Other Ordination Techniques

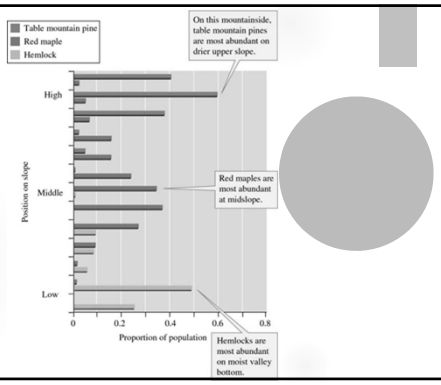
LECTURE 04

Objectives

- At the ends of this series of lectures you should be able to:
  - Define terms.
  - Discuss the problems associated with PCA.
  - Discuss detrending.
  - Describe different ordination techniques, their advantages and when they are appropriate.
  - Interpret basic ordinations.

Problems with PCA

- Outliers
- Arch or horseshoe effect
- Linearity
  - Problem for community analyses – other biological analyses
  - Do species respond in a linear fashion to environmental gradients?
    - Whittaker



Common Ordination Techniques

- Classification
  - Direct vs. indirect
  - Distance vs. eigenanalysis
  - Linear vs. unimodal

Common Ordination Techniques

	Indirect	Direct
	Distance Polar ordination, PO Principal Coordinates Analysis, PCO Nonmetric Multidimensional Scaling, NMDS	
Linear	Eigenanalysis Principal Components Analysis, PCA	Redundancy Analysis, RDA
Unimodal	Correspondence Analysis, CA Detrended Correspondence Analysis, DCA	Canonical Correspondence Analysis, CCA Detrended Canonical Correspondence Analysis, DCCA

Detrending

- Arch effect
  - Horseshoe
- Break the arch and realign the means
  - Demonstrate
  - An inelegant solution

Polar Ordination

- Bray-Curtis Ordination or PO
- Rationale
  - Polar ordination arranges samples between endpoints or 'poles' according to the distance matrix. These endpoints can be the two samples with the highest ecological distance between them, or two samples which are suspected of being at opposite ends of an important gradient.
  - Demonstrate

Polar Ordination

- Advantages
  - Fast – important before ready access to computers
  - Good on problems that have a conceptual reference point.
  - One of the best performing ordinations for community data – despite a undeserved poor reputation.
- Disadvantages
  - Can be somewhat subjective.
  - Sensitive to outliers (particularly in the first two points – poles).
  - Not a general solution or description.

Principal Coordinates Analysis

- PCO or PCoA
- Rationale
  - It maximizes the linear correlation between the distances in the distance matrix, and the distances in a space of low dimension.
    - Same as PCA if Euclidean distance is used.

Principal Coordinates Analysis

- Advantages
  - Performs better than
- Disadvantages
  - Arch effect
  - One cannot easily put new points in a PCO.
  - PCO assumes that there are a fixed number of gradients. Other techniques assume that there are potentially many gradients, but of declining importance.

Nonmetric Multidimensional Scaling

- NMDS
- Rationale
  - PCA and PCO suffer from arch effect because of maximizing linear correlations
  - NMDS maximizes rank order correlation.
    - Brief algorithm:
      - Select the number of dimensions (N) for the solution and choose an appropriate distance metric.
      - The distance matrix is calculated.
      - An initial configuration of samples in N dimensions is selected. Usually derived from another ordination technique.
      - Stress is calculated (mismatch between the rank order of distances in the data and the rank order of distances in the ordination).
      - The samples are moved slightly in a direction that decreases the stress.
      - Prior two steps are repeated until "stress appears to reach a minimum.

Nonmetric Multidimensional Scaling

- Advantages
  - "nonparametric"
  - No assumptions of linearity
  - Uses lots of data types (expressed as distances)
  - A top performer in community analysis
- Disadvantages
  - Time consuming – computationally expensive
  - Local optimums – Although this maybe overstated
  - Order of axes is not important – rotation may help determine important axis.
  - Species identity is hidden after calculation of distance matrix.

Principal Components Analysis

- PCA or "Factor Analysis"
- Rationale
  - See earlier lecture.

Principal Components Analysis

- Advantages
  - PCA is available in most statistical packages.
  - Elegant
  - PCA does not change the positions of points relative to each other; it just changes the coordinate system.
  - PCA can place new points in an old ordination.
  - Good performer when linear relationships are present
- Disadvantages
  - Arch or horseshoe effect
    - Avoid in community analyses or when linear response is not expected.
  - Sensitive to outliers.

Correspondence Analysis

- CA or RA (Reciprocal Averaging),
- Can be detrended, DCA – DECORANA
- Rationale
  - Sample scores are calculated as a weighted average of species scores, and species scores are calculated as a weighted average of sample scores, and iterations continue until there is no change.
  - Simultaneously ordinates species and samples. There are as many axes as there are species or samples, whichever is less.

Correspondence Analysis

- Advantages
  - Software
  - Conceptually similar to PCA with inclusion of cases as "variables."
- Disadvantages
  - Arch effect – hence the need for detrending
  - Sensitive to outliers (?)

Correspondence Analysis

- DCA is quite popular in ecology because of some influential books.
  - It does not perform as well as other techniques (PO, NMDS, CCA).
    - First axis is good if there is a strong dominant gradient, but other axes are poor regardless of presence of other gradients. Detrending improves.
    - Compression at end of gradients. Detrending improves.
    - Exaggerates the importance of rare species.

Indirect Gradient Analyses

- NMDS and DCA are the most popular indirect gradient analyses.
  - NMDS performs better.

Canonical Correspondence Analysis

- CCA -- CANOCO
- Can be detrended – DCCA
- Rationale
  - Uses two matrices: a community matrix and a environmental or predictor matrix.
  - CCA is a cross between multiple regression and CA and multiple regression.
  - Like CA, CCA maximizes the correlation between species scores and sample scores.
  - In CCA, the sample scores are constrained to be linear combinations of explanatory variables.

Canonical Correspondence Analysis

- Advantages
  - Software
  - Direct gradient analysis – Determines which environmental factors are important in generating the observed community structure.
- Disadvantages
  - Arch effect – hence the need for detrending
  - Poorer performing at representing structure between the communities.
  - All the potential problems with multiple regression.
  - Large numbers of predictor variables can lead to spurious conclusions.
  - R2 difficult to interpret.
  - DCCA is magic – Possibly black magic – CANOCO

Redundancy Analysis

- RDA
- A special case of CCA – a linear relationship between species and gradient rather than unimodal.

Interpreting an Ordination

- The direction of the axes (e.g. left vs. right; up vs. down) is arbitrary and should not affect the interpretation.
- The numeric scale on the axis is not very useful for the interpretation.
- In most techniques, the order of the axes is important. Thus, axis 1 is more important than axis 2, etc. The meaning of 'importance' depends on the technique employed, but ideally related to the relative influence of environmental gradients.

Interpreting an Ordination

- Third and higher axes can be constructed. The choice of 'when to stop' interpreting new axes is largely a matter of taste, the quantity and quality of the data, and the ability to interpret the results.
- It is desirable that axes not be correlated, because you would like them to represent different gradients. Most techniques automatically result in uncorrelated (or orthogonal) axes.
- A biologist's insight, experience, and knowledge of the literature are the most important tools for interpreting indirect gradient analysis.