Spatial Patterns Support Sound Environmental Decisions (Newsletter)*

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Everyone recognizes that environmental data have spatial attributes. We are all familiar with GIS-produced maps showing where data were collected in relation to each other and to other variables. However, maps do not provide a critical requirement to objectively make operational decisions, justify environmental policies and regulations, or help finders of fact in litigation reach sound decisions. What maps lack is the quantitative description of patterns and relationships that reflect underlying environmental processes.

Recall that there are two types of environmental variables: response (dependent) and explanatory (independent). The response variable is the quantity we want to predict or explain. The explanatory variables are the quantities that can be used to predict or explain the response.

There are three types of spatial data:

1. Points (geostatistics). The response variable has a value everywhere, but we measure it at only specific sites. Point data are collected in contamination (pollution) studies involving ground water, sediments, soils, rocks, and air. The measurement locations (their geographic coordinates) and other variables (e.g., distance from a river, land use, soil mapping unit) are explanatory variables of the measured response.

Point statistics are used to interpolate quantities in un-measured locations, measure autocorrelation by distance and direction, or identify potential sources. Projects involving air quality, brownfields, waste disposal areas, and Superfund sites all require spatial point analyses to understand the data and their implications.

2. Areal. There are two categories of areal data: grids and shapes. Grids have a uniform, regular size while shapes can vary in size and appearance.

An example of gridded areal data are population abundances in townships (a rectangular component of the Public Lands Survey System). An example of shape areal data are population abundance in counties (which have irregular shapes). Areal spatial statistics answer questions about compliance with the Clean Water Act, Endangered Species Act, and other laws where the interest is in the magnitudes of the response variable explained by the area and other explanatory variables.

3. Point pattern. These data are response variables and our interest is in the pattern at a location. Patterns could be random (infrequent in environmental data), regular (also infrequent in environmental data), or clumped/clustered (the common environmental data pattern.)

Examples of point patterns include locations of nests, wallows, and individuals of the same species. One common question is which explanatory variables most influence the locations of the observed response variable. Analyses of point pattern data calculate point intensity (the average number of points per unit area) and fit models that explain how the densities vary by location or to other explanatory variables (e.g., altitude, vegetation type, soil pH). Point pattern statistical analyses provide insights valuable for operational, regulatory, and legal decisions involving the Clean Water Act, Superfund, and Endangered Species Act.

In addition to the three spatial dimensions of longitude, latitude, and elevation is the fourth dimension of time. Natural ecosystems are constantly changing and exhibit patterns at scales from days to seasons, years, and longer. Measurements of air pollutants need to be associated with wind direction and strength to be useful in identifying potential sources and impact areas. Winds shift seasonally, stream water levels fluctuate throughout the year, and many animals migrate from summer to winter range or from breeding to non-breeding habitats. Quantifying these changes requires the use of spatio-temporal statistical models.

Setting baseline and compliance monitoring data in the appropriate spatial and temporal contexts have value for everyone: operators, regulators, policy makers, and the public. When regulators and the public are shown that methods are technically sound and legally defensible and they quantify project interactions with ecosystems delays, appeals, and legal challenges could be shortened or eliminated.

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