

5. New PERMANOVA Design file

- [Overview of new 'Design' options and tools](#)

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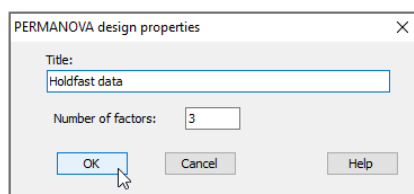
Re-vamped interface

To run a PERMANOVA in PRIMER 8, there are two essential steps. From a resemblance matrix of your choice (with associated factors) you:

1. specify the design (click **PERMANOVA+** > **Create PERMANOVA Design...**); then
2. run the PERMANOVA analysis (click **PERMANOVA+** > **PERMANOVA...**).

In PRIMER 8, however, the interface for specifying the design and the specific model you wish to analyse has been substantially re-vamped, with a full re-design of the **Design file** itself (Fig. 5.1).

PRIMER 7

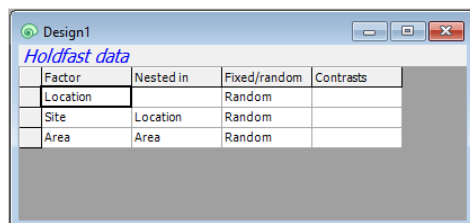


PERMANOVA design properties

Title: Holdfast data

Number of factors: 3

OK Cancel Help

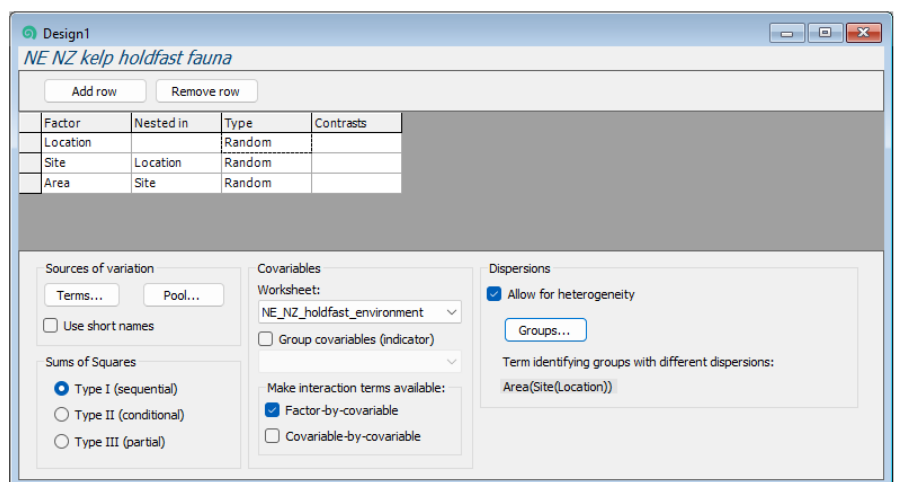


Design1

Holdfast data

Factor	Nested in	Fixed/random	Contrasts
Location		Random	
Site	Location	Random	
Area	Area	Random	

PRIMER 8



Design1

NE NZ kelp holdfast fauna

Add row Remove row

Factor	Nested in	Type	Contrasts
Location		Random	
Site	Location	Random	
Area	Site	Random	

Sources of variation

Terms... Pool...

☐ Use short names

Sums of Squares

☒ Type I (sequential)

☐ Type II (conditional)

☐ Type III (partial)

Covariables

Worksheet: NE_NZ_holdfast_environment

☐ Group covariables (indicator)

Make interaction terms available:

☒ Factor-by-covariable

☐ Covariable-by-covariable

Dispersions

☒ Allow for heterogeneity

Groups...

Term identifying groups with different dispersions:

Area(Site(Location))

Fig. 5.1. Comparison of the details of the PERMANOVA Design file in PRIMER 7 (left) versus PRIMER 8 (right).

In PRIMER 7, you used to specify the number of factors first in a separate little 'pre-amble' window. The design file itself then consisted solely of a matrix specifying the names of the factors, their relationships (nested or crossed) with one another, whether each was fixed or random, and details of any specific contrasts desired (see the left-hand side of Fig. 5.1).

In PRIMER 8, *virtually all* of the relevant details of the PERMANOVA model you wish to fit are now part of the design file itself (see the right-hand side of Fig. 5.1). PRIMER 8 also implements a number of exciting new methodological developments that have evolved from research over the intervening years since the release of PRIMER 7.

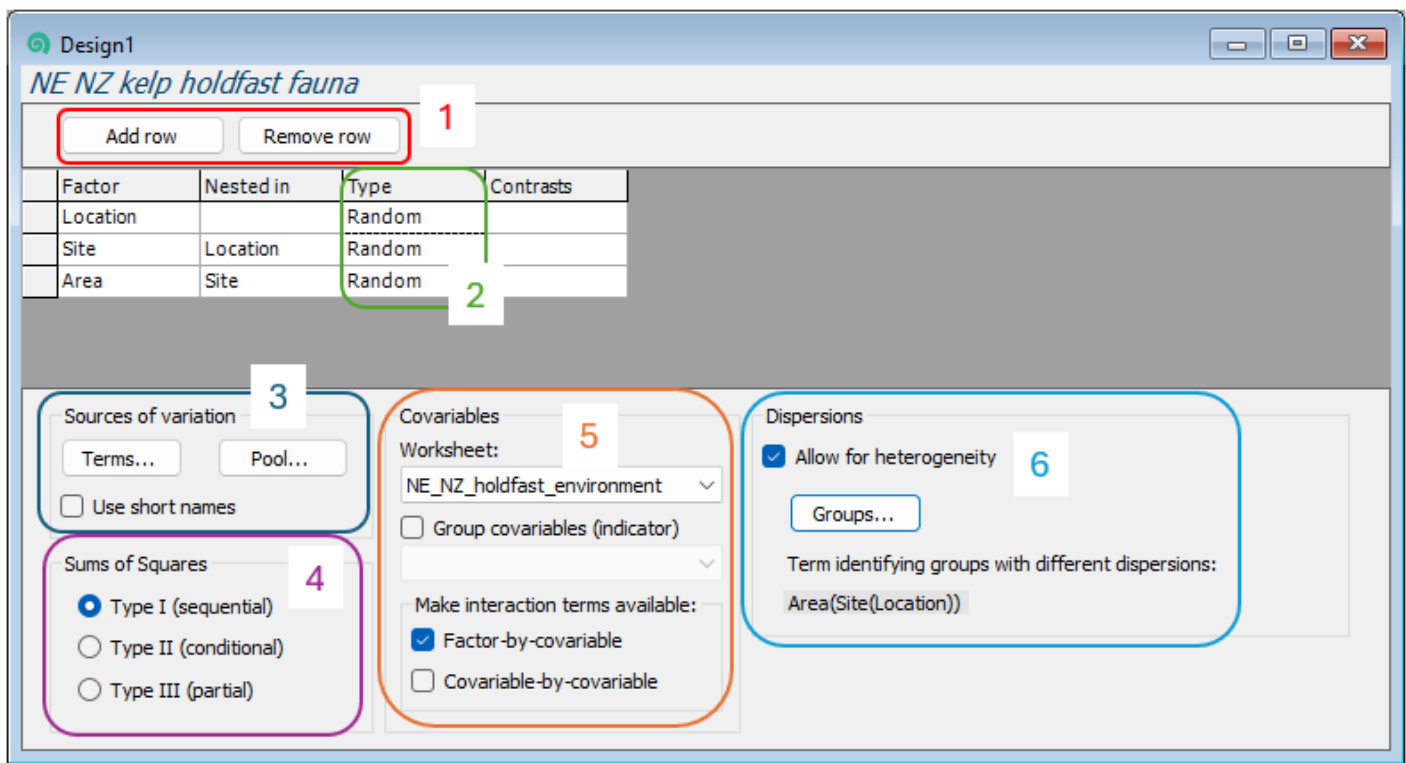


Fig. 5.2. Enumerated items to note in the re-vamped PERMANOVA Design file available in PRIMER 8.

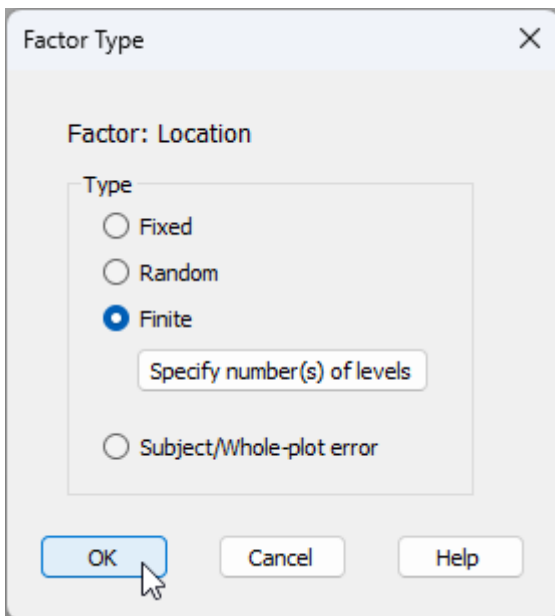
We enumerate below the fundamental ways that the new **Design file** in P8 differs from P7. Numbers below correspond to the numbers shown in Fig. 5.2 above. Each more substantial development will further be treated in greater detail (and implemented with examples), in subsequent chapters.

1. Add/Remove rows

Rather than specifying the number of factors at the outset, one can use the **Add row** and **Remove row** buttons at the top of the Design file to increase/decrease the number of factors in the design, respectively. This is both quicker and more intuitive than having a separate step at the outset for specifying the total number of factors.

2. New types of factors

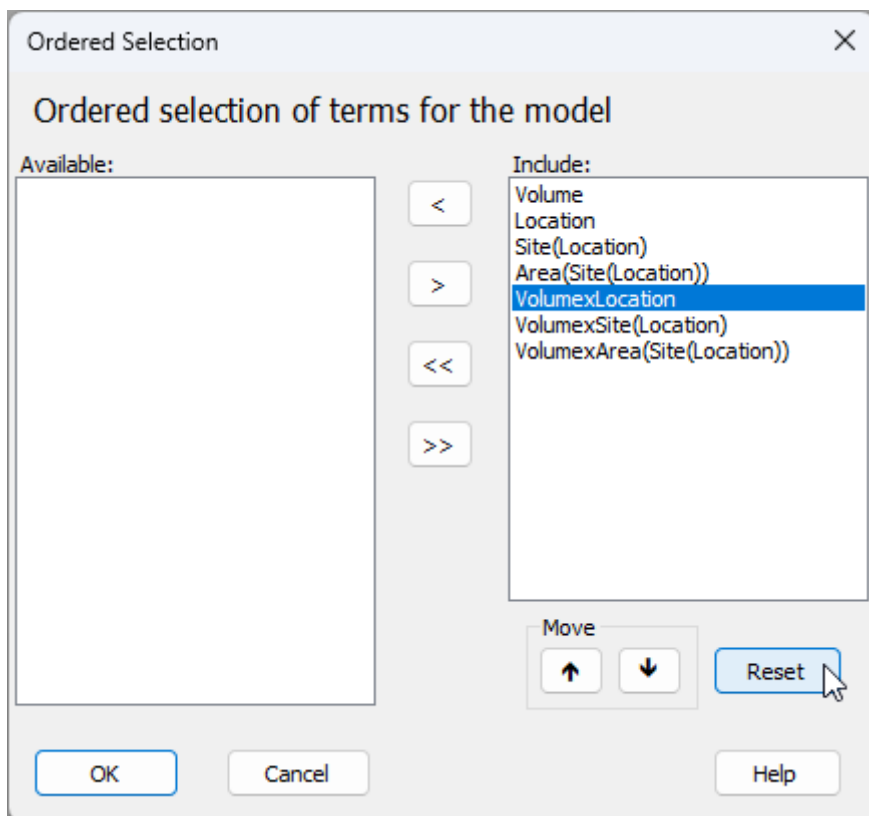
In addition to the possibility of specifying a factor as either 'Fixed' or 'Random', the new PERMANOVA Design file offers you the option of specifying two new types of factors as well. Clicking inside any cell in the column 'Type' in the Design file will bring up the following dialog:



- **Finite factors** - [Anderson et al. \(2025\)](#) have recently articulated how the classical binary dichotomy between fixed and random factors may, instead, be viewed as a series of incremental steps from fixed to random, depending on the number of levels of a factor that are sampled from a potentially finite population of possible levels. There are many situations where the number of levels of a factor included in a study is a substantial fraction of all possible levels in the population. By articulating explicitly the *finiteness* of certain factors in a design, one can greatly increase the power for the tests of greatest interest (e.g., in environmental impact studies).
- **Subject/Whole-plot error** - There are situations where a nested factor contributes a source of variation to the model at a spatial or temporal scale that is larger than the residual, but there is a lack of replication at that level in the study design. In such cases, any interactions with that factor are impossible to estimate and should simply be omitted - that nested factor should be viewed simply as an additional 'error' term. Classic examples include *repeated-measures designs* (e.g., in medical studies where multiple 'Subjects' are being repeatedly measured over time) or *split-plot designs* (e.g., in agricultural studies where some experimental factors occur at a broad spatial scale and others occur at a small spatial scale).

3. Remove, re-order or pool terms in the PERMANOVA model

In complex PERMANOVA models, one may wish to remove individual terms in a model, re-order them, or pool some terms that are deemed to have a variance component equal to zero. You can now click on either the 'Terms...' button (see the image below) or the 'Pool...' button directly in the design file itself, making it much easier to specify the model you want to fit, given the factors in the design.



This window is also now scaleable (just by clicking and tugging on one of its corners), making it a breeze to see all of the terms, including those that have very long names. There is also now a new 'Reset' button if you decide you would like to go back to the full list of all terms implied by the original factors and their specified relationships.

4. New default Type of SS

The Type of Sums of Squares (SS) is fundamental to the fitting of any PERMANOVA model that has any kind of unbalance, so the 'Type of SS' options are now included as part of the design file. In PRIMER 8 we have also changed the default from Type III to **Type I SS**. We have seen over many years that Type III SS is highly conservative to the point of often being counter-productive. More specifically, when fitting unbalanced designs, studies having incomplete cell structure (i.e., where some combinations of levels of crossed factors are completely missing, with $n = 0$), yielding ragged arrays with severe imbalance) will often give 'No test' for quite a few terms in the PERMANOVA model. This is unhelpful and arises through non-independence (overlap) among terms. Imbalance (no matter the severity) is much more sensibly handled, in our view, by running PERMANOVA using Type I SS. One can always re-run the analysis again after changing the order of the terms in the model to investigate rigorously and quantitatively any effects of overlap in explained SS.

5. Inclusion of covariables and their interactions

The design file now includes the specification of any covariable(s) in your model. New in PRIMER 8 is the ability to fit one or more *groups* of covariables (identified by an indicator) as a single line in a PERMANOVA model. This opens the door for users to specify models in PERMANOVA that involve

periodicity (e.g., using the sin and cos of radians around the circumference of a circle), or sets of covariables that collectively encapsulate spatial relationships (such as latitude, longitude or functions of them). Another new tool available here is the ability to include/exclude interactions either: (i) between covariables and other factors in the model or (ii) among covariables. Rapid specification of models for complex designs has never been so easy.

6. Allow for heterogeneity of dispersions

[Anderson et al. \(2017\)](#) provided some solutions to the multivariate Behrens-Fisher problem for dissimilarity-based analyses. PERMANOVA in P8 now allows you the unprecedented ability to test for differences in multivariate centroids while allowing for heterogeneity in multivariate dispersions - at the click of a button. You need only to specify the Term in your model that identifies the groups (cells) having different dispersions. Specifically, by clicking on the 'Groups...' button in the Design file's dialog (shown in Fig. 5.2 above), you will see the dialog window below, where you can specify these groups (or cells):

