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# Spatial modelling: a comprehensive framework for principal coordinate analysis of neighbour matrices (PCNM)

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## Abstract

Spatial structures of ecological communities may originate either from the dependence of community structure on environmental variables or/and from community-based processes. In order to assess the importance of these two sources, spatial relationships must be explicitly introduced into statistical models. Recently, a new approach called principal coordinates of neighbour matrices (PCNM) has been proposed to create spatial predictors that can be easily incorporated into regression or canonical analysis models, providing a flexible tool especially when contrasted to the family of autoregressive models and trend surface analysis, which are of common use in ecological and geographical analysis. In this paper, we explore the theory of the PCNM approach and demonstrate how it is linked to spatial autocorrelation structure functions. The method basically consists of diagonalizing a spatial weighting matrix, then extracting the

eigenvectors that maximize the Moran's index of autocorrelation. These eigenvectors can then be used directly as explanatory variables in regression or canonical models. We propose improvements and extensions of the original method, and illustrate them with examples that will help ecologists choose the variant that will better suit their needs.

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## Keywords

Ecological community; Eigenvalue; Eigenvector; Induced spatial dependence; Moran's $I$; Principal coordinates of neighbour matrices (PCNM); Spatial autocorrelation; Spatial model; Spatial structure

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