

## PRIMER and PERMANOVA+

*Courses in Multivariate Analysis for Ecology & Other Sciences*

**PRESENTERS:** Dr Adam N. H. Smith &  
Distinguished Professor Marti J. Anderson

**DATES:** *Week 1: PRIMER* 26 - 30 August 2024  
*Week 2: PERMANOVA+* 2 - 6 September 2024

**HOSTED BY:** School of Biological Sciences (SBS), University of Auckland

**VENUE:** Biology Building 106, 3A Symonds Street, Auckland, New Zealand

### OVERVIEW

PRIMER-e is pleased to announce an **in-person offering** of back-to-back courses in *Multivariate Analysis for Ecology & Other Sciences* to be held over two weeks at the University of Auckland in New Zealand. *Week 1* will cover the core non-parametric methods implemented in PRIMER software. *Week 2* will cover the semi-parametric methods encapsulated in PERMANOVA+ and other advanced topics. Sessions will run 5 days per week, Monday to Friday, from **8:30 am to 5:30 pm** each day. Participants may register for **week 1 only**, **week 2 only**, or **both weeks**. Each day will include a mixture of lectures and computer lab sessions for participants to practice implementing the new methods and techniques learned on example datasets. Participants will also have the opportunity to discuss and analyse their own data in consultation with the presenter. **Participants are expected to bring their own laptop**. Software may be purchased at a discounted price (see below), or a **free** fully functional (but time-limited) licence of the software can be made available to registered participants for trial use during the course. Note that PRIMER is a Windows-only product, so Macs need to run in Windows emulation. This course will cater both to those who are new to PRIMER and to those who are familiar with PRIMER methods but would like a refresher regarding the latest techniques and approaches.

### WEEK 1 - PRIMER

Week 1 will provide an extensive overview of statistical methods in non-parametric analysis of multivariate data implemented in the software **PRIMER**. Non-parametric statistics and permutation tests make the methods intuitively simple to understand, so **no prior background in statistics is required**.

The topics covered in Week 1 include:

- Properties of multivariate data (summary statistics, shade plots, histograms, draftsman plots, etc.);
- Pre-treatment of data (transformations, normalisations, standardisations, cumulate, aggregate, dispersion/variable weighting);
- Measures of resemblance: distance, similarity and dissimilarity (Euclidean, Bray-Curtis, Sørensen, Jaccard, modified Gower, etc.);
- Cluster analysis (hierarchical agglomerative, divisive and k-R cluster methods using **CLUSTER**), including tests for significant structure within clusters (**SIMPROF**) to permit non-arbitrary classifications of samples/species;
- Ordination *via* projection using principal components analysis (**PCA**) for continuous variables;
- Ordination to preserve sample relationships *via* non-metric, metric or threshold metric multi-dimensional scaling (**MDS**, **mMDS**, **tmMDS**);

- Non-parametric permutation tests for differences among *a priori* groups of samples (analysis of similarities; **ANOSIM** for one-, two- and three-way multi-factor designs and for ordered factors);
- Visualising group differences and variation in the group averages using **bootstrap averages**;
- Relating biotic to abiotic data, including tests of association between resemblance matrices (**RELATE**), and finding optimal subsets of environmental (or other) variables that generate a 'best' match to patterns among samples based on species variables (**BEST**);
- Measures of biodiversity, including richness, even-ness/dominance, abundance-biomass curves, and taxonomic and/or functional diversity and distinctness (**DIVERSE**);
- Identifying important subsets of species and their roles in generating overall multivariate patterns (**BIOENV**, coherence curves) or group/cluster differences (**SIMPER**);
- Identifying roles of environmental (or other) variables in generating biotic patterns or distinctive splits using non-parametric classification and regression trees (**LINKTREE**);
- Graphical tools for effective presentation of results, including **matrix displays** and a variety of plot types (bar, box, violin, means, line, histogram, scatter, surface, shade), **animations** of ordinations captured to video files, bubble plots and multi-variable **segmented bubble plots**.

## WEEK 2 - PERMANOVA+

**PERMANOVA+** allows robust analysis of multivariate data in response to complex sampling/experimental designs on the basis of a resemblance measure of choice, with rigorous inferences obtained using permutation methods. The broader suite of methods in PERMANOVA+ enable formal models, tests, and predictions to be achieved for multivariate ecological (and other) systems that are over-parameterised (i.e., have too many variables) and/or that demonstrate substantial non-normality. Familiarity with the core methods in PRIMER and/or some prior knowledge of basic multivariate methods is desirable. However, Week 2 (like Week 1) will emphasise conceptual understanding, software implementation of the methods and interpretation of results for scientists and practitioners, so **no prior specific background in statistics is assumed**.

The topics covered in Week 2 include:

- Partitioning variation for high-dimensional data on the basis of a resemblance measure of choice – a geometric approach (**PERMANOVA**);
- Tests for differences in centroids (location) for *a priori* groups and constructing specific contrasts (**PERMANOVA**);
- Multivariate variation (spread), tests for homogeneity of multivariate dispersions and comparisons of beta diversity (**PERMDISP**);
- Constructing (pseudo) F-ratios and permutation methods for correct tests of individual terms in multi-factorial designs, based on expectations of mean squares (EMS).
- Complex multi-factor experimental designs, identifying **fixed and random factors** that are **nested or crossed** with one another;
- Quantifying components of variation for individual terms in a PERMANOVA model, simplifying models by pooling or removing terms;
- Advanced experimental design topics, including repeated measures, randomized blocks, inclusion of covariates, imbalance & asymmetry, and BACI designs.
- Fitting multivariate response data (e.g., species) to continuous predictor variables (e.g., environmental), including model selection (**DISTLM**);
- Visualising and quantifying explained (fitted) variation using dissimilarity-based redundancy analysis (**dbRDA**);
- Dissimilarity-based discriminant analysis *via* canonical analysis of principal coordinates (**CAP**), including leave-one-out allocation success and the predictive placement of new points into existing canonical model spaces;
- Discriminate positions along an environmental (or other) continuous variable axis; rotate two sets of variables to explore inter-relationships in a (dissimilarity-based) canonical correlation analyses (**CAP**).

## VENUE

This course is being hosted by the School of Biological Sciences (SBS) at the University of Auckland. All sessions will be held at the University's city campus in Auckland, New Zealand. The course will be held in the Computer Lab, room 014 of the Old Biology Building, Bldg 106, 3A Symonds Street, Auckland 1010. For a map of the campus and additional local information, including accommodation options, parking, directions to the venue, etc., please click [here](#). If you have any other questions regarding on-the-ground logistics at the venue, please contact the local hosts: Jenn Jury ([jenn.jury@auckland.ac.nz](mailto:jenn.jury@auckland.ac.nz)) or Mary Sewell ([m.sewell@auckland.ac.nz](mailto:m.sewell@auckland.ac.nz)). For information regarding registration or any other course-related matters, contact the PRIMER-e admin team directly on +64-(0)9-869-2230 or email us at: [primer@primer-e.com](mailto:primer@primer-e.com).

## COURSE FEES

The course fee **includes** all course materials, coffee/tea and snacks during breaks, free Wi-Fi, and a temporary fully functional time-limited software licence key for the duration of the course, **but not** accommodation, lunches or other meals, or the separate (discounted) cost of purchasing time-unlimited software.

The **registration fees** (*excl. 15% NZD GST*) are:

<i>Prices shown excl. 15% GST</i>	For <b>either</b> Week 1 or Week 2	For <b>both</b> Weeks 1 and 2
<b>EARLY BIRD</b> On or before 21 June 2024	NZD \$1,300 (\$980 for full-time students)	NZD \$2,500 (\$1,800 for full-time students)
<b>AFTER</b> 21 June 2024	NZD \$1,500 (\$1,100 for full-time students)	NZD \$2,800 (\$2,000 for full-time students)

All prices are in New Zealand Dollars(\$NZD). **GST will be applied at invoicing for all registrations.** Please note that our [Global Equitability Pricing \(GEP\)](#) percentage discounts **do not apply to registration fees for in-person courses** such as this one.

## DISCOUNTED SOFTWARE PRICES FOR COURSE PARTICIPANTS

We are pleased to offer all course participants a **special discounted price** of **10% off** our standard base prices to purchase time-unlimited PRIMER software in **\$ NZD**. Course participants may also be eligible for a [Global Equitability Pricing \(GEP\)](#) discount on all our software products. Any GEP discount will be applied **on top of** the **special discounted price**. **All** discounts for which you are eligible (including, for example, discounts for upgrades, etc.) will be applied on invoice. **New Zealand residents will also pay an added 15% for GST on software purchases.** If you would like a quotation from us for course registration + software prior to registering, please get in touch with us directly at: [primer@primer-e.com](mailto:primer@primer-e.com).

## REGISTRATION

To register, please fill out the registration form available on the [PRIMER-e website](#) and return it directly to [primer@primer-e.com](mailto:primer@primer-e.com) to secure your place. The deadline for registration and payment is **Friday 16<sup>th</sup> August 2024**. Late registrants will only be accepted if space permits. Please get in touch with us directly if you have any questions [primer@primer-e.com](mailto:primer@primer-e.com), and especially if you would like:

- to **obtain a quote** for your registration (with or without software), including all discounts for which you are eligible;
- to register **more than one individual** from your organisation and pay on a single invoice (please include separate registration forms for each individual participant); or
- to purchase **more than one software licence** at discounted prices on a single invoice.

## ABOUT THE PRESENTERS

**Adam Smith** obtained his PhD from Massey University (MU) in Auckland, New Zealand and is currently a Senior Lecturer in Statistics at MU and a Research Associate at PRIMER-e. Adam specialises in the application of modern statistical methods to ecology and management, including fisheries and marine reserve assessment. Adam has a wealth of multi-disciplinary experience and lectures across a wide range of areas, including data mining, quantitative ecology, and biostatistics. He has been a key consultant to industry and government, having worked as an in-house statistician for the Department of Conservation (DoC) and the National Institute for Water and Atmospheric Sciences (NIWA) in New Zealand. Adam is an enthusiastic and engaging lecturer with a passion for natural environments and for teaching and learning.

**Marti J. Anderson** is the Director of PRIMER-e (Quest Research Limited), a Fellow of the Royal Society of New Zealand (FRSNZ) and Distinguished Professor Emerita at the New Zealand Institute for Advanced Study (NZIAS) at Massey University in Auckland. Her core research is in community ecology, biodiversity, multivariate analysis, experimental design and resampling methods, with a special focus on developing novel statistical methods for ecology. She has developed all of the statistical methods in PERMANOVA+ and especially enjoys engaging in the dynamic interactions with students, academics and professionals that have become a trademark of the PRIMER/PERMANOVA+ international courses, shedding new light on multivariate data.