1.38 Environmental impacts

Some further comments are appropriate here regarding experimental designs to detect environmental impact (Green (1979) , Underwood (1991) , Underwood (1992) , Underwood (1994)). These designs generally include measurements of a response variable of interest before and after a potential impact from one or more control site(s) and from the purportedly impacted site(s). These are referred to as “BACI” designs[51] as an acronym for the two levels in each of the two major factors of the design: the temporal factor (“before”/“after”) and the spatial factor (“control”/“impact”). Importantly, a significant interaction between these two factors would (potentially) lead to inferences regarding significant impact, so the ability formally to test the interaction term(s) in such models is paramount here. With regard to extending non-parametric multivariate hypothesis-testing methods to handle such designs, Clarke (1993) conceded: “This would appear to defy development within the similarity-based framework… and must be accepted as a limitation of the current methodology, though there is clearly scope for further study here” (p. 138).

Indeed, further study led to the development of PERMANOVA, which allows (under slightly less general conditions, e.g., the approach is no longer fully non-parametric) tests of interaction terms for any multi-factorial model on the basis of any resemblance measure of choice, with *P*-values obtained by appropriate permutation techniques. Its new implementation as an add-on to PRIMER also now allows appropriate analyses of asymmetrical designs (i.e., in the case of there being multiple control sites, but only one impact site – see the section Asymmetrical designs), as required. In essence, as PERMANOVA can be used to analyse multivariate responses to any ANOVA model, it therefore can be used readily for the analysis of assemblages in response to either BACI or beyond BACI experimental designs in environmental impact studies.

A further contribution of Underwood (Underwood (1991) , Underwood (1992) , Underwood (1994)) in the area of experimental designs to detect environmental impacts (in addition to proposals to extend the basic model to include multiple sites and times of sampling and thus avoid pseudo-replication) was to propose the use of two-tailed *F*-tests to detect potential impacts on *variability* in the response variable, and not just to detect changes in means. Recently, Terlizzi, Anderson, Fraschetti, S. *et al.* (2007) have implemented these ideas for multivariate data (albeit not in the context of environmental impact, but to investigate patterns along a depth gradient). More particularly, they used bootstrapping to place confidence intervals on differences in the sizes of multivariate components of variation. Although the current PERMANOVA+ software does not implement this approach, direct measures of the components of variation for each term in the model are provided as part of the PERMANOVA output. Thus, the sizes of multivariate (or univariate) components of variation for different sub-sets of the data may be calculated directly in this way.

Another approach to addressing hypotheses concerning variability in assemblage structure is to use the PERMDISP routine (see chapter 2), which can be applied either to individual replicates

within groups (or cells), or can be applied to centroids (calculated from PCO axes when non-Euclidean measures are being used, see chapter 3) to compare dispersions for higher-level factors in more complex designs.

---

[51] Much to the delight of Italian ecologists!

Revision #5
Created 9 August 2022 13:13:29 by Arden
Updated 3 December 2024 22:15:05 by Abby Miller