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GIS and Spatial Analysis: An Introduction

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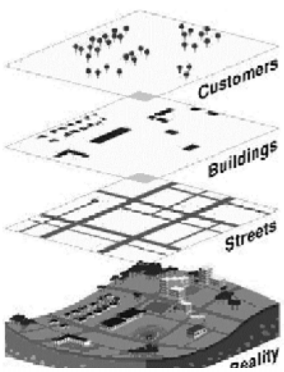
1. GIS

1.1. What is GIS?

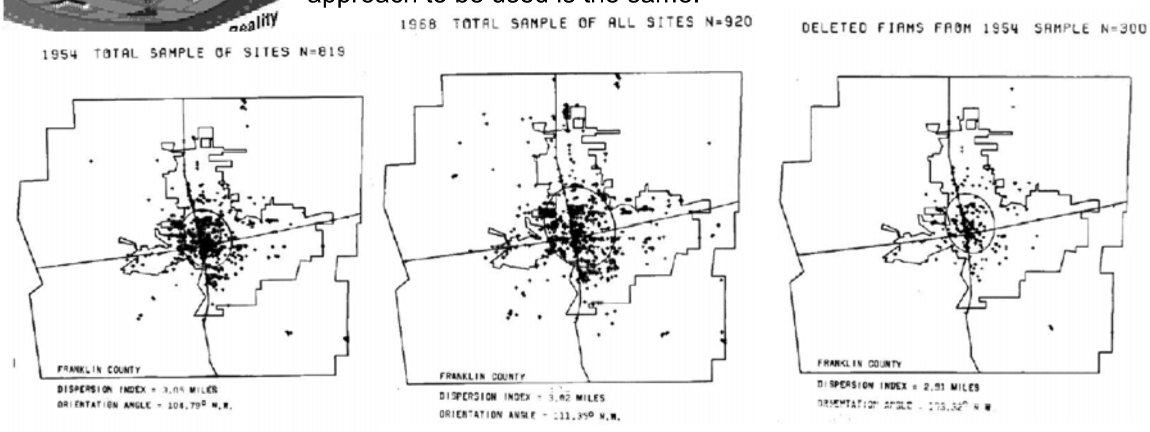
"A decision support system involving the integration of spatially referenced in a problem solving environment" [1]

1.2. How does GIS work?



GIS stores information about the world as a collection of thematic layers that can be linked together by geography [2].

An example of GIS use is provided below [3]. Industrial sites in Franklin County, SC, were mapped in two years, 1954 and 1958, and the changes were tracked by overlaying the two images. This example indicates two things: (a) GIS techniques are not as recent as people think (this example is from 1971), and (b) GIS techniques have a wide area of application: imagine that we could have dealt with emerging cases of a certain disease recorded "before" and "after" the implementation of a prevention program instead of deleted industrial sites. The approach to be used is the same.



2. Spatial Statistics

2.1. Autocorrelation

"Near things are more related than distant things" [4].

2.2. Clusters

Clusters may indicate health problems. There is a wide range of methods to detect spatial clusters:

- Analysis of disease risk from environmental hazard at three levels: analyses of distribution, analyses of sentinel events, and case cluster strategies;
- Measures of aggregation based on the counts of individuals in randomly sampled quadrates;

- Indices based on the spacing of the individuals, calculated from either nearest neighbor or "point to plant" distances;
- Models of attenuations of point sources and their effects on the surrounding population;
- Ederer-Myers-Mantel procedure;
- Locally most powerful test for several parametric models designed to allow an increased within-family infectivity;
- Vigilance for unusual environmental exposures, evaluating their possible impact.

The computation of the DAC statistic is based on the empirical cumulative distribution function. The

$$F_n(x_1,\ x_2) = \frac{m(x_1,\ x_2)}{n}$$

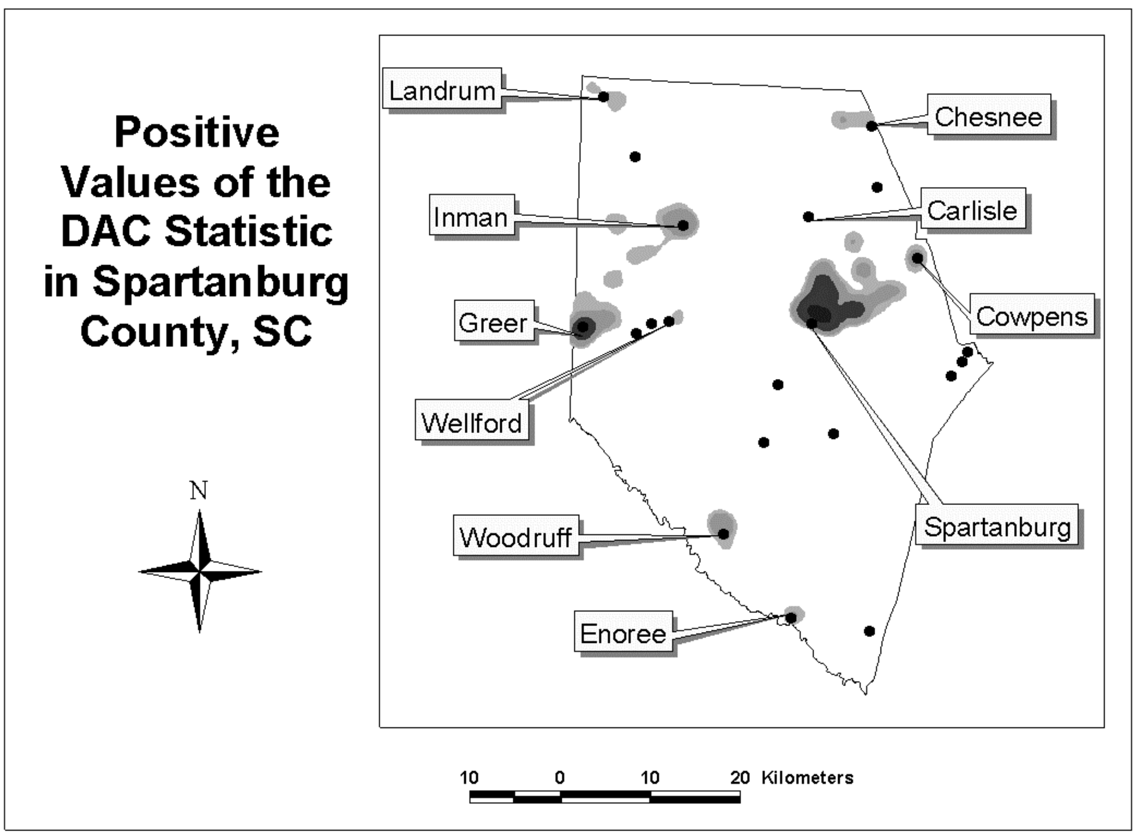
empirical cumulative distribution function is:
Where $m(x_1, x_2)$ is the number of points of the sample of size n such that $x_{1_i} \le x_1$ and $x_{2j} \le x_2$. As (x_1, x_2) covers the entire sample from (0, 0) to (max x_1, max x_2), $m(x_1, x_2)$ spans the interval [0, n].

$$DAC(x_1,\ x_2) = F_m(x_1,\ x_2) - F_n(x_1,\ x_2)$$

The DAC statistic is, for all permissible values of (x_1, x_2):
F_m is the empirical cumulative distribution function of all cases, and F_n is the empirical cumulative distribution function of the total population [5].

Example:

For the period 1989-1992 nearly all of the live births in Spartanburg County SC were geocoded. The longitude and latitude of the mother's home was affixed to the birth certificate data of the baby. Cases were low birthweight babies, defined as those less than or equal to 2500 grams. Positive DAC density map for Spartanburg County, SC. Accumulation of positive values indicates that cases accumulate faster than base population.

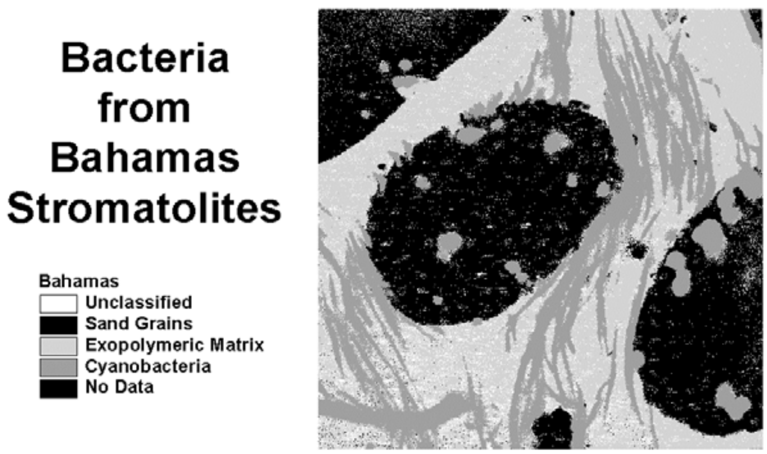


The peaks detected around cities, especially the larger ones, Spartanburg and Greer, may indicate problems in these areas. Epidemiological studies conducted in these areas might explain the causes of these clusters [6].

3. A Novel Application

3.1. Change detection in bacterial biofilms

Biofilms are formed by bacterial colonies encapsulated in an extra-cellular polymeric substances matrix. They form in short time if environmental conditions are favorable. The study of biofilms is facilitated by advances in microscopy, such as the scanning confocal laser microscopy used in conjunction with digital image processing techniques. Images are transformed in maps using GIS and change detection is used similarly to the example presented in the "***GIS***" section [7]. This technique may be extrapolated to the cell level.



Contrast-enhanced, filtered, and classified image of a section through a bacterial biofilm from Bahamas stromatolites presented as a map using ArcView GIS

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