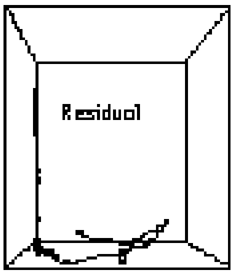

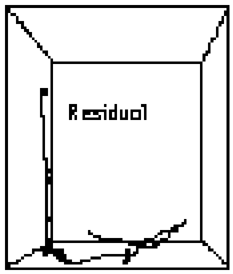

Ecological Computations Series (ECS): Vol. 4

CONAPACK: PROGRAM FOR CANONICAL ANALYSIS OF CLASSIFICATION TABLES

László Orlóci

REVISED INTERNET EDITION - Porto Alegre 2002

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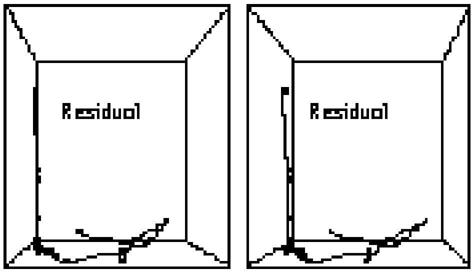

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Contents

Preface

Classification tables, known also as contingency tables, arrange data in some purposeful way. For example, when species densities (table cells) are placed according to soil moisture regime (rows) and soil texture (columns), the classification table displays the density pattern under moisture x texture effect. While the classification in this case is completely extrinsic (independent from the data), other possible classifications with purposes of their own could be completely intrinsic. For example, densities may be placed in the table according to species groups and relevé groups, established in a direct analysis of densities, to reveal the strength of group-to-group predictivity. Classification criteria may be mixed, such as in a species x pH arrangement of species density data. Canonical contingency table analysis, as implemented in the CONAPACK application, described in this book, is designed to probe the data for the structural consequences of classification:

1. **Structure type.** Both discrete and continuous structures are of interest. Detection is by data grouping and ordering, in manners already mentioned.

2. Structure sharpness. This depends on the strength of the row x column effect. Sharpness varies from low, when the structure is a chance construct, to high when the structure is trended.

3. **Dimensions.** Structural sharpness begets in some complicated ways a latent row/column/cell/block ordering in the table. The ordering can be compared to placing unit objects, as points, in n-space at distances proportional to their dissimilarities. It is to be expected that as dimensionality increases, structure complexity increases also, but not all dimensions will be worth investigating. In fact, the dimensions of interest are only those which define a definite trend. Consequently, the ideal method of analysis is the one that can isolate the trended subspace from the nontrended. How well does canonical contingency table analysis measure up to being an "ideal" method? It certainly isolates linear trends, but it leaves the nonlinear ones to collect in a grab-bag category of "random variation". This is a weakness, traceable directly to the product matrix and Eigenanalysis, the pillars of canonical contingency table analysis. To compensate for this weakness, it is important to shorten the ordering resource (pH gradient, salinity gradient, etc.) as needed to render all species responses linear[1], or at least decidedly monotonic.

4. **Trended structures, environmental links**. Trended structures are begot, as it were, by species response processes linked to external effects. How to identify the links? Consider the case where pH is the ordering variable and species density is the deemed response. When presented in a density x pH graph, one will have a faulty model if the raw data were graphed, since neither pH nor species density could conceivably be independent from other variables in their respective geographic domain. In fact, it is certain that density and pH interact with many other variables. Because of this, the height of the graph at any pH point will not measure a density

[1] This necessarily implies linear correlations.

response to pH *per se*, but to pH, to other influential variables which vary with, have influence on and being affected by pH, and to influences in other categories that vary independently from pH, yet capable of triggering responses. The effects of the variables in this last category, potentially critical as they are, will be trapped as "random effects" and will be oblivious to detection based on inspection of the raw density x pH graph. Clearly, real trends can be masked in this way, and a trend undetected will not be proof that density production and pH are independent. What does this have to do with canonical contingency table analysis as implemented in CONAPACK? Very much! It will be seen that the analysis generates residual data from which the graphs are free of interference issuing from "random" sources.

5. Vegetation edges unexpected by chance. Assume that the rows of the classification table, ordered or unordered, describe plant species performance in quadrats, and further, that the quadrat records (columns) are ordered in a natural way according to position on a geographic transect. Although the ordering criterion is geographic, edges are sought in the vegetation. In this, the problem amounts to finding intrinsic boundary conditions (tension points, lines, surfaces, or solids) which fragment the relevant transect mappings in analytical space into homogeneous segments at scales inherent in the unit of sampling. CONAPACK supplies the basic data for edge detection and the graphs on which the vegetation edges are found and the environmental edges can be overlain.

The book contents revolve around the topics just described. The main text begins with primary data manipulations, followed by root analyses. The technicalities in running the CONAPACK application are discussed next. The main text concludes with realistic examples documented by data files, startup dialogue, PRINTDA and KEP files (which contain the alphanumeric results and graphics), and models of interpretation. The final chapters include a glossary of terms and an extensive bibliography.

CONAPACK incorporates a set of integrated programs activated by selection of options. CONAPACK exists in Macintosh and DOS versions, compiled and linked, requiring no interpreters to run. The memory requirement is not prefixed, but depends on the problem since all the arrays are dynamic. The Macintosh version has a full-fledged graphics routine, including storage of screen pages in disk files for editing and printing in external PAINT or DRAW applications. The DOS version has fewer of these graphics capabilities. Both versions produce output that can be processed by programs of our EPIC package (Orlóci 1991a), such as STEREO, METRICS, SSA, TREE and CHIPROBS. These programs perform tertiary data manipulations, such as construction of stereograms and dendrograms, computation of metrics, cluster analysis, and probability computations. CONAPACK is offered to users on one high density Macintosh or DOS formatted diskette.

L. Orlóci

London 1991

1
Primary data manipulations

1.1 Concentration of table entries

Designate as ***U*** the raw data table and as U_{rs} the value in the intersection of row r and column s. ***U*** has p rows and n columns. The data type is one of the following:

- occupancy (0,1) records such as species presence/absence.
- density records such as counts of plants within quadrats.
- frequency records such as counts of occupied units.

Assume that cluster analysis is performed (formal or informal) and allocations are made to assign the p rows to q groups and the n columns to t groups. The results is a rearrangement of the records in q x t table blocks. Based on this, a q x t table ***f*** can be created of the block totals as shown in symbolic terms in Table 1.1.1.

Table 1.1.1 Classification table ***f***. The contents of table ***U*** are condensed.

Column group		1	2	...	t	*Total*
	1	f_{11}	f_{12}	...	f_{1t}	$f_{1\cdot}$
Row	2	f_{21}	f_{22}	...	f_{2t}	$f_{2\cdot}$
group	.	.	.	...	.	.
	q	f_{q1}	f_{q2}	...	f_{qt}	$f_{q\cdot}$
Total		$f_{\cdot 1}$	$f_{\cdot 2}$	...	$f_{\cdot t}$	$f_{\cdot\cdot}$

Symbols:

f_{ij} - sum of all U_{rs} in block *ij*

$f_{i\cdot}$ - sum of all U_{rs} in row group *i*

$f_{\cdot j}$ - sum of all U_{rs} in column group *j*

$f_{\cdot\cdot}$ - grand sum

1.2 Block size adjustments

The q x t blocks of the rearranged **U** are likely to have different sizes. This affects the block totals, and in turn, prevents a direct comparison of the blocks. Block size equalization is in order. The function used for this by CONAPACK is

$$f_{ij} := \frac{\frac{f_{ij}}{n_{ij}} f_{\cdot\cdot}}{\sum_{k=1}^{q} \sum_{m=1}^{t} \frac{f_{km}}{n_{km}}}$$

It is noted that the adjustment will leave the table total unchanged. Regarding symbols, read *"*f_{ij}*:="* as *"the value in the cell ij becomes"* and n_{ij} as *"the size of block ij"*. The latter is equal to the number of row units times the number of column units in the block. Other symbols in the equation accord with their definitions as used in Table 1.1.1.

1.3 Removing serial dependences

If the column vectors of **f** are arranged in a natural order, it is conceivable that the ordering variable procreates serial dependences of some orders. As options, CONAPACK performs autocorrelation and positional correlation analysis to test the series for 1st order linear dependences and generates data residuals from which these dependences are removed.

1.3.1 Autocorrelation

Designate the quantity of population h in quadrat j as f_{hj} and in quadrat $j+1$ as $f_{h(j+1)}$, the number of quadrats as t, the mean over the first $t-1$ quadrats as $\bar{f}_{hX}$, and the mean over the last $t-1$ quadrats as $\bar{f}_{hY}$. In these terms, an autocorrelation of lag 1 can be computed by

$$r_{h|1} = \frac{\sum_{j=1}^{t-1} (f_{hj} - \bar{f}_{hX})(f_{h(j+1)} - \bar{f}_{hY})}{\left(\sum_{j=1}^{t-1} (f_{hj} - \bar{f}_{hX})^2 \sum_{j=1}^{t-1} (f_{h(j+1)} - \bar{f}_{hY})^2 \right)^{1/2}}$$

(see Kendall and Stuart 1976, pp. 375-376, Orlóci and Orlóci 1990). The regression coefficient of $f_{h(j+1)}$ on f_{hj} is

$$b_{h|1} = \frac{\sum_{j=1}^{t-1} (f_{hj} - \bar{f}_{hX})\ (f_{h(j+1)} - \bar{f}_{hY})}{\sum_{j=1}^{t-1} (f_{hj} - \bar{f}_{hX})^2}$$

and the residual data accord with

$$f_{hj} := (f_{h(j+1)} - \overline{f}_{hY}) - b_{h|1}\,(f_{hj} - \overline{f}_{hX}) + \overline{f}_{hY} = f_{h(j+1)} - b_{h|1}\,(f_{hj} - \overline{f}_{hX})$$

This is computed for all $f_{hj} \neq 0$. Note that by convention, zeros are not changed. Consequently, populations are not introduced arbitrarily by the arithmetic. An *a posteriori* adjustment is applied uniformly to render the f_{hj} positive in a_h.

1.3.2 Correlation with position

The positional correlation computed in CONAPACK is for the f_{hj} with the series $(1 \;\; 2 \;\; \ldots \;\; t)$ at lag 0. Data residuals are computed under a convention which leaves any zero f_{hj} as zero. Any f_{hj} equal to the height of the regression line is given the value $\overline{f}_{hY}$.

2
Root analyses

2.1 Structure sharpness

This is measurable as heterogeneity and interaction. The relevant physical property is chi-squared (χ^2) based on which can be tested under the null hypothesis (H_o) that the q x t blocks in ***U*** are indistinguishable, and under component hypotheses (H_{o1}, H_{o2}, H_{o3}) which stipulate other types of indistinguishability and independence (see the observed concentrations within the q x t table blocks of ***U***, do not deviate significantly from the elements in a null table $\boldsymbol{f}^o$ which would arise if the concentrations were the outcome of a completely random process. The component hypotheses are:

$$H_{o1}: [E(f_{i.}) = f^o_{i.}; \ f^o_{i.} = \frac{f_{..}}{q} \text{ for all } i]; \text{ the } q \text{ row groups are indistinguishable.}$$

H_{o2}: $[E(f_{.j}) = f^o_{.j}\ ;\ f^o_{.j} = \frac{f_{..}}{t}$ H_{o1}: $[E(f_{.j}\ ) = f^o_{.j};\ f^o_{.j} = \frac{f_{..}}{t}$ for all $j]$; the t column groups are indistinguishable.

H_{o3}: $[E(f_{ij}) = f^o_{ij};\ f^o_{ij} = \frac{f_{i.} f_{.j}}{f_{..}}$ for all $ij]$; the row and column criteria which define the $q \times t$ blocks are independent.

Rejection of the null hypothesis implies distinguishability of the row groups, the column groups, or the $q \times t$ blocks, or lack of independence. The test criteria are formulated in information theoretical terms (not included in CONAPACK):

Hypothesis	Degrees of freedom	χ^2
H_{o1}	$q-1$	$2 \sum_{i=1}^{q} f_{i.} \ln \frac{f_{i.} q}{f_{..}}$
H_{o2}	$t-1$	$2 \sum_{j=1}^{t} f_{.j} \ln \frac{f_{.j}}{f_{..} t}$
H_{o3}	$(q-1)(t-1)$	$2 \sum_{i=1}^{q} \sum_{j=1}^{t} f_{ij} \ln \frac{f_{ij} f_{..}}{f_{i.} f_{.j}}$
H_o	$qt-1$	$2 \sum_{i=1}^{q} \sum_{j=1}^{t} f_{ij} \ln \frac{f_{ij} qt}{f_{..}}$

The symbols are similarly defined as used in Table 1.1.1. For theory and applications Kullback (1959), Kullback, Kupperman and Ku (1962), Orlóci (1978) and Feoli, Lagonegro and Orlóci (1984) are key references. The criterion χ^2 will have the axiomatic chi-squared sampling distribution, provided that the null hypothesis is true, sampling is random, the sampled population is Poisson, and $f_{..}$ is very large. α level sharpness is declared if the condition

$$\chi^2 \geq \chi^2_{a;n}$$

is satisfied.

2.2 Compositional trend

If a structure is deemed sharp, a compositional trend[2] is assumed among the q x t table blocks. Canonical contingency table analysis will partition it in

$$m \leq INF(q\text{-}1, t\text{-}1)$$

dimensions simultaneously with the additive partition of the total chi-squared:

$$\chi^2 = \chi^2_1 + \ldots + \chi^2_m) = f_{..} R^2_1 + \ldots + f_{..} R^2_m)$$

The value m depends on the complexity of the structure. The coefficients

$$R^2_1 , \ldots , R^2_m$$

called "squared canonical correlations" are the nonzero Eigenvalues of the product matrix

$$\boldsymbol{S} = \delta\delta'$$

A typical element in $\boldsymbol{S}$ is given by

$$S_{rs} = \sum_{j=1}^{t} \delta_{rj}\delta_{sj}$$

where

$$\delta_{rj} = \frac{f_{rj}}{\sqrt{f_{r\cdot} f_{\cdot j}}} - \frac{\sqrt{f_{r\cdot} f_{\cdot j}}}{f_{..}}$$

---

[2] The term "gradient" and "trend" are used interchangeably in the ecological literature, and also in this book.

δ_{sj} is similarly defined.

The term "canonical' is a reference to variables that come in groups $(\boldsymbol{X_i}, \boldsymbol{Y_i})$. In our unique case, one member of the group

$$\boldsymbol{X}_i = [X_{1i}\, X_{2i} \ldots X_{qi}]$$

is specific to the q row groups, and the other member

$$\boldsymbol{Y}_i = [Y_{i1}\ Y_{i2} \ldots Y_{it}]$$

is specific to the t column groups. There are m X,Y pairs. Transfer of values between X and Y is simple:

$$X_{hi} = \sum_{j=1}^{t} \frac{f_{hj} Y_{ij}}{f_{h\cdot} R_i}$$

or in the reverse,

$$Y_{ij} = \sum_{h=1}^{q} \frac{f_{hj} X_{hi}}{f_{\cdot j} R_i}$$

In these equations, X_{hi} is the score of row h on canonical variate X_i and Y_{ij} is the score of the column j on canonical variate Y_i. The $\boldsymbol{X}$ and $\boldsymbol{Y}$ vectors are derived from the Eigenvectors (α) of $\boldsymbol{S}$:

$$X_{hi} = \sqrt{\frac{f_{\cdot\cdot}}{f_{h\cdot}}}\, \alpha_{hi}$$

Note that α_{hi} will satisfy the double constraint,

$$\sum_{h=1}^{q} f_{h.} \alpha_{hi} = 1 \quad \text{and} \quad \sum_{h=1}^{q} \sqrt{f_{h.}}\, \alpha_{hi} = 0$$

From the point of computations, reversibility is important. When t is less than q, computer time will be saved if a $t \times t$ $\boldsymbol{S}$ is analyzed. Incidentally, identical results will be obtained, but the analysis will take longer, if the dual $q \times q$ $\boldsymbol{S}$ is analyzed.

2.3 Dimensionality

The X,Y canonical variates are linked to responses which may be weak or strong. Their strength is measured by the magnitude of the chi-squared specific to an X,Y pair. Considering the ith pair,

$$L_i = \frac{f..R_i^2}{\chi^2}$$

or

$$L_{i\%} = 100L_i.$$

are relative measures of strength. The descending values

$$L_1 > L_2 > ... > L_m$$

invite the same pertinent question as the descending Eigenvalues in component analysis: "How many of them should be retained?" To find this out, the $f..R_i^2$ are compared. However, the comparison would is heuristic, since for this type of chi-squared no axiomatic distribution is available (see Kendall and Stuart, 1968, pp. 595; also Gittins, 1979.) Monte Carlo simulation is the proper test vehicle (Edgington 1987), but it is tedious and requires a program. In a simpler approach, a threshold is set and any canonical correlation below it is ignored. What ever number of dimensions remain after these will be taken as the dimensionality of the trend.

2.4 Links

One should attempt to attach ecological significance to the structural dimensions. To this end, CONAPACK finds two matrices of canonical scores,

$$\boldsymbol{X} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ . & . & \cdots & . \\ X_{q1} & X_{q2} & \cdots & X_{qm} \end{bmatrix}$$

$$\boldsymbol{Y} = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1t} \\ Y_{21} & Y_{22} & \cdots & Y_{2t} \\ . & . & \cdots & . \\ Y_{m1} & Y_{m2} & \cdots & Y_{mt} \end{bmatrix}$$

and writes them in separate files. These can be used as input in tertiary analyses to determine correlations with environmental variables. The computation is performed by specific programs (CORRELATIONS, METRICS, PINDEX, etc.) in the EPIC package.

2.5 Deviations profiles

Each set of deviations

$$[\Delta_{hj} = f_{hj}; -f^{o}_{hj};\ j = 1, ..., t \text{ or } h = 1, ..., q]$$

define a profile over the ordering variable. This profile is conceived to be a composite of m independent profiles. The ith independent profile is constructed from deviations:

$$[\Delta_{ihj};\ j = 1, ..., t \text{ or } h = 1, ..., q]$$

These are such that for any *hj* cell in ***f*** there are m deviation partitions,

$$\Delta_{hj} = \Delta_{1hj} + \Delta_{2hj} + \dots + \Delta_{mhj}$$

These are computed by CONAPACK as weighted products of the canonical scores:

$$\Delta_{ihj} = \frac{X_{hi} Y_{ij} R_i f_{h.} f_{.j}}{f_{..}}; \ i = 1, .., m$$

In total, there are m sets of $q \times t$ Δ_{ihj} values:

$$\Delta_1, \ \Delta_2, \ \dots, \ \Delta_m$$

Each is an independent "Deviations partitions table". The following are relevant properties:

1. Independence is linear, *i.e.,* $\boldsymbol{X}_i \boldsymbol{X}'_j = \boldsymbol{Y}_i \boldsymbol{Y}'_j = 0.$

2. The rows and columns in any deviations partitions table Δ_i have the same identity as the rows (or groups of rows) and the columns (or groups of columns) in the original table $\boldsymbol{U}$, or in the condensed table $\boldsymbol{f}$.

3. The chi-squared term associated with Δ_i is

$$\chi_i^2 = f_{..} R_i^2$$

The ratio

$$\frac{\chi_1^2}{\chi^2}$$

is a relative measure of the weight of Δ_i in accounting for structure.

4. Should Y_i impose an ecologically meaningful order on the m column entities in terms of the levels of some extrinsic factor E, the graph

$$[\Delta_{ih1} \quad \Delta_{ih2} \quad \dots \quad \Delta_{iht}]$$

will characterize variation among the *t* column entities within the hth row entity with respect to E in terms of its ith (analytical) component effect. A positive Δ_{ihj} indicates an f_{hj} higher than expected and a negative Δ_{ihj} indicates an f_{hj} lower than expected. The expectation under H_o is the zero line in the graph. Row and column graphs are drawn by CONAPECK according to the option selected by the user.

5. The tables

$$\Delta_1,\ \Delta_2,\ \ldots,\ \Delta_m$$

are ordered according to the size of the associated chi-squared values

$$\chi_1^2 > \ldots > \chi_m^2$$

Accordingly, as the analysis moves from high to low chi-squared values trendedness is reduced and randomness increased.

2.6 Angles and distances profiles

Designating by b,c,d any three consecutive points in a full dimensional, unidirectional structure mapping, CONAPACK computes the subtending angle at c based on

$$\cos A_c^o = \frac{d_{bc}^2 + d_{cd}^2 - d_{bd}^2}{2 d_{bc} d_{cd}}$$

The distances $d_{bc},\ d_{bd},\ d_{cd}$ are Euclidean (Orlóci 1978.) Note that when the arc tangent of A_c^o is negative, 180^o - A_c^o is taken as the angle. The graph

$$[A_2^o\ A_3^o \ldots\ A_{t-1}^o]$$

is an angles profile and the graph

$$[d_{12}\ d_{23}\ \ldots\ d_{t-1t}]$$

is a distances profile, both drawn automatically by CONAPACK.

2.7 Mapping external vectors into canonical planes

In specific applications, such as in gradient studies, a transect may traverse several bioclimatic zones. Under these circumstances, determination of a new relevé's zonal belonging is a request to be expected. This is a mapping problem within the model (parental) configuration created in the CONAPACK run.

The *modus operandi* involves manipulations of the new relevé's data file, and other files from the CONAPACK run by program CONAMAP. If the new relevé, the external mappable object $\boldsymbol{f}_E$, is conceived as a t-valued row vector (Case 1) with a characteristic element f_{Ej} and total $f_{E.}$, the map of $\boldsymbol{f}_E$ is an m-valued vector of X canonical scores

$$\boldsymbol{X}_E = (X_{E1}\ \ldots\ X_{Em})$$

and a set of deviations profiles

$$\Delta_E = \begin{bmatrix} \Delta_{E11} & \ldots & \Delta_{Et1} \\ . & \ldots & . \\ \Delta_{E1m} & \ldots & \Delta_{Etm} \end{bmatrix}$$

The elements of $\boldsymbol{X}_E$ are computed in CONAMAP (see equation for X_{hi} in Section 2.2 but replace h by E in the subscripts). The computations require:

- $m \times t$ column canonical scores from the CONAPACK run

$$\boldsymbol{Y} = \begin{bmatrix} Y_{11} & \ldots & Y_{1t} \\ . & \ldots & . \\ Y_{m1} & \ldots & Y_{mt} \end{bmatrix}$$

(stored in file COLS.)

- m Eigenvalues (file EIG) the square roots of which are the canonical correlations $(R_1, ..., R_m)$, also from the CONAPACK run.

- column totals $f_{.1}, ..., f_{.t}$ (file COLT) from the original data $\boldsymbol{f}$.

If the new relevé, $\boldsymbol{f}_E$, is conceived as a q-valued column vector (Case 2) with a characteristic element f_{hE} and total $f_{.E}$, the map of $\boldsymbol{f}_E$ is an m-valued vector of Y canonical scores

$$\boldsymbol{Y}_E = (Y_{1E} \;\; \ldots \;\; Y_{mE})$$

and a set of deviations profiles

$$\Delta_E = \begin{bmatrix} \Delta_{11E} & \ldots & \Delta_{m1E} \\ . & \ldots & . \\ \Delta_{1qE} & \ldots & \Delta_{mqE} \end{bmatrix}$$

The elements of $\boldsymbol{Y}_E$ are computed in CONAMAP (see equation for Y_{ij} in Section 2.2 but replace j by E in the subscripts). The computations require:

- $q \times m$ row canonical scores from the CONAPACK run

(stored in file ROWS.)

$$\boldsymbol{X} = \begin{bmatrix} X_{11} & \ldots & X_{1m} \\ . & \ldots & . \\ X_{q1} & \ldots & X_{qm} \end{bmatrix}$$

- m Eigenvalues (file EIG), the square roots of which are the canonical correlations $(R_1, ..., R_m)$, also from the CONAPACK run.

- row totals $f_{1.}, ..., f_{t.}$ (file ROWT) from the original data $\boldsymbol{f}$.

The computation of the elements of Δ_E follow the equation Δ_{ihj} given in Section 2.5 (with h replace by E and subscripts rearranged according to case). The computations based on:

- $\boldsymbol{X}_E$ (CONAMAP run) and $\boldsymbol{Y}$ canonical scores (CONAPACK run) in Case 1 or the $\boldsymbol{X}$ (CONAPACK run) and $\boldsymbol{Y}_E$ canonical scores (CONAMAP) in Case 2;

- m canonical correlations (CONAPACK run);

- the total $f_{E.}$ (CONAMAP run) and t column totals from the CONAPACK run in Case 1, or $f_{.E}$ (CONAMAP run) and q row totals (CONAPACK run).
- the grand total from CONAPACK run.

An additional vector is computed containing the column totals of Δ_E in Case 1, $\Delta_{E1.}, ..., \Delta_{Et.}$ and the row totals of Δ_E in Case 2.

3
Running CONAPACK

3.1 General

CONAPACK is a set of interacting programs which do data adjustments (Chapter 1) and perform the root tasks described in Chapter 2. The specifics in the following descriptions assume a Macintosh system. Similar considerations apply under DOS, except that the graphics tools in that case are rudimentary.

3.2 Sample data The CONAPACK run is illustrated on a data set **f** from Feoli and Orlóci (1979, p. 50.) The f_{hj} are occupancy counts in various sized blocs of a vegetation table from the fossil terraces of the Coquihallaa River in southern British Columbia. The analysis is limited to 9 blocks only at the intersections of species groups 2, 3, 4 and quadrat groups a, b, c in the Feoli-Orlóci table. Sums of squares clustering (program SSA in the EPIC package) created the groupings (Orlóci 1967.)

The original quadrat group labels (a,b,c) are retained in the following text. The species-group labels are changed to A, B, and C. Block sizes (**n**, Table 3.2.1) are stored as file N79.DAT and the unadjusted occupancy counts (**f**, Table 3.2.2) as file O79.DAT. Note that the average block size is 130. To understand exactly the derivation of the **f** and **n** matrices, consider the first block (2,a) in the original Feoli-Orlóci table. In this block, 10 rows intersect with 14 columns, therefore the the first entry (A,a) in matrix **n** is 140. Two cells are occupied (*Amelanchier alnifolia*, quadrat 2; *Rosa gymnocarpa,* quadrat 1) out of the 140 which makes 2 the value in the 1,1 cell of **f**.

Table 3.2.1 Block sizes (matrix **n**) in the Coquihallaa River data.

$$\begin{bmatrix} 10\text{x}14 & 10\text{x}20 & 10\text{x}11 \\ 9\text{x}14 & 9\text{x}20 & 9\text{x}11 \\ 7\text{x}14 & 7\text{x}20 & 7\text{x}11 \end{bmatrix} = \begin{bmatrix} 140 & 200 & 110 \\ 126 & 180 & 99 \\ 98 & 140 & 77 \end{bmatrix}$$

Table 3.2.2 Occupancy counts (matrix **f**) in the Coquihallaa River data.

Quadrat group		a	b	c	Total
Species	A	2	15	71	88
group	B	74	21	2	97
	C	16	112	35	163
Total		92	148	108	348

3.3 File name

To prepare a run, gain familiarity with the data to be entered. Some data entry is through the keyboard during the run. File names and dimension are in this category. Data from the **n** and **f** matrices are entered from disk files. The full file name for the **n** matrix could look like this:

HD:WORK:N79.DAT

and for the **f** matrix:

HD:WORK:O79.DAT

Leading or trailing blanks are permitted in names, but not advised. Upper/lower case characters are not distinguished in file names. HD:WORK:N79.DAT and HD:WORK:O79.DAT locates files N79.DAT and O79.DAT in the folder named WORK on hard disk named HD. It is good practice to collect program and data files in a common WORK folder on hard disk (with ample free memory) in which case the HD:WORK: portion of the file name is not needed.

The primary data files are through screen entree. An editing program, such as the public domain program EDIT, may be used for this purpose. In all cases, the files contain numbers. A file begins with a number and each number, except the last, is followed by an end-of-paragraph mark (¶, unseen except in paragraph mode.) Press the RETURN key to create an end-of-paragraph mark. Blank lines are not permitted inside or preceding the number set and zeros must be entered as zeros. In the example below, matrix **n** is entered by row, 9 numbers in total, each number on a different screen line:

```
140
200
110
126
180
99
98
140
77
```

The format is the same when entering occupancy counts (matrix **f**):

```
 2
15
```

71
74
21
2
16
112
35

This entry mode keeps the row records conterminous. Data entry could be by column. As a rule, enter the **n** and **f** matrices by row or column, which ever is the lesser dimension.

3.4 Startup dialogue

Open a WORK folder and drag the ikons of CONAPACK, **n** and **f** files[3] to this folder. Run CONAPACK from the WORK folder by clicking twice on the CONAPACK ikon. The run begins with the start-up dialogue (Table. 3.4.1.) If CONAPACK and data file ikons are not in the same folder, or not outside any folder and the run has already started, respond on the 1st screen line by pressing key N. This will stop the run. Drag application and data file ikons to the same folder and try a new run. If instead of the N key, the Y key is pressed, the run continues and the program requests new specifications.

Table 3.4.1 First screen page in the Coquihallaa analysis. Startup dialogue and subsequent exchanges are shown. Note that CONAPACK does not distinguish between upper and lower case characters in user responses.

[3] The block sizes file **n** is optional, not needed if block sizes are the same, in which case do not select the "adjust" option in the startup dialogue.

```
 File  Edit  Custom  Run  Windows  Help
Are the input data file(s) in one folder with this program? -- press Y or N:Y
Specify output file name extension:tes
Press Y to store intermediate results on a printable file:Y
________________________________________________________________
Name frequency table file:o79.dat
Specify the number of rows:3
Specify the number of columns:3
Press Y to adjust frequencies to equal block size
(- if no block sizes file exists, press a key other than Y):Y
Name block sizes file:n79.dat

Do you wish to perform autocorrelation analysis? -- press Y or N:N
Do you wish to perform covariance analysis with transect
position? -- press Y or N:N

Weight options are:
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis
To specify weight option, press key 1, 2, 3, or 4: 3
Eigenanalysis -- iteration:  25
Press Y to weight canonical scores by eigenvalues:Y

Working
Specify relative graph size. Type 1 for normal size:? .75
Specify tick mark spacing (1,5,10, etc):? 1
Do you wish to plot deviations table rows or columns? -- press R or C:R
```

On the 2nd screen line, the file name extension is specified. This extension distinguishes the current PRINTDA and the KEP files, which store the numerical and graphical output, from previous files. Old PRINTDA and KEP files with the same file name extension are destroyed.The extension used in the Coquihallaa run is tes. The full names are PRINTDACONA.tes, KEP.tes/1, KEP.tes/2, etc. If Y is pressed on the 3rd screen line, intermediate results will be stored in the PRINTDA file. This is a potent decision, since it may rapidly deplete disk space if the contingency table dimensions are large. If no disk space is left, the run will ungracefully collapse.

The data file name (screen line 4) is the full name under which the **f** matrix is registered in the disk directory. The contingency table dimensions are for the data on file. For example, if a 5 x 17 matrix were entered by columns (17) than the file will contain 17 sets of 5 conterminous entries. Therefore, the appropriate file dimension specification is 17 x 5, that is 17 rows and 5 columns. All subsequent output will be interpreted accordingly. Adjustment option are specified next. If Y is pressed on screen line 8, a block sizes file (**n**) name will be requested. If the autocorrelation option is selected (pressing Y), data residuals will be computed within rows. If the covariance analysis option is chosen, correlations with position will be computed within rows and data residuals will be produced accordingly. Activate the autocorrelation and covariance options only if edge detection is intended.

The weighting options accord with reasoning set out in Orlóci (1978, p. 152 et seq.) Choose Option 3 to activate contingency table analysis proper or edge detection analysis. Eigenweighting of canonical scores is recommended to establish a scale in the canonical variates proportional to the squares of the canonical correlations. At this point under Option 3, the graphics routines begin. Note that graph size is screen independent and the normal graph is about 2 cm high and 3 cm wide. Reduction of graph size will allow a higher number of graphs per screen page and fewer KEP files will have to be stored on disk. Choose option R or C to draw row or column deviations profiles from the Δ, Δ_1, Δ_2, ..., Δ_m tables. After completing m+1 graphs (one row or column vector each from Δ, Δ_1, Δ_2, ..., Δ_m), processing can be directed to any specific set of graphs. After the deviations graphs are drawn, the deviations are squared, pooled, and new squared deviations graphs are drawn. Angles and distances graphs complete the graphics, all stored on disk. After this, return to the beginning of the graphics routines is optional.The last screen page (Table 3.4.2) is a reminder of important file names. Important: Do not press the RETURN key when options are specified as Y, N, C, R or 1,2,3,4. CONAPACK assumes GET KEY input in these cases.

Table 3.4.2 Last screen page in the Coquihallaa analysis.

```
File  Edit  Custom  Run  Windows  Help

Your main printable file is: PRINTDACONA.tes
Graphs are stored in KEP files with extension: .tes
Open and print the PRINTDA file from EDIT
Open and edit KEP files from a PAINT program
Press any key to exit
```

CONAMAP computes the elements of $\mathbf{X}_E$ and Δ_E, and draws deviations profiles based Δ_E. Regarding the following example, the raw sample data set comes from Table 3.2.2 and the adjusted data set from file ADJUSTDAT (from the CONAPACK run):

```
1.728
9.073
78.081
71.046
14.113
2.444
19.750
96.777
54.987
```

These are displayed in structured form in CONAPACK's PRINTDA file (Table 3.5.1).

The following considerations regarding adjustments are relevant only if the cells of the contingency table associate with different sample sizes. This is so in the case of the Coquihalla data (Table 3.2.1). Because of this in anticipation of the adjustments to be applied to the new relevé $\mathbf{f}_E$, the data elements in ADJUSTDAT are conceived as occupancy counts out of 130 trials which is the average block size in the rearranged Coquihalla table. Two new relevés to be mapped are given as

$$\mathbf{f}_{E1} = \begin{bmatrix} 98 \\ 10 \\ 3 \end{bmatrix} \quad \text{and} \quad \mathbf{f}_{E2} = \begin{bmatrix} 3 \\ 12 \\ 95 \end{bmatrix}$$

These column vectors have the same number of elements as the number of rows in **f** (Table 3.2.2). They are occupancy vectors directly comparable to the entities of Table 3.2.2 but they come from a different locality. To clarify the adjustments to be applied to the elements

```
98
10
3
3
12
95
```

it is relevant that these number express occupancy counts based on 25 quadrats each. Considering that the row groups in the raw data have 10, 9 and 7 species respectively, the deemed block sizes for $\mathbf{f}_{E1}$ and $\mathbf{f}_{E2}$ are

```
10*25 = 250
 9*25 = 225
 7*25 = 175
```

The average block size 130 (Table 3.2.1) and the deemed block sizes give,

```
98*(130/250) = 50.960
10*(130/225) =  5.778
 3*(130/175) =  2.229
```

and

```
 3*(130/250) =  1.560
12*(130/225) =  6.933
95*(130/175) = 70.571
```

or

$$\mathbf{f}_{E1} = \begin{bmatrix} 50.960 \\ 5.778 \\ 2.229 \end{bmatrix} \quad \text{and} \quad \mathbf{f}_{E2} = \begin{bmatrix} 1.560.6 \\ 933 \\ 70.571 \end{bmatrix}$$

The elements are stored in file EXVECT:

```
50.960
 5.778
 2.229
 1.560
 6.933
70.571
```

The files required in the CONAMAP run, in addition to EXVECT, include:

-- the row totals of **f** (file ROWTOTS from the CONAPACK run, Table 3.5.1)

```
88.882
87.604
171.514
```

-- the row canonical scores (2 sets of 3 values from the CONAPACK run, file ROWS, Table 3.5.1)

```
-1.0801
1.6264
-.2710
-1.3224
-.5721
.9775
```

-- the nonzero Eigenvalues (squared canonical correlations from the CONAPACK run, file EIG, Table 5.5.1)

```
.56098009
.20533392
```

The startup dialogue of CONAMAP is reproduced in Table 3.4.3 and the PRINTDA file in Table 3.5.2.

Table 3.4.3 Screen pages with startup dialogue and end-of-run message in the CONAMAP run.

```
Have you run CONAPACK before this run?-- press Y or N: Y
Are data files in the same folder as the program?-- press Y or N: Y
Do you perceive the mappable external vectors as row or column entities
with reference to the contingency table whose CONAPACK analysis supplies
some input in this run?-- press R or C: C
Name the column scores file from the CONAPACK run if you pressed R, else
name the row scores file: rows.tes
PRINTDA file name extension: map
Eigenvalues file from CONAPACK run: eig.tes
Rank of model configuration from CONAPACK run: 2
```

```
External vector(s) file: exvect.tru
Number of external vectors: 2
Number of cells per external vector: 3
Row totals file from CONAPACK run: rowtots.tes
Number of columns in contingency table: 3
Column canonical scores file fromCONAPACK run: cols.tes
Specify relative graph size. Type 1 for normal size:? 2
Specify tick mark spacing. Type a number (1,2, etc.): ? 1
Width of screen in cm units: ? 34
```

(Screen graphs follow, and then run is terminated.)

```
Printda file: Printda.tes
Press a key to exit.
```

3.5 PRINTDA file

The output is stored in the PRINTDA file. The intermediate results are included when so requested in the startup dialogue. Inspect the PRINTDA file in Table 3.5.1 for details.

Table 3.5.1 PRINTDA file in the Coquihallaa analysis (PRINTDACONA.tes). Block size equalizing transformations and Eigenadjustments[4] were applied (Section 1.2.) Legend of symbols: R1, R2 - canonical correlations (Eigenvalues); $f_{..}$ - table total (348); R^2 -square of R; $f_{..}$R^2 - a chi-squared partition, the sum of all $f_{..}$R^2 values is the interaction chi-squared (266.68); Cum % - cumulative percentage; Rank - rank of matrix **S** (2).

```
Program: CONAPACK
________________
Input file for raw contingency table data:o79.dat
Number of rows:  3
Number of columns:  3
Program ADJUST:::
Input file for block sizes:n79.dat
```

[4] $\mathbf{X}_i \mathbf{X}_i' = \mathbf{Y}_i \mathbf{Y}_i' = R_i^2$

```
Adjusted frequencies stored in file: ADJUSTDAT.tes

Program CONA:::
Input data file:  ADJUSTDAT.tes
Weighting option selected: # 3
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis

Row totals
        88.882        87.604       171.514

Column totals
        92.525       119.963       135.512

3 x 3  table
         1.728         9.073        78.081
        71.046        14.113         2.444
        19.750        96.777        54.987

GRAND TOTAL =        348.000

 3 x 3  SCALAR PRODUCT MATRIX
          .2588         -.2105         -.0359
         -.2105          .3905         -.1275
         -.0359         -.1275          .1170

CANONICAL CORRELATIONS AND CHI-SQUARED PARTITIONS
Can corr R 1 =    .7490 F..R^2 =       195.2211 Cum % =  73.2050
Can corr R 2 =    .4531 F..R^2 =        71.4562 Cum % = 100.0000

TEST FOR COMPOSITIONAL SHARPNESS OF THE  9  BLOCKS
Chi squared =        266.6773
Degrees of freedom =  4
Rank =  2

EIGEN-ADJUSTED ROW SCORES
SET  1
         -.4104          .6180         -.1030
SET  2
         -.3442         -.1489          .2544

EIGEN-ADJUSTED COLUMN SCORES
SET  1
          .6401         -.0596         -.3843
SET  2
         -.1503          .3658         -.2212


ROW SCORES (unadjusted)
SET  1
        -1.0801         1.6264         -.2710
SET  2
        -1.3224         -.5721          .9775

COLUMN SCORES (unadjusted)
SET  1
         1.5632         -.1455         -.9385
SET  2
         -.5635         1.3710         -.8290

Row totals in file: rowtots.tes
Column totals in file: coltots.tes
Row canonical scores in file(s): ROWS.tes and rowsadj.tes
 ( 2  sets of  3  numbers)
Column canonical scores in file(s): COLS.tes and colsadj.tes
```

```
 ( 2  sets of  3  numbers)
Run PLOT with ROWS... or COLS... to draw scattergram
Eigenvalues stored in file: EIG.tes
Deviations information stored in file: LAT.tes

Program DEVIATIONS:::
Input data files are: LAT.tes and EIG.tes
The number of canonical variates is:  2

DEVIATIONS FROM RANDOM EXPECTATION (Fhj - Fh.F.j/F..)

=== Table of deviations partitions  1
          -29.8833           3.6059           26.2774
           44.3522          -5.3518          -39.0004
          -14.4688           1.7459           12.7229

=== Table of deviations partitions  2
            7.9797         -25.1727           17.1929
            3.4026         -10.7338            7.3312
          -11.3824          35.9065          -24.5241

=== Sum of deviations partitions tables
          -21.9036         -21.5668           43.4704
           47.7548         -16.0856          -31.6692
          -25.8512          37.6523          -11.8011
Graphs in file: GRAPHS.tes

Program ANGLES AND DISTANCES:::
Input data file:COLS.tes
Output in files:ANGLES.tes and DISTANCES.tes
Number of axes: 2
Number of units: 3
Print in following order:
Point B; squared distances AB,AC,BC; angle at B
  2:       .755957      1.054449       .449999     82.537301

Program LATGRAPHS:::
Input data file: GRAPHS.tes
Number of deviations partitions: 2
DEVIATIONS PROFILES: rows are plotted
ANGLES PROFILE: columns are the points
DISTANCES PROFILES: columns are the points
Elapsed time:  130.583  seconds
```

Remark: Unadjusted scores are used in deviations computations.

Table 3.5.2 PRINTDA file generated in the CONAMAP run. Two external vectors ($\mathbf{f}_{E1}$ and $\mathbf{f}_{E2}$, file EXVECT) are mapped into the model configuration created by CONAPACK in the analysis of the Coquihalla sample. Data files are listed in Section 3.4.2. The deviations profiles are drawn in Section 3.6.7.

```
Program CONAMAP
===============
Name of this file: PRINTDA.map
   External vectors are mapped onto canonical planes and
deviations profiles are constructed for the external
vectors.
Row scores file from CONAPACK run:rows.tes
EIGEN file from CONAPACK run:eig.tes
External vector(s) perceived as column vector(s)!
Row totals file from CONAPACK run:
```

```
External vector(s) file: exvect.tru
Number of external vectors:  2
Number of cells per external vector:  3
Rank of model configuration from CONAPACK run:  2
Canonical scores file created: YSCORES.map
Deviations file created: DEVS.map
Combination scores file of 2 sets of  3 + 2
     elements for plotting in scattergram: YCOM.map
Picture files created: Kep/1, Kep/2, ...

Canonical scores of ext. vector # 1 on 2 canonical variates:
-1.04711        -2.56423

Deviations profiles of ext. vector # 1 -- 2 canonical planes:
 12.7572        -18.934          6.17674
 23.1418          9.86793       -33.0099

Total deviations:
 35.899         -9.06608        -26.8331

Canonical scores of ext. vector # 2 on 2 canonical variates:
-.160993         1.75721

Deviations profiles of ext. vector # 2 -- 2 canonical planes:
 2.62989        -3.90324         1.27333
-21.2634        -9.06694         30.3305

Total deviations:
-18.6335        -12.9702         31.6038

Deviations profiles are comparable to the column profiles in the CONAPACK run.
```

3.6 Review

3.6.1 The Coquihallaa environment

Quadrat groups a,b,c depict successively higher and edaphically xeric terraces. These are described in Table 3.6.1.1. The site, once an ecological demonstration site, has been logged and subdivided for housing.

Table 3.6.1.1 Terrace characteristics .

Terrace:	Low	Medium	High
Quadrat group:	a	b	c
Moisture regime:	Wet	Moist	Dry
Disturbance:*	No logging	Selective logging	No logging

*at time of survey in 1975

3.6.2 Block size adjustments

Owing to differences in block sizes, the data had to be adjusted. The adjusted data matrix is **f**,

$$\mathbf{f} = \begin{bmatrix} 1.7 & 9.1 & 78.1 \\ 71.0 & 14.1 & 2.4 \\ 19.8 & 96.8 & 55.0 \end{bmatrix}$$

The formula in Section 1.2 are relevant. For example:

$$f_{11} = \frac{\frac{2}{140}}{2.8767}\ 348.0 = 1.7$$

The adjustments, automatic in CONAPACK, are also available externally in program ADJUST of the EPIC package.

3.6.3 Product matrix

This is by the rows of **f**,

$$\mathbf{S} = \begin{bmatrix} 0.258850 & -0.210473 & -0.035920 \\ -0.210473 & 0.390458 & -0.127538 \\ -0.035920 & -0.127538 & 0.117006 \end{bmatrix}$$

according to Section 2.2. A typical element is

$$S_{12} = \sum_{j=1}^{3} \delta_{1j}\delta_{2j} = -0.2105$$

where

$$\delta_{11} = \frac{1.728}{\sqrt{88.882 \times 92.525}} - \frac{\sqrt{88.882 \times 92.525}}{348} = -0.241535$$

$$\delta_{21} = \frac{71.046}{\sqrt{87.604 \times 92.525}} - \frac{\sqrt{87.604 \times 92.525}}{348} = 0.530420$$

$$\delta_{12}= \frac{9.073}{\sqrt{88.882 \text{ x}.119.963}} - \frac{\sqrt{88.882 \text{ x } 119.963}}{348} = -0.208857$$

$$\delta_{22}= \frac{14.113}{\sqrt{87.604 \text{ x } 119.963}} - \frac{\sqrt{87.604 \text{ x } 119.963}}{348} = -0.156914$$

$$\delta_{13}= \frac{78.081}{\sqrt{88.882 \text{ x } 135.512}} - \frac{\sqrt{88.882 \text{ x } 135.512}}{348} = 0.396091$$

$$\delta_{23}= \frac{2.444}{\sqrt{87.604 \text{ x } 135.512}} - \frac{\sqrt{87.604 \text{ x } 135.512}}{348} = -0.290661$$

or in symbolic terms,

$$\delta_{rj} = \frac{f_{rj}}{\sqrt{f_{r\cdot}f_{\cdot j}}} - \frac{\sqrt{f_{r\cdot}f_{\cdot j}}}{f_{\cdot\cdot}} \ ; \ r = 1,2$$

The structure described by **S** is the structure detectable in canonical contingency table analysis.

3.6.4 Structure sharpness – general test

The criterion interaction chi-squared is 266.677 with 4 degrees of freedom (Table 3.5.1). This is a very large chi-squared value in probability terms:

$[\chi^2 = 266.7] >> [\chi$**Error!**$) = 18.5]$

or the probability of an at least as large chi-squared as the observed, assuming that H is true, is much less than .001. Supposing that specific conditions are fulfilled[5], the conclusion that the structure as observed is a low probability event, therefore

[5] Probability points or probabilities are found by running program CHIPROBS of the EPIC package, or in less accurate determinations by checking a statistical table. In this regard a word of warning is in order: tables and also program CHIPROBS present probabilities and probability points obtained by solving the chi-squared probability integral or its inverse. These use a density function derived under the assumption that H_o is true and that the sampled populations are Poisson.

significantly sharp, is appropriate. The structure may indeed be sharp, albeit not intensely sharp, as the Cramér coefficient indicates:

$$C = \frac{\chi^2}{f_{..}(\mathrm{INF}(t\text{-}1,q\text{-}1))} = \frac{266.7}{348 \times 2} = 0.38 \text{ or } 38\ \%$$

Read "INF(t-1,q-1)" as "the lesser of the two quantities, t-1 and q-1".

3.6.5 Structure sharpness – specific tests

These are homogeneity tests of the species and quadrat group totals in **f** (Section 3.6.2.) For species groups (rows), the test criterion is an I-divergence information (Kullback 1959):

$$\chi^2 = 2\left[88.9 \ln \frac{88.9(3)}{348.0} + 87.5 \ln \frac{87.5(3)}{348.0} + 171.6 \ln \frac{171.6(3)}{348.0}\right] = 37.739$$

which have 2 degrees of freedom. Considering that

$$[\chi^2 = 37.739\ ] >> [\chi\textbf{Error!}) = 13.807]$$

we declare significant distinguishability on the species groups (reject H_{o1}, Section 2.1) For the quadrat groups, the test

$$[\chi^2 = 8.364] > [\chi\textbf{Error!}) = 5.992]$$

leads to a similar conclusion at a lower significance level.

3.6.6 Dimensionality

Judged by the rank of the **S** matrix, the dimensionality of the gradient is 2. This number is acceptable since the two canonical variates each account for a sizable portion of the interaction chi-squared. On this basis, one may proceed to construct species and quadrat scattergrams. The two types are superimposed in Fig.

3.6.6.1. The relevant program is STEREOC which obtains canonical scores for coordinates from files ROWS.tes and COLS.tes.

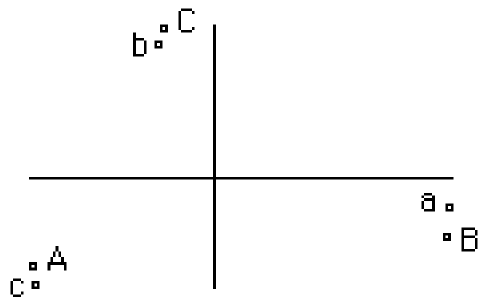


Figure 3.6.6.1 Scattergrams of the X_1,X_2 and Y_1,Y_2 canonical planes superimposed. The coordinates are canonical scores under "rows" for species groups A,B,C and "columns" for quadrat groups a,b,c (fossil terraces) in Table 3.6.1.1.

3.6.7 Deviations, angles and distances profiles

Given two non-zero canonical correlations, there are two "Tables of deviations partitions" (Table 3.5.1):

$$\Delta_1 = \begin{bmatrix} \Delta_{11} \\ \Delta_{12} \\ \Delta_{13} \end{bmatrix} = \begin{bmatrix} 29.883 & 3.606 & 26.277 \\ 44.352 & -5.352 & -39.000 \\ -14.469 & 1.746 & 12.723 \end{bmatrix}$$

and

$$\Delta_2 = \begin{bmatrix} \Delta_{21} \\ \Delta_{22} \\ \Delta_{23} \end{bmatrix} = \begin{bmatrix} 7.980 & -25.173 & 17.193 \\ 3.402 & -10.734 & 7.331 \\ -11.382 & 35.906 & -24.524 \end{bmatrix}$$

Δ_2 has an associated chi-squared

$$f_{..}R_1^2 = 348 \text{ x } 0.749^2 = 195.221$$

and the second has

$$f_{..}R_2^2 = 71.456$$

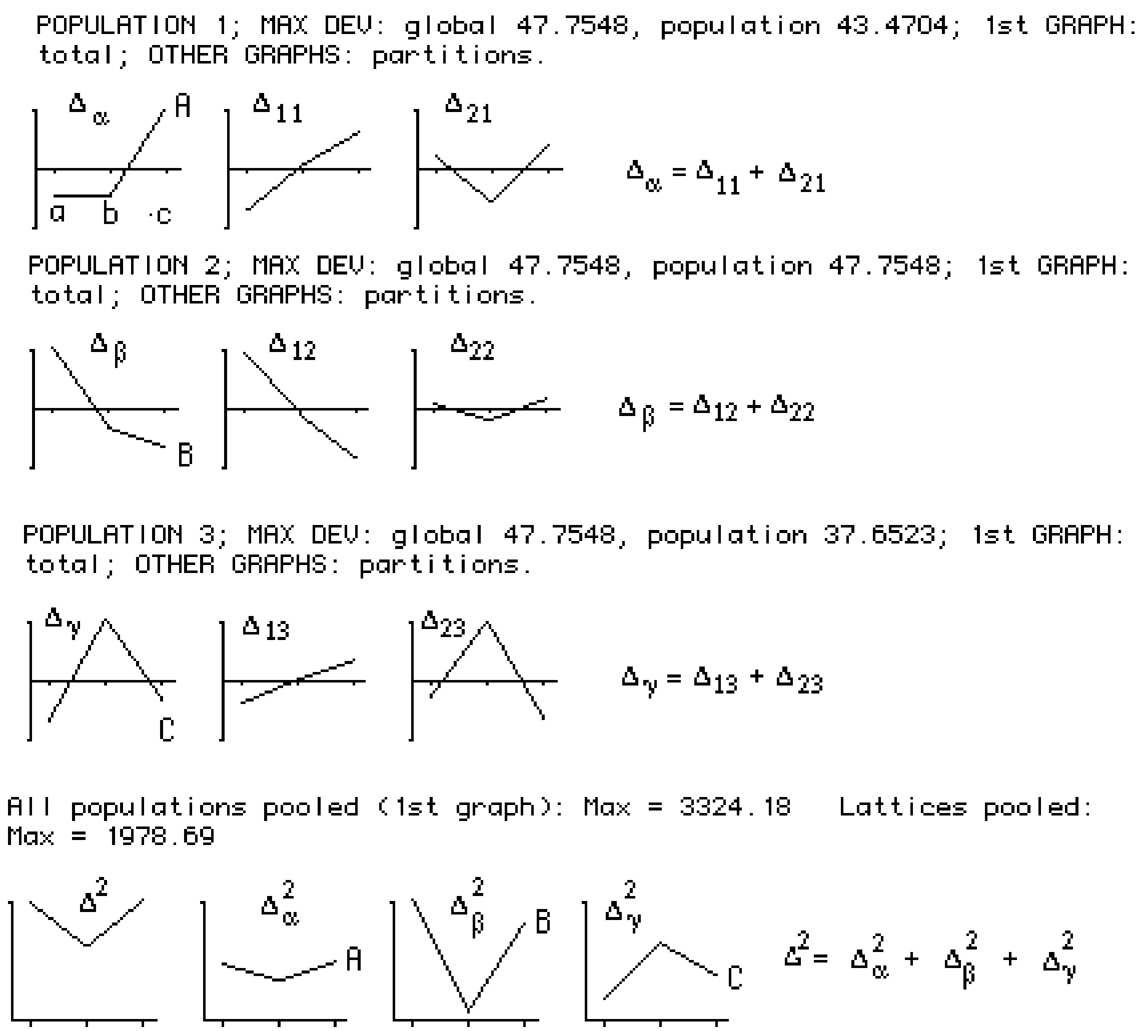
The sum of the two tables is the total deviations table:

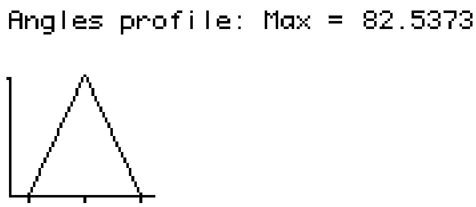
$$\Delta = \Delta_1 + \Delta_2 = \begin{bmatrix} -21.904 & 21.567 & 43.470 \\ 47.755 & -16.086 & -31.669 \\ -25.851 & 37.652 & -11.801 \end{bmatrix}$$

Each row vector in each of

$$\Delta, \ \Delta_1, \ \Delta_2$$

defines a deviations profile drawn for the species groups over terrace height in Fig. 3.6.7.1.





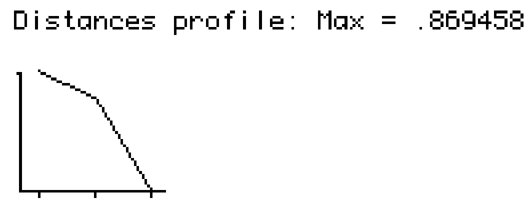


Figure 3.6.7.1 Deviations, angles and distances profiles for species groups A, B, C over quadrat groups a, b, c in the Coquihallaa analysis. Tick marks on the horizontal axis indicate the quadrat groups arranged according to increasing terrace height. "Population" in the captions refers to "species group". "Global" refers to the complete set of populations. First 3 rows of graphs display deviations profiles. Graphs in the 4th row contain the pooled squared deviations profiles. Pooling accords with the equations given. The height of apex b in the angles profile indicates the square of the angle at b in the run of quadrat groups as adjacent apices: a to b to c. The height of apex b in the distances profile indicates the squared compositional distance from b to c. Angles are undefined for the 1st and last quadrats. Distance is not defined for the last quadrat.

It is important to remember that

$$\Delta_\alpha, \quad \Delta_\beta, \quad \Delta_\gamma$$

are composite profiles. Their decomposition into component profiles is in the sequence:

$$\Delta = \begin{bmatrix} \Delta_\alpha \\ \Delta_\beta \\ \Delta_\gamma \end{bmatrix} = \Delta_1 + \Delta_2 = \begin{bmatrix} \Delta_{11} \\ \Delta_{12} \\ \Delta_{13} \end{bmatrix} + \begin{bmatrix} \Delta_{21} \\ \Delta_{22} \\ \Delta_{23} \end{bmatrix}$$

Δ, Δ_1 and Δ_2 are q x t matrices, Δ_α, Δ_β and Δ_γ are t-valued vectors. Δ_{11}, Δ_{21}, Δ_{12}, Δ_{22}, Δ_{13} and Δ_{23} are also t-valued vectors. Symbols q and t are the number of rows and the number of columns in **f**. On average, the Δ_1 graphs (X_1,Y_1 canonical plane) are the most significant in chi-squared terms, since they account collectively for 73% of the interaction chi-squared vis-a-vis the Δ_2 graphs (X_2,Y_2 canonical plane) which account fpr 27%. Average tendencies notwithstanding, a specific profile in the X_2,Y_2 canonical plane, such as Δ_{23}, can have higher significance than its counterpart in the X_1,Y_1 canonical plane.

The interpretation of the profiles is based on height and shape. Height indicates the magnitude and sense of deviation. Profile shape describes dispersion pattern over the ordering variable. Generally speaking, small deviations in an oscillating pattern, such as in the Δ_{22} profile, probably are a consequence of weak random and other nonlinear effects.[6]

Soil coarseness should be pointed out as the factor most responsible for edaphic aridity on the top terrace, under an otherwise high atmospheric humidity regime. Seepage near the surface affects soil moisture and soil nutritional quality on the low terrace. As the soil conditions change, so does the vegetation. The profiles are indicative of this:

- The xerophilous group (A) and the mesophilous group (C) have ascending profiles. That is, the species in the group perform better than expected as the terrace height increases.
- The profiles in the hygrophilous group (B) are descending.
- Groups A and C are strongly convergent in the X_1,Y_1 canonical plane, but strongly divergent in the X_2,Y_2 canonical plane.

All the above having been said to suggest characteristics on which the interpretations can be focussed. In addition, it is important also to realize that an ascending or descending profile may, but does not necessarily signal increases or decreases in species quantity. This is because the profiles display deviations. These reflect on the actual species quantities only indirectly in relative terms. It is perfectly conceivable that the f_{hj} quantities are the same or they may even show

[6] Random and nonrandom types of nonlinearity are inseparable in the analysis.

declines, while the deviations profile is ascending. The Δ_{13} profile is an example of this.

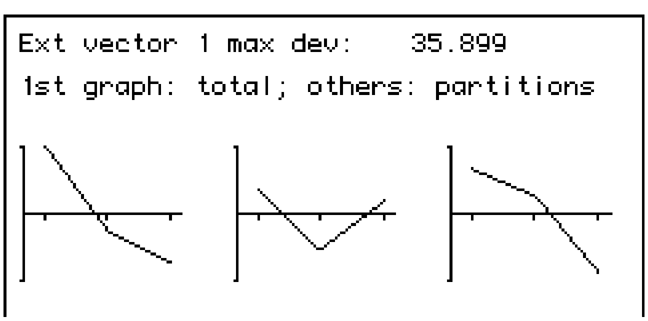
3.6.8 Mappings of external vectors

The derivation of the mappings $\mathbf{X}_E$ and Δ_E are explained in section 2.7. The numerical values for the example of Section 3.4 are given in Table 3.5.2. The deviations profiles Δ_E are displayed in Fig. 3.6.8.1. The deviations profiles of the model configuration (columns of Δ from the CONAPACK run, Table 3.5.1) are plotted n Fig. 3.6.8.2.

The model column canonical scores (in this case unadjusted) from the CONAPACK run (file COLS, Table 3.5.1) and the canonical scores of the external vectors $\mathbf{f}_{E1}$ and $\mathbf{f}_{E2}$ from the CONAMAP run (Table 3.5.2, file YSCORES) are pooled in file YCOM:

```
1.5632              !Terrace a
-.145482            !Terrace b
-.938537            !Terrace c
-1.04711            !Exvect 1
-.160993            !Exvect 2
-.563503            !Terrace a
1.37103             !Terrace b
-.828967            !Terrace c
-2.56423            !Exvect 1
1.75721             !Exvect 2
```

The joint scatter is drawn in program PLOT (see EPIC program description in Orlóci 1991a) in Fig. 3.6.8.3 and the associated PRINTDA file is reproduced in Table 3.6.8.1.



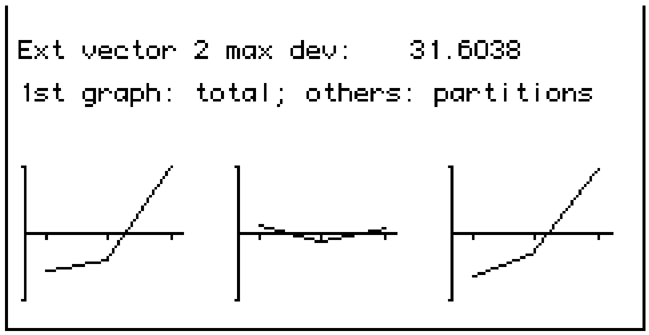


Figure 3.6.8.1 Graphs-related dialogue in the CONAMAP run and deviations profiles for external vectors $\mathbf{f}_{E1}$ and $\mathbf{f}_{E2}$ (EXVECT) It is clear when compared to the profiles in Fig. 3.6.8.2 that external vector $\mathbf{f}_{E1}$ is closest to the profile of terrace c and $\mathbf{f}_{E2}$ to the profile of terrace b. Main text and caption in Fig. 3.6.7.1 contain relevant explanations regarding the row profiles.

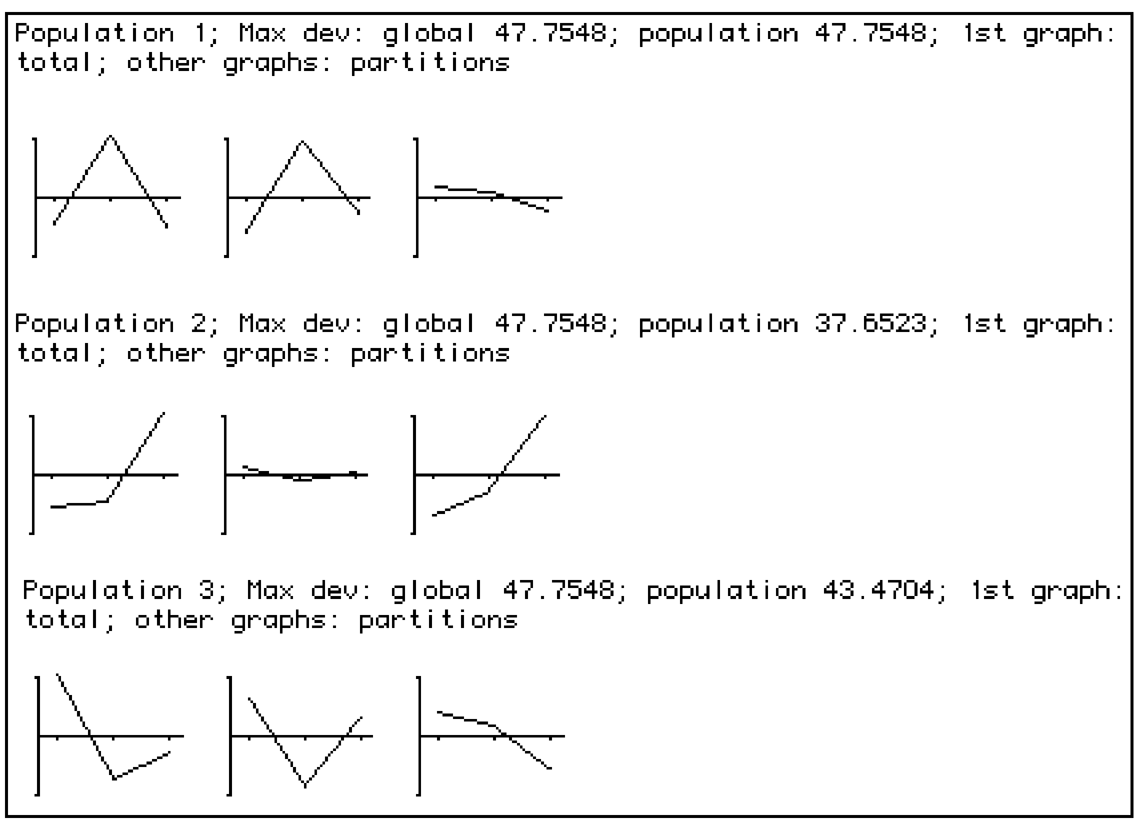


Figure 3.6.8.2 Deviations profiles of terraces a, b, c (labeled respectively as Population 1, 2, 3 on the screen) plot data from the columns of the deviations matrices in Table 3.5.1. See explanations in the caption of Fig. 3.6.7.1 for additional information.

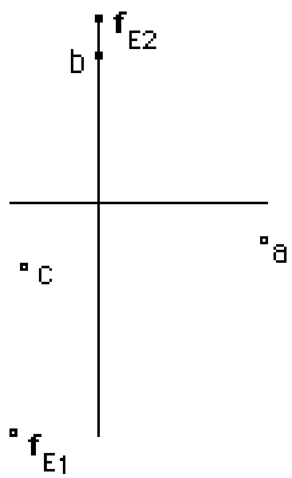


Figure 3.6.8.3 Dispersion graph showing mappings of the external vectors $\mathbf{f}_{E1}$ and $\mathbf{f}_{E2}$ (file EXVECT) and the column vectors of Table 3.2.2. The coordinate data is from file YCOM. Points a, b, c represent river terraces identified in Table 3.6.1.1. The 1st (horizontal) and 2nd (vertical) canonical variates (Table 3.6.1.1 and Fig 3.6.1) are the axes. The canonical scores are not Eigenadjusted. The deviation profiles place external vector $\mathbf{f}_{E1}$ nearest to terrace c (Fig. 3.6.7.1) and external vector $\mathbf{f}_{E2}$ closest to terrace b. This result agrees with the conclusions drawn from the deviations graphs.

Table 3.6.8.1 PRINTDA file from the PLOT run.

```
PROGRAM: PLOT
=====================
COORDINATES FILE: ycom.tes, VOLUME

--------------------------------------------------------
          COORDINATES
POINT  AXIS  1     AXIS  2
--------------------------------------------------------
  1      1.563     -0.564
  2     -0.145      1.371
```

```
  3     -0.939     -0.829
  4     -1.047     -2.564
  5     -0.161      1.757
--------------------------------------------------------
ORIGIN IS AT X=  -0.146 AND Y=  -0.166

HORIZONTAL AXIS IS AXIS  1
SEQUENCE OF POINTS (LEFT TO RIGHT) IS:
  4  3  5  2  1

VERTICAL AXIS IS AXIS  2
--------------------------------------------------------
SEQUENCE OF POINTS (TOP TO BOTTOM) IS:
  5  2  1  3  4
```

4
Pre-Alps pH gradient

4.1 General

The objective is to give an example of canonical contingency table analysis which reveals species behaviour patterns from general survey records and incidental environmental data. The evidence matrix (**f**) to be considered contains species (local) frequencies within pH classes. The pH classes are *a posteriori* sampling strata with unequal numbers of sampling units. Class size equalization is by averaging. Table 4.1.1 presents the average frequencies.

Table 4.1.1 The evidence matrix in the Pre-Alps analysis (after Feoli and Orlóci 1985, p. 114.) Average frequencies are shown. Species code: 1 - *Agrostis tenuis;* 2 - *Brachypodium pinnatum;* 3 - *Dactylis glomerata;* 4 - *Anthoxanthum odoratum;* 5 - *Bromus erectus;* 6 - *Arrhenatherum elatius;* 7 - *Festuca pratensis;* 8 - *Festuca* *tenuifolia;* 9 - *Festuca rubra;* 10 - *Danthonia decumbens;* 11 - *Crysopogon grillus;* 12 - *Nardus stricta.* pH class limits from 1 to 5: 5.5 and under; 5.6 - 6.0; 6.1 - 6.5; 6.6 - 7.0; 7.1 and over.

pH class	Species 1	2	3	4	5	6	7	8	9	10	11	12
1	4.5	2.5	0.0	12.0	3.0	0.5	0.0	10.5	10.0	8.0	1.0	7.5
2	8.0	7.0	3.0	10.0	8.0	8.0	1.0	4.5	7.0	3.0	2.0	1.0
3	5.5	5.5	3.0	11.5	11.5	1.5	3.5	5.5	5.0	3.0	1.5	0.0
4	0.0	5.0	4.0	4.0	15.0	1.0	2.0	0.5	5.5	0.5	5.0	0.0
5	1.0	7.0	4.5	6.0	15.0	10.0	2.5	4.0	4.0	3.0	0.5	0.0

4.2 *Modus operandi*

A 5 x 5 **S** matrix is computed and Eigenanalysis is performed. After these, deviations are partitioned, distances and angles are computed, and species profiles and stereograms are drawn. These are inspected for an evidence of trends.

4.3 Startup dialogue and PRINTDA file

The startup screen is reproduced in Table 4.3.1. Inspection reveals that the intermediate results are stored, but data adjustments are not performed. Column vectors are specified as profiles. The small box directly below the startup dialogue box displays the last screen page. The PRINTDA file is listed in Table 4.3.2.

Table 4.3.1 Startup dialogue and last screen in the Pre-Alps analysis.

```
   File  Edit  Custom  Run  Windows  Help

Are the input data file(s) in one folder with this program? -- press Y or N:Y
Specify output file name extension:85
Press Y to store intermediate results on a printable file:Y
________________________________________________________________
Name frequency table file:F&O/T.dat
Specify the number of rows:5
Specify the number of columns:12
Press Y to adjust frequencies to equal block size
(- if no block sizes file exists, press a key other than Y):N

Do you wish to perform autocorrelation analysis? -- press Y or N:N
Do you wish to perform covariance analysis with transect
position? -- press Y or N:N
```

```
Weight options are:
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis
To specify weight option, press key 1, 2, 3, or 4: 3
Eigenanalysis -- iteration:  26
Press Y to weight canonical scores by eigenvalues:Y

Working
Specify relative graph size. Type 1 for normal size:? .75
Specify tick mark spacing (1,5,10, etc):? 1
Do you wish to plot deviations table rows or columns? -- press R or C:C
```

```
 File  Edit  Custom  Run  Windows  Help

Your main printable file is: PRINTDACONA.85
Graphs are stored in KEP files with extension: .85
Open and print the PRINTDA file from EDIT
Open and edit KEP files from a PAINT program
Press any key to exit
```

Table 4.3.2 The PRINTDA file in the Pre-Alps analysis. See explanations and models of interpretation in preceding sections.

```
Program CONA:::
Input data file:  F&O/T.dat
Weighting option selected: # 3
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis

Row totals
        59.500        62.500        57.000        42.500        57.500
Column totals
        19.000        27.000        14.500        43.500        52.500
        21.000
         9.000        25.000        31.500        17.500        10.000
         8.500

 5 x 12  table
         4.500         2.500          .000        12.000         3.000
          .500
          .000        10.500        10.000         8.000         1.000
         7.500
         8.000         7.000         3.000        10.000         8.000
         8.000
         1.000         4.500         7.000         3.000         2.000
         1.000
         5.500         5.500         3.000        11.500        11.500
         1.500
         3.500         5.500         5.000         3.000         1.500
          .000
```

```
         .000          5.000          4.000          4.000         15.000
        1.000
        2.000           .500          5.500           .500          5.000
         .000
        1.000          7.000          4.500          6.000         15.000
       10.000
        2.500          4.000          4.000          3.000           .500
         .000

GRAND TOTAL =        279.000

 5 x 5  SCALAR PRODUCT MATRIX
         .1691         -.0133         -.0182         -.0782         -.0728
        -.0133          .0300         -.0023         -.0231          .0044
        -.0182         -.0023          .0256          .0035         -.0077
        -.0782         -.0231          .0035          .0985          .0154
        -.0728          .0044         -.0077          .0154          .0638

CANONICAL CORRELATIONS AND CHI-SQUARED PARTITIONS
Can corr R 1 =    .4974 F..R^2 =         69.0184 Cum % =  63.9158
Can corr R 2 =    .2823 F..R^2 =         22.2340 Cum % =  84.5059
Can corr R 3 =    .1962 F..R^2 =         10.7431 Cum % =  94.4548
Can corr R 4 =    .1465 F..R^2 =          5.9879 Cum % = 100.0000

TEST FOR COMPOSITIONAL SHARPNESS OF THE  60  BLOCKS
Chi squared =        107.9834
Degrees of freedom =  44
Rank =  4

EIGEN-ADJUSTED ROW SCORES
SET  1
         .3855         -.0033         -.0299         -.2606         -.1731

SET  2
         .0569         -.1112          .0147          .2236         -.1178

SET  3
         .0551         -.0616         -.1306          .0302          .1171

SET  4
         .0043         -.0969          .0875         -.0459          .0480


EIGEN-ADJUSTED COLUMN SCORES
SET  1
         .0757         -.0675         -.1390          .0523         -.1143
        -.0934         -.1238          .1278          .0519          .1400
        -.1107          .3564
SET  2
        -.0716         -.0197          .0104         -.0034          .0400
        -.1732          .0209         -.0147          .0401         -.0088
         .1856          .0753
SET  3
        -.1211         -.0042          .0133         -.0396          .0197
         .0699         -.0501          .0072          .0088          .0358
        -.0148          .1126
SET  4
        -.0393         -.0097          .0010          .0147          .0173
        -.0326          .0871          .0343         -.0270          .0240
        -.0869         -.0250


ROW SCORES (unadjusted)
SET  1
        1.7523         -.0150         -.1358        -1.1844         -.7869

SET  2
```

```
          .4814        -.9408         .1241        1.8909        -.9962

SET  3
          .6185        -.6911       -1.4652         .3389        1.3131

SET  4
          .0645       -1.4495        1.3093        -.6867         .7185


COLUMN SCORES (unadjusted)
SET  1
          .6594        -.5884       -1.2107         .4556        -.9955
         -.8139       -1.0782        1.1135         .4517        1.2194
         -.9645        3.1052
SET  2
        -1.0578        -.2910         .1541        -.0503         .5915
        -2.5590         .3090        -.2176         .5920        -.1300
         2.7426        1.1125
SET  3
        -2.5456        -.0875         .2797        -.8323         .4133
         1.4689       -1.0524         .1524         .1841         .7536
         -.3111        2.3666
SET  4
        -1.2167        -.3004         .0310         .4550         .5371
        -1.0081        2.6969        1.0610        -.8361         .7440
        -2.6928        -.7757

Row totals in file: rowtots.85
Column totals in file: coltots.85
Row canonical scores in file(s): ROWS.85 and rowsadj.85
 ( 4  sets of  5  numbers)
Column canonical scores in file(s): COLS.85 and colsadj.85
 ( 4  sets of  12  numbers)
Run PLOT with ROWS... or COLS... to draw scattergram
Run Stereo to draw stereograms
Eigenvalues stored in file: EIG.85
Deviations information stored in file: LAT.85

Program DEVIATIONS:::
Input data files are: LAT.85 and EIG.85
The number of canonical variates is:  4

DEVIATIONS FROM RANDOM EXPECTATION (Fhj - Fh.F.j/F..)

=== Table of deviations partitions  1
Table row  1
             2.3288          -2.9529           -3.2629           3.6837
            -9.7145          -3.1769           -1.8037           5.1741
             2.6449           3.9663           -1.7927           4.9059

Table row  2
             -.0209            .0265             .0293           -.0331
              .0873            .0285             .0162           -.0465
             -.0238           -.0356             .0161           -.0441

Table row  3
             -.1729            .2193             .2423           -.2735
              .7214            .2359             .1339           -.3842
             -.1964           -.2945             .1331           -.3643

Table row  4
            -1.1243           1.4256            1.5753          -1.7785
             4.6901           1.5338             .8708          -2.4980
            -1.2769          -1.9149             .8655          -2.3685

Table row  5
            -1.0106           1.2814            1.4160          -1.5986
```

```
          4.2157            1.3786             .7827           -2.2454
         -1.1478           -1.7212             .7780           -2.1290


=== Table of deviations partitions  2
Table row  1
          -.5825            -.2277             .0648            -.0634
           .8999           -1.5574             .0806            -.1577
           .5404            -.0659             .7948             .2741

Table row  2
          1.1957             .4675            -.1329             .1301
         -1.8474            3.1972            -.1654             .3236
         -1.1094             .1353           -1.6317            -.5626

Table row  3
          -.1439            -.0563             .0160            -.0157
           .2223            -.3847             .0199            -.0389
           .1335            -.0163             .1963             .0677

Table row  4
         -1.6342            -.6389             .1817            -.1779
          2.5249           -4.3696             .2261            -.4423
          1.5162            -.1849            2.2301             .7689

Table row  5
          1.1648             .4554            -.1295             .1268
         -1.7997            3.1145            -.1612             .3153
         -1.0807             .1318           -1.5895            -.5481


=== Table of deviations partitions  3
Table row  1
         -1.2518            -.0611             .1050            -.9370
           .5616             .7984            -.2451             .0986
           .1501             .3413            -.0805             .5206

Table row  2
          1.4693             .0717            -.1232            1.0998
          -.6591            -.9371             .2877            -.1157
          -.1761            -.4006             .0945            -.6111

Table row  3
          2.8409             .1387            -.2383            2.1266
         -1.2745           -1.8119             .5563            -.2238
          -.3405            -.7746             .1827           -1.1816

Table row  4
          -.4899            -.0239             .0411            -.3667
           .2198             .3125            -.0959             .0386
           .0587             .1336            -.0315             .2038

Table row  5
         -2.5685            -.1254             .2154           -1.9226
          1.1523            1.6382            -.5030             .2023
           .3079             .7003            -.1652            1.0683


=== Table of deviations partitions  4
Table row  1
          -.0466            -.0163             .0009             .0399
           .0568            -.0427             .0489             .0534
          -.0531             .0262            -.0542            -.0133

Table row  2
          1.0997             .3859            -.0214            -.9415
         -1.3415            1.0071           -1.1546           -1.2618
```

```
          1.2528            -.6193            1.2810             .3136

Table row  3
          -.9058            -.3179             .0176             .7755
          1.1050            -.8296             .9511            1.0394
         -1.0320             .5102           -1.0552            -.2584

Table row  4
           .3542             .1243            -.0069            -.3033
          -.4321             .3244            -.3719            -.4065
           .4036            -.1995             .4126             .1010

Table row  5
          -.5015            -.1760             .0097             .4294
           .6118            -.4593             .5266             .5754
          -.5713             .2824            -.5842            -.1430


=== Sum of deviations partitions tables
Table row  1
           .4480           -3.2581           -3.0923            2.7231
         -8.1962           -3.9785           -1.9194            5.1685
          3.2823            4.2679           -1.1326            5.6873

Table row  2
          3.7437             .9516            -.2482             .2554
         -3.7608            3.2957           -1.0161           -1.1004
          -.0565            -.9203            -.2401            -.9041

Table row  3
          1.6183            -.0161             .0376            2.6129
           .7742           -2.7903            1.6613             .3925
         -1.4355            -.5753            -.5430           -1.7366

Table row  4
         -2.8943             .8871            1.7912           -2.6263
          7.0027           -2.1989             .6290           -3.3082
           .7016           -2.1658            3.4767           -1.2948

Table row  5
         -2.9158            1.4355            1.5116           -2.9651
          4.1801            5.6720             .6452           -1.1523
         -2.4919            -.6066           -1.5609           -1.7518

Graphs in file: GRAPHS.85

Program ANGLES AND DISTANCES:::
Input data file:rowsadj.85
Output in files:ANGLES.85 and DISTANCES.85
Number of axes: 4
Number of units: 5
Print in following order:
Point B; squared distances AB,AC,BC; angle at B
  2:      .203301       .215744       .055302     78.339983
  3:      .055302       .189319       .140502     87.891962
  4:      .140502       .100954       .140538     50.149664

Program LATGRAPHS:::
Input data file: GRAPHS.85
Number of deviations partitions: 4
DEVIATIONS PROFILES: columns are plotted
ANGLES PROFILE: rows are the points
DISTANCES PROFILE: rows are points
Elapsed time:  126.083  seconds
```

4.4 Species profiles

Inspection of the contents in Table 4.3.2 reveals a 4-d structure. There are 4 "Deviations partitions tables" and 5 profiles per species. The column vectors in the the "Sum of deviations partitions tables" Δ and in the "Tables of deviations partitions" Δ_1, Δ_2, Δ_3, Δ_4 are plotted as profiles in Fig. 4.4.1. Remember that each Δ is a 5 x 12 matrix arranged in the same way as the records in Table 4.1.1: pH classes as rows and species as columns. The difference is that while the elements in Table 4.1.1 are frequencies, the elements in the Δ matrices are frequencies expressed as deviations from random expectation. For example, given $f_{11} = 4.5$, the value in the 1st cell of Table 4.1.1, the expectation of this is

$$f^o_{11} = \frac{f_{1.}f_{.1}}{f_{..}} = \frac{59.5 \times 19.0}{279} = 4.052$$

and the deviation is

$$\Delta_{11} = f_{11} - f^o_{11} = 4.5 - 4.052 = 0.448$$

The value 0.448 and all the other values in table Δ are partitioned to obtain tables Δ_1, Δ_2, Δ_3 and Δ_4. For example, the value in the 1st cell of Δ is such that

$$\Delta_{11} = \Delta_{111} + \Delta_{211} + \Delta_{311} + \Delta_{411}$$

$$= 2.329 - 0.582 - 1.252 - 0.047 = 0.448$$

The column vectors of Δ, Δ_1, Δ_2, Δ_3 and Δ_4 are plotted as profiles in Fig. 4.4.1. For example, the first row of 5 graphs *(Agrostis tenuis)* has a 1st profile:

0.448
3.743
1.618
-2.894
-2.916

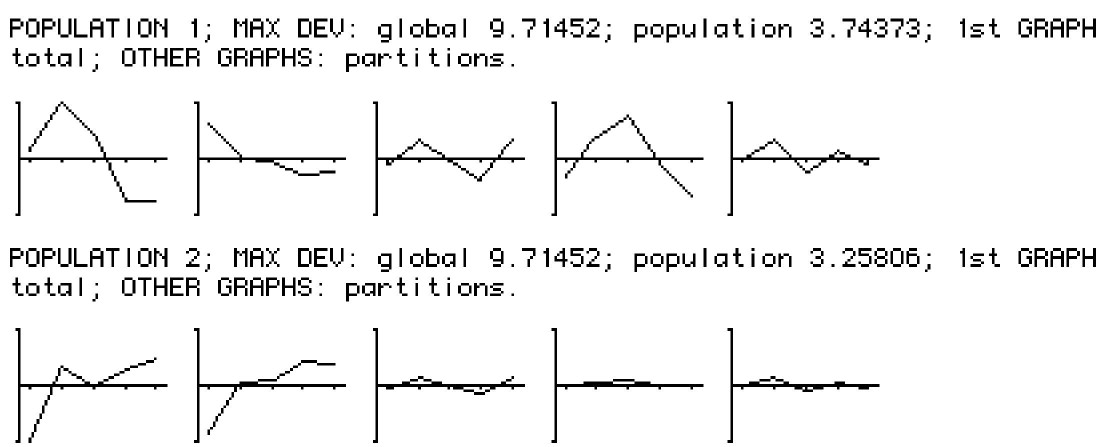
which is the first column vector in the "Sum of deviations partitions tables" Δ in Table 4.3.2. In the same manner, the 2nd profile in the 1st row of Fig. 4.4.1 corresponds to the 1st column vector in the "Table of deviations partitions 1" Δ_1:

2.329
-0.021
-0.173
-1.124
-1.011

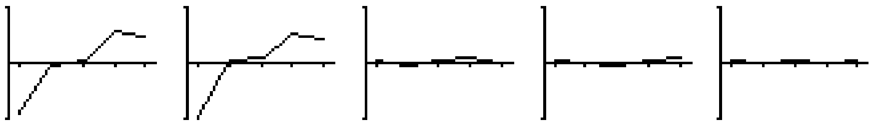
The graphics continue with other profiles from the 2nd, 3rd, etc. columns of tables Δ, Δ_1, Δ_2, Δ_3 and Δ_4, until the 5th profile in the 12th row of Fig. 4.4.1 is plotted:

-0.013
0.314
-0.258
0.101
-0.143

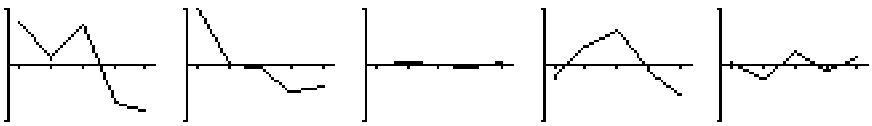
This is the 12th column vector in the "Table of deviations partitions 4" Δ_4. Positive deviations indicate frequencies higher than expected and negative deviations indicate frequencies lower than expected. The zero horizontal lines in the graphs indicate expectations.



POPULATION 3; MAX DEV: global 9.71452; population 3.26293; 1st GRAPH: total; OTHER GRAPHS: partitions.

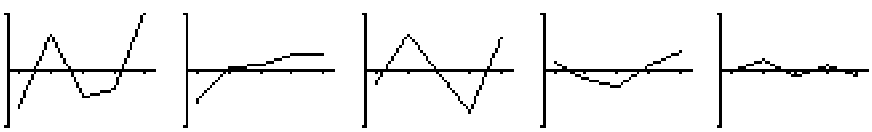


POPULATION 4; MAX DEV: global 9.71452; population 3.68365; 1st GRAPH: total; OTHER GRAPHS: partitions.



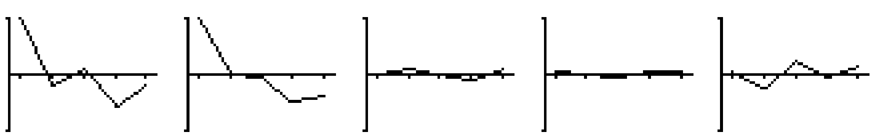
POPULATION 5; MAX DEV: global 9.71452; population 9.71452; 1st GRAPH: total; OTHER GRAPHS: partitions.

POPULATION 6; MAX DEV: global 9.71452; population 5.67205; 1st GRAPH: total; OTHER GRAPHS: partitions.

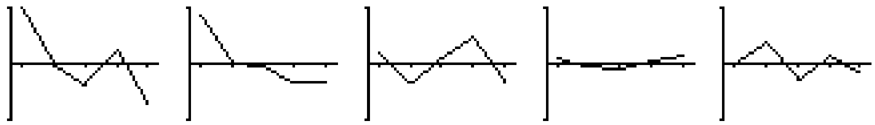


POPULATION 7; MAX DEV: global 9.71452; population 1.91936; 1st GRAPH: total; OTHER GRAPHS: partitions.

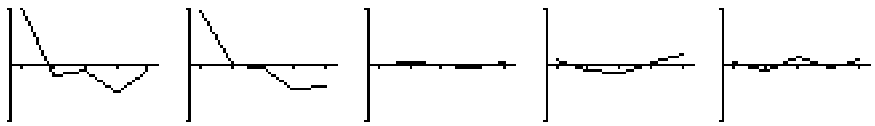
POPULATION 8; MAX DEV: global 9.71452; population 5.17408; 1st GRAPH: total; OTHER GRAPHS: partitions.



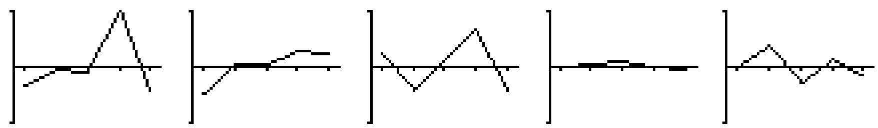
POPULATION 9; MAX DEV: global 9.71452; population 3.28226; 1st GRAPH: total; OTHER GRAPHS: partitions.



POPULATION 10; MAX DEV: global 9.71452; population 4.26793; 1st GRAPH: total; OTHER GRAPHS: partitions.



POPULATION 11; MAX DEV: global 9.71452; population 3.4767; 1st GRAPH: total; OTHER GRAPHS: partitions.



POPULATION 12; MAX DEV: global 9.71452; population 5.68728; 1st GRAPH: total; OTHER GRAPHS: partitions.

Figure 4.4.1 Dispersion profiles of 12 species in the Pre-Alps analysis. The sets of graphs are presented in the same order as the species in Table 4.1.1. The ith graph within the hth set corresponds to the hth column vector in the "Table of deviations partitions h" Δ_i (numerical values in Table 4.3.2.) Heights indicates deviation from expectation (positive or negative). The maximum positive deviation is given in the caption of each set. Tick marks on horizontal axis indicate pH classes in the same order as given in Table 4.1.1. The pH range is from about 5.0 to about 7.5. Since pH is the ordering variable, profile shape is interpretable (monotonic, convex, etc.) See additional definitions in preceding sections.

4.5 Stereograms and dendrogram

The stereograms (Fig. 4.5.1) and dendrogram (Fig. 4.5.2) are based on the 1st 3 sets of columns (species) canonical coordinates (Table 4.3.2.) Program STEREOC draws the stereograms and the clustering program SSA produces input for TREE, which draws the dendrogram. Stereogram construction and cluster analysis are explained in Orlóci (1978, p. 171.) It is noted that the groupings in the stereograms and in the dendrogram separate the good forage species and the poor ones on opposite sides. The relevant PRINTDA files are listed in Tables 4.5.1 and 4.5.2.

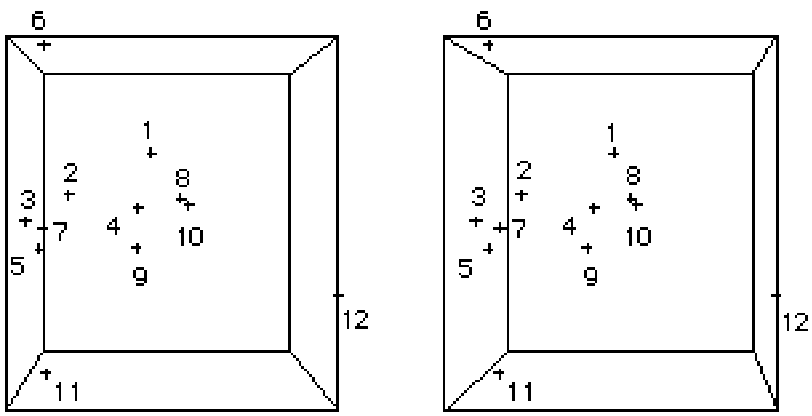


Figure 4.5.1 Stereograms with species as points. Numbers identify species as given in Table 4.1.1. Coordinates are based on the column canonical scores in Table 4.3.2. Study stereo viewing in Avery (1962.)

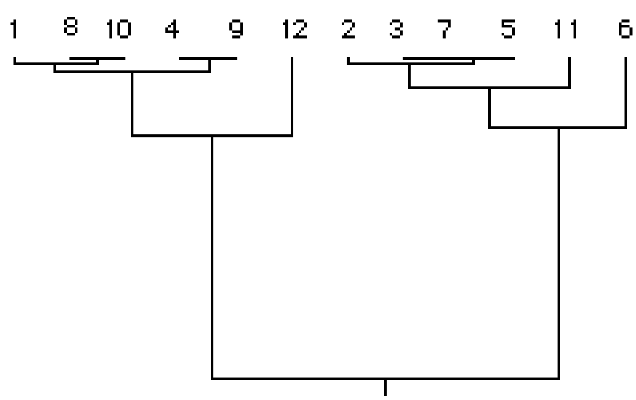


Figure 4.5.2 Dendrogram in the the Pre-Alps analysis. Numbers identify species as given in Table 4.1.1. Note the clear separation of the good (2,3,7,5,11,6) and poor (1,8,10,4,9,12) forage species. The

clustering algorithm is SSA and column canonical scores (Table 4.3.2) are the data. Dendrogram is drawn by program TREE.

Table 4.5.1 PRINTDA file of output by STEREOC in the Pre-Alps analysis. Legend: "axis 1" - ordinate; "axis 2" - abscissa; "data" - 1st 3 sets of column canonical scores in Table 4.3.2. Ranges are adjusted on axes.

```
=== PROGRAM: STEREO ===
Input data in file:COLS.85
Number of data points: 12

Data
 7.56969e-2 -6.75429e-2 -.138975  5.22979e-2 -.114277 -9.34272e-2 -.123771
 .127817  5.18548e-2  .139973 -.110713  .356446  0  0  0  0  0  0  0  0
-7.15913e-2 -1.96967e-2  1.04289e-2 -3.40328e-3  4.00302e-2 -.173191
 2.09105e-2 -1.47269e-2  4.00642e-2 -8.7962e-3  .185619  7.52953e-2  0  0  0
 0 0  0  0  0
-.121089 -4.16005e-3  1.33073e-2 -3.95902e-2  1.96601e-2  6.98753e-2
-5.00593e-2  7.24854e-3  8.75523e-3  3.58466e-2 -1.47972e-2  .112575  0  0  0
 0  0  0  0  0

Range of variable  1  =  .495421
Range of variable  2  =  .35881
Range of variable  3  =  .233664

Order on axis 1 :
 3  5  7  6  11  2  9  4  1  8  10  12

Order on axis 2 :
 6  1  2  8  10  4  3  7  9  5  12  11

SPREAD COEFFICIENTS
 2.92557  3.3  2.80692

VIEWPOINTS
 1.287  2.112
 1.287  1.287
 10.89  9.9

STEREO COORDINATES
Left             Right
axis 1
12 points
 1.26768          6.76768
 .293704          5.67154
-.224009          5.1324
 1.11395          6.53246
-6.38904e-2       5.28448
-2.70785e-3       5.27713
-.011996          5.41787
 1.62304          6.98698
 1.10013          6.46221
 1.72267          7.04995
 1.81178e-2       5.40854
 3.49458          8.70809
8 box corners
 0                5.5
 2.92557          8.42557
 2.92557          8.42557
 0                5.5
-.446922          4.76659
```

```
 3.49458         8.70809
 3.49458         8.70809
-.446922         4.76659
axis 2
12 points
 .934419         .934419
 1.43016         1.43016
 1.75869         1.75869
 1.58867         1.58867
 2.08489         2.08489
-.343457        -.343457
 1.82752         1.82752
 1.48551         1.48551
 2.07405         2.07405
 1.55904         1.55904
 3.56737         3.56737
 2.63203         2.63203
8 box corners
 0               0
 0               0
 3.3             3.3
 3.3             3.3
-.446922        -.446922
-.446922        -.446922
 3.99903         3.99903
 3.99903         3.99903

Stereogram file:kepCOLS.85
```

Table 4.5.2 PRINTDA files of output by METRICS, SSA and TREE in the Pre-Alps analysis.

```
PROGRAM: METRICS
========================
DATA FILE:cols.85, VOLUME
NUMBER OF VARIABLES =  2
NUMBER OF OBSERVATIONS PER VARIABLE =  12
DISTANCE OPTION (3): EUCLIDEAN

DISTANCES FILE:
------------------------------------------------------------------------
      0.0000
      0.1524      0.0000
      0.2298      0.0775      0.0000
      0.0721      0.1209      0.1918      0.0000
      0.2203      0.0758      0.0386      0.1721      0.0000
      0.1973      0.1557      0.1892      0.2237      0.2142      0.0000
      0.2199      0.0694      0.0185      0.1777      0.0213      0.1965
     0.0000
     0.0771      0.1954      0.2680      0.0764      0.2482      0.2721
     0.2541      0.0000
     0.1142      0.1335      0.1931      0.0435      0.1661      0.2580
     0.1767      0.0937      0.0000
     0.0899      0.2078      0.2796      0.0878      0.2589      0.2855
     0.2654      0.0135      0.1008      0.0000
     0.3177      0.2098      0.1775      0.2496      0.1456      0.3592
     0.1652      0.3115      0.2182      0.3172      0.0000
     0.3169      0.4345      0.4996      0.3142      0.4720      0.5139
     0.4833      0.2457      0.3066      0.2322      0.4800      0.0000


DISTANCES FILE: dist.85
```

```
PROGRAM: SSA
====================
DISTANCES FILE: dist.85
NUMBER OF OBJECTS:  12

CLUSTERING PASS  1
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  2
FUSION SUM OF SQUARES:       0.000
INDIVIDUALS:    8  10

CLUSTERING PASS  2
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  2
FUSION SUM OF SQUARES:       0.000
INDIVIDUALS:    3   7


CLUSTERING PASS  3
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  3
FUSION SUM OF SQUARES:       0.001
INDIVIDUALS:    3   7   5

CLUSTERING PASS  4
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  2
FUSION SUM OF SQUARES:       0.001
INDIVIDUALS:    4   9

CLUSTERING PASS  5
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  4
FUSION SUM OF SQUARES:       0.005
INDIVIDUALS:    2   3   7   5

CLUSTERING PASS  6
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  3
FUSION SUM OF SQUARES:       0.005
INDIVIDUALS:    1   8  10

CLUSTERING PASS  7
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  5
FUSION SUM OF SQUARES:       0.013
INDIVIDUALS:    1   8  10   4   9

CLUSTERING PASS  8
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  5
FUSION SUM OF SQUARES:       0.029
INDIVIDUALS:    2   3   7   5  11

CLUSTERING PASS  9
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  6
FUSION SUM OF SQUARES:       0.069
INDIVIDUALS:    2   3   7   5  11   6

CLUSTERING PASS  10
--------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  6
FUSION SUM OF SQUARES:       0.079
INDIVIDUALS:    1   8  10   4   9  12
```

```
CLUSTERING PASS  11
------------------------------------------------------------
NUMBER OF INDIVIDUALS IN FUSION GROUP:  12
FUSION SUM OF SQUARES:       0.325
INDIVIDUALS:    1   8  10   4   9  12   2   3   7   5  11   6

DENDROGRAM DATA STORED IN FILE tree.85
RUN PROGRAM TREE TO PLOT THE DENDROGRAM!



PROGRAM: TREE
=====================
DENDROGRAM FILE: tree.85
NUMBER OF OBJECTS:  12

HORIZONTAL SEQUENCE:
-------------------------------------------------------
   1   8  10   4   9  12   2   3   7   5  11   6

DISSIMILARITY VALUES (VERTICALLY FROM TOP DOWN):
-------------------------------------------------------
        0.00009        0.00017        0.00076        0.00094        0.00471
0.00474        0.01336        0.02857        0.06940        0.07904
        0.32451
```

4.6 Overview

The first point to be made is about structure sharpness. Bearing on this is the size of the interaction chi-squared (107.983). With 44 degrees of freedom, the probability of an at least as large chi-squared under H_o is

$$P(\chi^2_{RND} \geq 107.983) << 0.001$$

This indicates that species frequencies ordered by pH generate a sharp intrinsic structure. This is to be interpreted in the light of the Cramér index,

$$\frac{107.983}{279 \text{ x } 4} = 0.97 \text{ or } 9.7\ \%$$

which is very low. It can be concluded that the structure detected may be a very low probability event, it approaches the chi-squared of the theoretically sharpest structure in magnitude to the extent of less than 10%.

It is interesting to observe that in practically all cases, the species have a strong monotonic profile in the the X_1,Y_1 canonical plane. The monotonic profiles account for about 64% of the total chi-squared. Profiles Δ_2, Δ_3, Δ_4 in the 2nd, 3rd and 4th canonical planes account for a meager 11%, 10% and 6% respectively. It can be concluded that major species responses are triggered by effects from factors for which pH is symptomatic. Two types of basic responses are evident:

Species with ascending Δ_1 profiles – *Brachypodium pinnatum, Dactylis glomerata, Bromus erectus, Arrhenatherum elatius, Festuca pratensis.*

Species with descending Δ_1 profiles – *Agrostis tenuis, Anthoxanthum odoratum, Festuca tenuifolia, Festuca rubra, Danthonia decumbens, Nardus stricta.*

The first group contains the preferred forage species. These thrive the neutral and basic side of the observed pH range. The second group collects the less desired species, characteristics for more acidic soils.

5
Edges detection

5.1 General

This chapter describes edges detection in vegetation when canonical contingency table analysis supplies the analytical evidence. Method and data are the same as used in Orlóci and Orlóci (1990.) The survey site is in the northern Chihuahua Desert under complex landscape. The data comprise cover/abundance estimates of 41 Character Set Types (CSTs; Orlóci and Orlóci 1985, 1990, Orlóci 1988, 1991) within 90 30 m. sq. quadrats laid end-to-end on a transect.

5.2 *Modus operandi*

The cover/abundance values are ordered within CST vectors according to transect position. Data entree is by CSTs, designated as rows. The analysis moves through transformation, which generate the data residuals, computation of a 41 x 41

S matrix, and Eigenanalysis of **S**. Following these, deviations, distances and angles are computed. Finally, profiles and stereograms are constructed, which are inspected for evidence of edges.

5.3 Startup dialogue and PRINTDA file

Several runs are involved under different options. The startup dialogue of the main run is displayed in Table 5.3.1. The contents of an abbreviated PRINTDA file of the same run appear in Table 5.3.2. The profiles and the scattergrams from all runs are shown in Figs. 5.3.1 to 5.3.5.

Table 5.3.1 Startup dialogue and last screen from main run in the Chihuahua analysis. See the explanations in preceding sections.

```
File  Edit  Custom  Run  Windows  Help
Are the input data files in one folder with this program? -- press Y or N:Y
Specify output file name extension:j88/
Press Y to store intermediate results on a print file:N

Name frequency table file:j88/41/90
Specify the number of rows:41
Specify the number of columns:90

Press Y to adjust frequencies to equal block size
(- if no block sizes file exists, press a key other than Y):N

Do you wish to perform autocorrelation analysis? -- press Y or N:N

Do you wish to perform covariance analysis with
transect position? -- press Y or N:N

Weight options are:

1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis
```

```
Specify weight option (1-4):3

Eigenanalysis -- iteration:  22
Press Y to weight canonical scores by eigenvalues:Y

Working


Specify relative graph size. Type 1 for normal size:? .5
Specify tick mark spacing:? 10
Do you wish to plot table ROWS or COLUMNS? -- press R or C:R
Deviations graphs are now constructed. This may take some time.
```

```
 File  Edit  Custom  Run  Windows  Help

Your main printable file is: PRINTDACONA.j88/
Graphs are stored in KEP files with extension: .j88/
Open and print the PRINTDA file from EDIT
Open and edit KEP files from a PAINT program
Press any key to exit
```

Table 5.3.2 PRINTDA file from main run in the Chihuahua analysis. Refer to definitions and models of interpretation in preceding chapters.

```
Program: CONAPACK
________________
Program CONA:::
DATA FILE:  j88/41/90
NUMBER OF ROWS:   41
NUMBER OF COLUMNS:   90
Weighting option selected: # 3
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis

GRAND TOTAL =      26668.000

CANONICAL CORRELATIONS AND CHI-SQUARED PARTITIONS
Can corr R1  =     .8526  F..R^2 =      19384.1828 Cum % =  26.7949
Can corr R2  =     .5971  F..R^2 =       9509.4620 Cum % =  39.9399
Can corr R3  =     .5240  F..R^2 =       7321.7025 Cum % =  50.0608
Can corr R4  =     .4794  F..R^2 =       6128.9189 Cum % =  58.5329
Can corr R5  =     .4267  F..R^2 =       4854.3880 Cum % =  65.2431
Can corr R6  =     .3798  F..R^2 =       3846.5271 Cum % =  70.5602
Can corr R7  =     .3458  F..R^2 =       3188.6288 Cum % =  74.9679
Can corr R8  =     .2880  F..R^2 =       2212.5251 Cum % =  78.0263
Can corr R9  =     .2738  F..R^2 =       1998.9902 Cum % =  80.7895
Can corr R10 =     .2490  F..R^2 =       1653.8063 Cum % =  83.0756
Can corr R11 =     .2401  F..R^2 =       1537.6391 Cum % =  85.2011
Can corr R12 =     .2188  F..R^2 =       1277.2242 Cum % =  86.9666
Can corr R13 =     .2146  F..R^2 =       1228.0281 Cum % =  88.6641
Can corr R14 =     .1905  F..R^2 =        967.7469 Cum % =  90.0018
Can corr R15 =     .1858  F..R^2 =        920.7196 Cum % =  91.2745
Can corr R16 =     .1692  F..R^2 =        763.8384 Cum % =  92.3304
```

```
TEST FOR COMPOSITIONAL SHARPNESS OF THE  3690  BLOCKS
Chi-squared =      66794.3281
Degrees of freedom =  3560
Rank =  16

Row totals in file: rowtots.j88/
Column totals in file: coltots.j88/
Row canonical scores in file(s): ROWS.j88/ and rowsadj.j88/
 ( 16  sets of  41  numbers)
Column canonical scores in file(s): COLS.j88/ and colsadj.j88/
 ( 16  sets of  90  numbers)
Run PLOT with ROWS ... or COLS ... to draw scattergram
Run Stereo to draw stereograms
Eigenvalues stored in file: EIG.j88/
Deviations information stored in file: LAT.j88/

Program ANGLES AND DISTANCES:::
Input data file:colsadj.j88/
Output in files:ANGLES.j88/ and DISTANCES.j88/
Number of axes: 16
Number of units: 90
Print in following order:
Point B; squared distances AB,AC,BC; angle at B
  2:       .011891       .036055       .041244     67.316716
  3:       .041244       .024531       .006906     45.593726
  4:       .006906       .277954       .242463    110.442859
  5:       .242463       .228724       .013006     76.223854
  6:       .013006       .139347       .152089     73.174265
  7:       .152089       .234321       .039621    105.929732
  8:       .039621       .091697       .098850     68.055833
  9:       .098850       .086343       .008071     68.637748
 10:       .008071       .037091       .033692     81.856426
 11:       .033692       .034275       .002467     84.069712
 12:       .002467       .003899       .003148     72.070828
 13:       .003148       .006327       .010793     49.223540
 14:       .010793       .011950       .005888     72.738675
 15:       .005888       .002534       .003045     40.919390
 16:       .003045       .004621       .001846     86.734217
 17:       .001846       .012095       .008065    106.440185
 18:       .008065       .008566       .000757     87.036092
 19:       .000757       .000547       .001154     43.129268
 20:       .001154       .002104       .001522     77.540890
 21:       .001522       .054482       .057604     75.643561
 22:       .057604       .051748       .001069     63.818918
 23:       .001069       .004823       .002437    114.068744
 24:       .002437       .001213       .005532     23.069150
 25:       .005532       .029475       .055784     25.002648
 26:       .055784       .054975       .001978     82.378538
 27:       .001978       .001728       .002002     55.537786
 28:       .002002       .001977       .000782     71.187361
 29:       .000782       .003316       .005942     37.762213
 30:       .005942       .009891       .001808    109.052056
 31:       .001808       .001095       .002134     43.555219
 32:       .002134       .002846       .001463     77.733420
 33:       .001463       .015286       .017453     68.946922
 34:       .017453       .019775       .003431     85.891296
 35:       .003431       .032439       .035449     73.021946
 36:       .035449       .003794       .033511     19.028064
 37:       .033511       .027131       .009038     63.707595
 38:       .009038       .008896       .001378     77.566483
 39:       .001378       .023345       .027536     63.123147
 40:       .027536       .002336       .031044     15.876222
 41:       .031044       .039169       .009570     87.598001
 42:       .009570       .014926       .001354    123.771296
 43:       .001354       .004816       .008917     38.282710
```

44:	.008917	.001983	.005431	27.325265
45:	.005431	.004432	.014318	29.713241
46:	.014318	.013883	.001007	79.050277
47:	.001007	.001928	.001020	87.216757
48:	.001020	.001162	.001639	54.626216
49:	.001639	.002494	.003774	54.072440
50:	.003774	.002547	.001728	54.659359
51:	.001728	.002052	.004057	45.181282
52:	.004057	.005689	.002419	82.777781
53:	.002419	.001715	.002923	46.999871
54:	.002923	.002969	.002338	63.991886
55:	.002338	.002124	.004248	44.935960
56:	.004248	.002944	.001199	56.318096
57:	.001199	.001467	.002326	51.958340
58:	.002326	.002225	.001541	64.301831
59:	.001541	.002948	.001192	94.548699
60:	.001192	.009030	.007110	97.189630
61:	.007110	.009361	.000671	111.202395
62:	.000671	.001553	.001798	65.363269
63:	.001798	.008884	.003720	130.607261
64:	.003720	.005784	.002001	90.667024
65:	.002001	.001523	.000709	60.110214
66:	.000709	.003906	.003033	93.203877
67:	.003033	.005728	.002861	88.384414
68:	.002861	.007707	.006188	80.823479
69:	.006188	.011429	.006249	85.353820
70:	.006249	.001277	.004068	26.302564
71:	.004068	.019184	.007739	131.099586
72:	.007739	.029786	.016815	103.260355
73:	.016815	.002033	.015596	20.294466
74:	.015596	.021661	.003285	101.194438
75:	.003285	.010266	.015903	51.889155
76:	.015903	.006984	.004494	37.502888
77:	.004494	.016767	.007827	112.012364
78:	.007827	.011014	.004106	85.352346
79:	.004106	.004711	.000788	87.092995
80:	.000788	.009297	.009059	84.093394
81:	.009059	.004982	.002063	44.752730
82:	.002063	.000697	.003095	28.020665
83:	.003095	.001785	.002254	47.572379
84:	.002254	.003665	.002796	73.985889
85:	.002796	.001271	.003140	38.069487
86:	.003140	.046531	.042734	91.625668
87:	.042734	.035651	.007006	65.975575
88:	.007006	.002454	.006434	35.101300
89:	.006434	.320378	.267988	123.596900

```
Program DEVIATIONS:::
Input data files are: LAT.j88/ and EIG.j88/
The number of canonical variates is:  16


Program DEVIATIONS:::
Input data files are: LAT.j88/ and EIG.j88/
The number of canonical variates:  16
Graphs in file: GRAPHS.j88/


Program LATGRAPHS:::
Input data file: GRAPHS.j88/
Number of deviations partitions: 16
DEVIATIONS PROFILES: rows are plotted
ANGLES PROFILE: columns are the points
DISTANCES PROFILES: columns are the points
Elapsed time:  1459.45  seconds
```

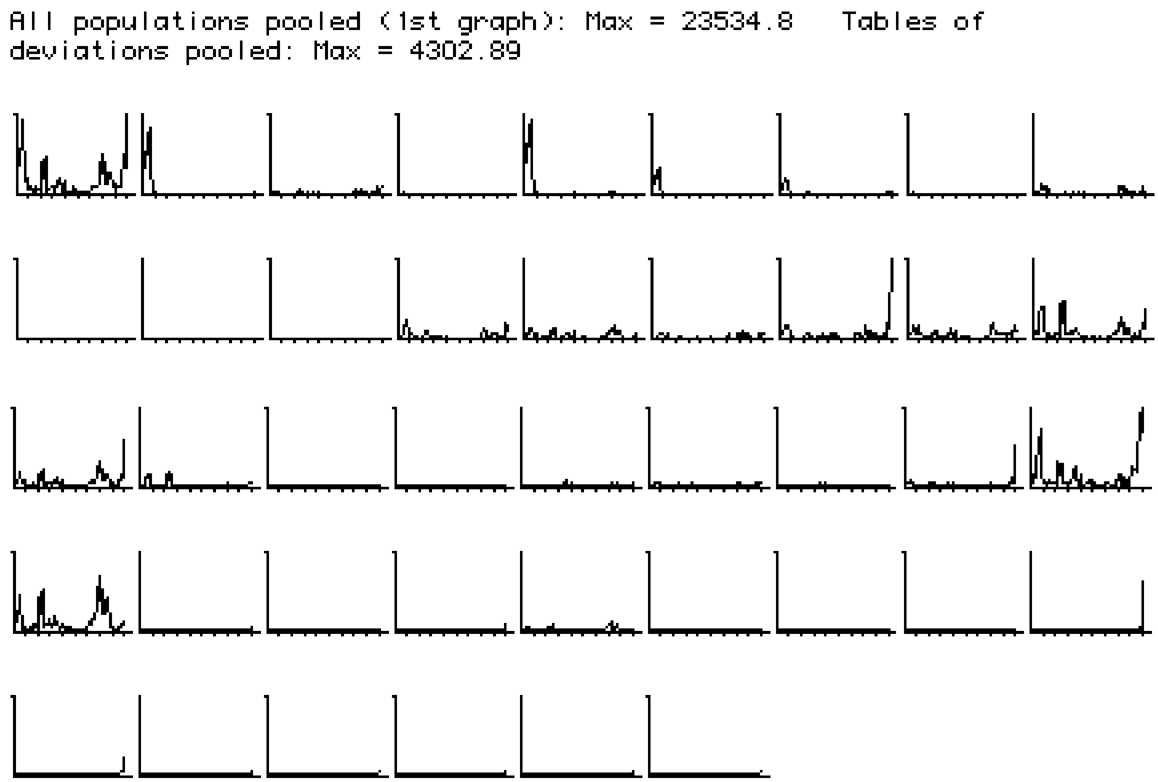
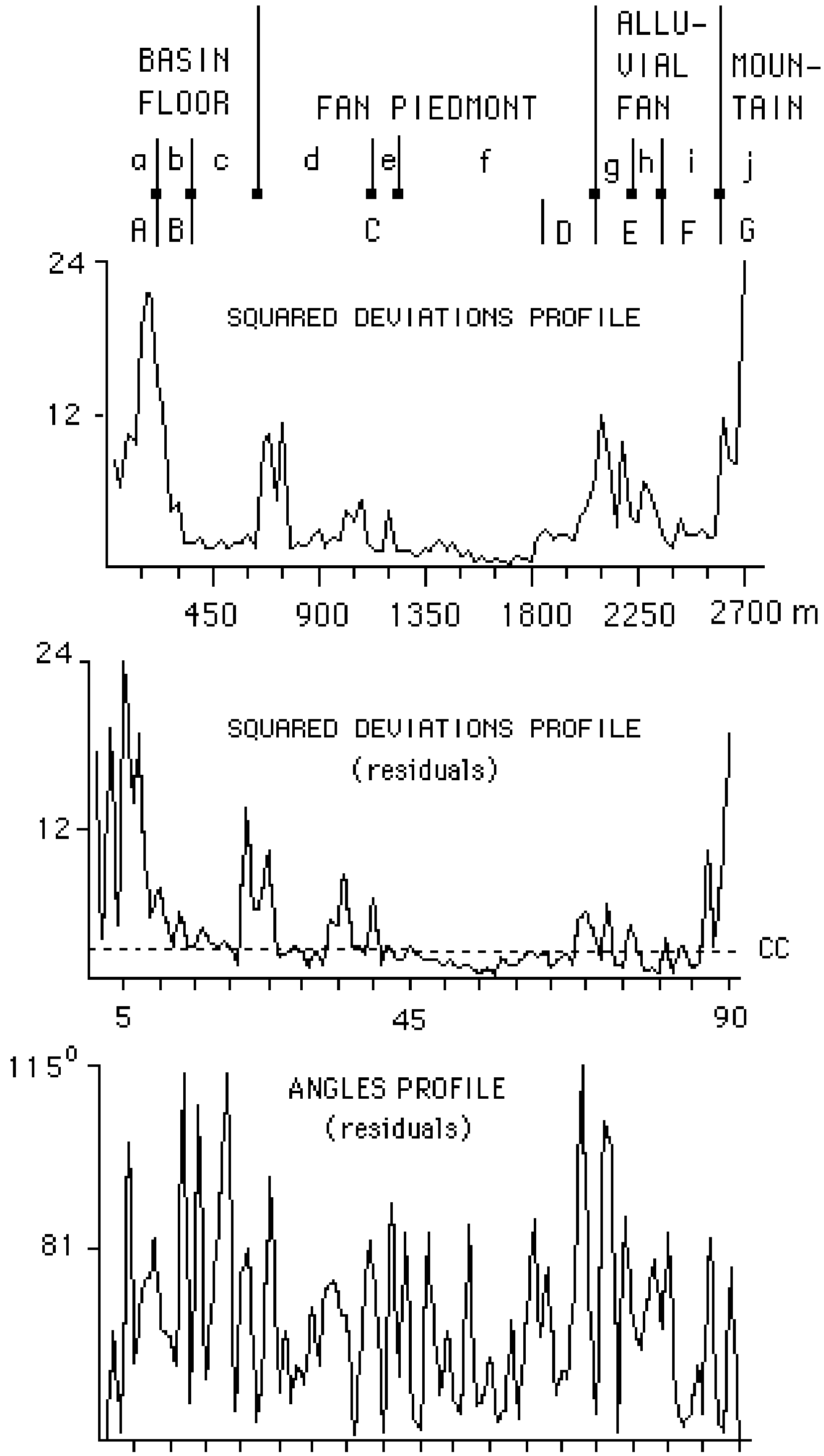


Figure 5.3.1 Squared deviations profiles over 90 quadrats in the transect. The 4th row of graphs in Fig. 3.6.7.1 is the model. 1st graph: all CSTs pooled. 2nd and subsequent graphs: 41 CSTs. Vertical scales: 23534.8 maximum in 1st graph; 4302.89 maximum in second and following graphs.


BASIN FLOOR
FAN PIEDMONT
ALLU- VIAL FAN
MOUN- TAIN
a b c d e f g h i j
A B C D E F G
24
12
SQUARED DEVIATIONS PROFILE
450 900 1350 1800 2250 2700 m
24
12
SQUARED DEVIATIONS PROFILE (residuals)
CC
5 45 90
115°
81
ANGLES PROFILE (residuals)

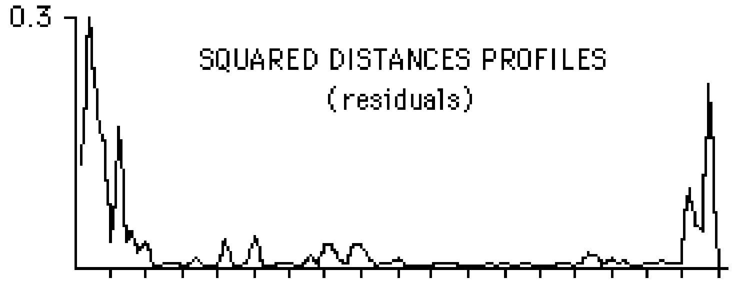


Figure 5.3.2 Profiles over 90 quadrats in the Chihuahua transect.[7] The 1st graph in the 4th row of Fig. 3.6.7.1 and the angles and distances graphs in the last row of the same figure are models. The top graph (enlarged from Fig. 5.3.1) displays squared deviations computed from unadjusted CST records. The middle and lower graphs display deviations, angles, and distances based on residual data after removal of serial effects (see Section 1.3.) Vertical axis is in thousand units in the top two graphs and in the last graph. Angles are shown on a quadratic scale in the 3rd graph. Tick marks on horizontal axes identify quadrat positions in the transect in steps of 5. Distances from transect origin are shown. High peaks in the deviations and distances profiles are mirrored closely by the low valleys in the angles profile. The mirroring coefficient[8] is 75%. The Cramér coefficient is -0.5 for directional changes (up/down, down/up) above the 2500 deviation level (marked by line CC in the 2nd graph.) The negative sign of the index indicates an observed value in the +,+ cell of the 2 x 2 table smaller than the expected value. Note the close correspondence of high peaks in the deviations and distances profiles, and the low points in the angles profile, with dramatic landform and soil changes along the transect. Legend to soils and vegetation zones: a - Dalby soil series; b - Headquarters series; c - Buckle Bar series; d - Berino series; e - Onite series; f - Doña Ana series; g - erosion fan remnant channel, h - side slope, i - summit (Aladdin soil series); j - montane rockland; A - playa grassland; B - playa fringe *Prosopis* thicket; C - mixed basin slope

[7] Figure of Orlóci and Orlóci (1990) recomputed.
[8] See definition in Orlóci and Orlóci (1990)

vegetation; D - *Larrea* shrubland; E - lower grassland; F - upper grassland; G - montane shrubland.

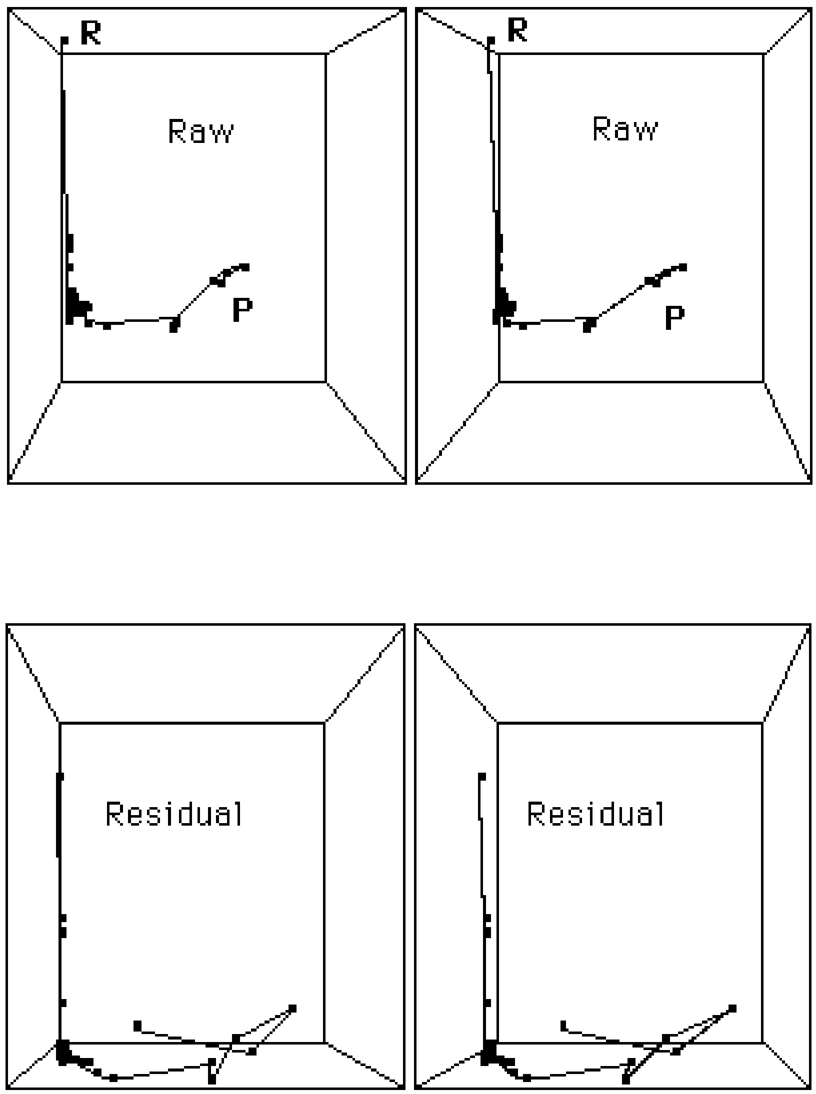
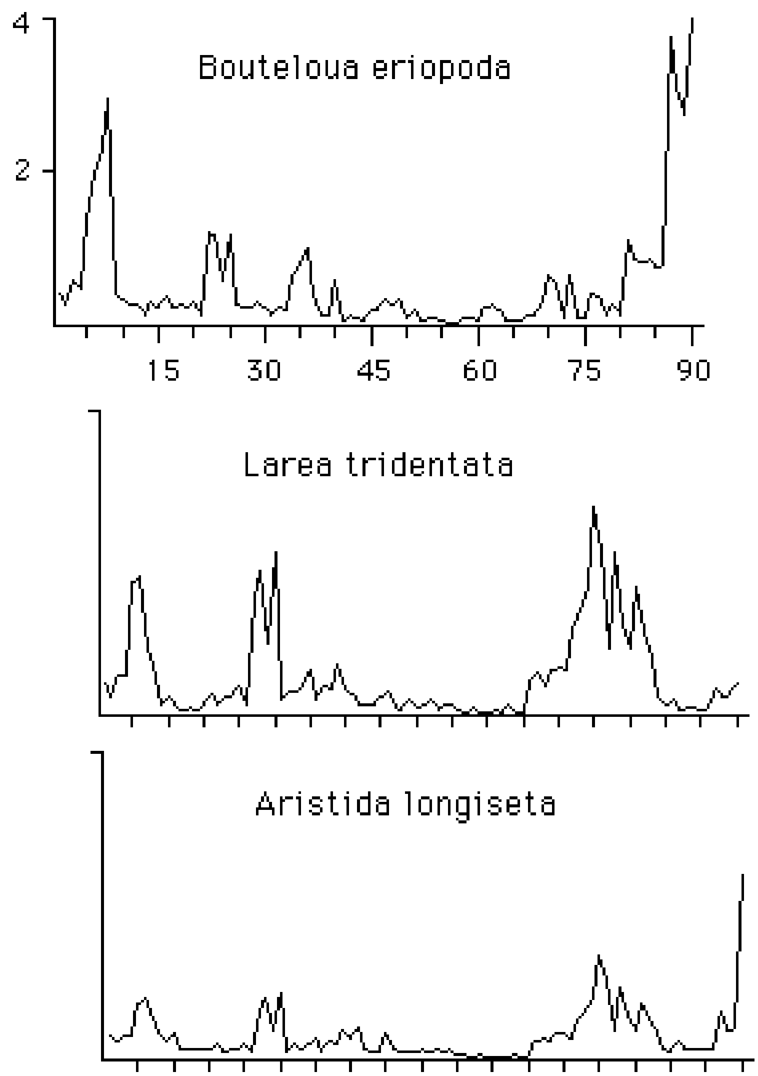


Figure 5.3.3 3-d mappings of the Chihuahua transect for stereo viewing. The axes are canonical variates. These jointly account for approximately 50% of the total chi-squared (Table 5.3.2.) Quadrats are shown as small full squares. These are connected in the direction of progress from basin floor (P, quadrat 1) to montane rockland (R, quadrat 90.) The length of a connecting lines in full

dimensions is proportional to compositional dissimilarity. Its square is a heights in the distances graph (Fig. 5.3.2.) Sharp apices identify dramatic compositional changes (compare with Figs. 5.3.1 and 5.3.2.) The upper stereo pair is based on canonical scores derived from the raw data. The lower stereo pair is based on scores derived from data residuals (Section 1.3.)



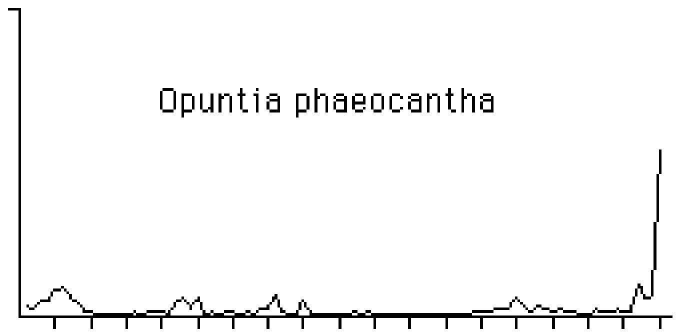


Figure 5.3.4 Dispersion profiles of selected species. The profiles are enlarged from Fig. 5.3.1. Vertical axis displays squared deviations in thousand units. Tick marks on the horizontal axes identify transect positions as in Fig. 5.3.2. Peaks indicate under- or overrepresentation of the species, relative to random expectation, in cover/abundance terms.

5.4 Edges detection - a discussion

The method uses evidence from deviations, distances and angles profiles, and other analytical mappings, such as the 3-d scattergrams, to identify vegetation edges. The key attributes include the height of the peaks in the profiles, the acuteness of subtending angles at the apices of full dimensional analytical mappings, and the inter-apex distances. Edges are recognized where an acute apex is seen isolated by large inter-apex distances. An edge is declared sharp where the subtending angle is acute, and intense where the associated deviation (or distance) is large in probability terms.

Concerning method and results, further comments are in order to clarify:

1. The CST scheme in community descriptions, not mandated by the edge detection method *per se*, has advantages. For one thing, character choice need not be affected

by considerations issued at another time, under different study objectives and analytical circumstances, such as the phylogenetic considerations of the taxonomist which underly the species concept (cf. Ghiselin 1987.) The CST scheme allows flexibility when selecting a character set to distinguish plant populations. Accordingly, CSTs may be defined as ecological types, phenological types, or even inheritance types (such as species), etc., which is very important when an ecological study involves comparisons of vegetation samples from greatly contrasting environments or different floristic regions.

2. When distances are used such as in the last graph in Fig. 5.3.2, and in Ludwig and Cornelius (1987), the profile displays compositional dissimilarities of adjacent quadrats. Implicit in this is a comparison of vegetation stands according to the assumption that there is vegetation continuity if the adjacent transect locations are compositionally not distant. But a distance will not be interpretable in the terms of this assumption under serial effects which generate a slope or "plateau" effects in the sense that stands of greatly different composition may appear equally distant. This points up the need to remove the serial effects, before computing distances, and to complement the distances profile by an angles profile before interpretations.

3. Deviations express changes relative to a global null state. This state is reduced to a virtual random arrangement in data after removal of the serial effects. The plateau effect still remains a potential problem, and to overcome it, the deviations profile should be complemented by an angles profile before interpretations.

4. To identify environment links, the profiles are suitable construct. It is easy to juxtapose on them environmental and vegetation information. This has been done in Fig. 5.3.2 which shows that dramatic vegetation discontinuities and environmental discontinuities often coincide. Furthermore, the deviations profiles show major

vegetation discontinuities that are not picked up on the distances profile, such as the edges on the mixed basin slope (C, top of Fig. 5.3.2).

5. The Jornada results are interesting in yet another respect related to the method's handling of absences recorded as zeros in the data. When a distance is computed, matching zeros will not affect the comparison. But when a deviation is computed, zeros can have differential effects, depending on the transect position. Since in all nontrivial cases zeros have non-zero deviations from expectation, a population's absence may take on as much importance as its presence in edges detection. This is a reality, not captured by distance.

6. If absence is allowed to have an influence in the comparisons, even single populations can be effective indicators of vegetation edges. Fig. 5.3.4 shows this extremely well. But it should be remembered that the derivations in the individual profiles are derived from an analysis of the total sample. The consequence of this is that the sampling should be reasonably complete. Experience suggests that the profiles will start to stabilize after the Eigenstructure attained reasonable stability in the sample. Randomization tests[9] show this to happen in the Chihuahua sample at a relatively low number of CSTs as seen in Fig. 5.4.1. According to this, a random sample of 20 CSTs can stabilize the Eigenstructure in the 90-quadrat sample at a level nearly matching that of 41 CSTs. Preferential sampling could further reduced the CST number.

[9] See methods in Wildi and Orlóci (1987), Orlóci and Pillar (1989), and a complete methodology in Edgington (1987.)

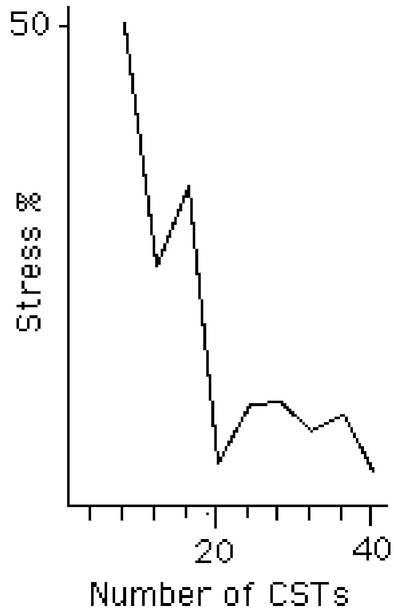


Figure 5.4.1 The stress function that measures Eigenstructure stability in the Chihuahua sample. Sampling/resampling of the CSTs is random. The number of quadrats is held constant at 90. Sampling step size is 4. Note the substantially reduced stress values (increased structural stability) after the number of CSTs is increased to 20 or more. The relevant program is SAMPLER (Orlóci and Pillar 1989.)

6
Community recovery

6.1 General

This chapter gives an example of the use of canonical contingency table analysis in recovery analysis. Orlóci and Orlóci (1988) describe the method. Two data sets are used, one from Lippe et al. (1985: Table 1) and the other from Stephens and Waggoner (1980:Table 2, last block). The Lippe data set contains cover estimates for bare ground, 7 species and 1 species group during 19 consecutive yearly surveys in a recovering heathland. The Stephens/Waggoner data set comprises density estimates for 30 species taken at 5 intervals during 5 decades in a recovering mixed forest.

6.2 *Modus operandi*

For computational convenience, the Lippe data are entered on file by species. The "row" designation is for the species. The Stephens–Waggoner data are entered by time period. In this case, the "column" designation is for species. The analysis generates a 9 x 9 **S** matrix (Lippe) and a 5 x 5 **S** matrix (StephensWaggoner.) Eigenanalysis follows, then deviations, distances, and angles are computed. Profiles and stereograms are constructed next and probed for evidence of temporal trends.

6.3 Heathland recovery

The startup dialogue is given in Table 6.3.1. No adjustments are requested and rows are specified as profile entities. The PRINTDA file is listed in Table 6.3.2. This contains the full record of the run. The data table shown in the PRINTDA file is the transpose of the original Lippe table. The order of the S matrix is 9 and its rank is 4. The analysis manages to pick up a definite linear time in the 1st canonical plain (X_1,Y_1) which accounts for 88 % of the total chi-squared (429.9.) Considering that

$$[\chi^2 = 429.9] \geq [\chi^2_{.001,144} = 202.2]$$

the compositional structure of the table is considered sharp. Note the low Cramér index:

$$\frac{429.9}{1900.9 \text{ x } 8} = 0.028 \text{ or } 2.8 \text{ \%}$$

This very low value dampens the anticipations considerably about the relative strength of the linear trend, compared to the theoretically possible strongest trend for which the discriminating chi-squared is 1908.9.

The stereograms are displayed in Fig. 6.3.1. These are based on the 19 column scores on the 1st 3 canonical variates. The various graphs are created in consecutive runs of program STEREOC, each time with a different option. Regarding scale, the scores are Eigenadjusted. In addition, the top stereo pair has axes adjusted to chi-squared, and the 2nd pair to range. The last pair is adjusted to equal spread. The third pair is not adjusted in either of these ways. While least viewable, the presentation of the recovery pathway in the 1st stereo pair is most consistent with the chi-squared manipulations in the model. The appearance of linearity before the process enters a chaotic state is expected (Orlóci and Orlóci 1988.) Best viewability is in the bottom stereo pair, but this distorts the linear trend.

The dispersion profiles in Fig. 6.3.2 are drawn from the row vectors of:

$$\Delta, \quad \Delta_1, \quad \Delta_2, \quad \Delta_3, \quad \Delta_4$$

(see numerical values in Table 6.3.2) according to logic already explained in the preceding sections. Focus on the graphs in the 1st canonical plane (X_1,Y_1), which appear as the 2nd graph in each set of 5 graphs. These accounts for 88 % of the total chi-squared. Observe how "bare ground" becomes more and more of a random variable with a declining percentage as time passes. Only *Erica tetralix* (#4) and *Rumex acetosella* (#8) mirror this behaviour. Interestingly, *Erica tetralix* (#4) and *Juncus squarrosus* (#7) are the only species with a substantial secondary profile in the 2nd canonical plane (X_2,Y_2.) All species show weak responses in deviations terms following severe draught around the 13th year. The response is positive in *Erica tetralix* (#4) and *Rumex acetosella* (#8), and negative in the other species. *Molinia caerulea* (#5) and *Carex pilulifera* (#6) have tertiary profiles in the 4th canonical plane (X_4,Y_4), mirrored by the group of other species (#9.) This mirroring may reflect response to some disturbance, perhaps the heather beetle plagues which appeared in the Netherlands between 1967 and 1980.

Table 6.3.1 Startup dialogue and last screen in the heathland analysis. No transformation is requested and row vectors are specified as profiles.

```
File  Edit  Custom  Run  Windows  Help
Are the input data file(s) in one folder with this program? -- press Y or N:Y
Specify output file name extension:L
Press Y to store intermediate results on a printable file:Y
_____________________________________________________________
Name frequency table file:lippe/t.dat
Specify the number of rows:9
Specify the number of columns:19
Press Y to adjust frequencies to equal block size
(- if no block sizes file exists, press a key other than Y):N

Do you wish to perform autocorrelation analysis? -- press Y or N:N
Do you wish to perform covariance analysis with transect
position? -- press Y or N:N

Weight options are:
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis
To specify weight option, press key 1, 2, 3, or 4: 3
Eigenanalysis -- iteration:  22
Press Y to weight canonical scores by eigenvalues:Y

WORKING
Specify relative graph size. Type 1 for normal size:? .7
Specify tick mark spacing (1,5,10, etc):? 1
Do you wish to plot deviations table rows or columns? -- press R or C:R
```

```
File  Edit  Custom  Run  Windows  Help

Your main printable file is: PRINTDACONA.L
Profiles are stored in KEP files with extension: L
Open and print the PRINTDA file from EDIT
Open and edit KEP files from a paint program
Press any key to exit
```

Table 6.3.2 The PRINTDA file in the heathland analysis. See the models of explanation in preceding sections.

```
Program: CONAPACK
________________
Input file for raw contingency table data:lippe/t.dat
Number of rows:  9
Number of columns:  19

Program CONA:::
Input data file:  lippe/t.dat
Weighting option selected: # 3
1. High weight for rows with high total
2. High weight for rows with low total
```

```
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis

Row totals
      307.700      1003.100       399.900       134.300         6.300
       18.600
        6.100        14.300        10.600
Column totals
      100.100       100.100       100.000       100.000       100.000
       99.900
       99.900       100.100       100.100       100.000       100.100
      100.100
      100.000       100.100       100.100       100.000       100.100
      100.100
      100.100
  9 x 19  table
       57.100        44.000        32.700        27.500        19.700
       10.700
        6.700         5.800         9.500         8.400         4.400
        8.500
        9.200         9.900        19.600        12.100         9.300
        7.300
        5.300
       17.900        25.000        34.900        36.800        46.100
       54.200
       55.700        61.100        57.600        62.100        67.900
       58.100
       62.200        58.200        48.400        58.100        65.100
       68.200
       65.500
        8.600        13.700        13.900        20.000        21.000
       22.200
       23.300        23.700        24.700        23.700        21.300
       25.800
       24.300        24.900        23.500        22.700        20.300
       21.500
       20.800
       11.600        12.200        14.300        14.100        10.800
       10.600
       10.400         6.900         6.600         3.600         3.300
        4.700
        2.500         3.700         5.700         4.800         2.700
        1.200
        4.600
         .000          .000          .000          .100          .100
         .700
         .300          .200          .400          .300          .200
         .600
         .600          .600          .300          .400          .000
         .500
        1.000
         .200         1.100          .500          .900          .700
         .600
        2.000         1.200          .600         1.200          .600
        1.300
         .900         1.100         1.200          .400         1.500
        1.000
        1.600
         .000          .200          .000          .200          .400
         .400
         .700          .700          .400          .100          .400
         .700
         .200          .700          .400          .000          .100
         .100
         .400
        4.700         3.900         3.700          .300          .500
         .000
```

```
         .100          .200          .000          .000          .000
         .000
         .000          .000          .100          .200          .200
         .100
         .300
         .000          .000          .000          .100          .700
         .500
         .700          .300          .300          .600         2.000
         .400
         .100         1.000          .900         1.300          .900
         .200
         .600

GRAND TOTAL =       1900.900

 9 x 9  SCALAR PRODUCT MATRIX
         .1219         -.0655         -.0292          .0369         -.0098
        -.0070
        -.0071          .0539         -.0116
        -.0655          .0376          .0147         -.0245          .0053
         .0034
         .0027         -.0281          .0067
        -.0292          .0147          .0088         -.0086          .0025
         .0017
         .0023         -.0149          .0024
         .0369         -.0245         -.0086          .0236         -.0036
        -.0018
        -.0007          .0159         -.0047
        -.0098          .0053          .0025         -.0036          .0023
         .0005
         .0008         -.0044          .0003
        -.0070          .0034          .0017         -.0018          .0005
         .0020
         .0010         -.0029          .0001
        -.0071          .0027          .0023         -.0007          .0008
         .0010
         .0018         -.0034          .0006
         .0539         -.0281         -.0149          .0159         -.0044
        -.0029
        -.0034          .0285         -.0055
        -.0116          .0067          .0024         -.0047          .0003
         .0001
         .0006         -.0055          .0045

CANONICAL CORRELATIONS AND CHI-SQUARED PARTITIONS
Can corr R 1 =    .4520 F..R^2 =       388.4297 Cum % =  88.4943
Can corr R 2 =    .1154 F..R^2 =        25.3234 Cum % =  94.2636
Can corr R 3 =    .0698 F..R^2 =         9.2586 Cum % =  96.3730
Can corr R 4 =    .0602 F..R^2 =         6.8966 Cum % =  97.9442

TEST FOR COMPOSITIONAL SHARPNESS OF THE  171  BLOCKS
Chi-squared =        429.9084
Degrees of freedom =  144
Rank =  4

EIGEN ADJUSTED ROW SCORES
SET  1
         .1758         -.0534         -.0375          .0891         -.1009
        -.0399         -.0685          .3686         -.0946
SET  2
        -.0129         -.0073          .0078          .0656         -.0038
         .0121          .0589         -.0673         -.0240
SET  3
        -.0075          .0030         -.0067          .0084         -.0007
         .0066         -.0054          .0665         -.0140
SET  4
        -.0002          .0003         -.0021          .0028         -.0240
```

```
         -.0105         -.0066         -.0013          .0537

EIGEN ADJUSTED COLUMN SCORES
SET  1
          .2864          .2077          .1489          .0851          .0306
         -.0266         -.0481         -.0643         -.0463         -.0634
         -.0899         -.0585         -.0625         -.0551          .0083
         -.0374         -.0606         -.0780         -.0764
SET  2
         -.0392         -.0088          .0143          .0512          .0295
          .0393          .0461          .0169          .0118         -.0151
         -.0209          .0024         -.0224         -.0096         -.0044
         -.0144         -.0301         -.0380         -.0086
SET  3
         -.0060          .0060          .0389         -.0258         -.0102
          .0043          .0150          .0143         -.0039         -.0026
          .0077         -.0076         -.0068         -.0141         -.0328
         -.0096          .0057          .0066          .0210
SET  4
          .0005         -.0062          .0034         -.0014          .0118
          .0008          .0018         -.0079         -.0085         -.0037
          .0411         -.0165         -.0218          .0001          .0030
          .0202          .0090         -.0158         -.0101

Row totals in file: rowtots.L
Column totals in file: coltots.L
Row canonical scores in file(s): ROWS.L and rowsadj.L
 ( 4  sets of  9  numbers)
Column canonical scores in file(s): COLS.L and colsadj.L
 ( 4  sets of  19  numbers)
Run PLOT with ROWS ... or COLS ... to draw scattergram
Run Stereo to draw stereograms
Eigenvalues stored in file: EIG.L
Deviations information stored in file: LAT.L

Program DEVIATIONS:::
Input data files are: LAT.L and EIG.L
The number of canonical variates is:  4

DEVIATIONS FROM RANDOM EXPECTATION (Fhj - Fh.F.j/F..)

=== Table of deviations partitions  1
           38.5684          27.9732          20.0323          11.4452
            4.1195          -3.5797          -6.4609          -8.6589
           -6.2357          -8.5294         -12.1071          -7.8801
           -8.4055          -7.4224           1.1233          -5.0318
           -8.1644         -10.4976         -10.2883
          -38.1734         -27.6867         -19.8272         -11.3280
           -4.0773           3.5430           6.3947           8.5702
            6.1718           8.4420          11.9831           7.7994
            8.3194           7.3464          -1.1117           4.9802
            8.0808          10.3901          10.1830
          -10.6859          -7.7503          -5.5502          -3.1710
           -1.1413            .9918           1.7901           2.3991
            1.7277           2.3632           3.3544           2.1833
            2.3289           2.0565           -.3112           1.3941
            2.2621           2.9085           2.8505
            8.5285           6.1856           4.4297           2.5308
             .9109           -.7916          -1.4287          -1.9147
           -1.3789          -1.8861          -2.6772          -1.7425
           -1.8587          -1.6413            .2484          -1.1127
           -1.8054          -2.3213          -2.2750
            -.4533           -.3288           -.2355           -.1345
            -.0484            .0421            .0759            .1018
             .0733            .1003            .1423            .0926
             .0988            .0872           -.0132            .0591
             .0960            .1234            .1209
```

-.5297	-.3842	-.2751	-.1572
-.0566	.0492	.0887	.1189
.0856	.1172	.1663	.1082
.1154	.1019	-.0154	.0691
.1121	.1442	.1413	
-.2978	-.2160	-.1547	-.0884
-.0318	.0276	.0499	.0669
.0482	.0659	.0935	.0609
.0649	.0573	-.0087	.0389
.0630	.0811	.0794	
3.7581	2.7257	1.9520	1.1152
.4014	-.3488	-.6296	-.8437
-.6076	-.8311	-1.1797	-.7678
-.8190	-.7232	.1095	-.4903
-.7955	-1.0229	-1.0025	
-.7149	-.5185	-.3713	-.2121
-.0764	.0663	.1198	.1605
.1156	.1581	.2244	.1461
.1558	.1376	-.0208	.0933
.1513	.1946	.1907	

=== Table of deviations partitions 2

1.7359	.3890	-.6331	-2.2654
-1.3039	-1.7383	-2.0380	-.7499
-.5219	.6666	.9244	-.1079
.9895	.4268	.1933	.6358
1.3339	1.6812	.3820	
3.2106	.7195	-1.1710	-4.1900
-2.4115	-3.2151	-3.7693	-1.3870
-.9653	1.2329	1.7097	-.1995
1.8301	.7894	.3575	1.1759
2.4671	3.1095	.7066	
-1.3735	-.3078	.5010	1.7926
1.0317	1.3755	1.6126	.5934
.4130	-.5275	-.7314	.0854
-.7829	-.3377	-.1529	-.5031
-1.0555	-1.3303	-.3023	
-3.8605	-.8651	1.4080	5.0383
2.8997	3.8660	4.5324	1.6677
1.1607	-1.4825	-2.0558	.2399
-2.2006	-.9492	-.4299	-1.4140
-2.9666	-3.7389	-.8496	
.0105	.0024	-.0038	-.0137
-.0079	-.0105	-.0123	-.0045
-.0032	.0040	.0056	-.0007
.0060	.0026	.0012	.0038
.0081	.0102	.0023	
-.0986	-.0221	.0360	.1287
.0741	.0988	.1158	.0426
.0297	-.0379	-.0525	.0061
-.0562	-.0242	-.0110	-.0361
-.0758	-.0955	-.0217	
-.1575	-.0353	.0575	.2056
.1183	.1578	.1849	.0681
.0474	-.0605	-.0839	.0098
-.0898	-.0387	-.0175	-.0577
-.1211	-.1526	-.0347	
.4217	.0945	-.1538	-.5504
-.3168	-.4223	-.4951	-.1822
-.1268	.1619	.2246	-.0262
.2404	.1037	.0470	.1545
.3241	.4084	.0928	
.1115	.0250	-.0407	-.1456
-.0838	-.1117	-.1310	-.0482
-.0335	.0428	.0594	-.0069
.0636	.0274	.0124	.0409
.0857	.1080	.0245	

=== Table of deviations partitions 3

.3981	-.3993	-2.5895	1.7153
.6784	-.2842	-.9956	-.9514
.2600	.1729	-.5105	.5083
.4547	.9360	2.1825	.6353
-.3786	-.4367	-1.3955	
-.5141	.5156	3.3439	-2.2150
-.8760	.3670	1.2856	1.2286
-.3357	-.2233	.6592	-.6563
-.5872	-1.2086	-2.8183	-.8203
.4889	.5640	1.8021	
.4645	-.4659	-3.0214	2.0013
.7915	-.3316	-1.1616	-1.1101
.3033	.2018	-.5956	.5930
.5306	1.0921	2.5465	.7412
-.4417	-.5096	-1.6283	
-.1950	.1956	1.2687	-.8403
-.3324	.1392	.4878	.4661
-.1274	-.0847	.2501	-.2490
-.2228	-.4586	-1.0693	-.3112
.1855	.2140	.6837	
.0007	-.0007	-.0047	.0031
.0012	-.0005	-.0018	-.0017
.0005	.0003	-.0009	.0009
.0008	.0017	.0040	.0012
-.0007	-.0008	-.0025	
-.0212	.0213	.1380	-.0914
-.0362	.0152	.0531	.0507
-.0139	-.0092	.0272	-.0271
-.0242	-.0499	-.1163	-.0339
.0202	.0233	.0744	
.0057	-.0057	-.0371	.0246
.0097	-.0041	-.0143	-.0136
.0037	.0025	-.0073	.0073
.0065	.0134	.0313	.0091
-.0054	-.0063	-.0200	
-.1644	.1649	1.0694	-.7083
-.2802	.1174	.4111	.3929
-.1074	-.0714	.2108	-.2099
-.1878	-.3865	-.9013	-.2623
.1563	.1804	.5763	
.0257	-.0258	-.1672	.1107
.0438	-.0183	-.0643	-.0614
.0168	.0112	-.0330	.0328
.0294	.0604	.1409	.0410
-.0244	-.0282	-.0901	

=== Table of deviations partitions 4

-.0017	.0199	-.0110	.0045
-.0379	-.0027	-.0059	.0254
.0272	.0117	-.1318	.0530
.0699	-.0005	-.0097	-.0647
-.0290	.0508	.0324	
.0094	-.1076	.0592	-.0241
.2049	.0145	.0319	-.1373
-.1469	-.0634	.7119	-.2865
-.3775	.0025	.0526	.3495
.1564	-.2746	-.1750	
-.0225	.2568	-.1414	.0575
-.4890	-.0346	-.0762	.3278
.3506	.1512	-1.6988	.6837
.9010	-.0060	-.1256	-.8341
-.3733	.6552	.4177	
.0104	-.1179	.0649	-.0264
.2245	.0159	.0350	-.1505
-.1610	-.0694	.7801	-.3140

-.4137	.0027	.0577	.3830
.1714	-.3009	-.1918	
-.0041	.0472	-.0260	.0106
-.0899	-.0064	-.0140	.0603
.0645	.0278	-.3125	.1258
.1657	-.0011	-.0231	-.1534
-.0687	.1205	.0768	
-.0054	.0613	-.0337	.0137
-.1166	-.0083	-.0182	.0782
.0836	.0361	-.4053	.1631
.2149	-.0014	-.0300	-.1990
-.0891	.1563	.0996	
-.0011	.0126	-.0069	.0028
-.0240	-.0017	-.0037	.0161
.0172	.0074	-.0834	.0336
.0442	-.0003	-.0062	-.0409
-.0183	.0322	.0205	
-.0005	.0057	-.0032	.0013
-.0109	-.0008	-.0017	.0073
.0079	.0034	-.0380	.0153
.0202	-.0001	-.0028	-.0187
-.0084	.0147	.0094	
.0156	-.1780	.0980	-.0399
.3390	.0240	.0529	-.2272
-.2431	-.1048	1.1778	-.4740
-.6247	.0041	.0871	.5783
.2588	-.4543	-.2896	

=== Sum of deviations partitions tables

40.7006	27.9828	16.7987	10.8995
3.4561	-5.6049	-9.5004	-10.3348
-6.4704	-7.6781	-11.8250	-7.4267
-6.8915	-6.0601	3.4893	-3.8254
-7.2380	-9.2023	-11.2694	
-35.4675	-26.5592	-17.5950	-17.7571
-7.1599	.7094	3.9430	8.2746
4.7239	9.3883	15.0638	6.6571
9.1848	6.9297	-3.5199	5.6854
11.1932	13.7889	12.5166	
-11.6174	-8.2672	-8.2120	.6804
.1929	2.0010	2.1648	2.2101
2.7946	2.1887	.3286	3.5454
2.9774	2.8049	1.9567	.7981
.3916	1.7239	1.3376	
4.4833	5.3982	7.1713	6.7024
3.7028	3.2296	3.6265	.0686
-.5066	-3.5228	-3.7028	-2.0655
-4.6958	-3.0463	-1.1931	-2.4548
-4.4151	-6.1472	-2.6327	
-.4462	-.2799	-.2700	-.1345
-.1450	.0247	.0478	.1558
.1351	.1324	-.1655	.2187
.2714	.0904	-.0311	-.0893
.0347	.2533	.1975	
-.6550	-.3238	-.1349	-.1062
-.1353	.1548	.2394	.2904
.1851	.1061	-.2643	.2504
.2499	.0264	-.1727	-.1999
-.0325	.2283	.2936	
-.4508	-.2444	-.1413	.1446
.0722	.1796	.2168	.1374
.1165	.0153	-.0811	.1115
.0259	.0317	-.0011	-.0507
-.0818	-.0456	.0453	
4.0149	2.9909	2.8644	-.1422
-.2065	-.6545	-.7152	-.6257
-.8339	-.7372	-.7824	-.9886

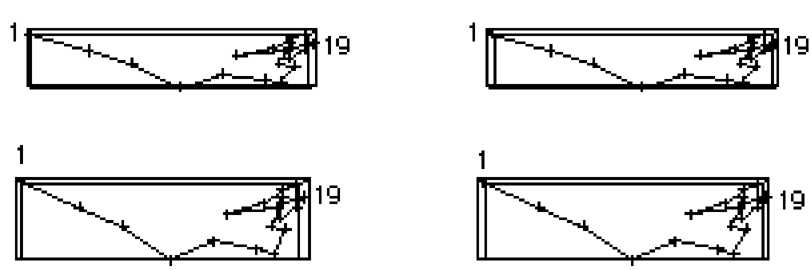
-.7463	-1.0062	-.7477	-.6168
-.3235	-.4194	-.3240	
-.5620	-.6973	-.4812	-.2868
.2227	-.0397	-.0226	-.1764
-.1443	.1073	1.4287	-.3021
-.3759	.2296	.2196	.7535
.4714	-.1799	-.1644	

Graphs in file: GRAPHS.L

Program ANGLES AND DISTANCES:::
Input data file:colsadj.L
Output in files:ANGLES.L and DISTANCES.L
Number of axes: 4
Number of units: 19
Print in following order:
Point B; squared distances AB,AC,BC; angle at B

2:	.007304	.023795	.005171	157.061650
3:	.005171	.019676	.009651	110.095961
4:	.009651	.016707	.003856	105.209597
5:	.003856	.013529	.003706	142.128564
6:	.003706	.007204	.000621	161.425239
7:	.000621	.002097	.001211	98.802289
8:	.001211	.001645	.000682	82.176018
9:	.000682	.001329	.001038	76.547544
10:	.001038	.005555	.002841	119.193933
11:	.002841	.000521	.005078	13.129769
12:	.005078	.004915	.000659	77.008424
13:	.000659	.000476	.000750	48.451768
14:	.000750	.006630	.004414	113.763861
15:	.004414	.000758	.003026	23.912143
16:	.003026	.006936	.001144	137.999400
17:	.001144	.003758	.000980	140.440629
18:	.000980	.001310	.001104	68.148711

Program LATGRAPHS:::
Input data file: GRAPHS.L
Number of deviations partitions: 4
DEVIATIONS PROFILES: rows are plotted
ANGLES PROFILE: columns are the points
DISTANCES PROFILES: columns are the points
Elapsed time: 337.167 seconds



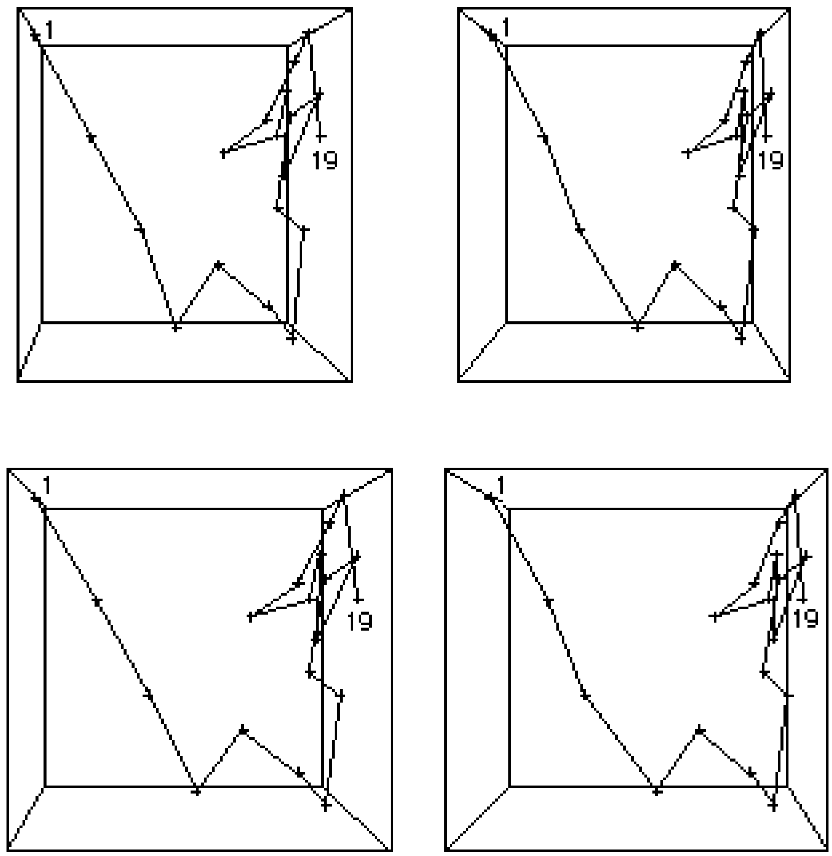
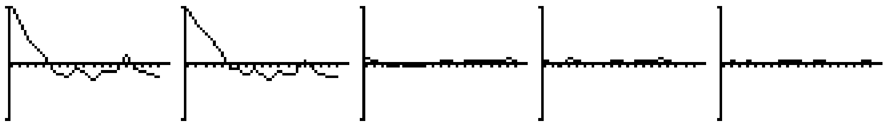
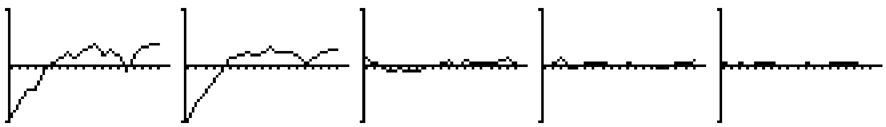


Figure 6.3.1 Stereo representation of the recovery pathway in heathland. The stereo coordinates are derived from canonical scores. The + marks are time points (1 to 19.) Axes in top stereo pair are scaled to percent chi-squared. Axes in 2nd stereo pair are scaled to range. The 3rd pair is not scaled in these ways. Equal spread is applied on all axes in the last stereo pair for optimal viewing. Find models of interpretation in the preceding sections.

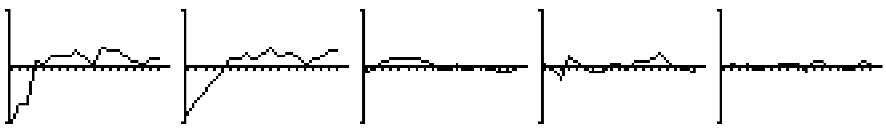
Population 1; Max dev: global 40.7006, population 40.7006; 1st graph: total; other graphs: partitions



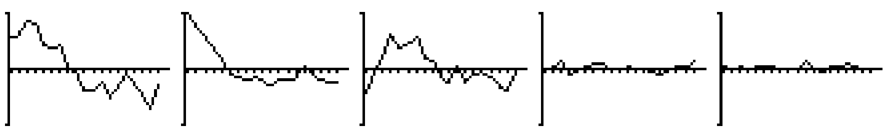
Population 2; Max dev: global 40.7006, population 38.1734; 1st graph: total; other graphs: partitions



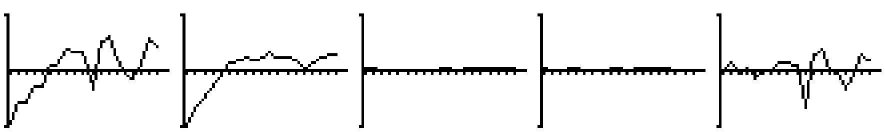
Population 3; Max dev: global 40.7006, population 11.6174; 1st graph: total; other graphs: partitions



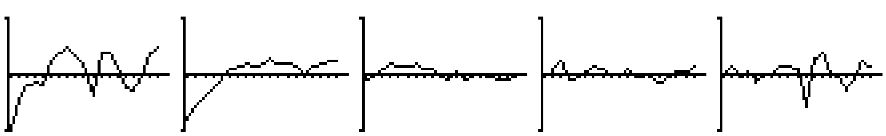
Population 4; Max dev: global 40.7006, population 8.52852; 1st graph: total; other graphs: partitions



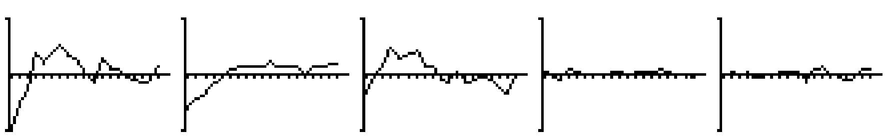
Population 5; Max dev: global 40.7006, population .453335; 1st graph: total; other graphs: partitions



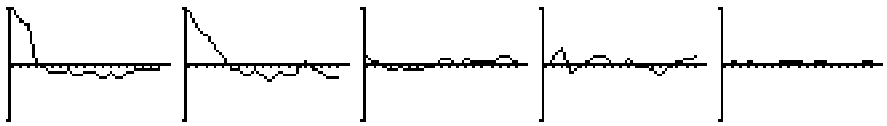
Population 6; Max dev: global 40.7006, population .654958; 1st graph: total; other graphs: partitions



Population 7; Max dev: global 40.7006, population .450751; 1st graph: total; other graphs: partitions



Population 8; Max dev: global 40.7006, population 4.01494; 1st graph: total; other graphs: partitions



Population 9; Max dev: global 40.7006, population 1.42865; 1st graph: total; other graphs: partitions

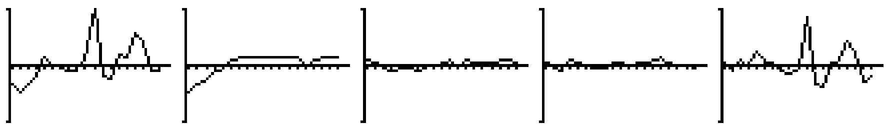


Figure 6.3.2 Dispersion profiles for bare ground, 7 species, and one species group along the temporal axis (1963 - 1981) in heathland recovery. Legend to populations: 1. *Bare ground*, 2. *Empetrum nigrum,* 3. *Calluna vulgaris,* 4. *Erica tetralix,* 5. *Molinia caerulea,* 6. *Carex pilulifera,* 7. *Juncus squarrosus,* 8. *Rumex acetosella,* 9. Other sporadic species. Method of construction and interpretations follow the model established in earlier sections.

6.4 Mixed hardwood recovery

The specifics in the startup dialogue Table 6.4.1) accord with the Stephens-Waggoner data setup (5 rows, 30 columns). "Rows" refer to time points and "columns" designate species. No adjustments are requested and columns are specified as dispersion profiles. Table 6.4.2 records the PRINTDA file. The data table shown in Table 6.4.2 is the transpose of the original Stephens-Waggoner percentages matrix, converted into densities by simple post multiplication the stems/acre totals as a column vector. The order of the S matrix is 5 and its rank is 4. The analysis detects a definite linear time trend in the 1st canonical plain (X_1,Y_1) which accounts for 87% of the total chi-squared. Considering that

$$[\chi^2 = 413.8] \geq [\chi^2_{.001,116} = 168.8]$$

the compositional structure of the table is considered sharp. This and the very low value of the Cramér index

$$\frac{413.8}{3380 \times 4} = 0.031 \text{ or } 3.1\ \%$$

characterizes the time trend. This shows that the theoretically possible strongest linear trend in an 8 x 30 table with total 3380 is approached to the extent of a mere 3.1% .

The stereograms in Fig. 6.4.1 are based on the time point scores on the 1st 3 canonical variates. The scores are Eigenadjusted, and in addition, the 1st stereo pair (top) has axes adjusted to chi-squared. While the presentation of the recovery pathway in this pair is natural, the lower pair, which is easier for viewing, strongly distorts the trend. The graphs are created in two consecutive runs of program STEREOC.

The column vectors of

$$\Delta,\quad \Delta_1,\quad \Delta_2,\quad \Delta_3,\quad \Delta_4$$

(numerical values in Table 6.4.2.) are the profiles plotted in Fig. 6.4.2. Focus is on the profiles in the 1st canonical plane (X_1,Y_1), which appear as the 2nd graphs in the sets of 5 graphs. These profiles account for 87% of the total chi-squared. Interpretation of the individual profiles follows the model in the preceding sections.

Table 6.4.1 Startup dialogue and last screen in the mixed hardwood analysis. No transformation is requested and column vectors (species) are specified as profiles.

```
File  Edit  Custom  Run  Windows  Help
Are the input data file(s) in one folder with this program? -- press Y or N:Y
Specify output file name extension:S
Press Y to store intermediate results on a printable file:Y
```

```
Name frequency table file:stephens/t.dat
Specify the number of rows:5
Specify the number of columns:30
Press Y to adjust frequencies to equal block size
(- if no block sizes file exists, press a key other than Y):N

Do you wish to perform autocorrelation analysis? -- press Y or N:N
Do you wish to perform covariance analysis with transect
position? -- press Y or N:N

Weight options are:
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis
To specify weight option, press key 1, 2, 3, or 4: 3
Eigenanalysis -- iteration:  26
Press Y to weight canonical scores by eigenvalues:Y

WORKING
Specify relative graph size. Type 1 for normal size:? .7
Specify tick mark spacing (1,5,10, etc):? 1
Do you wish to plot deviations table rows or columns? -- press R or C:C
```

```
File  Edit  Custom  Run  Windows  Help

Your main printable file is: PRINTDACONA.S
Profiles are stored in KEP files with extension:S
Open and print the PRINTDA file from EDIT
Open and edit KEP files from a paint program
Press any key to exit
```

Table 6.4.2 The PRINTDA file in the mixed hardwood analysis. Interpretations follow the model in the preceding sections.

```
Program: CONAPACK
________________
Input file for raw contingency table data:stephens/t.dat
Number of rows:  5
Number of columns:  30

Program CONA:::
Input data file:  stephens/t.dat
Weighting option selected: # 3
1. High weight for rows with high total
2. High weight for rows with low total
3. NO WEIGHTING -- Canonical contingency table analysis proper
4. Correspondence analysis

Row totals
      1053.129       753.307       520.448       449.680       603.436
Column totals
       186.890       940.490       260.300        98.270        61.430
       244.210
        89.930       372.100       494.990        14.183        12.204
        28.515
```

```
        83.025        19.385       104.300        39.520       141.520
        16.825
        12.204        16.825        21.040          .913        21.960
         1.683
         9.423        15.015        51.865         6.408         8.608
         5.971

 5 x 30  table
        42.680       266.750        96.030        32.010        21.340
       128.040
        32.010        85.360       128.040         5.335         5.335
        10.670
        42.680         5.335        10.670        10.670        64.020
         5.335
         5.335         5.335        10.670          .533         5.335
          .533
         5.335        10.670        10.670          .533          .533
         5.335
        37.950       197.340        68.310        30.360        15.180
        75.900
        22.770        68.310        98.670         3.795         3.795
         7.590
        22.770         3.795        15.180         7.590        37.950
         3.795
         3.795         3.795         7.590          .380         3.795
          .380
         3.795         3.795         3.795          .380          .380
          .380
        35.840       143.360        46.080        15.360        10.240
        25.600
        20.480        61.440        71.680         2.560         2.560
         5.120
        10.240         5.120        15.360         5.120        20.480
         2.560
         2.560         2.560         2.560          .000         2.560
          .256
          .000          .256         5.120         2.560         2.560
          .256
        35.200       145.200        26.400         8.800         8.800
         8.800
         8.800        57.200        79.200         2.200          .220
         2.200
         4.400         2.200        22.000         4.400        13.200
         2.200
          .220         2.200          .220          .000         4.400
          .220
          .000          .000         8.800          .000         2.200
          .000
        35.220       187.840        23.480        11.740         5.870
         5.870
         5.870        99.790       117.400          .293          .293
         2.935
         2.935         2.935        41.090        11.740         5.870
         2.935
          .293         2.935          .000          .000         5.870
          .293
          .293          .293        23.480         2.935         2.935
          .000

GRAND TOTAL =       3380.000

 5 x 5  SCALAR PRODUCT MATRIX
          .0351          .0157         -.0067         -.0220         -.0388
          .0157          .0109         -.0018         -.0110         -.0220
         -.0067         -.0018          .0066          .0031          .0020
         -.0220         -.0110          .0031          .0167          .0241
         -.0388         -.0220          .0020          .0241          .0531
```

```
CANONICAL CORRELATIONS AND CHI-SQUARED PARTITIONS
Can corr R 1 =    .3263 F..R^2 =       359.9410 Cum % =  86.9779
Can corr R 2 =    .0998 F..R^2 =        33.6961 Cum % =  95.1204
Can corr R 3 =    .0593 F..R^2 =        11.8944 Cum % =  97.9946
Can corr R 4 =    .0496 F..R^2 =         8.2988 Cum % = 100.0000

TEST FOR COMPOSITIONAL SHARPNESS OF THE  150  BLOCKS
Chi-squared =        413.8303
Degrees of freedom =  116
Rank =  4

EIGEN ADJUSTED ROW SCORES
SET  1
         -.1449         -.0901          .0249          .1432          .2372

SET  2
         -.0318          .0131          .0751          .0296         -.0477

SET  3
          .0005          .0040         -.0294          .0486         -.0167

SET  4
          .0186         -.0401          .0165          .0135         -.0067


EIGEN ADJUSTED COLUMN SCORES
SET  1
          .0206          .0109         -.0303         -.0247         -.0208
         -.0745         -.0323          .0329          .0225         -.0387
         -.0641         -.0315         -.0660          .0010          .0818
          .0273         -.0518         -.0020         -.0641         -.0020
         -.0835         -.1005          .0364         -.0020         -.0913
         -.0993          .0804          .0833          .0921         -.1104

SET  2
          .0135          .0005          .0078          .0050          .0093
         -.0101          .0188         -.0016         -.0028          .0184
          .0112          .0052         -.0076          .0207         -.0060
         -.0152          .0017         -.0003          .0112         -.0003
         -.0041         -.0277         -.0075         -.0003         -.0299
         -.0399         -.0312          .0132          .0258         -.0514

SET  3
          .0035          .0018         -.0015         -.0023          .0044
         -.0006         -.0050         -.0028          .0013          .0086
         -.0116         -.0055         -.0008         -.0106         -.0001
         -.0067          .0024          .0001         -.0116          .0001
         -.0037          .0054          .0072          .0001          .0038
          .0015         -.0050         -.0524         -.0050         -.0015

SET  4
          .0014          .0003          .0001         -.0086          .0015
         -.0017          .0029         -.0002         -.0006          .0031
         -.0020         -.0010          .0028          .0055         -.0034
         -.0027          .0027         -.0001         -.0020         -.0001
         -.0074         -.0149          .0011         -.0001         -.0150
          .0083          .0045          .0069          .0140          .0380

Row totals in file: rowtots.S
Column totals in file: coltots.S
Row canonical scores in file(s): ROWS.S and rowsadj.S
 ( 4  sets of  5  numbers)
Column canonical scores in file(s): COLS.S and colsadj.S
 ( 4  sets of  30  numbers)
Run PLOT with ROWS ... or COLS ... to draw scattergram
```

Run Stereo to draw stereograms
Eigenvalues stored in file: EIG.S
Deviations information stored in file: LAT.S

Program DEVIATIONS:::
Input data files are: LAT.S and EIG.S
The number of canonical variates is: 4

DEVIATIONS FROM RANDOM EXPECTATION (Fhj - Fh.F.j/F..)

=== Table of deviations partitions 1

-9.9637	-26.5566	20.3704	6.2700
3.3038	47.0301	7.5065	-31.6313
-28.7847	1.4185	2.0218	2.3222
14.1607	-.0503	-22.0549	-2.7920
18.9458	.0853	2.0218	.0853
4.5424	.2372	-2.0663	.0085
2.2243	3.8558	-10.7853	-1.3796
-2.0499	1.7042		
-4.4308	-11.8096	9.0586	2.7882
1.4692	20.9141	3.3381	-14.0663
-12.8005	.6308	.8991	1.0327
6.2972	-.0223	-9.8077	-1.2416
8.4251	.0379	.8991	.0379
2.0200	.1055	-.9189	.0038
.9892	1.7147	-4.7962	-.6135
-.9116	.7578		
.8456	2.2538	-1.7288	-.5321
-.2804	-3.9913	-.6371	2.6844
2.4429	-.1204	-.1716	-.1971
-1.2018	.0043	1.8717	.2369
-1.6079	-.0072	-.1716	-.0072
-.3855	-.0201	.1754	-.0007
-.1888	-.3272	.9153	.1171
.1740	-.1446		
4.2040	11.2051	-8.5949	-2.6455
-1.3940	-19.8436	-3.1673	13.3463
12.1453	-.5985	-.8530	-.9798
-5.9749	.0212	9.3057	1.1780
-7.9939	-.0360	-.8530	-.0360
-1.9166	-.1001	.8718	-.0036
-.9385	-1.6269	4.5507	.5821
.8649	-.7191		
9.3449	24.9073	-19.1053	-5.8806
-3.0986	-44.1093	-7.0404	29.6669
26.9971	-1.3304	-1.8962	-2.1780
-13.2812	.0471	20.6852	2.6186
-17.7692	-.0800	-1.8962	-.0800
-4.2603	-.2225	1.9380	-.0080
-2.0862	-3.6163	10.1155	1.2939
1.9226	-1.5984		

=== Table of deviations partitions 2

-6.7683	-1.1743	-5.4789	-1.3309
-1.5334	6.6321	-4.5373	1.5584
3.7047	-.7014	-.3689	-.3973
1.6908	-1.0762	1.6886	1.6188
-.6378	.0142	-.3689	.0142
.2305	.0679	.4400	.0014
.7584	1.6107	4.3431	-.2273
-.5968	.8241		
1.9994	.3469	1.6185	.3932
.4530	-1.9592	1.3403	-.4603
-1.0944	.2072	.1090	.1174
-.4995	.3179	-.4988	-.4782
.1884	-.0042	.1090	-.0042
-.0681	-.0201	-.1300	-.0004

-.2240	-.4758	-1.2830	.0672
.1763	-.2434		
7.9067	1.3718	6.4004	1.5547
1.7913	-7.7475	5.3004	-1.8204
-4.3277	.8194	.4310	.4641
-1.9752	1.2572	-1.9726	-1.8911
.7451	-.0166	.4310	-.0166
-.2692	-.0793	-.5140	-.0017
-.8860	-1.8816	-5.0735	.2656
.6972	-.9626		
2.6934	.4673	2.1803	.5296
.6102	-2.6392	1.8056	-.6201
-1.4742	.2791	.1468	.1581
-.6728	.4283	-.6719	-.6442
.2538	-.0057	.1468	-.0057
-.0917	-.0270	-.1751	-.0006
-.3018	-.6410	-1.7283	.0905
.2375	-.3279		
-5.8311	-1.0117	-4.7202	-1.1466
-1.3211	5.7138	-3.9090	1.3426
3.1917	-.6043	-.3178	-.3423
1.4567	-.9272	1.4547	1.3947
-.5495	.0123	-.3178	.0123
.1986	.0585	.3790	.0012
.6534	1.3877	3.7417	-.1959
-.5142	.7099		

=== Table of deviations partitions 3

.0786	.2036	-.0468	-.0271
.0327	-.0173	-.0542	-.1248
.0773	.0146	-.0169	-.0186
-.0076	-.0246	-.0014	-.0319
.0412	.0001	-.0169	.0001
-.0094	.0006	.0191	.0000
.0043	.0027	-.0312	-.0402
-.0052	-.0011		
.4281	1.1085	-.2546	-.1473
.1781	-.0942	-.2953	-.6792
.4206	.0795	-.0920	-.1015
-.0412	-.1337	-.0079	-.1736
.2244	.0007	-.0920	.0007
-.0511	.0032	.1038	.0001
.0234	.0150	-.1697	-.2187
-.0282	-.0057		
-2.1723	-5.6251	1.2919	.7476
-.9036	.4779	1.4987	3.4469
-2.1344	-.4036	.4667	.5152
.2092	.6783	.0400	.8809
-1.1386	-.0038	.4667	-.0038
.2592	-.0163	-.5266	-.0004
-.1187	-.0759	.8614	1.1100
.1430	.0290		
3.0962	8.0178	-1.8414	-1.0656
1.2879	-.6812	-2.1362	-4.9131
3.0423	.5753	-.6653	-.7344
-.2982	-.9669	-.0571	-1.2556
1.6229	.0054	-.6653	.0054
-.3695	.0232	.7506	.0005
.1691	.1082	-1.2278	-1.5822
-.2038	-.0414		
-1.4307	-3.7048	.8509	.4924
-.5951	.3148	.9871	2.2702
-1.4058	-.2658	.3074	.3393
.1378	.4468	.0264	.5802
-.7499	-.0025	.3074	-.0025
.1707	-.0107	-.3468	-.0002
-.0782	-.0500	.5673	.7311

.0942	.0191		

=== Table of deviations partitions 4

1.1029	1.2427	.0819	-3.5207
.3968	-1.6951	1.0749	-.3799
-1.1845	.1841	-.1033	-.1209
.9674	.4461	-1.4597	-.4384
1.5764	-.0069	-.1033	-.0069
-.6490	-.0567	.1001	-.0007
-.5882	.5226	.9835	.1841
.5033	.9475		
-1.6992	-1.9146	-.1262	5.4243
-.6113	2.6116	-1.6560	.5853
1.8249	-.2836	.1591	.1863
-1.4905	-.6873	2.2489	.6755
-2.4288	.0107	.1591	.0107
1.0000	.0874	-.1542	.0011
.9063	-.8051	-1.5153	-.2836
-.7755	-1.4599		
.4829	.5442	.0359	-1.5417
.1737	-.7423	.4707	-.1664
-.5187	.0806	-.0452	-.0529
.4236	.1953	-.6392	-.1920
.6903	-.0030	-.0452	-.0030
-.2842	-.0248	.0438	-.0003
-.2576	.2288	.4307	.0806
.2204	.4149		
.3422	.3856	.0254	-1.0925
.1231	-.5260	.3335	-.1179
-.3675	.0571	-.0320	-.0375
.3002	.1384	-.4529	-.1360
.4892	-.0022	-.0320	-.0022
-.2014	-.0176	.0311	-.0002
-.1825	.1621	.3052	.0571
.1562	.2940		
-.2288	-.2579	-.0170	.7305
-.0823	.3517	-.2230	.0788
.2458	-.0382	.0214	.0251
-.2007	-.0926	.3029	.0910
-.3271	.0014	.0214	.0014
.1347	.0118	-.0208	.0001
.1221	-.1084	-.2041	-.0382
-.1044	-.1966		

=== Sum of deviations partitions tables

-15.5506	-26.2846	14.9266	1.3914
2.1998	51.9498	3.9899	-30.5776
-26.1873	.9158	1.5327	1.7854
16.8113	-.7049	-21.8274	-1.6435
19.9256	.0927	1.5327	.0927
4.1144	.2490	-1.5072	.0093
2.3989	5.9918	-5.4899	-1.4631
-2.1486	3.4747		
-3.7026	-12.2689	10.2964	8.4584
1.4890	21.4724	2.7271	-14.6206
-11.6494	.6339	1.0752	1.2348
4.2660	-.5254	-8.0655	-1.2179
6.4091	.0452	1.0752	.0452
2.9008	.1760	-1.0993	.0045
1.6948	.4487	-7.7642	-1.0487
-1.5390	-.9512		
7.0629	-1.4554	5.9994	.2285
.7811	-12.0031	6.6327	4.1445
-4.5379	.3760	.6809	.7293
-2.5441	2.1351	-.7000	-.9652
-1.3111	-.0307	.6809	-.0307
-.6797	-.1406	-.8214	-.0031

```
           -1.4510          -2.0559          -2.8661          1.5733
            1.2346           -.6633
           10.3359          20.0758          -8.2307         -4.2740
             .6273         -23.6900          -3.1644          7.6952
           13.3458            .3130          -1.4036         -1.5937
           -6.6457           -.3790           8.1238          -.8578
           -5.6280           -.0384          -1.4036          -.0384
           -2.5792           -.1215           1.4784          -.0038
           -1.2537          -1.9975           1.8998          -.8525
            1.0548           -.7943
            1.8543          19.9330         -22.9917         -5.8043
           -5.0972         -37.7291         -10.1853         33.3584
           29.0288          -2.2387          -1.8852         -2.1558
          -11.8875           -.5258          22.4692          4.6844
          -19.3957           -.0688          -1.8852          -.0688
           -3.7563           -.1630           1.9494          -.0069
           -1.3889          -2.3870          14.2205          1.7910
            1.3982          -1.0659
Graphs in file: GRAPHS.S


Program ANGLES AND DISTANCES:::
Input data file:rowsadj.S
Output in files:ANGLES.S and DISTANCES.S
Number of axes: 4
Number of units: 5
Print in following order:
Point B; squared distances AB,AC,BC; angle at B
  2:      .008478      .041139      .021377    114.779068
  3:      .021377      .059548      .022153    111.596408
  4:      .022153      .060854      .019487    117.540754

Program LATGRAPHS:::
Input data file: GRAPHS.S
Number of deviations partitions: 4
DEVIATIONS PROFILES: columns are plotted
ANGLES PROFILE: rows are the points
DISTANCES PROFILE: rows are points
Elapsed time:  172.017  seconds
```

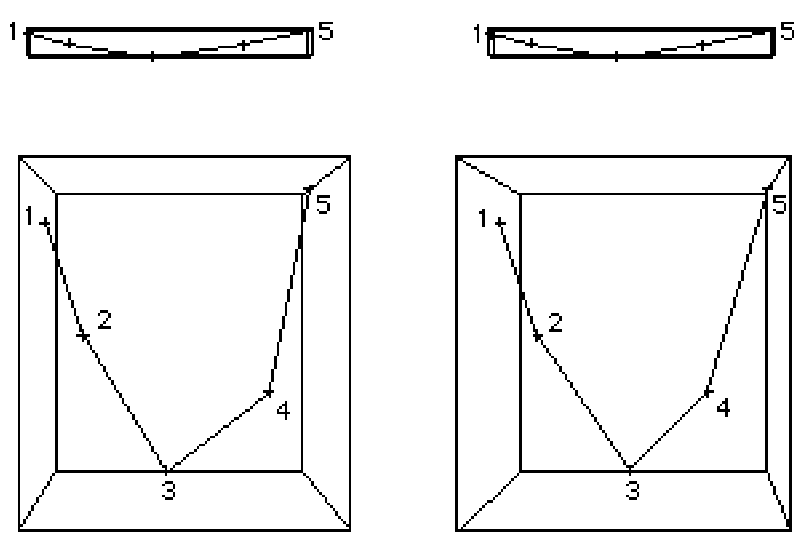
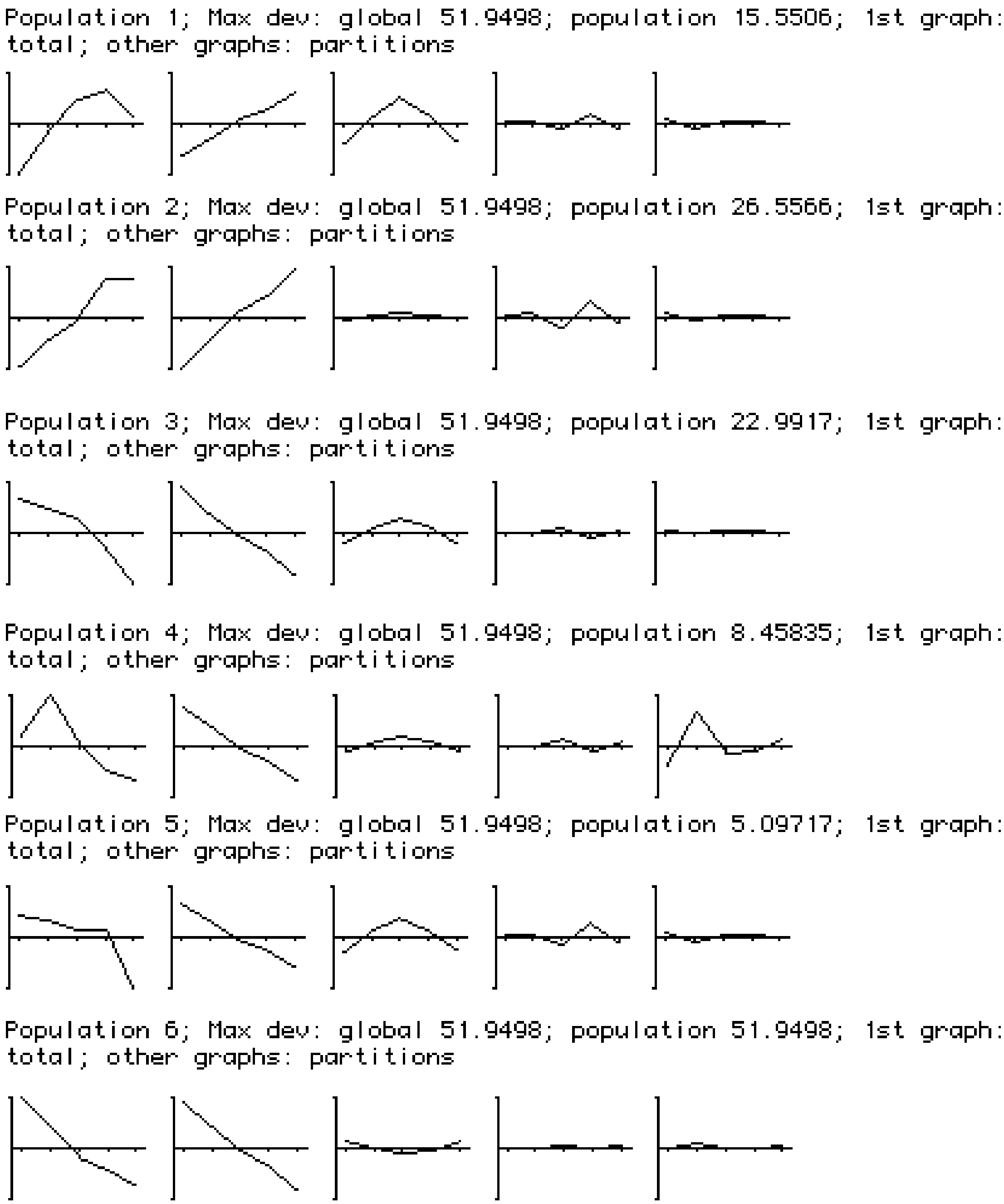
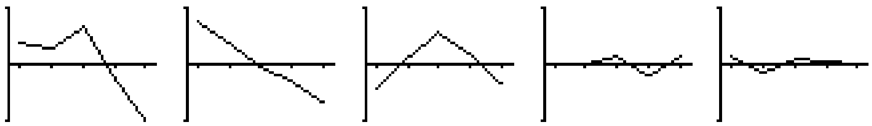


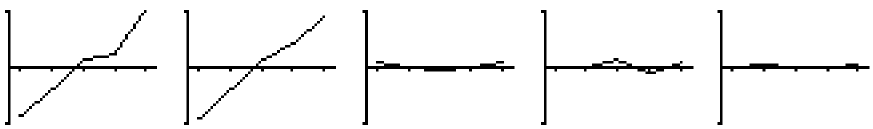
Figure 6.4.1 Stereo representation of the recovery pathway in mixed hardwood succession. The + marks locate time points (1 to 5.) Axes in 1st stereo pair (top) are scaled to percent chi-squared. Axes in 2nd stereo pair are not scaled. See further details in the main text.



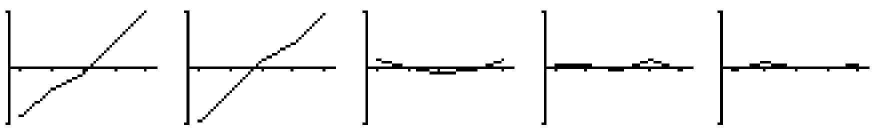
Population 7; Max dev: global 51.9498; population 10.1853; 1st graph: total; other graphs: partitions



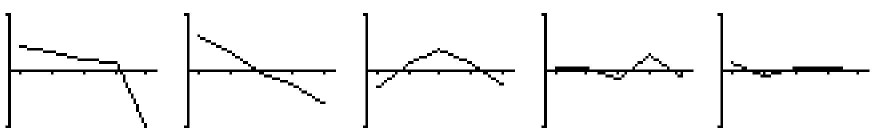
Population 8; Max dev: global 51.9498; population 33.3584; 1st graph: total; other graphs: partitions



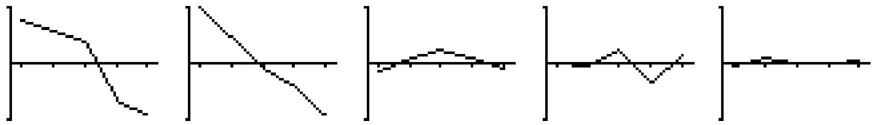
Population 9; Max dev: global 51.9498; population 29.0288; 1st graph: total; other graphs: partitions



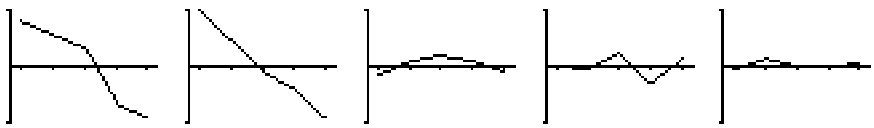
Population 10; Max dev: global 51.9498; population 2.2387; 1st graph: total; other graphs: partitions



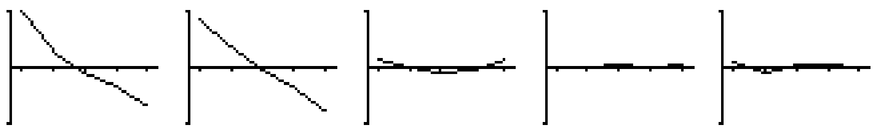
Population 11; Max dev: global 51.9498; population 2.02176; 1st graph: total; other graphs: partitions



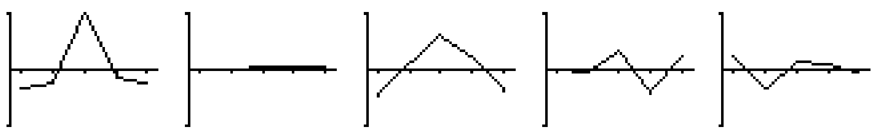
Population 12; Max dev: global 51.9498; population 2.32222; 1st graph: total; other graphs: partitions



Population 13; Max dev: global 51.9498; population 16.8113; 1st graph: total; other graphs: partitions

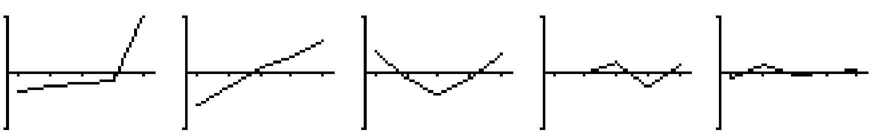


Population 14; Max dev: global 51.9498; population 2.13512; 1st graph: total; other graphs: partitions

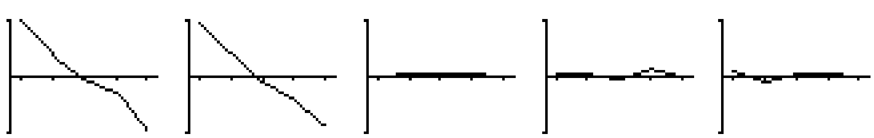


Population 15; Max dev: global 51.9498; population 22.4692; 1st graph: total; other graphs: partitions

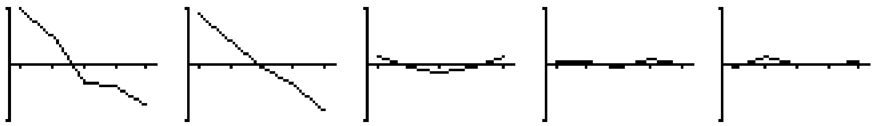
Population 16; Max dev: global 51.9498; population 4.68444; 1st graph: total; other graphs: partitions



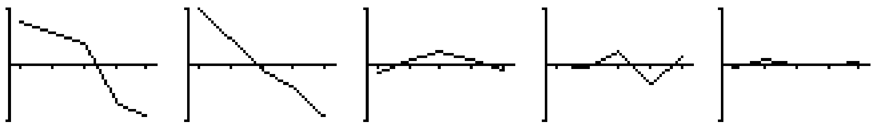
Population 17; Max dev: global 51.9498; population 19.9256; 1st graph: total; other graphs: partitions



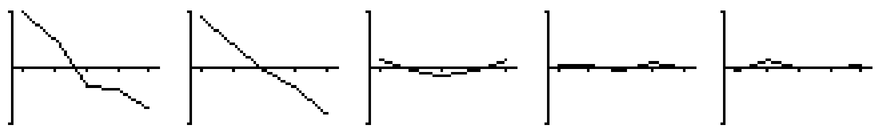
Population 18; Max dev: global 51.9498; population 9.27239e-2; 1st graph: total; other graphs: partitions



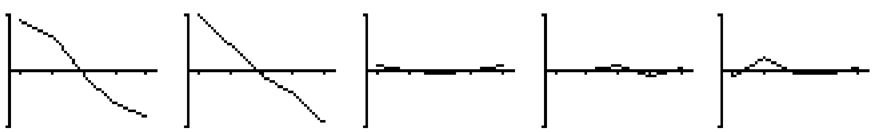
Population 19; Max dev: global 51.9498; population 2.02176; 1st graph: total; other graphs: partitions



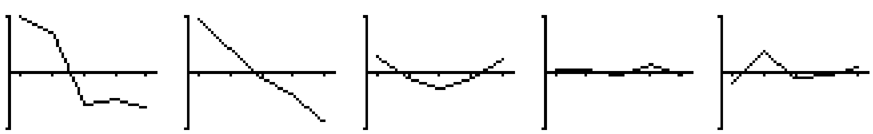
Population 20; Max dev: global 51.9498; population 9.27239e-2; 1st graph: total; other graphs: partitions



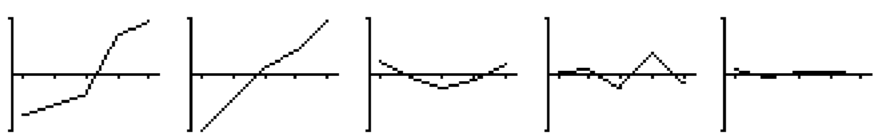
Population 21; Max dev: global 51.9498; population 4.54235; 1st graph: total; other graphs: partitions



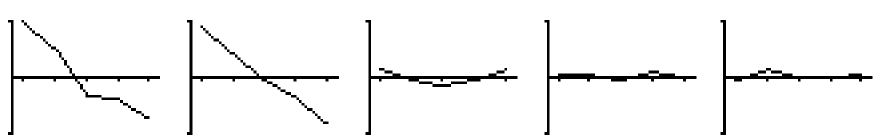
Population 22; Max dev: global 51.9498; population .24903; 1st graph: total; other graphs: partitions



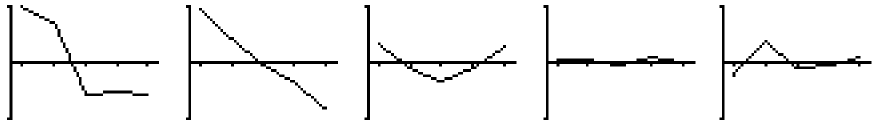
Population 23; Max dev: global 51.9498; population 2.06632; 1st graph: total; other graphs: partitions



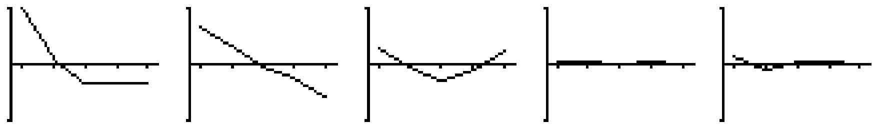
Population 24; Max dev: global 51.9498; population 9.27235e-3; 1st graph: total; other graphs: partitions



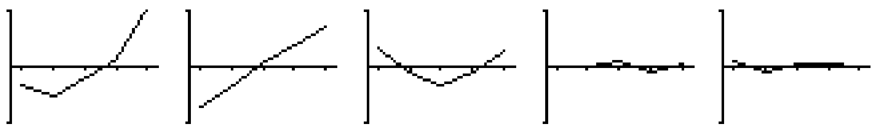
Population 25; Max dev: global 51.9498; population 2.39885; 1st graph: total; other graphs: partitions



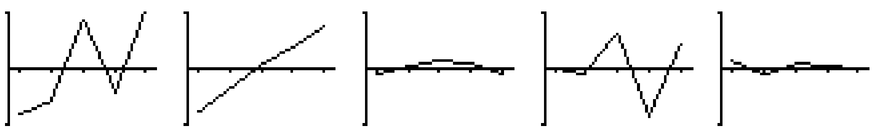
Population 26; Max dev: global 51.9498; population 5.99182; 1st graph: total; other graphs: partitions



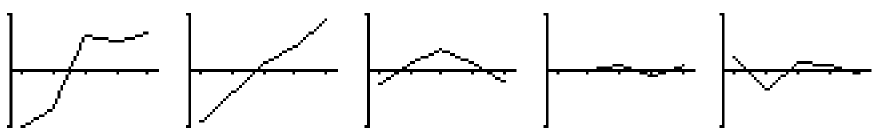
Population 27; Max dev: global 51.9498; population 14.2205; 1st graph: total; other graphs: partitions



Population 28; Max dev: global 51.9498; population 1.79097; 1st graph: total; other graphs: partitions



Population 29; Max dev: global 51.9498; population 2.14856; 1st graph: total; other graphs: partitions



Population 30; Max dev: global 51.9498; population 3.47473; 1st graph: total; other graphs: partitions

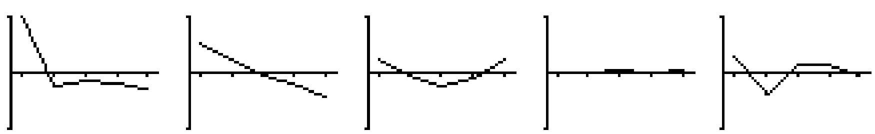


Figure 6.4.2 Dispersion profiles of 30 species (1927-77) in the mixed hardwood recovery. Legend to populations: 1. Sugar maple, 2. Red maple, 3. Red oak, 4. Black oak, 5. Scarlet oak, 6. White oak, 7. Chestnut oak, 8. Yellow birch, 9. Black birch, 10. Paper birch, 11. Bitternut hickory, 12. Mockernut hickory, 13. Pignut hickory, 14. Shagbark hickory, 15. Beech, 16. Tulip tree, 17. White ash, 18. Black ash, 19. Basswood, 20. Elm, 21. Bigtoot aspen, 22. Quakling aspen, 23. Pepperige,

24. Locust, 25. Butternut, 26. Black cherry, 27. Sassafras, 28. White pine, 29. Hemlock. 30. Redcedar. Method construction and interpretations follow the model established in earlier sections.

Glossary

Angles profile - a graph portraying acute angles subtending inner transect positions as apices in hyperspace.

Apex - point representation of a transect segment (sampling unit, quadrat) in hyperspace such that the lengths of the connecting line segments are proportional to compositional differences.

Canonical - taken in as a group; performed in twos, threes, etc.

Canonical contingency table analysis - a method which partitions chi-squared into components and produces sets of canonical scores, distinguished by pre- and post-analysis adjustments from other Eigenordinations.

Contingency table - a data table with rows and columns purposefully arranged; a classification table.

Continuity - here a type of compositional change under random effects and/or monotone serial effects; pattern not interrupted by edges.

CST - Character Set Type; a population with member objects characterized by a common score vector; a taxon with or without phylogenetic constraints.The specification of a CST is a score vector. This vector has as many elements as there are characters in the descriptive scheme. A given element indicates the states of a defining character. Only the character set and character states are predefined, the CSTs emerge in the course of the survey.

Deviations profiles - a portrayal of deviations from an expected global null state over the states of an ordering variable.

Dimensionality - rank; the number of independent dimensions.

Discontinuity - an edge.

Dispersion profile - a graph, showing the performance pattern of a population over the states of an ordering variable.

Distance - the shortest line segment between two points; a measure of compositional difference in the vegetation of adjacent transect segments (sampling units, quadrats.)

Distance profile - a portrayal of compositional distances.

Edge - a discontinuity; where one type ends and another begins; sharp transition; narrow ecotone.

Eigenanalysis - the mathematical method of rigid rotation; the algorithm in Eigenordinations; a type of linear transformation which in itself does not scramble the sample structure in vegetation hyperspace; a linear filter.

Gradient - a progression through levels of a variable; the path leading from one composition to another through intermediates; a trend.

Hyperspace - here a space of several dimensions, each representing a population or a factor. Transect positions (quadrats, vegetation stands) are the spatial points and the population quantities are the coordinates.

Metric - a distance; a function which satisfies the metric space axioms.

Ordination - arrangement of sample points on axes; a map of the transect in analytical space space.

Probabilistic - taking into account chance; reasoning on the basis of probabilities.

Random - due to chance; unpredictable based on known facts.

Rank - the number of independent dimensions; the number of nonzero Eigenvalues.

Residuals - here population data from which serial effects are removed by analytical isolation of 1st order dependences, defined as a linear correlation of the series with itself at lag 1 and linear correlations with transect position at lag 0.

Serial dependence - here as a linear correlation of the series with itself at lag 1 and linear correlations with transect position at lag 0; the predictability of population performance or vegetation composition in one transect segment from the same in the directly preceding segment.

Species-free - vegetation analysis not based on the species concept; the definition of a population without requiring uniformity in inheritance; based on CSTs.

Stochastic - associated with a probability law; chance variation generated by mechanisms driven by a probability law.

Structure - a set of interactions, distances, angles., deviations, etc.

Structure intensity- an expression of how close the observed structure approaches the theoretically possible sharpest structure.

Structure sharpness - inverse of the probability of an at least as extreme structure arising by chance.

Terrace - a flat portion of the landscape with steep, albeit short adjacent slopes created by aggredation and erosion owing to overflow by flood water.

Transect - here a chain of contiguous quadrats, all equal in size, laid on a line, one unit deep, across the landscape; in the example, the 30m x 2700m piece of the Chihuahua desert.

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