A new method for detecting and interpreting biodiversity and ecological community thresholds

1. Matthew E. Baker[1,*],
2. Ryan S. King[2,*]

Article first published online: 1 FEB 2010

DOI: 10.1111/j.2041-210X.2009.00007.x

Methods in Ecology and Evolution

Volume 1, Issue 1, pages 25–37, March 2010

Summary

1. Existing methods for identifying ecological community thresholds are designed for univariate indicators or multivariate dimension-reduction of community structure. Most are insensitive to responses of individual taxa with low occurrence frequencies or highly variable abundances, properties of the vast majority of taxa in community data sets. We introduce Threshold Indicator Taxa ANalysis (TITAN) to detect changes in taxa distributions along an environmental gradient over space or time, and assess synchrony among taxa change points as evidence for community thresholds.

2. TITAN uses indicator species scores to integrate occurrence, abundance and directionality of taxa responses. It identifies the optimum value of a continuous variable, *x*, that partitions sample units while maximizing taxon-specific scores. Indicator *z* scores standardize original scores relative to the mean and SD of permuted samples along *x*, thereby emphasizing the relative magnitude of change and increasing the contributions of taxa with low occurrence frequencies but high sensitivity to the gradient. TITAN distinguishes negative (*z*−) and positive (*z*+) taxa responses and tracks cumulative responses of declining [sum(*z*−)] and increasing [sum(*z*+)] taxa in the community. Bootstrapping is used to estimate indicator reliability and purity as well as uncertainty around the location of individual taxa and community change points.

3. Using two simulated data sets, TITAN correctly identified taxon and community thresholds in more than 99% of 500 unique versions of each simulation. In contrast, multivariate change-point analysis did not distinguish directional taxa responses, resulting in much wider confidence intervals that in one instance failed to capture thresholds in 38% of the iterations.

4. Retrospective analysis of macroinvertebrate community response to a phosphorus gradient supported previous threshold estimates, although TITAN produced narrower confidence limits and

revealed that several taxa declined at lower levels of phosphorus. Re-analysis of macroinvertebrate responses to an urbanization gradient illustrated disparate change points for declining (0·81–3·3% urban land) and increasing (6·8–26·6%) taxa, whereas the published threshold estimate (20–30%) missed the declining-taxa threshold because it could not distinguish their synchronous decline from the gradual increase in ubiquitous taxa.

5.*Synthesis and applications.* By deconstructing communities to assess synchrony of taxon-specific change points, TITAN provides a sensitive and precise alternative to existing methods for assessing community thresholds. TITAN has tremendous potential to inform conservation of rare or threatened species, develop species sensitivity models, identify reference conditions and to support development of numerical regulatory criteria.