xy, xy, …, R>


D
A
B
C
2000
John
Mary
1970
Fred
1940
D
A
B
C
1910

Challenges of GIS

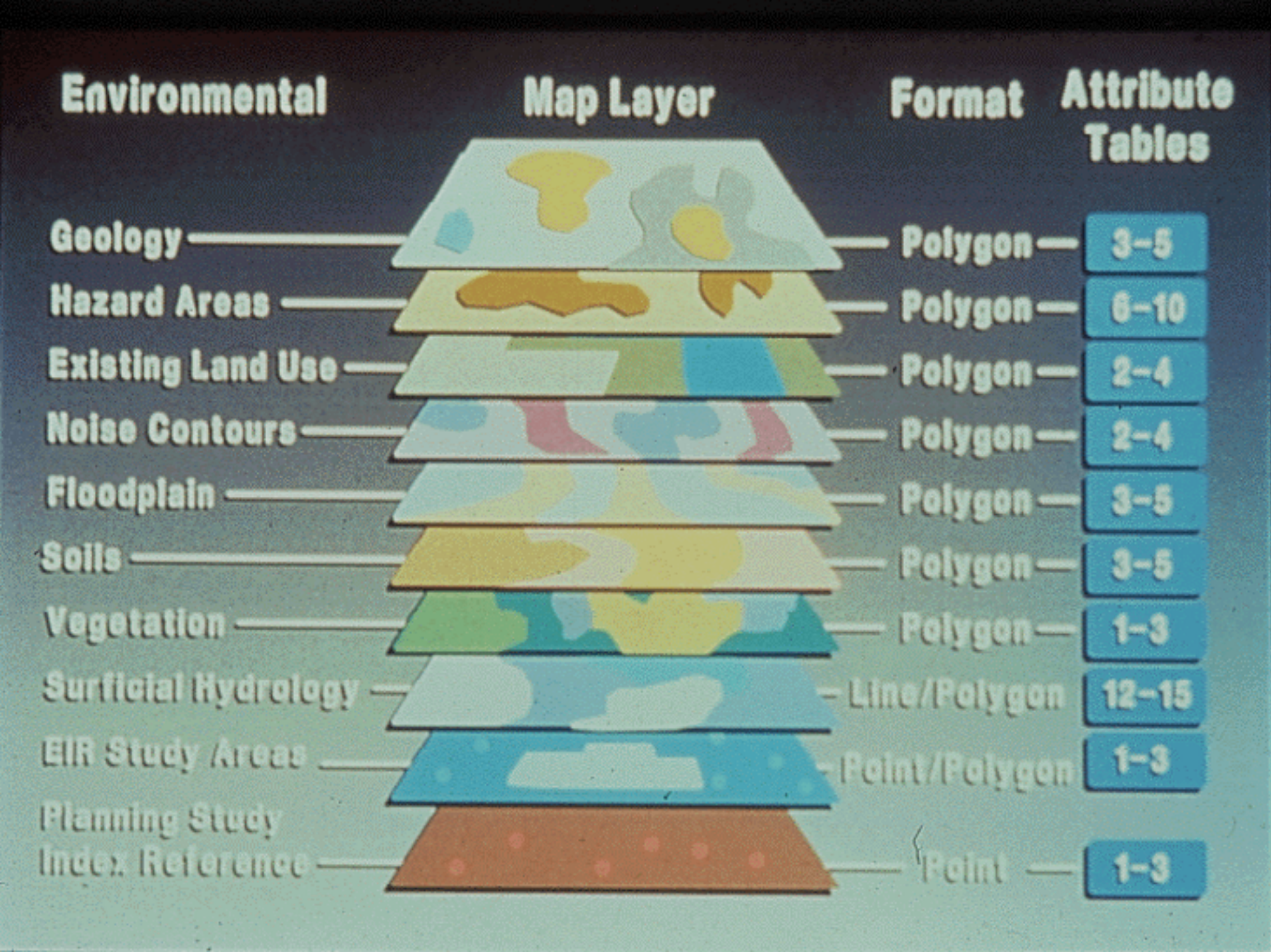
- How to characterize what is missing?
  - error, accuracy, uncertainty
- How to choose the best representation?
  - confounding influences
- How to support many data models in a single software package

Weaknesses of GIS

- There are too many possible data models
  - special-purpose GIS
  - lack of interoperability
- Difficult to add data models retroactively

General principles: 1. Integration

- Linking data through common location
  - the layer cake
- Linking processes across disciplines
  - spatially explicit processes
  - e.g. economic and social processes interact at common locations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Point/Polygon
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6-10
2-4
2-4
3-5
3-5
1-3
12-15
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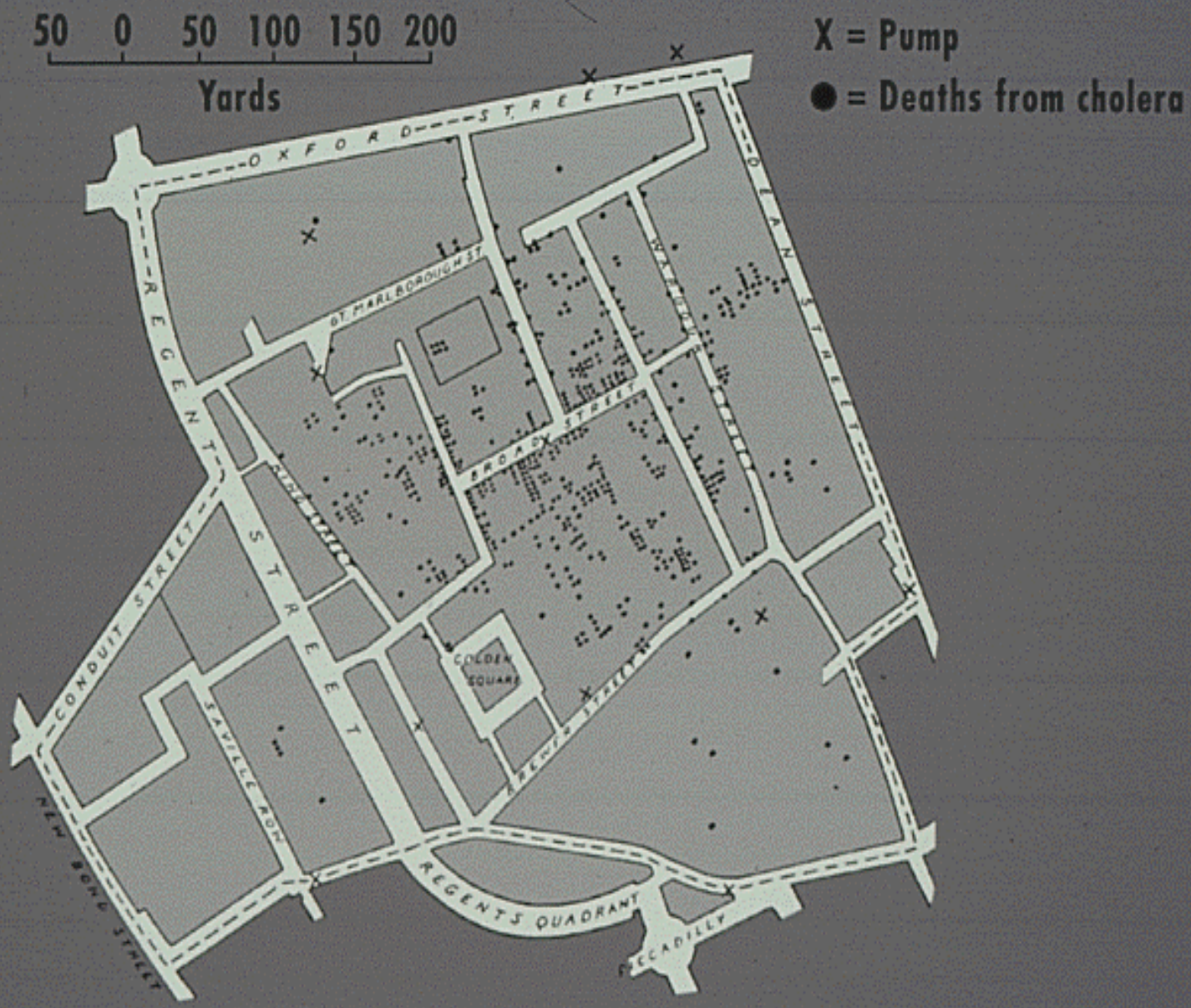
1-3

2. Spatial analysis

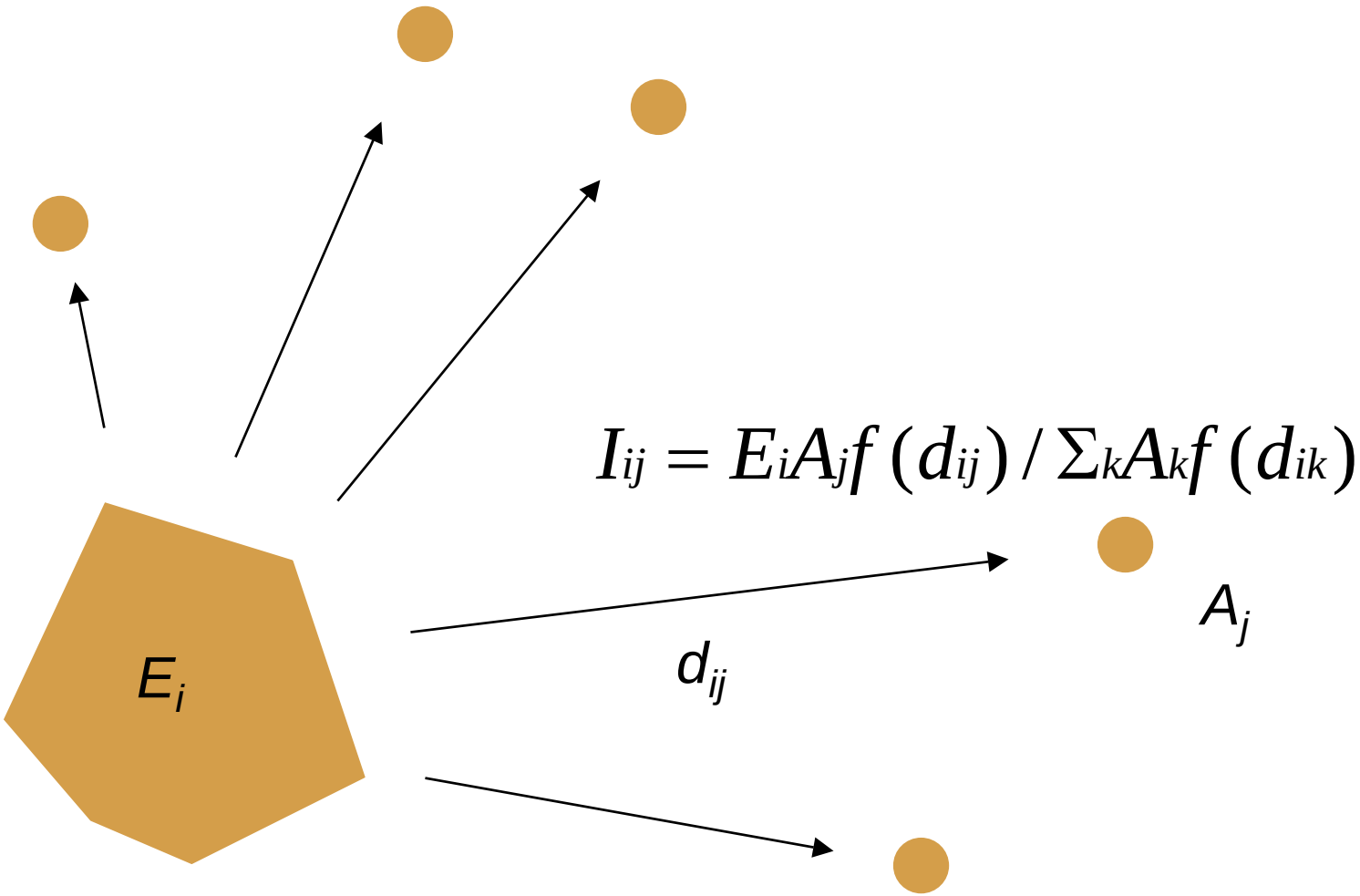
- Social data collected in cross-section
  - longitudinal data are difficult to construct
- Cross-sectional perspectives are rich in context
  - can never confirm process
  - though they can perhaps falsify
  - useful source of hypotheses, insights



The Snow Map of Cholera Incidence in the Area of Broad Street, London, in 1854.
The contaminated water pump is located at the center of the map, just to the right of the D in BROAD STREET.

3. Spatially explicit theory

- Theory that is not invariant under relocation
- Spatial concepts (location, distance, adjacency) appear explicitly
- Can spatial concepts ever *explain*, or are they always surrogates for something else?


$I_{ij} = E_i A_j f(d_{ij}) / \Sigma_k A_k f(d_{ik})$
A_j
d_{ij}
E_i

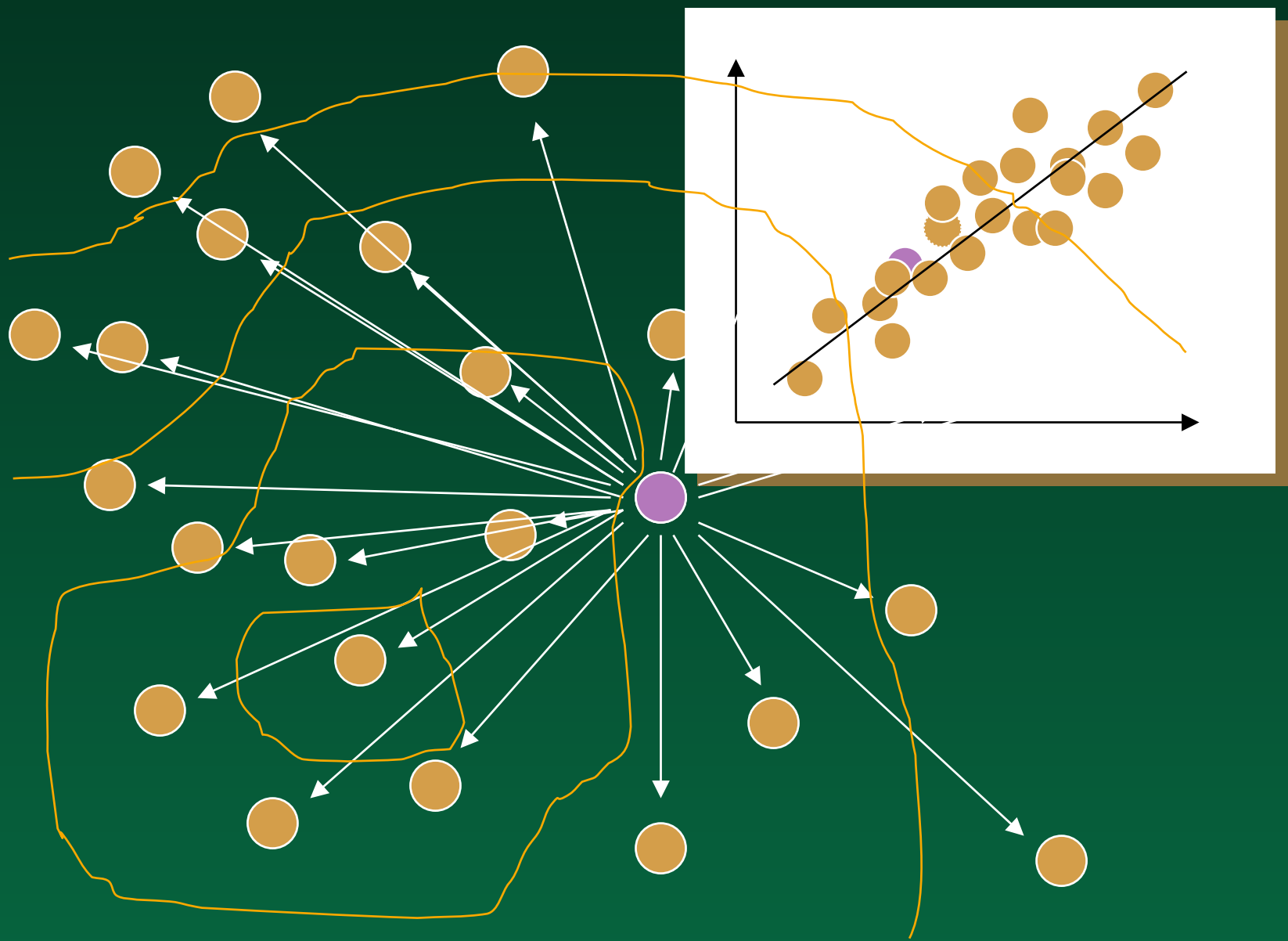
4. Place-based analysis

- Nomothetic - search for general principles
- Idiographic - description of unique properties of places
- An old debate in Geography

The Earth's surface

- Uncontrolled variance
- There is no average place
- Results depend explicitly on bounds
- Places as samples
- Consider the model:

  $y = a + bx$



5. Knowledge and policy

- Policy requires the projection of general knowledge in spatial context
  - the implications of this process in this location
  - alternative futures visualized under local circumstances
- GIS combines the general (processes, models, algorithms) with the specific (database of local details)

6. Place-based search

- Location as an organizing dimension to information
  - much information can be georeferenced
  - much more than maps and images
- The Geolibrary
  - what have you got about *there*?
  - impossible physically, feasible digitally

Prototype geolibraries

- National Geospatial Data Clearinghouse
  - *www.fgdc.gov*
- Microsoft's Terraserver
  - *terraserver.microsoft.com*
- Alexandria Digital Library
  - *alexandria.ucsb.edu*

EXANDRIA DIGITAL LIBRARY

CDL CALIFORNIA DIGITAL LIBRARY

ADL HOME · CDL HOME · HELP

NICK PLACENAME SEARCH

earch the entire world for...

Find

er "Rome" if you want Rome, Italy.
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NERAL SEARCH

Select collection to search

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Set geographic region

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N 34.43

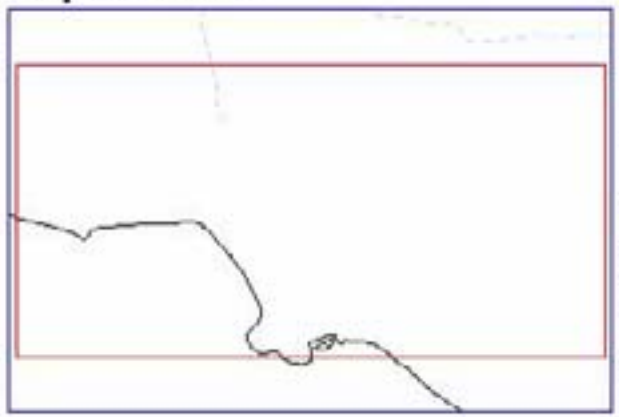
W -118.97 -117.57 E

33.73 S

Words to search for

Any of the above words
All of the above words
Exact phrase

Map Browser



Click map to:

Recenter & Zoom in

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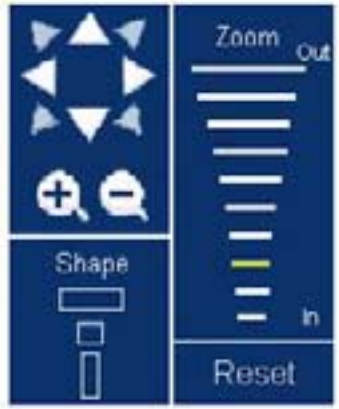

ADL Search Results

The query that produced these results can be found at the bottom of this page.

1. **DRG o33117g6, Digital Raster Graphic of BLACK STAR CANYON, CA.**
   Type: maps. **Format:** TIFF. **Date:** 1988. **ADL identifier:** adl_catalog:800279.
   HIGHLIGHT IN MAP · COMPLETE DESCRIPTION · BROWSE GRAPHIC · ACCESS/DOWNLOAD

2. **DRG o33117g7, Digital Raster Graphic of ORANGE, CA.**
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   HIGHLIGHT IN MAP · COMPLETE DESCRIPTION · BROWSE GRAPHIC · ACCESS/DOWNLOAD

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   Type: maps. **Format:** TIFF. **Date:** 1981. **ADL identifier:** adl_catalog:800281.
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Center for Spatially Integrated Social Science

- The CSISS mission recognizes the growing significance of space, spatiality, location, and place in social science research. It seeks to develop unrestricted access to tools and perspectives that will advance the spatial analytic capabilities of researchers throughout the social sciences.

Seven CSISS programs

- National Workshops
- Software Tools
- Virtual Community
- Best Practice Examples
- Place-Based Search
- Learning Resources
- Specialist Meetings