12.1 Introduction

In Chapter 11 we have seen how both the univariate and multivariate community attributes can be correlated with natural and anthropogenic environmental variables. With careful sampling design, these methods can provide strong evidence as to which environmental variables appear to affect community structure most, but they cannot actually *prove* cause and effect. In experimental situations we can investigate the effects of a single factor (the *treatment*) on community structure, while other factors are held constant or controlled, thus establishing cause and effect. There are three main study types which have been labelled ‘experiments’ (though many ecologists – and most statisticians! – would argue that it is a misnomer in the first case):

1. *‘Natural experiments’*. Nature provides the treatment, i.e. we compare places or times which differ in the intensity of the forcing factor in question.

2. *Field experiments.* The experimenter provides the treatment, i.e. environmental factors (biological, chemical or physical) are manipulated in the field.

3. *Laboratory experiments.* Environmental factors are manipulated by the experimenter in laboratory mesocosms or microcosms.

The degree of ‘naturalness’ (hence realism) *decreases* from 1-3, but the degree of control which can be exerted over potentially confounding environmental variables *increases* from 1-3.

In this chapter, each class of experiments is illustrated by a single example. These all happen to concern the meiobenthos, since such data is readily available to the authors(!) but also because the smaller the biotic size component the more amenable it is to community level manipulations (see Chapter 13).¶

In all cases care should be taken to avoid *pseudoreplication*, i.e. the *treatments* should be replicated, rather than a series of (pseudo-)replicate samples taken from a single treatment (e.g. Hurlbert (1984)). This is because other confounding variables, often unknown, may also differ between the treatments. It is also important to run experiments long enough for community changes to occur; this favours components of the fauna with short generation times (Chapter 13).

It should be made clear at the outset that the treatment of experiments in this chapter is somewhat cursory. The subject of ecological experiments requires a book of its own, indeed it gets an excellent one in Underwood (1997) . The latter, though, in common with other biologically oriented texts on experiments, concerns *univariate* analysis (e.g. of a population abundance). Ecological experiments with multiple outcomes using multivariate methods are now, however, commonplace in publications: useful methods papers include Anderson (2001a) ; Anderson (2001b) ; Chapman & Underwood (1999) ; Krzanowski (2002) ; Legendre & Anderson (1999) ; McArdle & Anderson (2001) ; Underwood & Chapman (1998) ; Clarke, Somerfield, Airoldi *et al.*

(2006) .

¶ *A self-evident truth from the explosion of assemblage studies using the PRIMER and PERMANOVA+ multivariate methods on microbiological communities in the last few years, many of which are a result of manipulative experiments. This manual is deficient in not representing such studies in its illustrations, but it is clear that there are few, if any, different issues of principle in carrying over the macro-scale examples to microbiological or genetic contexts.*

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