

Section: [Ordination analysis](#)

Ordination diagrams

Theory R functions Examples

Ordination diagrams are (usually two-dimensional) representations of the ordination analysis results. Different ordination methods may differ in conventions which and how the results are displayed (see the comparison of PCA, CA, RDA and CCA ordination diagrams on [Fig. 1](#); visual appearance also varies among programs and authors. Important for plotting ordination diagrams is the fact that ordination methods return “scores” for descriptors (often species, but could also be e.g. environmental variables) and samples (sites), which are their positions (coordinates) along ordination axes. Most of the ordination methods contain many ordination axes (with the number of axes depending on the algorithm used), but only a few of them are worth to display and interpret, which makes drawing of ordination diagrams meaningful.

The following are standard conventions for displaying ordination diagrams:

- Samples (sites) – points; distances between points approximate compositional dissimilarity among samples (represented by relevant distance, e.g. Euclidean in PCA/RDA or chi-square in CA/DCA/CCA).
- Species – arrows for linear and centroids for unimodal and distance-based methods; arrows indicate the direction in which abundance of species increases and centroids indicate the position of the species optima in ordination diagram from which the abundance of given species decreases in all directions;
- Ordination axes – horizontal one is always more important than vertical (axis of higher order, e.g. horizontal = 1st axis and vertical 2nd, or horizontal 2nd and vertical 3rd); axes represent main gradients in species composition.
- Environmental variables – arrows for quantitative, centroids for qualitative; arrows indicate in which direction the value of environment increases and centroid indicates in which part of the diagram the qualitative variable has which state.

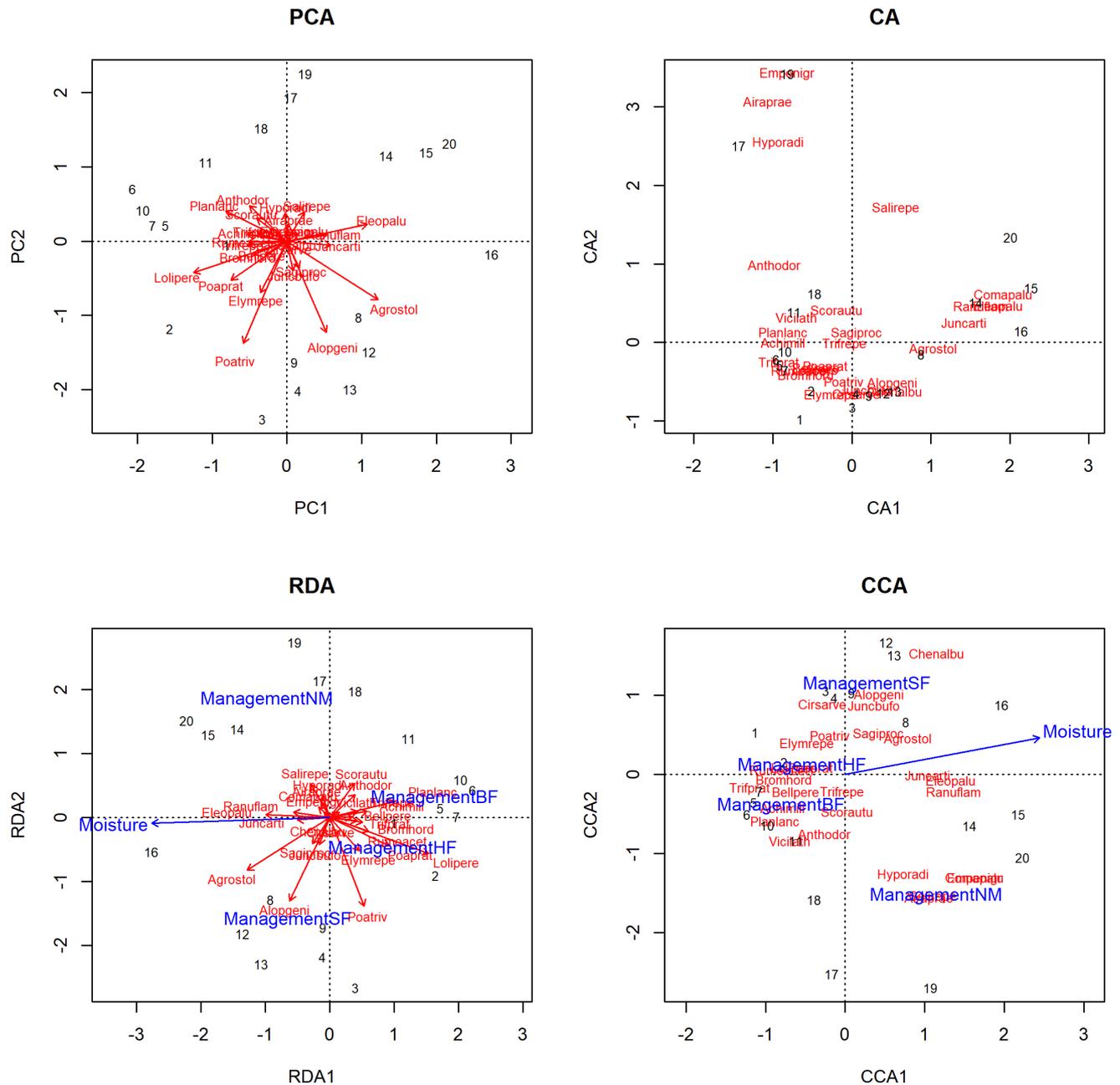


Figure 1: Comparison of ordination diagrams for constrained and unconstrained ordination (upper and lower row, respectively) and for linear and unimodal methods (left and right column, respectively).

Types of ordination plots

Several different types of ordination diagrams are used, depending on the number or type of variables displayed (Fig. 2): **scatterplot (one type of data, e.g. only species scores or only site scores)**, **biplot (two types of data, e.g. species scores and environmental variables)**, **triplet (three types of data, e.g. species and samples scores and environmental variables)**. Joint plots** are another term used for ordination diagrams mostly showing the vectors of environmental variables, used to interpret the relationship (correlation) between them (from the angle and the length of the vector, more on this in the section [Supplementary variables \(unconstrained ordination\)](#)).

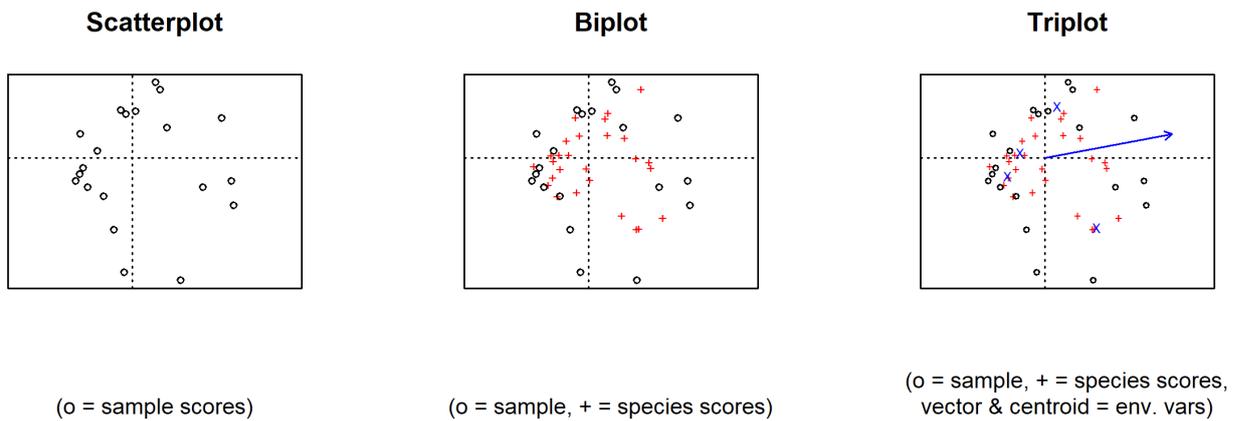


Figure 2: Types of ordination diagrams.

How many ordination axes to consider?

Most often two, sometimes three, rarely four, almost never more. If you are familiar with your data (e.g. sampling design, environmental variability), you will probably know what number of ecological dimensions is worth to consider (e.g. reflecting the number of main uncorrelated environmental variables shaping species composition). But do not attempt to interpret too many axes; as put by [McCune & Grace \(2001\)](#): “Very few ecologists have dared to venture into the uncertain waters of four or more dimensions”.

In the case of *unconstrained ordinations*, you may plot the scree plot (barplot) of eigenvalues. Eigenvalue represents the variation in data which is captured by given ordination axis, and ordination axes are ordered according to their eigenvalues (from highest to lowest). From the scree plot, you can see whether there is some major discontinuity (i.e. whether there is a steep decline in the eigenvalue from some of the axis) and use only those axes which capture a considerably higher number of variation. Also, the following two methods can help with the decision of how many axes to keep ([Borcard et al. 2011, Fig. 3](#)):

- Kaiser-Guttman criterion – calculate the mean of all eigenvalues and interpret only axes with eigenvalues larger than this mean;
- *broken stick model* – randomly divides the stick of unit length into the same number of pieces as there are PCA axes and then sorts these pieces from the longest to the shortest. Repeats this procedure many times and averages the results of all permutations (analytical solution to this problem is also known). *Broken stick model* represents a null model and generates values of eigenvalues, which would occur at random. One may want to interpret only those PCA axes with eigenvalues larger than values generated by *broken stick model*.

In the case of *constrained ordination*, you may consider testing the significance of individual axes and project only those, which are significant.

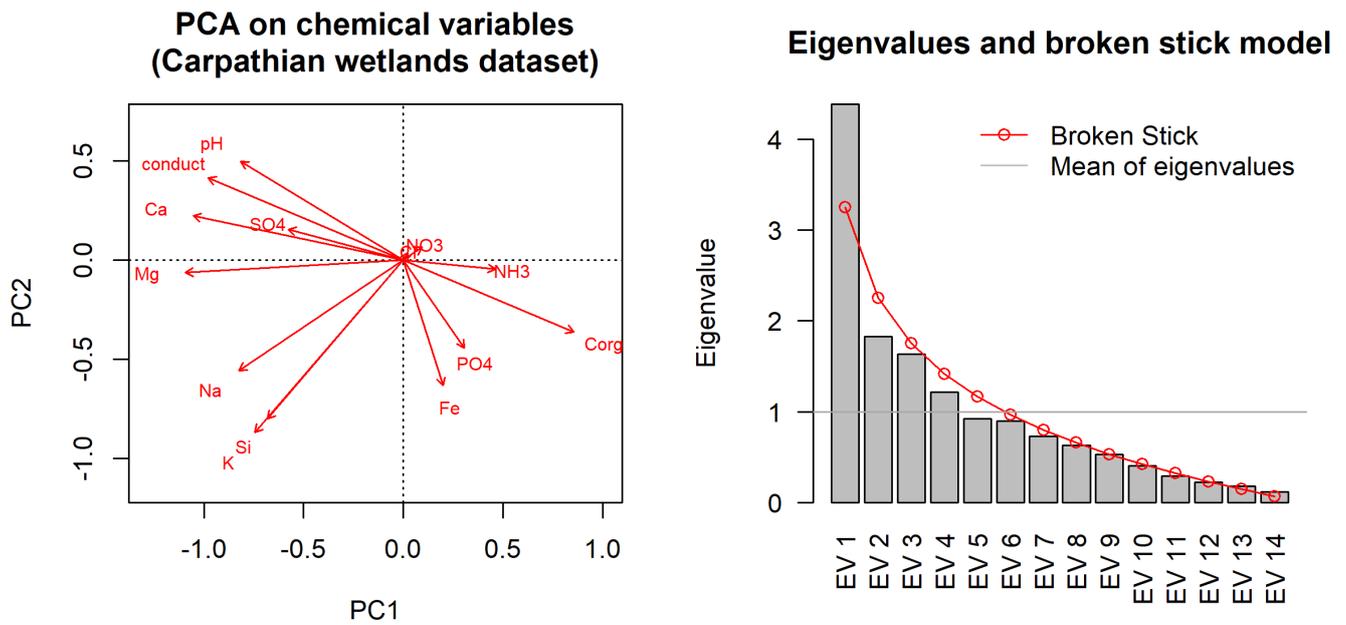


Figure 3: PCA ordination on chemical variables from the Carpathian wetlands dataset. Left: ordination biplot, right: comparison of real eigenvalues (grey bars) with null model values generated by the broken stick model (red broken line) and mean eigenvalues (Keiser-Guttman criterion, grey horizontal line).

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