

Some recent work in spatial analysis for ecological data

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1. Introduction

During 2002 two international ecology journals published special issues on spatial statistics in ecology. *Ecography* volume 25, pp. 553 – 640, contained six papers arising from an NC [redacted] designed to integrate the statistical modelling of spatial data in ecology. [redacted] volume 9, number 2 contained ten papers, edited by Marie-Josée Fortin.

This talk will focus on one of these papers that illustrated and provided guidelines for selecting statistical methods for quantifying spatial pattern in ecological data (Perry *et al.*, 2002). This study compared different methods to measure spatial pattern, built around a set of four case studies, and tried to help ecologists make the right choice of spatial methods to suit their data and questions. The paper featured a taxonomy of data, including point- and area- referenced data, with and without attributes, which distinguishes spatially and non-spatially explicit data. The effects of sampling and other transformations that convert one data type to another were discussed; the possible loss of spatial information was considered. Techniques for analyzing spatial pattern, developed in plant ecology, animal ecology, landscape ecology, geostatistics and applied statistics were reviewed briefly and their overlap in methodology and philosophy noted. The techniques were categorized according to their output and the inferences that may be drawn from them, in a discursive style without formulae. Methods were compared for four case studies with field data covering a range of types. These were: (i) percentage cover of three shrubs along a line transect; (ii) locations and volume of a desert plant in a 1 ha area; (iii) a remotely-sensed spectral index and elevation from 10^5 km² of a mountainous region; and (iv) land cover from three rangeland types within 800 km² of a coastal region. Initial approaches utilized mapping, frequency distributions and variance-mean indices. Analysis techniques compared included: local quadrat variance, block quadrat variance, correlograms, variograms, angular correlation, directional

variograms, wavelets, SADIE, nearest neighbour methods, Ripley's $L(t)$, and various landscape ecology metrics. The large number of figures helped give a empirical basis to the paper, and to facilitate a visual feel for what the analysis of spatial pattern entails. Our advice to ecologists was to use simple visualization techniques for initial analysis, and subsequently to select methods that are appropriate for the data type and that answer their specific questions of interest. It is usually prudent to employ several different techniques.

A companion paper in this series dealt with the issue of spatial scale (Dungan *et al.*, 2002). Concepts of spatial scale, such as extent, grain, resolution, range, footprint, support and cartographic ratio are not interchangeable. Because of the potential confusion among the definitions of these terms, it was suggested that authors avoid the term "scale" and instead refer to specific concepts. In particular, care is required to discriminate between observation scales, scales of ecological phenomena and scales used in spatial statistical analysis. When scales of observation or analysis change, that is, when the unit size, shape, spacing or extent are altered, statistical results are expected to change also. The kinds of results that may change include estimates of the population mean and variance, the strength and character of spatial autocorrelation and spatial anisotropy, patch and gap sizes and multivariate relationships. The first three of these results (precision of the mean, variance and spatial autocorrelation) can sometimes be estimated using geostatistical support-effect models. Four case studies of organism abundance and cover were presented to illustrate some of these changes and how conclusions about ecological phenomena (process and structure) may be affected. Many problems may be avoided by careful construction of sampling design and analysis. A set of considerations was recommended for sampling design to allow useful tests for specific scales of a phenomenon under study. It was also recommended that ecological studies report completely all components of observation and analysis scales, to increase the possibility of cross-study comparisons.

One of the papers for the *Ecoscience* special issue extended the methodology termed SADIE, from the analysis of spatial pattern for a single set of data to the measurement of spatial association through the comparison of two patterns (Perry & Dixon, 2002). This features a measure of local association for counts, defined for each sample unit. The new measure is based on a comparison of the spatial SADIE clustering index of the two sets at each sample unit; the mean of the measure is represented by the simple correlation coefficient between the clustering indices of the two sets. A randomization method allows the construction of a test and critical values. For the first time, spatial association may be mapped for count data; clusters of units with positive association or negative dissociation may be identified. The method was exemplified by analysis of spatial pattern and spatial association of counts of male and female tupelo trees from three plots in a South Carolina swamp forest. In addition, methods were presented to distinguish larger-scale apparent association between the sexes, caused by indirect effects, from direct smaller-scale association. No tendency was found for the

sexes to occur together at the small-scale, only an apparent affinity caused through their co-location in particular subareas of each plot. The conversion from mapped to count data requires a choice of unit size; the conclusions of these analyses were not affected greatly by changes in unit size.

These and other papers, and further information about the SADIE methodology, are available for downloading from my website:

References

- Perry, J.N. & Dixon, P. (2002) *A new method for measuring spatial association in ecological count data*. *Ecoscience*, **9**, 133-141.
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- Dungan, J.L., Perry, J.N., Dale, M.R.T., Citron-Pousty, S., Fortin, M.-J., Jakomulska, A., Miriti, M. & Rosenberg, M. (2002) *A balanced view of scale in spatial statistical analysis*. *Ecography*, **25**, 626-640.