

EPIC program package 2006

ECOLOGICAL PROGRAMS FOR INSTRUCTIONAL COMPUTING

László Orlóci

A SCADA Documentation

The EPIC program package

An external appendix to: Orłóci, L. 1995. Sampling and Data Analysis, Mimeographed.
Can be obtained from SCADA 107-1500 Richmond Street, London, Canada N6A 4V1

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Contents

Preface	ix
1. Data entry	1
1.1 Locating files	1
1.2 File format	2
1.3 Creating files	5
2. Running programs	7
2.1 Initial preparations and start-up dialogue	7
2.2 The PRINTDA file	8
2.3 Capturing screen objects	8
3. Programs and examples	9
3.1 Capturing the data structure	9
3.1.1 Program ANGLES	9
3.1.2 Program CALHOUN	10
3.1.3 Program CORRELATION	11
3.1.4 Program GENDIST	11
3.1.5 Program METRICS	13
3.1.6 Program PINDEX	14
3.2 Measuring commonness	15
3.2.1 Program CHIPROBS	15
3.2.2 Program DISTRIBUTIONS	16
3.2.3 Program ENTROPY/DIST	17
3.2.4 Program FPROBS	18
3.2.5 Program NPROBS	18
3.2.6 Program TPROBS	19
3.3 Describing distributions	19
3.3.1 Program ENTROPY	19
3.3.2 Program ENTROGRA	20
3.3.3 Program EST/H	22
3.3.4 Program MOMENTS	23
3.3.5 Program NORMAL	24
3.4 Probabilistic comparisons	25
3.4.1 Program ANOVA	25

3.4.2 Program CANCOR	29
3.4.3 Program CSA	31
3.4.4 Program DISC	48
3.4.5 Program EMVO	50
3.4.6 Program FANOVA	57
3.4.7 Program LIMITS	58
3.4.8 Program TESTCOV/1	60
3.4.9 Program TESTCOV/2	61
3.5 Importance <i>a posteriori</i>	63
3.5.1 Program WEIGHTING/INF	63
3.5.2 Program WEIGHTING/SCP	66
3.6 Cluster recognition	67
3.6.1 Program ALC	67
3.6.2 Program SLC	68
3.6.3 Program SSA	69
3.6.4 Program TRGRPS	70
3.7 Trend seeking	71
3.7.1 Programs CONA, LATTICE, LATGRAPHS	71
3.7.2 Program EIGENAN	75
3.7.3 Program MDSCAL	76
3.7.4 Program PCAR	83
3.7.5 Program REGRESSION	84
3.8 Accessory programs	88
3.8.1 Program ADJUST	88
3.8.2 Program CONVERTER	88
3.8.3 Program INVERT/DET	89
3.8.4 Program PLOT	89
3.8.5 Program STEREO	91
3.8.6 Program TRANSPOSE	93
3.8.7 Program TREE	93
Glossary	95
References	97

Preface

The reasoned approach to problem solving begins with isolation of the individual tasks that bear on the solution. How well can this be done? It depends on how much is already known about the problem. As expected, the available information is low initially. It is a consequence of this that problem solving progresses through levels of approximation.

One pre-requisite is the versatility and task specificity of the analytical tools. The tools are versatile if not case dependent. Specificity implies that although the tools may be packaged, they are addressable individually or in combination as the task may require. The present volume describes computer programs with these kept in mind, but in a format where each program supports an individual task. The utility of this is clear to instructors of introductory courses in ecological data analysis.

The first set of the EPIC programs began their evolution in the early '60s on the ELLIOTT 803 of the University College of North Wales in Professor Peter Greig-Smith's lab. The programs continued to evolve through many revisions (1975, 1978, 1991), earlier adopted for processing on the Macintosh and later on PCs. ¹

All programs are conversational, a feature which encourages the reasoned use of the programs. As a drawback, the "conversation" will present difficulties for new users, but this can be helped by prior study and long-hand practice with examples. The identification code, for example Ex41221, in each case references a specific example in lecture notes (see page v) available with the programs at cost.

The programs are presented as free-standing applications. They should run on any reasonably recent PC with a reasonably large memory. It is good practice not to bury programs and data files in layers of file folders.

The required minimum computer memory depends on the code and on the size of the arrays. The arrays are dynamically dimensioned, meaning that the computer memory may be sufficient to run a program with one data set, but not with another. There is no simple means to tell what exactly crashed an application. Low memory will certainly stop the processing.

The manual has three parts. The first two describe data entry and discuss the mechanics of running the programs. The third part describes the programs assigned to groups and presents worked examples. The runs

¹A later phase of the process involved the help of N.C. Kenkel who contributed code for such important programs as REGRESSION, ANOVA, FANOVA and MDSCAL.

produce printable disk files, except the graphics. In most cases the screen image has to be captured [PrintScrn key] while the program is running.

L. Orłóci

Lahaina, Winter 2006

1

Data entry

1.1 Locating files

All programs require some data entry through the keyboard during the run. Most also require mass data entry from disk.

File name and location are among the information items requested by the during start-up dialogue. A typical file designation may take the form of

`C:\WORKS\ex41221`

This locates a data file named ex41221 in the folder named WORKS on disk (volume) C. The file name happens to refer to Example 4.1.2.2.1 in the

Lecture Notes (see page x). It is good practice to collect program and data files in a common WORKS folder on hard disk in the uppermost directory segment with ample free space on hard disk.

1.2 File format

The data format on file must conform to the format expected by the program. In all cases data files contain numerals irrespective of variable type. The file begins with a number and each number, except the last, must end with an end-of-paragraph mark (unseen, except in paragraph mode) created when the RETURN key is pressed. Blank lines are not permitted inside or preceding the number set. Zeros must be entered as zeros. For example, the 3 by 5 matrix

```
2 3 1 0 5
8 4 40 6 -9
0 0 4 10 2
```

will appear in disk file as 15 numbers, each entered on a new line:

```
2
3
1
0
5
8
4
40
6
-9
0
0
4
10
2
```

The above arrangement is called "entry by row". "Entry by column" looks like this:

2
8
0
3
4
0
1
40
4
0
6
10
5
-9
2

From the programming point of view, the sole purpose of the "row" or "column" arrangement is to keep track of "row" or "column" specific operations and output by position without engaging an elaborate labelling system. Files are written in the programs as sequential or random access. Three primary data arrangements are distinguished:

Arrangement 1 or full matrix arrangement. The forgoing examples are typical for this mode of data entry by row or column.

Arrangement 2 or half matrix arrangement. Data from the upper half of a symmetric matrix is entered by row, each row beginning with the value in the principle diagonal cell. For example, given the 3 x 3 matrix

0	0.2	1.9
0.2	1	0.5
1.9	0.5	3

the numbers entered are:

0
0.2
1.9
1
0.5
3

Arrangement 3 or single vector arrangement. This is the same as Arrangement 1, except the grouping of unrelated vectors is involved in a single file. For example, given the 4-valued vector,

3 1 6 19

and a 3-valued vector

82 5 17

on which the same operation has to be repeated, such as entropy determination, the data entry is in the form

3
1
6
19
82
5
17

1.3 Creating files

A program may create the data file for input in another program. If so then the format and arrangement is automatic.

Users create primary data files through keyboard entry. After entry, select SAVE AS from the file menu, key-in a volume name and file name (see previous section) and click SAVE. Do not use leading or trailing blanks in file names! Make the names short and descriptive. Always create a backup file on a different disk under a different file name (e.g., ex41221.BAK).

1.3 Important note

The examples are set up for long-hand verification in most cases. This makes it necessary to rely upon small data sets notwithstanding the logical requirements of the problem that may suggest validity of the solution only when the sample size is remarkably large.

2

Running programs

2.1 Initial preparations and start-up dialogue

It is good practice before starting the run, to place program and data file (backed up somewhere else) into a WORKS folder. Start program by clicking twice on the program's disk icon. The output from some programs is a matter of a few numbers on screen which can be copied long-hand. If the output is more voluminous, it is directed automatically to a disk file, often under the name PRINTDA.

The start-up dialogue is important and user responses must be precise. Users must be familiar not with just the technical terms but also with the methods. The lecture notes provide a good basis for this.

2.2 The PRINTDA file

Most results and vital information about the run are stored in the run's specific PRINTDA file. This file is placed by the program with the input data file under an extended name. The file name extension is keyed in by the user when so requested in the start-up dialogue. It is prudent to use a short descriptive extension name.

The PRINTDA file can be opened in a word processing program, format-adjusted if needed, and printed.

2.3 Capturing screen objects

Some programs will draw graphs or print information on the screen which are lost if not captured. To capture any screen object follow the system manual of your computer. In Windows pressing the [PrintScreen] key will copy the screen to the Clipboard. The copy can be pasted in some paint program, edited, and saved on permanent file.

A warning: the "Shift+Command+3" keys technique on Macintosh may create only a limited number of "Screen X" files (X being a number) in succession before files have to be renamed, not to be lost.

3

Programs and examples

The programs are grouped in sections according to generic type. The descriptions are structured:

Part 1: brief characterisation.

Part 2: data file identification.

Part 3: PRINTDA file listing, showing input/output file names, other information, and some results of the run.

Part 4: graphics screen, if any.

3.1 Capturing the data structure

3.1.1 Program ANGLES

P1: Inner angles are computed for lines connecting the tips of vectors ordered in n-dimensional analytical space. The vectors may represent relevés. For example, if

A B C D E

represent relevé vectors with tips

a b c d e

the angles computed are for lines a,b and c,d, and c,d at d,e. Data entry on file is by variable (Arrangement 1). Angles are stored in a user-specified file.

P2: EX41221 Starfish counts in tidal pools.

Species	Tidal pools						
Heliaster kubiniji	26	29	29	29	30	35	39
Pisaster ochraceus	28	31	31	33	27	38	36
Pisaster brevispinus	18	14	13	13	19	15	15

P3: PROGRAM ANGLES

CO-ORDINATES FILE: ex4221, VOLUME c:\qb45\works
ANGLES FILE: c:\qb45\works\angles4221
NUMBER OF AXES: 3
NUMBER OF UNITS: 7
OUTPUT IN FOLLOWING ORDER:
POSITION ON TRANSECT, DISTANCE AB, DISTANCE AC, DISTANCE BC, COS, ANG
2: 34.00 43.00 1.00 -0.69 133.31
3: 1.00 5.00 4.00 0.00 90.00
4: 4.00 53.00 73.00 0.70 45.39
5: 73.00 65.00 162.00 0.78 38.59
6: 162.00 178.00 20.00 0.04 87.99

3.1.2 Program CALHOUN

P1: Calhoun's set theoretical distance is computed between pairs of relevés.

Data input is by variable (Arrangement 1). Half of the distance matrix is written by the program on an Arrangement 2 file.

P2: EX41221 (see table under section 3.1.1)

P3: PROGRAM CALHOUN

=====
COORDINATES FILE: ex41221 VOLUME c:\qb45\calhoun
NUMBER OF VARIABLES: 3
NUMBER OF POINTS: 7

CALHOUN DISTANCES MATRIX (LOWER HALF AND DIAGONAL CELL):

0
18 0
21 3 0
24 3 3 0
18 24 27 30 0

```

30  21  24  21  30  0
30  21  24  21  30  0  0

```

DISTANCES FILE: c:\qb45\calhoun\dis

3.1.3 Program CORRELATION

P1: Products and the product dual are computed between pairs of variables and relevés. Typically the covariance involves variables while the dual of the covariance involves relevés. The type of product, whether variables or relevés, depends on the option chosen. Data entry is by variable from an Arrangement 1 file. Products are stored in an Arrangement 2 file.

P2: EX 41221 (SECTION 3.1.1)

P3: PROGRAM CORRELATION

=====

COORDINATES FILE:ex41221, VOLUME c:\qb45\works

PRODUCTS MATRIX. CORRELATION (Option 2)

```

1.0000
0.7798      1.0000
-0.1433     -0.5472      1.0000
PRODUCTS FILE: c:\qb45\works\cor

```

3.1.4 Program GENDIST

P1: The Mahalanobis generalised distance is computed for given groups and one or more external assignable objects (relevé vectors) based on a common set of variables. Two data files are required: one for the groups (Arrangement 3) and one for the objects to be assigned (Arrangement 1). Data entry is by relevé. The distances are stored in an Arrangement 2 file under user specified name.

P2: EX1821grp

Species densities in two vegetation types:

Species	Type 1 (n1=6)					
Pseudotsuga menziesii	10	21	0	12	30	0
Acer macrophyllum	16	17	3	18	18	6

Thuja plicata 20 21 7 21 34 2

	Type 2 (n2=6)					
Pseudotsuga menziesii	10	30	10	12	28	11
Acer macrophyllum	10	41	4	11	43	8
Thuja plicata	6	55	9	8	20	12

EX1821X

New relevé vector to be assigned:

Pseudotsuga menziesii	10
Acer macrophyllum	30
Thuja plicata	10

P3: PROGRAM GENDIST

=====

GROUPS FILE: ex1821gr, VOLUME c:\qb45\works

NUMBER OF GROUPS: 2

NUMBER OF VARIABLES: 3

NUMBER OF ASSIGNABLE OBJECTS: 1

GROUP SIZES: 6 6

EXTERNAL ASSIGNABLE OBJECTS FILE:: c:\qb45\works\ex1821x

EXTERNAL OBJECT(S):

 OBJECT 1 : 10.000 30.000 10.000

=== GROUP 1 ===

 COVARIANCE MATRIX

 19.367 4.100 9.400
 4.100 47.500 -9.800
 9.400 -9.800 8.800

MEAN VECTOR

 16.167 23.500 3.000

INVERSE OF COVARIANCE MATRIX

 0.283695 -0.112963 -0.428838
 -0.112963 0.072313 0.201196
 -0.428838 0.201196 0.795772

ASSIGNMENT OF OBJECT 1

 GENERALIZED DISTANCE = 10.8270

F-VALUE = 140.669

(NUMERATOR DEGREES OF FREEDOM = 3)

(DENOMINATOR DEGREES OF FREEDOM = 3)

=== GROUP 2 ===

 COVARIANCE MATRIX

 4.700 -10.500 -0.600
 -10.500 158.167 -20.400
 -0.600 -20.400 8.000

MEAN VECTOR

```

-----
          9.500      36.167      9.000
INVERSE OF COVARIANCE MATRIX
-----
          0.303804      0.034431      0.110585
          0.034431      0.013323      0.036556
          0.110585      0.036556      0.226513

```

```

ASSIGNMENT OF OBJECT 1
-----
GENERALIZED DISTANCE =          0.5065
F-VALUE =          0.308
(NUMERATOR DEGREES OF FREEDOM = 3 )
(DENOMINATOR DEGREES OF FREEDOM = 3 )

```

Assign X to group for which its generalised distance is smallest if the observed F is small (its probability of occurring by chance is large). Use program FPROBS to compute the probability.

3.1.5 Program METRICS

P1: Distances are computed from data stored in an Arrangement 1 file. Data input is by variable and the distances involve pairs of relevés. The distances are stored in an Arrangement 2 file.

P2: EX 1511 Tree densities in plots laid on an elevation gradient at 200 m intervals.

	Elevation																			LO	HI	
Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
A	40	45	50	47	41	35	25	20	15	13	10	7	5	2	2	2	0	0	0	0		
B	10	16	22	37	40	45	42	40	36	30	25	20	16	13	7	3	2	1	0	0		
C	0	2	5	11	13	17	25	31	41	51	58	60	51	40	35	28	25	20	14	10		
D	0	0	1	1	1	2	5	8	12	15	19	26	35	52	60	66	60	49	36	30		

P3: PROGRAM METRICS

```

=====
DATA FILE:ex1511, VOLUM c:\qb45\works
NUMBER OF VARIABLES = 4
NUMBER OF OBSERVATIONS PER VARIABLE = 20
DISTANCE OPTION - EUCLIDEAN CHORD (4)
DISTANCES FILE (only first 6 lines of half matrix given):
-----
          0.0000
          0.1052      0.0000
          0.1929      0.0898      0.0000
          0.4536      0.3506      0.2650      0.0000
          0.5617      0.4600      0.3753      0.1118      0.0000
          0.7017      0.6024      0.5183      0.2592      0.1488      0.0000
etc.
DISTANCES FILE: c:\qb45\works\dist

```

3.1.6 Program PINDEX

P1: A version of Goodall's probabilistic similarity index is computed for pairs of relevés from data stored on Arrangement 1 file. Data entry is by variable. The similarity values are stored in an Arrangement 2 file.

P2: EX 41221 (Section 3.1.1)

P3: PROGRAM PINDEX

```
=====
COORDINATES FILE:EX41221, VOLUME C:\QB45\WORKS
NUMBER OF VARIABLES: 3
NUMBER OF OBSERVATIONS PER VARIABLE: 7
```

DIFFERENCE VECTORS

PAIR LABELS AND DIFFERENCES ARE PRINTED

```
VARIABLE 1 :
 1 2 3.0 1 3 3.0 1 4 3.0 1 5 4.0 1 6 9.0 1 7 13.0
 2 3 0.0 2 4 0.0
 2 5 1.0 2 6 6.0 2 7 10.0 3 4 0.0
 3 5 1.0 3 6 6.0 3 7 10.0 4 5 1.0
 4 6 6.0 4 7 10.0
 5 6 5.0 5 7 9.0 6 7 4.0
VARIABLE 2 :
 1 2 3.0 1 3 3.0 1 4 5.0 1 5 1.0 1 6 10.0 1 7 8.0
 2 3 0.0 2 4 2.0
 2 5 4.0 2 6 7.0 2 7 5.0 3 4 2.0
 3 5 4.0 3 6 7.0 3 7 5.0 4 5 6.0
 4 6 5.0 4 7 3.0
 5 6 11.0 5 7 9.0 6 7 2.0
VARIABLE 3 :
 1 2 4.0 1 3 5.0 1 4 5.0 1 5 1.0 1 6 3.0 1 7 3.0
 2 3 1.0 2 4 1.0
 2 5 5.0 2 6 1.0 2 7 1.0 3 4 0.0
 3 5 6.0 3 6 2.0 3 7 2.0 4 5 6.0
 4 6 2.0 4 7 2.0
 5 6 4.0 5 7 4.0 6 7 0.0
```

PAIR PROBABILITY VECTOR
COMPARED FOR VARIABLES

```
-----
 1 2 0.4286 0.3810 0.7619
 1 3 0.4286 0.3810 0.9048
 1 4 0.4286 0.6667 0.9048
 1 5 0.5238 0.0952 0.2381
 1 6 0.8095 0.9524 0.6190
 1 7 1.0000 0.8571 0.6190
 2 3 0.1429 0.0476 0.3333
```

2	4	0.1429	0.2381	0.3333
2	5	0.2857	0.4762	0.8095
2	6	0.7143	0.8095	0.2381
2	7	0.9524	0.6190	0.2381
3	4	0.1429	0.2381	0.0952
3	5	0.2857	0.4762	1.0000
3	6	0.7143	0.8095	0.5238
3	7	0.9524	0.6190	0.5238
4	5	0.2857	0.7143	1.0000
4	6	0.7143	0.5238	0.5238
4	7	0.9524	0.2857	0.5238
5	6	0.5714	1.0000	0.7619
5	7	0.7619	0.9048	0.7619
6	7	0.4762	0.1429	0.0476

PAIR COMPARED	CHI SQUARE	ALPHA PROB.	PROBABILITY INDEX (S)
1 2	4.1686	0.6539	0.3461
1 3	3.8249	0.7004	0.2996
1 4	2.7057	0.8448	0.1552
1 5	8.8662	0.1812	0.8188
1 6	1.4793	0.9609	0.0391
1 7	1.2674	0.9734	0.0266
2 3	12.1781	0.0581	0.9419
2 4	8.9592	0.1759	0.8241
2 5	4.4120	0.6211	0.3789
2 6	3.9657	0.6813	0.3187
2 7	3.9269	0.6866	0.3134
3 4	11.4647	0.0750	0.9250
3 5	3.9894	0.6781	0.3219
3 6	2.3888	0.8807	0.1193
3 7	2.3500	0.8849	0.1151
4 5	3.1785	0.7861	0.2139
4 6	3.2595	0.7756	0.2244
4 7	3.8964	0.6907	0.3093
5 6	1.6631	0.9479	0.0521
5 7	1.2879	0.9723	0.0277
6 7	11.4647	0.0750	0.9250

SIMILARITY VALUES IN FILE:C:\QB45\WORKS\SIM

3.2 Measuring commonness

3.2.1 Program CHIPROBS

P1: The algorithm uses polynomial approximation to compute a Chi-squared value when a probability (alpha) is given or a probability when a chi-squared value is given. The knowns (chi-squared or alpha, and the

degrees of freedom) are specified by user in keyboard input. Results should be copied from the screen.

P2: No disk file entry.
P3: No PRINTDA file created.

3.2.2 Program DISTRIBUTIONS

P1: Poisson or Bernoulli (Binomial) distributions are fitted to a sample distribution. Data entry is from an Arrangement 1 file. The fitted frequencies and goodness-of-fit measure are stored in the PPRINTDA file.

P2: EX421 Clutch size frequencies in *Turdus migratorius* nests.

```
X    0  1  2  3  4  >4
f(X) 6  15 19 14 7  1
```

EX422 Germination in 100 sets of 4 seeds.

```
X    0  1  2  3  4
f(X) 3  10 36 40 11
```

P4a: PROGRAM DISTRIBUTIONS

```
=====
DISTRIBUTION FILE: ex4211, VOLUME c:\qb45\works
NUMBER OF CATEGORIES: 6
OPTION: POISSON DISTRIBUTION.
MEAN = 2.064516
SECOND MOMENT = 1.447451
=====
```

X	OBSERVED DATA		FITTED VALUES	
	P(X)	F(X)	P'(X)	F'(X)
0	0.0968	6	0.1269	7.8665
1	0.2419	15	0.2619	16.2406
2	0.3065	19	0.2704	16.7645
3	0.2258	14	0.1861	11.5369
4	0.1129	7	0.0960	5.9545
5	0.0161	1	0.0587	3.6370

```
=====
NOTE: VALUES AT X= 5 INCLUDE THOSE GREATER THAN 5
TEST FOR GOODNESS OF FIT:
=====
```

```
2I (INFORMATION DIVERGENCE) = 4.223118
CHI-SQUARE = 3.457183
```

DEGREES OF FREEDOM = 4

P4b: PROGRAM DISTRIBUTIONS

=====
DISTRIBUTION FILE: ex4221, VOLUME c:\qb45\works
NUMBER OF CATEGORIES: 5
OPTION: BERNOULLI DISTRIBUTION.
MEAN = 2.46
SECOND MOMENT = .8484
BINOMIAL PROBABILITY (P) = .615

X	OBSERVED DATA		FITTED VALUES	
	P(X)	F(X)	P'(X)	F'(X)
0	0.0300	3	0.0220	2.1971
1	0.1000	10	0.1404	14.0384
2	0.3600	36	0.3364	33.6374
3	0.4000	40	0.3582	35.8217
4	0.1100	11	0.1431	14.3054

NOTE: VALUES AT X= 4 INCLUDE THOSE GREATER THAN 4
TEST FOR GOODNESS OF FIT:

2I (INFORMATION DIVERGENCE) = 3.01776
CHI-SQUARE = 2.872206
DEGREES OF FREEDOM = 3

3.2.3 Program ENTRDIST

P1: An empirical distribution is generated for interaction (mutual) information. The technique uses randomisation. Input of the constants is through the keyboard. The information values are stored in ascending order in the PRINTDA file. Probabilities can be inferred from position in the ordered sequence.

P2: Keyboard input of constants describing the contingency table characteristics in EX6221

Tree species 1112221123322331 1122233311221121
Yeast species 3234443341134213 3343411233433342

P3: PROGRAM ENTRDIST

=====
NUMBER OF STATES OF VARIABLE 1: 3
NUMBER OF STATES OF VARIABLE 2: 4
SAMPLE SIZE = 32
NUMBER OF ITERATIONS: 1000

SORTED INFORMATION VALUES:

1	0.00340	2	0.00634	3	0.00700	4	0.00828	5	0.00917
6	0.01023	7	0.01023	8	0.01026	9	0.01142	10	0.01258
11	0.01261	12	0.01402	13	0.01543	14	0.01653	15	0.01741
16	0.01878	17	0.01929	18	0.01929	19	0.01944	20	0.02036
21	0.02123	22	0.02164	23	0.02167	24	0.02169	25	0.02239
26	0.02289	27	0.02320	28	0.02330	29	0.02376	30	0.02377
31	0.02386	32	0.02405	33	0.02493	34	0.02509	35	0.02537
36	0.02627	37	0.02665	38	0.02682	39	0.02718	40	0.02719
41	0.02759	42	0.02784	43	0.02786	44	0.02883	45	0.02906
46	0.02925	47	0.02935	48	0.02966	49	0.02985	50	0.02991
51	0.03060	52	0.03126	53	0.03148	54	0.03154	55	0.03201
56	0.03216	57	0.03266	58	0.03319	59	0.03350	60	0.03363
61	0.03389	62	0.03392	63	0.03422	64	0.03422	65	0.03563
66	0.03564	67	0.03573	68	0.03573	69	0.03592	70	0.03648
71	0.03676	72	0.03714	73	0.03727	74	0.03758	75	0.03764
76	0.03767	77	0.03767	78	0.03795	79	0.03879	80	0.03886
81	0.03941	82	0.04012	83	0.04019	84	0.04024	85	0.04043
86	0.04134	87	0.04157	88	0.04163	89	0.04168	90	0.04174
91	0.04219	92	0.04220	93	0.04224	94	0.04272	95	0.04278
96	0.04278	97	0.04283	98	0.04291	99	0.04313	100	0.04371
.
991	0.14305	992	0.21094	993	0.20793	994	0.08435	995	0.10680
996	0.16833	997	0.28182	998	0.14051	999	0.127111000		0.19928

AVERAGE INFORMATION (BIAS) = 0.11552

VARIANCE = 1.258142E-04

Interpretation:

1. The information estimate I=0.11552 is unbiased.
2. The probability that under the rule of chance an I value will exceed 0.10680 is 5/1000. The 5/1000 proportion is valid for any 32 totalled 12-valued contingency table.

3.2.4 Program FPROBS

P1: Polynomial approximation is used to compute an F-value when a probability is given or a probability when an F-value is given at specified numerator and denominator degrees of freedom. Entry of the knowns is from the keyboard. Results should be copied from the screen.

P2:All input through the keyboard.

P3: No PRINTDA file created.

3.2.5 Program NPROBS

P1: The algorithm uses polynomial approximation to compute a Z-value when a probability is given or a probability when a Z value is given. The

knowns are entered through the keyboard. Results should be copied from the screen.

P2:All input through the keyboard.

P3: No PRINTDA file created.

3.2.6 Program TPROBS

P1: The technique is polynomial approximation. The output is a t-value when a probability is given or a probability when a t-value is given. Entry of t-value or probability, and the degrees of freedom is from the keyboard. The results appear on the screen.

P2:All input through the keyboard.

P3: No PRINTDA file created.

3.3 Describing distributions

3.3.1 Program ENTROPY

P1:Entropy and information quantities are computed. Interactions involve pairs of variables. Any number of variables are permitted. The data file is Arrangement 1, entered by variable. The data elements are taken as if they were diagnostic labels, unordered, coded as numerals. Sample size must be large.

P2: ex41331 Classification of plants in a stand between 3 life-forms and 4 strata.

```
Life-form X1  11111111112222 22222233333444
Stratum X2   11112223331222 22222233333333
```

P3: PROGRAM: ENTROPY

```
=====
DATA FILE: ex41331, VOLUME c:\qb45\entropy
NUMBER OF VARIABLES: 2
SAMPLE SIZE (NUMBER OF OBJECTS OBSERVED): 30
STATES OF VARIABLE 1
```

```
-----
  1  2  3  4
FREQUENCIES OF THESE STATES
-----
```

11 11 5 3
ENTROPY FUNCTIONS

1. SHANNON ENTROPY = 1.26464
2. LOG SIMPSON INDEX = 1.181994
(MAXIMUM OF THESE = 1.386294)
STATES OF VARIABLE 2

1 2 3
FREQUENCIES OF THESE STATES

6 12 12
ENTROPY FUNCTIONS

1. SHANNON ENTROPY = 1.05492
2. LOG SIMPSON INDEX = 1.021651
(MAXIMUM OF THESE = 1.098612)

JOINT FREQUENCIES, VARIABLES 1 AND 2

5 3 3
1 9 1
0 0 5
0 0 3

JOINT ENTROPY = 1.875967
MUTUAL ENTROPY (INFORMATION) = .4435931 (MAXIMUM = 1.098612)
RAJSKI'S METRIC = .763539
COHERENCE COEFFICIENT = .6457618

3.3.2 Program ENTROGRA

P1: Graphs are drawn, representing Rényi's entropy of order alpha. Lower limit of order must be given as zero or a number greater than zero. Any number of distributions are permitted and these may have different numbers of elements and different totals. Data entry is by distribution (Arrangement 3 file). The graphs drawn on screen are captured automatically in PICT files.

P2: ex41331 (see Section 3.3.1)

P3: PROGRAM EntroGraphs

Entropy of order alpha is computed and entropy graphs drawn for F and the limiting Fm and Fl.

Lower limit alpha= 0
Upper limit alpha= 12
Input data file name: c:\qb45\entrogaph\ex41331
DISTRIBUTION 1
PICT file: c:\qb45\entrogaph\kepgra1.bmp

Maximum entropy: 3.4012

alpha	H alpha	minimum	evenness
.0000	3.4012	3.4012	1.0000
1.0000	3.2870	2.3025	.9664
2.0000	3.1904	1.2847	.9380
3.0000	3.1135	.9881	.9154
4.0000	3.0534	.8796	.8977
5.0000	3.0063	.8250	.8839
6.0000	2.9688	.7921	.8729
7.0000	2.9386	.7702	.8640
8.0000	2.9139	.7545	.8567
9.0000	2.8935	.7428	.8507
10.0000	2.8764	.7336	.8457
11.0000	2.8619	.7263	.8414
12.0000	2.8495	.7203	.8378

Data file: ex41331

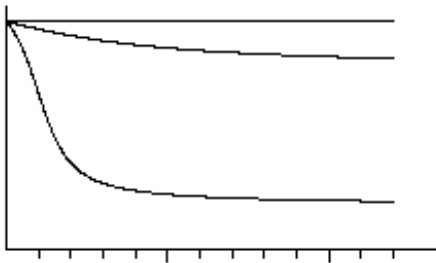
Distribution: 1

Alpha: 0 to 12

Maximum H= 3.4011974

Graphs: max H (top); H; min H

PRESS ANY KEY TO CONTINUE:



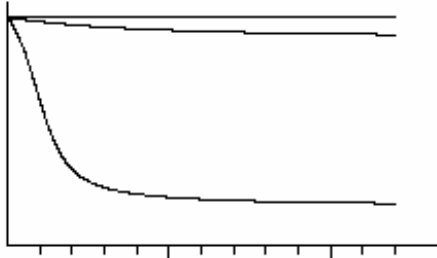
DISTRIBUTION 2

PICT file: c:\qb45\entrogaph\kepgra2.bmp

Maximum entropy: 3.4012

alpha	H alpha	minimum	evenness
.0000	3.4012	3.4012	1.0000
1.0000	3.3377	2.1461	.9813
2.0000	3.2912	1.1308	.9677
3.0000	3.2569	.8661	.9576
4.0000	3.2310	.7709	.9500
5.0000	3.2110	.7230	.9441
6.0000	3.1951	.6942	.9394
7.0000	3.1824	.6750	.9357
8.0000	3.1720	.6613	.9326
9.0000	3.1635	.6510	.9301
10.0000	3.1564	.6430	.9280
11.0000	3.1504	.6365	.9263
12.0000	3.1454	.6313	.9248

Data file: ex41331
 Distribution: 2
 Alpha: 0 to 12
 Maximum H= 3.4011974
 Graphs: max H (top); H; min H
 PRESS ANY KEY TO CONTINUE:



Graph information: Entropy is plotted on vertical axis. The horizontal axis for alpha is calibrated from 0 to 12. Horizontal line on top is maximum entropy. Lower curve represents entropy in the least dispersed limiting distribution of the case.

3.3.3 Program ESTH

P1: Entropy is estimated from cumulative frequencies. The entropy quantity is Brillouin's and the method is Pielou's. Data file type is Arrangement 1 and data entry is by distribution (relevé). Sample size (the number of relevés) must be large for improved accuracy of the estimates.

P2: ex6211 Plant counts of three species in 6 quadrats.

Species	Quadrats					
1	100	93	43	87	97	97
2	1	26	42	65	100	86
3	27	50	11	17	21	19

Important: The data entry on disk file is by column (ex6211t):

100
 1
 27
 93
 etc.

P3:

PROGRAM EST/H

=====

INPUT DATA FILE: ex6211t, VOLUME c:\qb45\works

NUMBER OF DISTRIBUTIONS: 6
NUMBER OF ELEMENTS PER DISTRIBUTION: 3

CUMULATIVE COUNTS (VARIABLES):

100	193	236	323	420	517
1	27	69	134	234	320
27	77	88	105	126	145

CUMULATIVE COLUMN (INDIVIDUAL) TOTALS:

128	297	393	562	780	982
-----	-----	-----	-----	-----	-----

H-ASTERISC VALUES ARE:

0.5321	0.8297	0.9317	0.9623	0.9804	0.9786
--------	--------	--------	--------	--------	--------

ESTIMATES OF H (FROM INFLECTION POINT UP):

1.2470	1.0335	1.0273	0.9713
--------	--------	--------	--------

CALCULATION OF H-HAT VALUE:

INFLECTION POINT: 2
MEAN H (UNBIASED ESTIMATE OF H) = 1.0698
MAXIMUM H = 1.0986
VARIANCE OF H-ESTIMATE = 0.0037

3.3.4 Program MOMENTS

P1: Moments, product moments and shape constants (gamma values) are computed for variables from data stored in an Arrangement 1 file. Data entry is by variable. All results are saved in the PRINTDA file.

P2: **ex41221** (see Section 3.1.1)

P3: PROGRAM MOMENTS

COORDINATES FILE: ex41221, VOLUME c:\qb45\works
NUMBER OF VARIABLES: 3
NUMBER OF OBSERVATIONS PER VARIABLE: 7

VARIABLE MEANS

31.0000	32.0000	15.2857
---------	---------	---------

PRODUCT-MOMENTS MATRIX

(DIAGONALS: SECOND MOMENTS, OFF-DIAGONALS: PRODUCT MOMENTS)

16.8571	11.8571	-1.2857
11.8571	13.7143	-4.4286
-1.2857	-4.4286	4.7755

COVARIANCE MATRIX

(DIAGONALS: VARIANCES, OFF-DIAGONALS: COVARIANCES)

19.6667	13.8333	-1.5000
13.8333	16.0000	-5.1667
-1.5000	-5.1667	5.5714

PRODUCT MOMENT CORRELATION MATRIX

1.0000	0.7798	-0.1433
0.7798	1.0000	-0.5472
-0.1433	-0.5472	1.0000

THIRD MOMENTS

60.8571	12.8571	6.4548
---------	---------	--------

FOURTH MOMENTS

718.0000	348.0000	43.1345
----------	----------	---------

3.3.5 Program NORMAL

P1: Normal densities are fitted to sample frequencies read from an Arrangement 3 file. The user must be prepared to key in the 1st class midpoint, the constant class interval and the number of classes when requested by the program.

P2: ex4241

Class mid point X	48	53	58	63	68	73
F(X)	5	11	23	31	10	1

P3: PROGRAM NORMAL

=====

FREQUENCIES FILE: ex4241, VOLUME c:\qb45\works
NUMBER OF CLASSES: 6
MIDPOINT OF THE 1ST CLASS: 48
CONSTANT CLASS INTERVAL: 5

SAMPLE VALUES:

MEAN = 60.03704
SECOND MOMENT = 30.10974
THIRD MOMENT = -58.19749
FOURTH MOMENT = 2508.263
SCALE FACTOR (B) USED IN FITTING = 29.4

TEST OF SKEWNESS:

GAMMA 1 = -.3522441

SKEWNESS TO THE LEFT IS INDICATED.

TEST OF KURTOSIS:

GAMMA 2 = -.2333191
PLATYKURTIC CURVE IS INDICATED.

CLASS INTERVAL	OBSERVED FREQUENCY	FITTED DENSITIES
45.5 - 50.5	5	2.65
50.5 - 55.5	11	12.92
55.5 - 60.5	23	27.44
60.5 - 65.5	31	25.41
65.5 - 70.5	10	10.26
70.5 - 75.5	1	1.81

TEST FOR GOODNESS OF FIT:

2I (INFORMATION DIVERGENCE) = 5.318571
CHI-SQUARED = 4.679772
DEGREES OF FREEDOM = 5

3.4 Probabilistic comparisons

3.4.1 Program ANOVA

p1: Variants of the single factor univariate ANOVA are performed on data according to design:

- Option 1 - Complete randomized.
- Option 2 - Randomized block.
- Option 3 - Latin Square.

Option 1 allows unequal replicates per treatment. Options 2 and 3 assume an equal number of blocks within each treatment and a single measurement from each of the blocks. Data entry is by treatment: all replicates of treatment A first, all replicates of treatment B second, etc. Option 3 requires two input files: the measurements file in which the numbers are entered by treatment (same as in Options 1 and 2), and a map (design) file whose elements identify the location of the measurements in the Latin Square. For example, if

67 65 61 43

represent the replicates of treatment A (the 1st data vector entered), the first set of numbers of the map file

2 4 3 1

will identify 67 as the value in the 1st column 2nd row of the Latin square, 65 as the measurement in the 2nd column 4th row of the Latin square, etc.

Given

36 47 30 26,

the 2nd set of numbers in the measurements file (treatment B), and

1 3 2 4,

the 2nd set of numbers in the map file, the Latin Square locations of the measurements are as follows:

36 in column 1 row 1

47 in column 2 row 3

30 in column 3 row 2

26 in column 4 row 4

A critical F probability point corresponding to given probability (alpha) and given numerator and denominator degrees of freedom (determined in the program) is keyed in by the user when requested.

P2a: ex11311
Fertilizer 1 2 3
Yield 34 40 44
37 39 49
40 37 43
36 50
37

P2b: ex11322
Animals 1 2 3
Groups 14 16 18
17 19 22
12 16 17
15 16 18

p2c ex11332

	1	2	3	4
1	36	40	32	43
2	67	36	30	22
3	40	47	61	32
4	43	65	23	26

ex11322m

Treatment			Rows	
A	2	4	3	1
B	1	3	2	4
C	3	1	4	2
D	4	2	1	3

P4a: PROGRAM ANOVA

=====

OPTION 1: COMPLETE RANDOMIZED DESIGN

MEASUREMENTS FILE: ex11311, VOLUME c:\qb45\works

TREATMENT	MEAN	VARIANCE
1	36.800	4.700
2	38.667	2.333
3	46.500	12.333
(GRAND MEAN =		40.500)

BARTLETT'S TEST (FOR EQUALITY OF VARIANCES)

CHI-SQUARE = 1.482

(DEGREES OF FREEDOM = 2)

ANOVA TABLE:

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
TREATMENT	222.533	2	111.267	16.561
ERROR	60.467	9	6.719	
TOTAL	283.000	11		

TEST OF TREATMENT DIFFERENCES

REJECT HO: AT LEAST SOME OF THE TREATMENTS ARE SIGNIFICANTLY DIFFERENT

SCHEFFE'S MULTIPLE COMPARISONS (ALL PAIRWISE)

COMPARISON	Q	F	ACCEPT/REJECT
1 2	0.986	0.486	A
1 3	5.579	15.561	R
2 3	3.957	7.828	R

FOR CONTRAST COEFFICIENTS: 0 -1 1
 Q = 3.957 F = 7.828 DECISION: REJECT H⁰

FOR CONTRAST COEFFICIENTS: -1 0 1
 Q = 5.579 F = 15.561 DECISION: REJECT H⁰

P4b: PROGRAM ANOVA

OPTION 2: RANDOMIZED BLOCK DESIGN
 MEASUREMENTS FILE: ex11322, VOLUME c:\qb45\works

TREATMENT	MEAN	VARIANCE
1	14.500	4.333
2	16.750	2.250
3	18.750	4.917
(GRAND MEAN = 16.667)		

BARTLETT'S TEST (FOR EQUALITY OF VARIANCES)

CHI-SQUARE = 0.421
 (DEGREES OF FREEDOM = 2)

ANOVA TABLE:

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
TREATMENT	36.167	2	18.083	34.264
BLOCKS	31.333	3	10.444	19.790
ERROR	3.167	6	0.528	
TOTAL	70.667	11		

TEST OF TREATMENT DIFFERENCES

REJECT H₀: AT LEAST SOME OF THE TREATMENTS ARE SIGNIFICANTLY DIFFERENT

SCHEFFE'S MULTIPLE COMPARISONS (ALL PAIRWISE)

COMPARISON	Q	F	ACCEPT/REJECT
1 2	4.380	9.592	R
1 3	8.273	34.225	R
2 3	3.893	7.579	R

FOR CONTRAST COEFFICIENTS: 1 0 -1
 Q = 8.273 F = 34.225 DECISION: REJECT H₀

FOR CONTRAST COEFFICIENTS: 0 1 -1
 Q = 3.893 F = 7.579 DECISION: REJECT H₀

P4c: PROGRAM ANOVA

```

=====
OPTION 3: LATIN SQUARE DESIGN
MEASUREMENTS FILE: ex11332, VOLUME c:\qb45\works
ASSIGNMENTS MAP FILE: ex11332 FROM VOLUME c:\qb45\works

```

TREATMENT	MEAN	VARIANCE
1	59.000	120.000
2	34.750	83.583
3	31.250	102.250
4	35.750	26.917
(GRAND MEAN = 40.188)		

BARTLETT'S TEST (FOR EQUALITY OF VARIANCES)

CHI-SQUARE = 1.451
(DEGREES OF FREEDOM = 3)

ANOVA TABLE:

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
TREATMENT	1932.188	3	644.063	33.787
ROWS	128.188	3	42.729	2.242
COLUMNS	755.688	3	251.896	13.214
ERROR	114.375	6	19.063	
TOTAL	2930.438	15		

TEST OF TREATMENT DIFFERENCES

REJECT H0: AT LEAST SOME OF THE TREATMENTS ARE SIGNIFICANTLY DIFFERENT

SCHEFFE'S MULTIPLE COMPARISONS (ALL PAIRWISE)

COMPARISON	Q	F	ACCEPT/REJECT
1 2	7.855	20.566	R
1 3	8.989	26.931	R
1 4	7.531	18.905	R
2 3	1.134	0.428	A
2 4	0.324	0.035	A
3 4	1.458	0.708	A

FOR CONTRAST COEFFICIENTS: 0 .5 -.5 0
Q = 1.134 F = 0.428 DECISION: ACCEPT H0

FOR CONTRAST COEFFICIENTS: .25 .25 -.25 -.25
Q = 6.127 F = 12.513 DECISION: REJECT H0

3.4.2 Program CANCOR

P1: Canonical correlation analysis is performed. Two data sets are involved, species densities and soil measurements in the example, both Arrangement 1. Data entry is by variable. The results are stored on a PRINTDA file. The canonical scores are stored on separate files.

P2: The columns are plots and the rows variables

```

      EX1241L Species.
80  70  80  60  55  40  45  30  25  30  20  25  30  35  25  20  25  40
90  80  80  70  60  60  50  50  60  50  40  45  45  40  55  50  30  45
10  20  40  50  40  90  60  80  50  60  90  90  80  85  80  70  75  85

```

```

      EX1241S Soil variables
7.5 7.5 7.5 7   6.5 6   6   6.5 5.5 6   5.5 5   5.5 5   4.5 5.5 6   5.5
4.5 4   3.5 4.5 6.5 5.5 4.5 5   6.5 6   5.5 6   5.5 7.5 7   5.5 6   6.5

```

P3:

PROGRAM CANCOR

```

=====
DATA FILE (LARGER SET): c:\qb45\works\ex1241L
DATA FILE (SMALLER SET): c:\qb45\works\ex1241S
NUMBER OF VARIABLES IN LARGER SET = 3
NUMBER OF VARIABLES IN SMALLER SET = 2
NUMBER OF MEASUREMENTS = 18

```

MATRIX PRODUCT

```

-----
      0.9251      -0.5879
      0.1874      -0.0292

```

CANONICAL CORRELATIONS

```

-----
CANONICAL VARIATE   1:  R-SQUARED =  0.7907  R =  0.8892 OR  88.3%
(CUMULATIVE: 88.3%)

```

```

CANONICAL VARIATE   2:  R-SQUARED =  0.1052  R =  0.3243 OR  11.7%
(CUMULATIVE:100.0%)

```

SIGNIFICANCE TEST FOR CANONICAL CORRELATIONS

```

-----
WILK'S LAMBDA =      0.1873
BARTLETT'S CHI-SQUARE =  23.452
(DEGREES OF FREEDOM =  6 )

```

VARIABLE WEIGHTS (TRANSFORMATION COEFFICIENTS) - SMALLER SET

```

-----
VARIATE   1  :
      1.2119      0.2769

```

```

VARIATE   2  :
     -1.2137     -1.6927

```

CANONICAL SCORES - LARGER SET

```

-----
SET 1
  0.4151   0.3837   0.3523   0.2516   0.2137  -0.0126
 -0.0754   0.1195  -0.1133   0.0188  -0.1761  -0.3082
 -0.1761  -0.2139  -0.4088  -0.1761   0.0188  -0.1133
SET 2
 -0.0769   0.1150   0.3069   0.0868  -0.5172   0.0304
  0.4143   0.0586  -0.1897  -0.1615   0.1942   0.1660
  0.1942  -0.4098  -0.0541   0.1942  -0.1615  -0.1897

VARIABLE WEIGHTS (TRANSFORMATION COEFFICIENTS) - LARGER SET
-----
VARIATE 1 :
  0.7669  -0.2229  -0.4870
VARIATE 2 :
 -0.0418   1.8482   1.6613
CANONICAL SCORES - LARGER SET
-----
SET 1
  0.5078   0.4007   0.3978   0.1974   0.2331  -0.1472
  0.0779  -0.1581  -0.0948  -0.0620  -0.2653  -0.2357
 -0.1410  -0.1013  -0.2219  -0.2033  -0.1123  -0.0718
SET 2
  0.0689  -0.0457   0.2772   0.1677  -0.2774   0.5502
 -0.2280   0.1076  -0.0982  -0.2204  -0.0070   0.1323
 -0.0343  -0.0967   0.2519  -0.0514  -0.5393   0.0426
STRUCTURE CORRELATIONS, SMALLER SET
-----
CANONICAL VARIATE 1 :
  0.9869  -0.7076
CANONICAL VARIATE 2 :
  0.1615  -0.7066
STRUCTURE CORRELATIONS, LARGER SET
-----
CANONICAL VARIATE 1 :
  0.9672   0.8469  -0.9178
CANONICAL VARIATE 2 :
  0.2122   0.4172   0.1432
REDUNDANCIES, SMALLER SET
-----
  0.5830   0.0276      (TOTAL =   0.6106)
REDUNDANCIES, LARGER SET
-----
  0.658  0.008      (TOTAL =   0.666)
U-CANONICAL SCORES (LARGER SET) FILE: c:\qb45\works\scoresL
V-CANONICAL SCORES (SMALLER SET) FILE: c:\qb45\works\scoresS

```

3.4.3 Program CSA

p1: Data entry is from a single Arrangement 1 file, containing all score matrices. This file is as follows:

1. Character states are coded as integer numbers, e.g., + as 1, - as 2, etc.

2. The coded values are entered by character.
3. The C/A values are entered as last vector for the score matrix².

The number of score matrices is not limited and the order in which they are arranged is arbitrary. Options permit to establish a firm order for score matrices and characters. Also, selection of a subset of score matrices is possible through specification when requested in the start-up dialogue. Correlation graphs are drawn on screen. Correlation values are stored on file by type. A PRINTDA file is created.

Run programs CSA/SELECTOR and CSA/LIMITS after CSA. Program CSA/SELECTOR prints the product and correlation matrices and creates a new file of chord distances with or without pooling partial products between character levels. The data input is from files created in by program CSA. The names of these files are on record in the PRINTDA file of each CSA run. Program CSA/LIMITS sorts, prints and graphs limits for correlation values. If 0 iteration is specified in the CSA run and one iteration is specified in the CSA/LIMITS run, the graphs printed will be the correlation profiles.

P2a: EX1251 Scores of stem succulents in two communities and cover abundance values. Rows are characters. The columns represent character set types.

Community 1

	a	b	c	d	e	f	g
1. Tall	1	2	2	2	1	2	2
2. Green	1	1	1	1	1	2	1
3. Spiny	1	2	1	1	1	1	1
4. Fleshy	2	2	1	2	1	1	1
5. Flat	2	2	1	2	2	2	2
C/A	25	15	7	3	5	1	2

Community 2

²For technical reasons to avoid scrambled limits for relevé correlation on the first variable, the first row in each score matrix may be duplicated to create a dummy variable. This has not been done in the example.

1. Tall	1	2	1	2	2	1	2
2. Green	1	2	2	2	1	1	1
3. Spiny	1	2	1	1	2	2	1
4. Fleshy	1	2	2	2	2	2	2
5. Flat	2	2	2	2	2	2	2
C/A	58	5	29	1	1	3	1

P4a: Program CSA/1c tasks:

=====

- (i) Character set analysis .
- (ii) Probabilistic limits set in random simulation.
- (iii) Partial correlation graphs drawn.

NUMBER OF CHARACTER SCORE MATRICES: 2

NUMBER OF CHARACTERS: 5

NAME OF SCORE MATRICES AND C/A VECTORS FILE:c:\qb45\works\ex1251

NUMBER OF ITERATIONS FOR LIMITS: 100

NUMBER OF CHARACTER SET TYPES PER CHARACTER SCORE MATRIX:

CSM 1 : 7

CSM 2 : 7

KEY CODE FOR CSM IDENTITIES:

MATRIX 1 IS CSM # 1

MATRIX 2 IS CSM # 2

NUMBER OF STATES PER CHARACTER:

CHR 2

CHR 2

CHR 2

CHR 2

CHR 2

NEW ORDER OF CHARACTERS

1 2 3 4 5

MATRIX 1

```

1 0 0 0 1 0 0
0 1 1 1 0 1 1
1 1 1 1 1 0 1
0 0 0 0 0 1 0
1 0 1 1 1 1 1
0 1 0 0 0 0 0
0 0 1 0 1 1 1
1 1 0 1 0 0 0
0 0 1 0 0 0 0
1 1 0 1 1 1 1

```

CAVS

25 15 7 3 5 1 2

MATRIX 2

```

1 0 1 0 0 1 0
0 1 0 1 1 0 1
1 0 0 0 1 1 1
0 1 1 1 0 0 0
1 0 1 1 0 0 1
0 1 0 0 1 1 0
1 0 0 0 0 0 0

```

0 1 1 1 1 1 1
0 0 0 0 0 0 0
1 1 1 1 1 1 1

CAVS

58 5 29 1 1 3 1

NUMBER OF POSSIBLE CSTS PER LEVEL

LEVEL 5 - 2
LEVEL 4 - 4
LEVEL 3 - 8
LEVEL 2 - 16
LEVEL 1 - 32

BLOCK SIZE BY LEVEL

LEVEL 5 - 16
LEVEL 4 - 8
LEVEL 3 - 4
LEVEL 2 - 2
LEVEL 1 - 1

X,0 DATA ANALYZED

=====

CUMULATIVE C/A ESTIMATES

CM 1

CHARACTER 1

30 1 / 28 2 / 0 0 / 0 0 / 0 0 / 0 0 / 0 0 /

CHARACTER 2

30 1 / 27 3 / 1 4 / 0 0 / 0 0 / 0 0 / 0 /

CHARACTER 3

30 1 / 15 6 / 12 5 / 1 7 / 0 0 / 0 0 / 0 /

CHARACTER 4

25 2 / 15 12 / 9 9 / 3 10 / 5 1 / 1 13 / 0 0 /

CHARACTER 5

25 4 / 15 24 / 7 17 / 3 20 / 5 2 / 1 26 / 2 18 /

CM 2

CHARACTER 1

90 1 / 8 2 / 0 0 / 0 0 / 0 0 / 0 0 / 0 /

CHARACTER 2

61 1 / 6 4 / 29 2 / 2 3 / 0 0 / 0 0 / 0 /

CHARACTER 3

58 1 / 5 8 / 29 3 / 1 7 / 1 6 / 3 2 / 1 5 /

CHARACTER 4

58 1 / 5 16 / 29 6 / 1 14 / 1 12 / 3 4 / 1 10 /

CHARACTER 5

58 2 / 5 32 / 29 12 / 1 28 / 1 24 / 3 8 / 1 20 /

CHARACTER 5 LEVEL 1 DF= 16

NOMINAL PRODUCTS 832.8750 130.3750

3941.8750

GLOBAL CORRELATIONS

1.0000 0.0720

1.0000

SUMS OF PRODUCT MATRIX (SPECIFIC)

455 154
 2121
 COVARIANCE MATRIX (SPECIFIC)
 28.4375 9.625
 132.5625
 CORRELATION MATRIX (SPECIFIC)
 1 .1567634
 1
 CHARACTER 4 LEVEL 2 DF= 8
 NOMINAL PRODUCTS 377.8750 -23.6250
 1820.8750
 SUMS OF PRODUCT MATRIX (SPECIFIC)
 165.5 -288
 1060.5
 COVARIANCE MATRIX (SPECIFIC)
 20.6875 -36
 132.5625
 CORRELATION MATRIX (SPECIFIC)
 1 -.6874453
 1
 CHARACTER 3 LEVEL 3 DF= 4
 NOMINAL PRODUCTS 212.3750 264.3750
 760.3750
 SUMS OF PRODUCT MATRIX (SPECIFIC)
 113.75 205.75
 485.25
 COVARIANCE MATRIX (SPECIFIC)
 28.4375 51.4375
 121.3125
 CORRELATION MATRIX (SPECIFIC)
 1 .8757524
 1
 CHARACTER 2 LEVEL 4 DF= 2
 NOMINAL PRODUCTS 98.6250 58.6250
 275.1250
 SUMS OF PRODUCT MATRIX (SPECIFIC)
 98.5 53.5
 65
 COVARIANCE MATRIX (SPECIFIC)
 49.25 26.75
 32.5
 CORRELATION MATRIX (SPECIFIC)
 1 .6686194
 1
 CHARACTER 1 LEVEL 5 DF= 1
 NOMINAL PRODUCTS 0.1250 5.1250
 210.1250
 SUMS OF PRODUCT MATRIX (SPECIFIC)
 .125 5.125
 210.125
 COVARIANCE MATRIX (SPECIFIC)
 .125 5.125
 210.125
 CORRELATION MATRIX (SPECIFIC)
 1 1
 1

M,0 DATA ANALYZED

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CUMULATIVE C/A ESTIMATES

CM 1

CHARACTER 1

16.57143 1 / 41.42857 2 / 0 0 / 0 0 / 0 0 / 0 0 /

CHARACTER 2

16.57143 1 / 33.14286 3 / 8.285714 4 / 0 0 / 0 0 / 0 0 /

CHARACTER 3

16.57143 1 / 8.285714 6 / 24.85714 5 / 8.285714 7 / 0 0 / 0 0 / 0 /

CHARACTER 4

8.285714 2 / 8.285714 12 / 16.57143 9 / 8.285714 10 / 8.285714 1 / 8.285714 13 / 0 0 /

CHARACTER 5

8.285714 4 / 8.285714 24 / 8.285714 17 / 8.285714 20 / 8.285714 2 / 8.285714 26 / 8.285714 18 /

CM 2

CHARACTER 1

42 1 / 56 2 / 0 0 / 0 0 / 0 0 / 0 0 /

CHARACTER 2

28 1 / 28 4 / 14 2 / 28 3 / 0 0 / 0 0 / 0 /

CHARACTER 3

14 1 / 14 8 / 14 3 / 14 7 / 14 6 / 14 2 / 14 5 /

CHARACTER 4

14 1 / 14 16 / 14 6 / 14 14 / 14 12 / 14 4 / 14 10 /

CHARACTER 5

14 2 / 14 32 / 14 12 / 14 28 / 14 24 / 14 8 / 14 20 /

CHARACTER 5 LEVEL 1 DF= 16

NOMINAL PRODUCTS 375.4464 170.3750

1071.8750

GLOBAL CORRELATIONS

1.0000 0.2686

1.0000

SUMS OF PRODUCT MATRIX (SPECIFIC)

171.6326 174

686

COVARIANCE MATRIX (SPECIFIC)

10.72704 10.875

42.875

CORRELATION MATRIX (SPECIFIC)

1 .5070927

1

CHARACTER 4 LEVEL 2 DF= 8

NOMINAL PRODUCTS 203.8138 -3.6250

385.8750

SUMS OF PRODUCT MATRIX (SPECIFIC)

51.48981 -29

343

COVARIANCE MATRIX (SPECIFIC)

6.436226 -3.625

42.875

CORRELATION MATRIX (SPECIFIC)

1 -.2182179

1

CHARACTER 3 LEVEL 3 DF= 4
 NOMINAL PRODUCTS 152.3240 25.3750
 42.8750

SUMS OF PRODUCT MATRIX (SPECIFIC)
 77.2347 0
 24.5

COVARIANCE MATRIX (SPECIFIC)
 19.30867 0
 6.125

CORRELATION MATRIX (SPECIFIC)
 1 0
 1

CHARACTER 2 LEVEL 4 DF= 2
 NOMINAL PRODUCTS 75.0893 25.3750
 18.3750

SUMS OF PRODUCT MATRIX (SPECIFIC)
 55.78062 14.5
 12.25

COVARIANCE MATRIX (SPECIFIC)
 27.89031 7.25
 6.125

CORRELATION MATRIX (SPECIFIC)
 1 .5547002
 1

CHARACTER 1 LEVEL 5 DF= 1
 NOMINAL PRODUCTS 19.3087 10.8750
 6.1250

SUMS OF PRODUCT MATRIX (SPECIFIC)
 19.30866 10.875
 6.125

COVARIANCE MATRIX (SPECIFIC)
 19.30866 10.875
 6.125

CORRELATION MATRIX (SPECIFIC)
 1 1
 1

X-M,0 DATA ANALYZED

=====

CUMULATIVE C/A ESTIMATES

CM 1

CHARACTER 1
 13.42857 1 /-13.42857 2 / 0 0 / 0 0 / 0 0 / 0 0 /
 CHARACTER 2
 13.42857 1 /-6.142857 3 /-7.285714 4 / 0 0 / 0 0 / 0 0 /
 CHARACTER 3
 13.42857 1 / 6.714286 6 /-12.85714 5 /-7.285714 7 / 0 0 / 0 0 / 0
 0 /
 CHARACTER 4
 16.71428 2 / 6.714286 12 /-7.571428 9 /-5.285714 10 /-3.285714 1
 /-7.285714 13 / 0 0 /
 CHARACTER 5
 16.71428 4 / 6.714286 24 /-1.285714 17 /-5.285714 20 /-3.285714 2
 /-7.285714 26 /-6.285714 18 /

CM 2

CHARACTER 1

```

48 1 /-48 2 / 0 0 / 0 0 / 0 0 / 0 0 / 0 /
CHARACTER 2
33 1 /-22 4 / 15 2 /-26 3 / 0 0 / 0 0 / 0 /
CHARACTER 3
44 1 /-9 8 / 15 3 /-13 7 /-13 6 /-11 2 /-13 5 /
CHARACTER 4
44 1 /-9 16 / 15 6 /-13 14 /-13 12 /-11 4 /-13 10 /
CHARACTER 5
44 2 /-9 32 / 15 12 /-13 28 /-13 24 /-11 8 /-13 20 /

CHARACTER 5 LEVEL 1 DF= 16
NOMINAL PRODUCTS 457.4283 -163.1428
2870.0000
GLOBAL CORRELATIONS
1.0000 -0.1424
1.0000
SUMS OF PRODUCT MATRIX (SPECIFIC)
220.6325 -81.57142
1435
COVARIANCE MATRIX (SPECIFIC)
13.78953 -5.098214
89.6875
CORRELATION MATRIX (SPECIFIC)
1 -.1449697
1

CHARACTER 4 LEVEL 2 DF= 8
NOMINAL PRODUCTS 236.7958 -81.5714
1435.0000
SUMS OF PRODUCT MATRIX (SPECIFIC)
125.8469 -272.9285
717.5
COVARIANCE MATRIX (SPECIFIC)
15.73086 -34.11606
89.6875
CORRELATION MATRIX (SPECIFIC)
1 -.9082736
1

CHARACTER 3 LEVEL 3 DF= 4
NOMINAL PRODUCTS 110.9489 191.3571
717.5000
SUMS OF PRODUCT MATRIX (SPECIFIC)
77.05611 95.96424
408.25
COVARIANCE MATRIX (SPECIFIC)
19.26403 23.99106
102.0625
CORRELATION MATRIX (SPECIFIC)
.9999999 .5410568
1

CHARACTER 2 LEVEL 4 DF= 2
NOMINAL PRODUCTS 33.8928 95.3928
309.2500
SUMS OF PRODUCT MATRIX (SPECIFIC)
11.35203 14.82143
21.25
COVARIANCE MATRIX (SPECIFIC)
5.676015 7.410713

```

10.625
CORRELATION MATRIX (SPECIFIC)
1 .9542755
1
CHARACTER 1 LEVEL 5 DF= 1
NOMINAL PRODUCTS 22.5408 80.5714
288.0000

SUMS OF PRODUCT MATRIX (SPECIFIC)
22.5408 80.5714
288

COVARIANCE MATRIX (SPECIFIC)
22.5408 80.5714
288

CORRELATION MATRIX (SPECIFIC)
1 .9999999
1

DATA TYPE 1
GRAPH 1 2
05-28-1999
DATA TYPE 2
GRAPH 1 2
05-28-1999
DATA TYPE 3
GRAPH 1 2
05-28-1999
SCORES

X,0 DATA ANALYZED
=====

CUMULATIVE C/A ESTIMATES

CM 1
CHARACTER 1
39 2 / 19 1 / 0 0 / 0 0 / 0 0 / 0 0 / 0 /
CHARACTER 2
29 4 / 10 3 / 13 1 / 6 2 / 0 0 / 0 0 / 0 /
CHARACTER 3
9 8 / 10 6 / 13 2 / 20 7 / 6 4 / 0 0 / 0 /
CHARACTER 4
4 15 / 10 12 / 13 4 / 20 14 / 6 7 / 5 16 / 0 0 /
CHARACTER 5
4 29 / 10 24 / 13 7 / 20 27 / 6 13 / 5 32 / 0 0 /

CM 2
CHARACTER 1
78 1 / 20 2 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 2
35 1 / 43 2 / 20 4 / 0 0 / 0 0 / 0 0 /
CHARACTER 3
35 1 / 43 4 / 20 7 / 0 0 / 0 0 / 0 0 /
CHARACTER 4
5 2 / 30 1 / 21 7 / 20 13 / 22 8 / 0 0 / 0 /
CHARACTER 5
5 3 / 30 1 / 21 14 / 20 26 / 14 15 / 8 16 / 0 0 /

CHARACTER 5 LEVEL 1 DF= 16
CHARACTER 4 LEVEL 2 DF= 8
CHARACTER 3 LEVEL 3 DF= 4

CHARACTER 2 LEVEL 4 DF= 2
CHARACTER 1 LEVEL 5 DF= 1

M,0 DATA ANALYZED

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CUMULATIVE C/A ESTIMATES

CM 1

CHARACTER 1
41.42857 2 / 16.57143 1 / 0 0 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 2
33.14286 4 / 8.285714 3 / 8.285714 1 / 8.285714 2 / 0 0 / 0 0 / 0
0 /
CHARACTER 3
16.57143 8 / 8.285714 6 / 8.285714 2 / 16.57143 7 / 8.285714 4 / 0
0 / 0 0 /
CHARACTER 4
8.285714 15 / 8.285714 12 / 8.285714 4 / 16.57143 14 / 8.285714 7
/ 8.285714 16 / 0 0 /
CHARACTER 5
8.285714 29 / 8.285714 24 / 8.285714 7 / 16.57143 27 / 8.285714 13
/ 8.285714 32 / 0 0 /

CM 2

CHARACTER 1
84 1 / 14 2 / 0 0 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 2
42 1 / 42 2 / 14 4 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 3
42 1 / 42 4 / 14 7 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 4
14 2 / 28 1 / 14 7 / 14 13 / 28 8 / 0 0 / 0 0 /
CHARACTER 5
14 3 / 28 1 / 14 14 / 14 26 / 14 15 / 14 16 / 0 0 /

CHARACTER 5 LEVEL 1 DF= 16
CHARACTER 4 LEVEL 2 DF= 8
CHARACTER 3 LEVEL 3 DF= 4
CHARACTER 2 LEVEL 4 DF= 2
CHARACTER 1 LEVEL 5 DF= 1

X-M,0 DATA ANALYZED

=====

CUMULATIVE C/A ESTIMATES

CM 1

CHARACTER 1
-2.42857 2 / 2.428572 1 / 0 0 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 2
-4.142856 4 / 1.714286 3 / 4.714286 1 / -2.285714 2 / 0 0 / 0 0 / 0
0 /
CHARACTER 3
-7.571428 8 / 1.714286 6 / 4.714286 2 / 3.428572 7 / -2.285714 4 / 0
0 / 0 0 /
CHARACTER 4
-4.285714 15 / 1.714286 12 / 4.714286 4 / 3.428572 14 / -2.285714 7
/ -3.285714 16 / 0 0 /
CHARACTER 5

-4.285714 29 / 1.714286 24 / 4.714286 7 / 3.428572 27 / -2.285714 13
/-3.285714 32 / 0 0 /

CM 2

CHARACTER 1
-6 1 / 6 2 / 0 0 / 0 0 / 0 0 / 0 0 /
CHARACTER 2
-7 1 / 1 2 / 6 4 / 0 0 / 0 0 / 0 0 /
CHARACTER 3
-7 1 / 1 4 / 6 7 / 0 0 / 0 0 / 0 0 /
CHARACTER 4
-9 2 / 2 1 / 7 7 / 6 13 / -6 8 / 0 0 / 0 0 /
CHARACTER 5
-9 3 / 2 1 / 7 14 / 6 26 / 0 15 / -6 16 / 0 0 /

CHARACTER 5 LEVEL 1 DF= 16
CHARACTER 4 LEVEL 2 DF= 8
CHARACTER 3 LEVEL 3 DF= 4
CHARACTER 2 LEVEL 4 DF= 2
CHARACTER 1 LEVEL 5 DF= 1

Simulated correlations by level in file GRAPH, volume c:\qb45\works
Specific products in file PRD_SPEC, volume c:\qb45\works
Specific correlations in file COR_SPEC, volume c:\qb45\works
Nominal products in file PRD_NOM, volume c:\qb45\works
Nominal correlations in file COR_NOM, volume c:\qb45\works
Run program CSASORTE to plot limits.

Run program CSASELEC to select levels for further analysis.

18:36:08 05-28-1999

P4b. Program CSA_Lims

Limits are printed for specific correlation.

=====
Data file: c:\qb45\works\graph.csa
Limit points for Specific Correlations generated
in randomisation in program CSA are printed in
descending order.

Confidence interval %: 80
Number of iterations: 100
Number of character matrices: 2
Number of variables: 5

DATA TYPE 1
VARIABLE 5
COMPARISON 1 2
.6280417 .5156512 .514064 .3994273 .3982161
.3879522 .3459722 .3144544 .297737 .2753741
.2689061 .2591892 .2364496 .2302332 .1983316
.1941918 .1875913 .1865472 .1819851 .1786323
.1673969 .1644521 .1550228 .1467958 .1395907
.1328374 .1245102 .122493 .1117229 .1095065
.1074106 .1061306 9.935217E-02 .0923274 8.968407E-02
8.256722E-02 8.044323E-02 7.647381E-02 6.951105E-02 6.759463E-02
6.614839E-02 6.342971E-02 6.143735E-02 6.004227E-02 5.100271E-02
5.084363E-02 4.254641E-02 .0414323 3.083712E-02 0
0 0 0 0 -2.178696E-03

-1.508929E-02 -.0528857 -5.501486E-02 -.056709 -5.676459E-02
-6.987249E-02 -7.159084E-02 -7.329776E-02 -7.701541E-02 -7.951955E-02
-8.241964E-02 -8.927779E-02 -9.779663E-02 -.1084174 -.1086735
-.1122024 -.1140104 -.1175739 -.1208944 -.1235309
-.1259847 -.1289626 -.1403122 -.1478453 -.1677943
-.1715921 -.1928329 -.1932826 -.1946657 -.2025945
-.219605 -.2431125 -.2743171 -.2794826 -.284181
-.3038522 -.3218364 -.3468303 -.3596529 -.4163445
-.4206581 -.4508792 -.4610626 -.4819564 -.5421783

VARIABLE 4

COMPARISON 1 2

.818516 .80733 .7324476 .728166 .6431481
.6409758 .6396952 .6258771 .6177673 .5994527
.5680034 .5107514 .4682325 .455055 .411542
.397595 .3731599 .3695882 .3670645 .3567123
.3530143 .3450959 .3390168 .3308463 .294705
.2838551 .2419513 .236653 .2322871 .2170024
.2009116 .1684148 .1665137 .1613356 .1410421
.1288525 .1152857 .1031885 .1028371 .1019153
9.653495E-02 8.852104E-02 6.560971E-02 5.983935E-02 4.303325E-02
3.015642E-02 1.344467E-02 1.245951E-02 1.079848E-02 0
0 -1.603016E-02 -3.631398E-02 -6.115877E-02 -6.279127E-02
-6.328619E-02 -.0728619 -7.704188E-02 -.0830805 -8.771921E-02
-9.501942E-02 -.101617 -.1218095 -.1265487 -.131656
-.13668 -.1527 -.1594537 -.1688656 -.1855774
-.194731 -.2118559 -.2284299 -.2356301 -.2400783
-.244861 -.2704822 -.2878959 -.2898625 -.294719
-.3019137 -.3147234 -.3386692 -.3957886 -.4102311
-.4138569 -.4193833 -.4681672 -.4688085 -.4712362
-.4770347 -.4775619 -.5032879 -.5084134 -.5983512
-.5988628 -.6703207 -.6896227 -.7752206 -.8450472

VARIABLE 3

COMPARISON 1 2

.9440819 .9339713 .829529 .7981625 .7706457
.7646224 .7352943 .7202961 .6671896 .6475075
.6435405 .6115756 .6090693 .5816259 .4925237
.4818795 .4807859 .4659725 .4655059 .4183433
.3901838 .3626456 .346638 .3271291 .3229732
.3145539 .3049869 .3040792 .2964076 .2913484
.2910924 .2823326 .2747094 .2067838 .1908044
.1763006 .1399062 .1389791 .1383213 .1369332
.1032682 .1015417 .100926 .1000556 7.180752E-02
6.128514E-02 5.951202E-02 5.363739E-02 3.692434E-02 3.547271E-02
3.324408E-02 3.027411E-02 1.890637E-02 .0108411 0
-1.809981E-02 -1.926786E-02 -2.725402E-02 -4.642976E-02 -4.997745E-02
-5.045363E-02 -9.407905E-02 -.1017301 -.1046163 -.1199336
-.1450254 -.1566572 -.1678888 -.1709829 -.2078147
-.2208523 -.2274178 -.2517121 -.278744 -.3289993
-.340017 -.3919342 -.4033284 -.4246871 -.4439784
-.5142015 -.529567 -.5409207 -.5494336 -.5695713
-.592917 -.6061334 -.6533174 -.6550802 -.6572671
-.6943909 -.704852 -.736488 -.741078 -.7889023
-.8007056 -.8033125 -.8366107 -.8524575 -.9598596

VARIABLE 2

COMPARISON 1 2

.9827018	.976575	.96	.9593655	.9535826	
.9417419	.9344878	.9333456	.9177221	.9158415	
.9136187	.9127806	.8997007	.8889745	.875034	
.8632478	.8134486	.798255	.7863184	.7814595	
.776562	.7714169	.7432941	.742838	.7317216	
.6804511	.6765903	.667545	.6525232	.6479784	
.615706	.6127104	.56921	.4713773	.4089472	
.402578	.316932	.2926168	.2900074	.2868369	
.2498001	.2312273	.2077552	.2072391	.1961161	
.1199334	8.334537E-02	7.297564E-02	6.707549E-02	5.255883E-02	
0	-4.608246E-03	-.1007506	-.1146241	-.1585204	
-.1699069	-.1951198	-.2707456	-.2747211	-.2774009	
-.3716833	-.3729979	-.3767843	-.4008188	-.4023477	
-.4166547	-.4654319	-.5501577	-.5667768	-.6380179	
-.6921526	-.7129843	-.7474093	-.750359	-.7514733	
-.78341	-.7961622	-.8052127	-.8306661	-.8615385	
-.88129	-.8847118	-.8884659	-.8933417	-.9095957	
-.9408874	-.9432408	-.95448	-.9582506	-.9593655	
-.9622061	-.9743912	-.9802436	-.9805807	-.9835291	
-.9881646	-.9950722	-.9985043	-.9990918	-.9999274	

VARIABLE 1

COMPARISON 1 2

.9998648	.9996109	.9993877	.9991882	.9990063	
.9981876	.9977416	.9976172	.9975945	.9965842	
.9951788	.9949301	.9932029	.9930041	.9918996	
.9915695	.9897759	.985914	.9835299	.9831905	
.9829075	.9789178	.978631	.9762198	.9723077	
.9625485	.961524	.9597374	.9583659	.9580575	
.9571501	.9556599	.9481191	.945373	.9451016	
.9451016	.9432926	.9421817	.9391083	.9351662	
.9349975	.9343144	.9296859	.9269965	.9268905	
.9127213	.9111019	.9073968	.9009842	.8980627	
.8952286	.8902112	.8867556	.8855205	.883349	
.8820723	.8820478	.8802794	.8765929	.8728967	
.8642428	.8555453	.8521997	.8510113	.8490842	
.8444204	.8439285	.8425303	.8311539	.8217406	
.8206768	.8194422	.8194422	.8178285	.7993744	
.7974886	.7917165	.7841936	.7829131	.7825079	
.7765079	.7289123	.7172708	.7154953	.7127815	
.6885632	.6859954	.6823183	.6720605	.6475321	
.629865	.6250362	.5692674	.5535669	.5310604	
.5056288	.4877874	.4848442	.4586691	.3713907	

DATA TYPE 2

VARIABLE 5

COMPARISON 1 2

.6030227	.4472136	.4444444	.4364358	.4020151	
.3418817	.3380617	.3380617	.3015113	.2981424	
.2981424	.2857143	.2857143	.2696799	.2581989	
.2519763	.2480695	.2279212	.2222222	.2010076	
.2	.1924501	.1690309	.1690309	.1690309	
.1690309	.1490712	.1428571	.1428571	.1428571	
.1428571	.1428571	.1428571	.13484	.1259882	

.1259882	.1259882	.1259882	.1111111	.1048285
.1005038	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
-.1048285	-.1048285	-.1111111	-.1259882	-.1259882
-.1259882	-.1428571	-.1490712	-.1690309	-.1690309
-.1924501	-.1924501	-.2	-.2	-.2
-.2	-.2	-.2581989	-.2581989	-.2857143
-.2857143	-.2981424	-.3380617	-.3380617	-.3380617
-.3418817	-.4020151	-.4472137	-.4472137	-.4558424
-.5039526	-.5070926	-.5070927	-.5163978	-.5773504

VARIABLE 4

COMPARISON	1	2			
.8451543	.797724	.6761234	.6761234	.6741999	
.6030227	.6030227	.5773503	.5773502	.5698029	
.5241424	.5070926	.5070925	.5070925	.4472139	
.4472139	.4285715	.4285715	.4	.4	
.3892494	.3849002	.3464102	.3202564	.2981424	
.2981424	.2981424	.2981424	.2857143	.2727273	
.2696799	.2581989	.2480695	.2279212	.2182179	
.2182179	.209657	.2	.1740776	.1690309	
.1690309	.1490712	.1240347	.1139606	.1048285	
.1005038	9.759001E-02	0	0	0	
0	0	0	0	0	
0	0	0	0	0	
0	0	0	-.1139606	-.1428571	
-.1490712	-.1601281	-.1601282	-.1672484	-.1690309	
-.1740777	-.1740777	-.1924501	-.1924501	-.19518	
-.2	-.2	-.2010076	-.2182179	-.2182179	
-.2581989	-.2581989	-.2696799	-.2857143	-.3481553	
-.4000001	-.4285714	-.4303315	-.4364357	-.4364358	
-.5070925	-.5163978	-.516398	-.5423262	-.5454546	
-.5962848	-.6546537	-.6761235	-.7142857	-.8000001	

VARIABLE 3

COMPARISON	1	2			
.9467292	.8944272	.8728716	.8006409	.8000001	
.7745966	.6666668	.6666667	.6666667	.6299409	
.6299408	.5962848	.5773507	.5773504	.5773502	
.5714287	.5547002	.5163977	.5070926	.5070925	
.5070924	.4583493	.4558423	.4285714	.4200841	
.420084	.3779648	.3779648	.3779645	.3779644	
.3757346	.3698001	.3481553	.3333333	.2981424	
.2508726	.2193817	.19518	.1490712	.1428572	
.13484	.13484	.1048285	0	0	
0	0	0	0	0	
0	0	0	0	0	
-.1005038	-.11547	-.1690309	-.1690309	-.1878673	
-.1924501	-.1924501	-.1924501	-.1924501	-.2519763	
-.2519763	-.2581989	-.2581989	-.2981424	-.3015113	
-.3015113	-.3015113	-.3464102	-.3481553	-.3481554	
-.3999999	-.438357	-.4472131	-.4472136	-.5025189	
-.5070927	-.5163977	-.5163978	-.5773502	-.5773503	
-.5773504	-.5962848	-.5962848	-.6546536	-.6837635	

-.7035264 -.7559291 -.7745966 -.7745968 -.7745968
-.7999999 -.8090398 -.8819171 -.8944272 -1

VARIABLE 2

COMPARISON 1 2
1 1 1 .9999998 .9922779
.9701425 .9701425 .9701424 .8944272 .8944272
.8944272 .8944271 .8944271 .8682432 .8682431
.8682429 .8320509 .8320503 .8320503 .8240419
.7999998 .7592567 .6 .6 .5999998
.5547006 .5547002 .5546997 .4705882 .4472144
.4472144 .4472141 .4472137 .4472137 .4472137
.4472136 .4472136 .4472136 .4472136 .4472135
.2425359 .2425356 .124035 2.104657E-06 0
0 0 0 0 0
0 0 0 -.1240344 -.1240345
-.1240347 -.1240347 -.2060105 -.2425354 -.2425356
-.3846154 -.3846154 -.4472118 -.4472135 -.4472135
-.4472135 -.4472136 -.4472136 -.496139 -.5546996
-.5547002 -.5999995 -.6507914 -.73994 -.7999998
-.8000001 -.8320484 -.8320495 -.8944263 -.8944269
-.8944269 -.8944269 -.8944269 -.8944271 -.8944272
-.8944272 -.9701425 -.9701425 -.98387 -.9922776
-.9922779 -.9922779 -.999999 -.999999 -.9999995
-.9999997 -1 -1 -1 -1

VARIABLE 1

COMPARISON 1 2
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 .9769
.9769 .9656158 .9656158 .9656158 .9656158
.9656158 .9656158 .9656158 .9656158 .9656157
.9656157 .9656157 .9656157 .9656157 .9656157
.9656157 .9656157 .9656157 .9656157 .9656157
.9656157 .9656157 .9656157 .96 .96
.96 .96 .96 .96 .96
.96 .96 .8877545 .8877545 .8877545
.8877545 .8877545 .8877545 .8877545 .8877545
.8877545 .8877545 .8541986 .8541986 .8541986
.8541986 .8541986 .8541986 .8541986 .8541986
.8541986 .8541986 .8541986 .8541985 .8541985
.8541985 .8541985 .8541985 .8541985 .8541985
.7233556 .7233556 .7233556 .7233556 .7233555
.6896552 .6896552 .6896552 .6896552 .6896552
.6896552 .6 .5189782 .5189782 .5189782
.5189782 .5189781 .5189781 .5189781 .3713907

DATA TYPE 3

VARIABLE 5

COMPARISON 1 2
.6060326 .5352068 .3532552 .3532274 .3467897
.3464282 .3212253 .320046 .2814405 .2500878
.2487361 .239698 .2351322 .2229664 .2199343

.2184961 .1965973 .1953364 .1928457 .1809891
.1753972 .1674641 .1674301 .152223 .1507062
.1440126 .1401395 .1320149 .126584 .1230658
.1103025 .0961696 8.948942E-02 8.776603E-02 7.860538E-02
6.906535E-02 4.622431E-02 4.017274E-02 3.696106E-02 3.547816E-02
1.634233E-02 1.432082E-02 0 0 0
0 0 0 0 -2.854045E-03
-7.409646E-03 -.0146882 -1.899368E-02 -2.505977E-02 -2.992577E-02
-3.056436E-02 -3.415351E-02 -3.749367E-02 -.0417923 -4.471034E-02
-5.121645E-02 -6.633892E-02 -6.673527E-02 -7.008077E-02 -7.879797E-02
-.0924513 -9.777965E-02 -9.822496E-02 -.1061292 -.12065
-.122708 -.1276655 -.1394186 -.1453108 -.151393
-.159437 -.1611689 -.1624867 -.1781304 -.2243212
-.2266729 -.2386074 -.2400983 -.2572643 -.2732618
-.2745829 -.2830668 -.2935753 -.294159 -.3093115
-.3142567 -.3413125 -.3697367 -.3779301 -.3787434
-.4278974 -.4367803 -.4403985 -.6300421 -.8254514

VARIABLE 4

COMPARISON 1 2

.7967579 .714712 .6218336 .5966591 .5176977
.4413352 .3930889 .3681067 .3655414 .334432
.3163185 .3160494 .3061422 .2994277 .2906314
.230359 .2287244 .2195377 .1985111 .198148
.1962876 .1765286 .159657 .1219155 .1188293
.1144305 .1033514 9.180093E-02 7.745124E-02 7.479311E-02
7.131789E-02 7.105599E-02 5.916569E-02 5.547298E-02 4.249056E-02
2.068222E-02 5.90736E-03 5.219765E-03 0 -1.529982E-02
-1.578411E-02 -1.709162E-02 -2.447808E-02 -2.844895E-02 -3.065645E-02
-5.127701E-02 -5.731844E-02 -8.030901E-02 -8.160351E-02 -8.690048E-02
-.1102403 -.1157619 -.1203984 -.1511894 -.167406
-.1705136 -.1723219 -.1807137 -.1861234 -.1875979
-.2008645 -.2093076 -.2154523 -.2309708 -.232281
-.2410915 -.2423108 -.2435429 -.2522619 -.2689745
-.2821338 -.2865509 -.2964369 -.3074027 -.3133271
-.3456995 -.3608813 -.3711292 -.381727 -.3904833
-.4054132 -.4129803 -.420056 -.4240151 -.4302333
-.4324277 -.4369985 -.4455817 -.4619519 -.4700425
-.5315967 -.5488481 -.5534493 -.587916 -.6048707
-.6793852 -.6966667 -.7352729 -.8252457 -.8700021

VARIABLE 3

COMPARISON 1 2

.9524307 .9441935 .8653994 .8646456 .861002
.8476099 .8443826 .7907327 .767836 .7496099
.7213634 .6551642 .6459098 .6377182 .6143224
.5074977 .4994544 .4455708 .43139 .399897
.393579 .3921254 .389734 .3474262 .331735
.2985341 .2928029 .2680415 .2457798 .2446369
.2171357 .2030681 .1956907 .1911099 .1748139
.1524163 .1403826 .1096823 8.507249E-02 6.989039E-02
6.295621E-02 1.821442E-02 1.16848E-03 -2.627145E-02 -3.647852E-02
-.037605 -5.427252E-02 -5.577124E-02 -6.482561E-02 -8.270343E-02
-9.246559E-02 -9.432557E-02 -.0964162 -.1233744 -.1246808
-.1254411 -.1400268 -.1408039 -.1460156 -.1483913
-.1802146 -.1847332 -.1911734 -.1974495 -.2171668
-.223855 -.2336109 -.2674427 -.2745878 -.2845662

-.3024642 -.319357 -.3308707 -.4040707 -.4284817
 -.4716377 -.4905668 -.5199592 -.5211081 -.5396967
 -.5599549 -.5672867 -.6282481 -.6510439 -.673211
 -.677011 -.6773291 -.6991643 -.6996745 -.7185081
 -.7439278 -.7459855 -.7496818 -.758674 -.7623915
 -.8118706 -.8297926 -.8436965 -.8935751 -.8940726

VARIABLE 2

COMPARISON 1 2
 1 .9997532 .9995287 .9986178 .9985264
 .9975444 .9957296 .9940716 .9922776 .9734172
 .955779 .9429904 .9306734 .922313 .9061832
 .8768123 .8613369 .8610336 .8333173 .829072
 .7966914 .7943579 .7904783 .7316412 .7213874
 .7180676 .6677543 .6305928 .6031699 .5654887
 .510202 .5011783 .5010363 .4935229 .4770918
 .4728177 .4472137 .4270064 .368544 .3589788
 .2631173 .1985528 .1414213 7.669634E-02 .0681641
 1.587103E-02 -2.127207E-02 -2.905753E-02 -3.224128E-02 -4.719139E-02
 -.1174607 -.1681153 -.2039543 -.2425355 -.3016207
 -.3162277 -.3398546 -.3908737 -.3917191 -.4151335
 -.4472134 -.5045271 -.5111324 -.5454559 -.5960518
 -.6230052 -.6643637 -.6839411 -.7106613 -.7186963
 -.7355451 -.7452414 -.7467653 -.7965317 -.8181921
 -.8264806 -.8502653 -.8546871 -.8673669 -.8708838
 -.8831157 -.8833492 -.8862132 -.8918487 -.9058446
 -.9064353 -.9363292 -.9605643 -.9746917 -.9751328
 -.9863939 -.9883716 -.9890304 -.9892033 -.994385
 -.9951941 -.9979104 -.998583 -.9997168 -.9999622

VARIABLE 1

COMPARISON 1 2
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 1 1 1
 1 1 .9999999 .9999999 .9999999
 .9999999 .9999999 0 0 0
 0 0 0 -.9999999 -.9999999
 -.9999999 -.9999999 -.9999999 -.9999999 -.9999999
 -.9999999 -.9999999 -.9999999 -.9999999 -1
 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1

P4c. PROGRAM CSA_SEL
 CONTENTS OF FILE: prd_spec.csa VOLUME c:\qb45\works is PRINTED.

LEVELS POOLED:

1 2

LEVEL FIRST NUMBER IN ROW.

AVERAGES IN LAST ROW AND SECOND LAST COLUMN.

STANDARD DEVIATIONS IN LAST COLUMN.

GRAND AVERAGE, LAST NUMBER IN LAST ROW.

DATA TYPE (a)

1	154.000	154.000	0.000
2	-288.000	-288.000	0.000
3	205.750	205.750	0.000
4	53.500	53.500	0.000
5	5.125	5.125	0.000

26.075 26.075

POOLED CHORD DISTANCES FILE: VOLUME c:\qb45\works

FILE prodtab 1

0.000 1.480

0.000

DATA TYPE (b)

1	174.000	174.000	0.000
2	-29.000	-29.000	0.000
3	0.000	0.000	0.000
4	14.500	14.500	0.000
5	10.875	10.875	0.000

34.075 34.075

POOLED CHORD DISTANCES FILE: VOLUME c:\qb45\works

FILE prodtab 2

0.000 1.181

0.000

DATA TYPE (c)

1	-81.571	-81.572	0.000
2	-272.928	-272.929	0.000
3	95.964	95.964	0.000
4	14.821	14.821	0.000
5	80.571	80.571	0.000

-32.629 -32.629

POOLED CHORD DISTANCES FILE: VOLUME c:\qb45\works

FILE prodtab 3

0.000 1.680

0.000

3.4.4 Program DISC

p1: Discriminant coefficients and scores are computed for two groups and an external vector. Each group is described by a mean vector and a covariance matrix, in different files. The covariance files are Arrangement 2.

The files for the mean vectors and external vector are Arrangement 3.
Canonical scores are stored on a file.

P2: MEA11821
16.167
23.5
3

MEA21821
9.5
36.167
9

EX1821X
10
30
10

COV11821
19.367 4.1 9.4
47.5 -9.8
8.8

COV21821
4.7 -10.5 -0.6
158.167 -20.4
8.0

P3: PROGRAM DISC

=====

GROUP 1 :
COVARIANCE FILE: cov11821
MEAN VECTOR FILE: mea11821, VOLUME c:\qb45\works
GROUP 2 :
COVARIANCE FILE: cov21821
MEAN VECTOR FILE: mea21821, VOLUME c:\qb45\works
GROUP SIZES ARE: 6 6
EXTERNAL VECTOR FILE: ex1821x
MISCLASSIFICATION COSTS ARE: 1 1
NUMBER OF VARIABLES: 3

DISCRIMINANT COEFFICIENTS:

1.1943 -0.3842 -2.0305

DISCRIMINANT SCORES:

EXTERNAL VECTOR -- 0.9358
1ST GROUP CENTROID -- 25.0114
2ND GROUP CENTROID -- 0.0000

DISCRIMINANT DISTANCES:

EXTERNAL VECTOR/1ST GROUP CENTROID -- 24.0756
EXTERNAL VECTOR/2ND GROUP CENTROID -- 0.9358

ASSIGNMENT BASED ONLY ON DISTANCE:GROUP 2
ASSIGNMENT CONSIDERING DISTANCE, GROUP SIZE AND MISCLASSIFICATION COST:
Q = -11.5699
Empirical proportions are used!
L = 0.0000

3.4.5 Program EMVO

P1: The hypothesis that given group mean vectors have common expectation is tested under different options. Several groups (k) and several variables (s) are permitted. The relation $s < k < n_{\min}$ must hold true. In this n_{\min} is the size of the smallest group. Unequal replicate numbers are permitted. Users specify a critical Theta-value (from Heck's charts) at selected probability (alpha) and constants (s, m, n) determined by the program. The options include:

1. Multivariate analysis of variance.
2. Canonical group analysis.
3. Profile analysis.

Canonical scores (Option 2) are stored on disk file under user specified name. All other information are stored on the PRINTDA file. Data entry is by relevé-by-groups (Arrangement 1), all groups stored within same disk file.

P2: ex1151r A,B,C,D are labels for peat bogs (treatments). Cover estimates of 3 species (*Sarracenia purpurea* X_1 , *Drosera rotundifolia* (X_2 , *Laedum groenlandicum* X_3) are given within 15 randomly sited plots (replicates).

Group Plot	A			B			C			D		
	X_1	X_2	X_3	X_1	X_2	X_3	X_1	X_2	X_3	X_1	X_2	X_3
1	16	11	21	18	27	13	43	14	5	36	14	3
2	15	12	18	19	34	14	38	17	4	39	12	9
3	18	9	34	23	32	11	37	18	7	39	17	8

4	12	17	27	19	36	10	39	12	7	45	16	4
5	18	15	20	25	31	14	44	14	4	40	14	3
6	9	9	23	24	29	12	40	13	3	40	11	5
7	15	17	24	22	35	9	42	11	6	38	12	4
8	9	16	21	27	30	15	40	13	7			
9	16	18	27	25	34	10						
10	18	9	29	19	32	11						
11	17	16	19	18	32	14						
12	13	12	30	26	35	12						
13	16	9	23	25	31	10						
14	15	17	26	26	34	9						
15	14	10	27	26	34	11						

To assist data entry, the user should compare the following data string to the table above:

```

16
11
21
15
12
18
. . .
14
10
27
18
27
13
...
38
12
4

```

P4a: PROGRAM EMVO

```

=====
OPTION 1-EMVO (COMPARE K MEAN VECTORS)
DATA FILE:ex1151r, VOLUME c:\qb45\works
NUMBER OF VARIABLES: 3
NUMBER OF GROUPS: 4
GROUP SIZES: 15 15 8 7
MEAN VECTOR, GROUP 1

```

```

-----
14.733 13.133 24.600

```

```

MEAN VECTOR, GROUP 2

```

```

-----
22.800 32.400 11.667

```

```

MEAN VECTOR, GROUP 3

```

```

-----
40.375 14.000 5.375

```

```

MEAN VECTOR, GROUP 4

```

```

-----
39.571 13.714 5.143

```

MEAN VECTOR, ALL GROUPS

 25.844 19.800 13.844

MEAN VECTOR, GROUPS

 17.489 22.289 19.917 19.476

GRAND MEAN = 19.830

H MATRIX

 4998.9893 -723.2770 -3513.7930
 -723.2770 3576.4382 -723.4860
 -3513.7930 -723.4860 2910.2461

E MATRIX

 360.9219 -14.1230 0.7041
 -14.1230 330.7617 -87.9141
 0.7041 -87.9141 389.6650

INVERSE OF MATRIX E (INV(E))

 0.00278 0.00012 0.00002
 0.00012 0.00322 0.00073
 0.00002 0.00073 0.00273

H*INV(E) MATRIX

 13.7034 -4.2604 -10.0034
 -1.5784 10.9066 0.6069
 -9.7755 -0.6542 7.3387

EIGENVALUE 1 = 21.386814 (CUMULATIVE: 21.38681)
 EIGENVECTOR: 0.77617 -0.28027 -0.56481
 EIGENVALUE 2 = 10.554990 (CUMULATIVE: 31.94180)
 EIGENVECTOR: 0.10068 0.98679 -0.12691
 EIGENVALUE 3 = 0.00691 (CUMULATIVE: 31.94871)
 EIGENVECTOR: 0.57951 0.27258 0.76803

TEST FOR EQUALITY OF THE 4 MEAN VECTORS

 THETA = 0.95533 (S = 3.0, M = -0.5 AND N = 18.5)
 THETA (AT CHOSEN alpha) = 0.27000
 REJECT HO. MEAN VECTORS DO NOT HAVE A COMMON EXPECTATION.

SIMULTANEOUS LIMITS (ALL PAIRWISE, FOR EACH VARIABLE):

VARIABLE	GROUPS	LOWER/UPPER LIMITS
1	1 2	-12.2855 -3.8478
1	1 3	-30.6999 -20.5834
1	1 4	-30.1267 -19.5495
1	2 3	-22.6333 -12.5168
1	2 4	-22.0601 -11.4828
1	3 4	-5.1761 6.7833

2	1	2	-23.3054	-15.2279
2	1	3	-5.7090	3.9756
2	1	4	-5.6438	4.4819
2	2	3	13.5577	23.2423
2	2	4	13.6229	23.7486
2	3	4	-5.4387	6.0101
3	1	2	8.5497	17.3170
3	1	3	13.9692	24.4808
3	1	4	13.9620	24.9523
3	2	3	1.0359	11.5475
3	2	4	1.0286	12.0190
3	3	4	-5.9811	6.4454

CONTRAST COEFFICIENTS FOR MEAN VECTORS: 1 -1 0 0
DESIGN VECTOR FOR VARIABLES: 1 1 0
LOWER LIMIT = -33.053 UPPER LIMIT = -21.613

P4b. PROGRAM EMVO

=====

OPTION 2-CANONICAL GROUPS ANALYSIS

DATA FILE:ex1151r, VOLUME c:\qb45\works

NUMBER OF VARIABLES: 3

NUMBER OF GROUPS: 4

GROUP SIZES: 15 15 8 7

MEAN VECTOR, GROUP 1

14.733 13.133 24.600

MEAN VECTOR, GROUP 2

22.800 32.400 11.667

MEAN VECTOR, GROUP 3

40.375 14.000 5.375

MEAN VECTOR, GROUP 4

39.571 13.714 5.143

MEAN VECTOR, ALL GROUPS

25.844 19.800 13.844

MEAN VECTOR, GROUPS

17.489 22.289 19.917 19.476

GRAND MEAN = 19.830

H MATRIX

4998.9893 -723.2770 -3513.7930
-723.2770 3576.4382 -723.4860
-3513.7930 -723.4860 2910.2461

E MATRIX

```
-----
360.9219   -14.1230    0.7041
-14.1230   330.7617   -87.9141
 0.7041    -87.9141   389.6650
```

INVERSE OF MATRIX E (INV(E))

```
-----
0.00278    0.00012    0.00002
0.00012    0.00322    0.00073
0.00002    0.00073    0.00273
```

H*INV(E) MATRIX

```
-----
13.7034    -4.2604    -10.0034
-1.5784    10.9066    0.6069
-9.7755    -0.6542    7.3387
```

```
EIGENVALUE 1 = 21.386814 (CUMULATIVE: 21.38681)
EIGENVECTOR: 0.77617 -0.28027 -0.56481
EIGENVALUE 2 = 10.554990 (CUMULATIVE: 31.94180)
EIGENVECTOR: 0.10068 0.98679 -0.12691
EIGENVALUE 3 = 0.00691 (CUMULATIVE: 31.94871)
EIGENVECTOR: 0.57951 0.27258 0.76803
```

TEST FOR EQUALITY OF THE 4 MEAN VECTORS

```
-----
THETA = 0.95533 (S = 3.0, M = -0.5 AND N = 18.5)
THETA (AT CHOSEN alpha) = 0.27000
REJECT HO. MEAN VECTORS DO NOT HAVE A COMMON EXPECTATION.
```

SIMULTANEOUS LIMITS (ALL PAIRWISE, FOR EACH VARIABLE):

```
-----
VARIABLE  GROUPS  LOWER/UPPER LIMITS
-----
1      1  2  -12.2855  -3.8478
1      1  3  -30.6999  -20.5834
1      1  4  -30.1267  -19.5495
1      2  3  -22.6333  -12.5168
1      2  4  -22.0601  -11.4828
1      3  4   -5.1761   6.7833
2      1  2  -23.3054  -15.2279
2      1  3   -5.7090   3.9756
2      1  4   -5.6438   4.4819
2      2  3  13.5577  23.2423
2      2  4  13.6229  23.7486
2      3  4   -5.4387   6.0101
3      1  2   8.5497  17.3170
3      1  3  13.9692  24.4808
3      1  4  13.9620  24.9523
3      2  3   1.0359  11.5475
3      2  4   1.0286  12.0190
3      3  4  -5.9811   6.4454
```

CONTRAST COEFFICIENTS FOR MEAN VECTORS: 1 -1 0 0
 DESIGN VECTOR FOR VARIABLES: 1 1 0
 LOWER LIMIT = -33.053 UPPER LIMIT = -21.613

CANONICAL GROUP ANALYSIS:

 CANONICAL (DISCRIMINANT) SCORES, SET 1

-9.216	-8.578	-14.446	-17.391	-8.220
-15.218	-13.368	-16.051	-14.567	-11.622
-8.712	-16.908	-9.785	-14.498	-13.877
-7.630	-9.380	-4.021	-7.682	-3.882
-2.968	-4.508	-2.615	-2.464	-7.125
-9.596	-3.098	-1.623	-1.123	-2.253
19.937	15.780	13.029	16.263	21.278
19.018	19.436	16.759	15.633	15.133
14.297	21.493	18.738	18.449	17.181

GROUP CENTROID SCORES:
 -12.830 -4.664 17.687 17.275

CANONICAL (DISCRIMINANT) SCORES, SET 2

-10.583	-9.316	-14.005	-5.827	-6.308
-13.515	-5.144	-6.354	-4.437	-13.371
-5.295	-11.041	-12.810	-5.398	-12.533
6.422	13.304	12.113	15.785	10.947
9.127	15.227	10.035	14.415	11.711
11.229	15.249	11.455	14.643	14.389
-2.874	-0.290	0.216	-5.504	-2.646
-3.909	-6.062	-4.416	-3.325	-5.758
-0.697	-0.572	-2.922	-6.136	-5.224

GROUP CENTROID SCORES:
 -9.062 12.403 -3.186 -3.519

CANONICAL (DISCRIMINANT) SCORES, SET 3

-2.608	-5.219	7.990	1.318	-1.127
-5.674	0.752	-5.302	3.908	4.150
-2.202	2.838	-1.617	2.288	0.568
-3.232	0.024	-0.507	-2.503	2.683
0.022	-1.805	4.338	0.429	-2.826
-1.101	2.817	-0.389	0.240	1.776
1.568	-1.280	0.717	0.241	1.380
-1.979	0.939	1.093	-4.025	1.777
2.372	2.504	-1.707	-0.988	-2.643

GROUP CENTROID SCORES:
 0.004 -0.002 0.335 -0.387

DISCRIMINANT SCORES IN FILE scores VOLUME c:\qb45\works

P4c. PROGRAM EMVO

=====

OPTION 3-PROFIL ANALYSIS

DATA FILE:ex1151r, VOLUME c:\qb45\works
 NUMBER OF VARIABLES: 3
 NUMBER OF GROUPS: 4
 GROUP SIZES: 15 15 8 7
 MEAN VECTOR, GROUP 1

 14.733 13.133 24.600

MEAN VECTOR, GROUP 2

 22.800 32.400 11.667

MEAN VECTOR, GROUP 3

 40.375 14.000 5.375

MEAN VECTOR, GROUP 4

 39.571 13.714 5.143

MEAN VECTOR, ALL GROUPS

 25.844 19.800 13.844

MEAN VECTOR, GROUPS

 17.489 22.289 19.917 19.476

GRAND MEAN = 19.830

H MATRIX

 10021.97897 -1509.40754 -2790.30675
 -1509.40754 7933.65516 -3633.73135
 -2790.30675 -3633.73135 2910.24563

E MATRIX

 719.93214 -433.50357 88.61786
 -433.50357 896.25595 -477.57976
 88.61786 -477.57976 389.66548

INVERSE OF MATRIX E (INV(E))

 .00278 .00290 .00292
 .00290 .00625 .00700
 .00292 .00700 .01048

H*INV(E) MATRIX

 15.28171 .11469 -10.49559
 8.19715 19.75797 13.02620
 -9.77549 -10.42968 -3.09106

EIGENVALUE 1 = 21.38676 (CUMULATIVE: 21.38676)
 EIGENVECTOR: .84035 .53689 -.07461
 EIGENVALUE 2 = 10.55594 (CUMULATIVE: 31.94270)
 EIGENVECTOR: -.06922 -.74769 -.66043

EIGENVALUE 3 = .00592 (CUMULATIVE: 31.94862)
EIGENVECTOR: .30183 .44379 .84377
TEST FOR EQUALITY OF THE 4 PROFILES

THETA = .955 (S = 2.0, M = .0 AND N = 19.0)
THETA (AT CHOSEN alpha) = .27
REJECT HO: PROFILES ARE NOT PARALLEL

TEST FOR THE EQUALITY OF GROUP EFFECTS
SUM OF SQUARES AMONG = 1564.56349
SUM OF SQUARES WITHIN = 878.68095
F = 24.335
(NUMERATOR DEGREES OF FREEDOM: 3 , DENOMINATOR DEGREES OF FREEDOM: 41)

3.4.6 Program FANOVA

P1: Factorial Model I ANOVA is performed. Complete randomised and randomised block designs are available as options. The program can handle up to 4 factors. A constant number of replicates is assumed in each factor combination. The replicates are entered by factor combination (Arrangement 1). For example, given 2 factors A, B with 2 and 3 levels respectively, the treatment combinations are:

(A1B1)
(A1B2)
(A1B3)
(A2B1)
(A2B2)
(A2B3)

P2: ex11342 Replicates within treatment combinations, pre-entry data:
A1B1 40 36 38 38
A1B2 32 34 35 35
A1B3 32 31 33 36
A2B1 35 33 32 36
A2B2 38 40 42 40
A3B3 44 42 44 42

P3: PROGRAM FANOVA

=====
INPUT (RAW DATA) FILE: ex11342, VOLUME c:\qb45\works
NUMBER OF FACTORS: 2
NUMBER OF TREATMENTS: 6

NUMBER OF REPLICATES PER TREATMENT COMBINATION: 4
 OPTION: COMPLETE RANDOMIZED DESIGN.

BARTLETT'S TEST (EQUALITY OF EXPECTED VARIANCES)

 CHI-SQUARE = 1.212
 (DEGREES OF FREEDOM = 5)

MEANS FOR MAIN EFFECTS AND FIRST ORDER INTERACTIONS

 LEVEL MEAN

 -> GRAND MEAN = 37.000
 FACTOR A
 1 35.000
 2 39.000
 FACTOR B
 1 36.000
 2 37.000
 3 38.000

ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
TREATMENT				
A	96.000	1	96.000	34.560
B	16.000	2	8.000	2.880
AB	208.000	2	104.000	37.440
ERROR	50.000	18	2.778	

TOTAL	370.000	23		

SCHEFFE'S MULTIPLE COMPARISONS (ALL MAIN EFFECTS, PAIRWISE)

COMPARISON	Q	F
=== FACTOR 1		
(NUMERATOR DEGREES OF FREEDOM: 1)		
(DENOMINATOR DEGREES OF FREEDOM: 18)		
1 2	5.879	34.560
=== FACTOR 2		
(NUMERATOR DEGREES OF FREEDOM: 2)		
(DENOMINATOR DEGREES OF FREEDOM: 18)		
1 2	1.200	0.720
1 3	2.400	2.880
2 3	1.200	0.720

3.4.7 Program LIMITS

p1: The equality of the expectation of a sample mean vector and a standard vector is tested. Two input data files are required:

1. Arrangement 1 file for sample data entered by variable.

2. Arrangement 3 file for standard vector.

Confidence limits are determined for the variables. Users must be prepared to specify a critical F-value for the degrees of freedom determined by the program.

P2: ex1041 Chemical analysis of soil samples from a field yielded the following data (in kg/ha units):

Sampling unit	1	2	3	4	5	6	7	8	9	10
Nitrate N	7.5	10.9	10.8	12.2	5.0	6.0	3.0	6.0	12.9	4.0
Ammoniacal N	20.1	20.4	17.9	18.0	15.4	12.1	21.0	16.1	13.8	18.0
Elementary K	42.0	43.2	40.4	84.3	69.5	99.8	110.4	101.4	87.7	115.2

EX 1041X

7 .92
17 .28
79 .39

P3: PROGRAM LIMITS

=====

DATA FILE: ex1041n, VOLUME: c:\qb45\works
NUMBER OF VARIABLES: 3
NUMBER OF OBSERVATIONS PER VARIABLE: 10
POPULATION MEANS FILE: ex1041x

SAMPLE MEANS:

7.9200 17.2800 79.3900

SAMPLE COVARIANCE MATRIX

12.5218	-1.0784	-52.3609
-1.0784	8.5351	-26.6524
-52.3609	-26.6524	840.4343

POPULATION MEAN VECTOR

7.0000 0.9200 17.0000

INVERSE OF SAMPLE COVARIANCE MATRIX:

0.120714	0.042995	0.008884
0.042995	0.145355	0.007288
0.008884	0.007288	0.001975

TEST FOR EQUALITY OF MEAN VECTORS:

GENERALIZED DISTANCE = 7.9928

T = 25.2754

F = 165.6267

H0 REJECTED. SAMPLE AND POP'N MEAN VECTORS DO NOT HAVE SAME EXPECTATION.

CONFIDENCE LIMITS FOR THE SAMPLE MEANS:

VARIABLE	CONTRAST, ERROR	LOWER, UPPER LIMITS
1	0.9200 4.5836	-3.6636 5.5036
2	16.3600 3.7843	12.5757 20.1443
3	62.3900 37.5517	24.8383 99.9417

3.4.8 Program TESTCOV1

P1: The hypothesis that a given standard square symmetric matrix is the expectation of a given sample covariance matrix is tested. Two data files are required, the sample covariance and the standard matrix, both Arrangement 2. Users need to know the sample size based on which the sample covariance matrix is computed.

P2: cov1041

$$\mathbf{s} = \begin{bmatrix} 12.5218 & -1.07844 & -52.3609 \\ -1.07844 & 8.53511 & -26.6524 \\ -52.3609 & -26.6524 & 840.4343 \end{bmatrix}$$

cov1051p

$$\mathbf{v}_o = \begin{bmatrix} 10.3014 & -1.36403 & -60.3333 \\ -1.36403 & 9.17830 & -22.4160 \\ -60.3333 & -22.4160 & 830.445 \end{bmatrix}$$

P3: PROGRAM TESTCOV1

=====
POPULATION COVARIANCE MATRIX FILE: cov1051p, VOLUME c:\qb45\works
SAMPLE COVARIANCE MATRIX FILE: cov1041, VOLUME c:\qb45\works
NUMBER OF VARIABLES (ORDER OF cov1041): 3
SAMPLE SIZE: 10

POPULATION COVARIANCE MATRIX (V)

10.3014 -1.3640 -60.3333
-1.3640 9.1783 -22.4160
-60.3333 -22.4160 830.4450

INVERSE OF POPULATION COVARIANCE MATRIX (INV(V))

0.2052 0.0716 0.0168
0.0716 0.1416 0.0090
0.0168 0.0090 0.0027

SAMPLE COVARIANCE MATRIX (S)

```
-----
12.5218   -1.0784  -52.3609
-1.0784    8.5351  -26.6524
-52.3609  -26.6524  840.4341
```

TEST FOR EQUALITY OF POP'N AND SAMPLE COVARIANCE MATRICES

```
-----
DETERMINANT OF SAMPLE COVARIANCE MATRIX (S) = 53538.43750
DETERMINANT OF POP'N COVARIANCE MATRIX (V) = 34697.19141
TRACE OF MATRIX PRODUCT S*(INV(V)) :      3.62414
CHI-SQUARE = 1.71356
CORRECTED CHI-SQUARE (FOR SMALL SAMPLE SIZES) = 1.507
(DEGREES OF FREEDOM = 6)
```

3.4.9 Program TESTCOV2

P1: The equality of the expectations of two or more sample covariance matrices is tested. Data entry is by relev -by-group (see Section 3.4.5). The file type is Arrangement 1.

P2: EX 1351r

P3: PROGRAM TESTCOV/2

```
=====
DATA FILE: ex1151r, VOLUME c:\qb45\works
NUMBER OF VARIABLES: 3
NUMBER OBSERVATIONS PER VARIABLE: 45
NUMBER OF GROUPS: 4
GROUP SIZES: 15 15 8 7
```

COVARIANCE MATRIX, GROUP 1

```
-----
8.495   -0.962   1.743
-0.962  12.410  -3.800
1.743   -3.800  20.257
```

INVERSE OF COVARIANCE MATRIX, GROUP 1

```
-----
0.120   0.007  -0.009
0.007   0.086   0.016
-0.009  0.016   0.053
```

DETERMINANT 1 = 1969.178

COVARIANCE MATRIX, GROUP 2

```
-----
11.029   0.657  -0.929
0.657    6.257  -2.429
-0.929  -2.429   3.810
```

INVERSE OF COVARIANCE MATRIX, GROUP 2

0.093	-0.001	0.022
-0.001	0.212	0.135
0.022	0.135	0.354

DETERMINANT 2 = 193.7626

COVARIANCE MATRIX, GROUP 3

5.982	-3.143	-1.304
-3.143	5.714	-0.286
-1.304	-0.286	2.554

INVERSE OF COVARIANCE MATRIX, GROUP 3

0.293	0.170	0.169
0.170	0.274	0.117
0.169	0.117	0.491

DETERMINANT 3 = 49.5277

COVARIANCE MATRIX, GROUP 4

7.619	2.024	-0.262
2.024	4.905	0.214
-0.262	0.214	5.810

INVERSE OF COVARIANCE MATRIX, GROUP 4

0.148	-0.061	0.009
-0.061	0.230	-0.011
0.009	-0.011	0.173

DETERMINANT 4 = 192.3915

POOLED COVARIANCE MATRIX

8.803	-0.344	0.017
-0.344	8.067	-2.144
0.017	-2.144	9.504

INVERSE OF POOLED COVARIANCE MATRIX

0.114	0.005	0.001
0.005	0.132	0.030
0.001	0.030	0.112

DETERMINANT 5 = 633.3682

TEST FOR EQUALITY OF THE 4 COVARIANCE MATRICES

CHI-SQUARE = 21.720
(B = 25.69015 AND 1/C = .8454478)
DEGREES OF FREEDOM = 18

3.5 Importance *a posteriori*

3.5.1 Program WEIGHINF

P1: Variables are given weights based on logarithmic expressions of entropy and information. The exact form of the weight function depends on the option. The data elements represent diagnostic categories coded as numerals. The data entry is by variable and storage is in an Arrangement 1 file. Sample size (the number of observations per variable) is assumed to be very large.

P2: ex1441 Sequence of arrival was recorded for the same five species of ruminants at a watering hole on 80 different occasions. The following are the records:

Species	Arrival sequences
A	2442132214522222133423224122113212522224 3255342231345212441524422252212241434544
B	1533451125333355425332141411422321113333 5322251352553443552233133131123414551215
C	532132555321511135221533533335553231152 2544533125232331335412511523351353325453
D	3214213332151533241154552255234135354511 1133425513121525223351255315535522212322
E	4155544441444444514541413544541444445445 4411114444414154114145344444444135143131

P3:

PROGRAM WEIGHINF

```
=====
DATA FILE: ex1441, VOLUME c:\qb45\works
NUMBER OF VARIABLES: 5
NUMBER OF OBJECTS: 80
WEIGHTING OPTION: INTERACTION INFORMATION
```

VARIABLE 1

```
-----
STATES:      2      4      1      3      5
FREQUENCY:   33     17     12     10     8
```

VARIABLE 2

```
-----
STATES:      1      5      3      4      2
```

FREQUENCY: 18 16 23 9 14

VARIABLE 3

STATES: 5 3 2 1 4
FREQUENCY: 23 25 14 14 4

VARIABLE 4

STATES: 3 2 1 4 5
FREQUENCY: 17 19 17 6 21

VARIABLE 5

STATES: 4 1 5 3
FREQUENCY: 44 19 12 5

JOINT FREQUENCIES

VECTOR 1 : 2 1 5 3 4 FREQUENCY = 4
VECTOR 2 : 4 5 3 2 1 FREQUENCY = 8
VECTOR 3 : 4 3 2 1 5 FREQUENCY = 4
VECTOR 4 : 2 3 1 4 5 FREQUENCY = 2
VECTOR 5 : 1 4 3 2 5 FREQUENCY = 6
VECTOR 6 : 3 5 2 1 4 FREQUENCY = 6
VECTOR 7 : 1 2 5 3 4 FREQUENCY = 6
VECTOR 8 : 5 3 2 1 4 FREQUENCY = 3
VECTOR 9 : 2 3 1 5 4 FREQUENCY = 10
VECTOR 10 : 2 3 5 1 4 FREQUENCY = 4
VECTOR 11 : 2 5 1 3 4 FREQUENCY = 2
VECTOR 12 : 3 2 5 4 1 FREQUENCY = 4
VECTOR 13 : 2 1 3 5 4 FREQUENCY = 8
VECTOR 14 : 2 4 3 5 1 FREQUENCY = 3
VECTOR 15 : 4 1 5 2 3 FREQUENCY = 5
VECTOR 16 : 5 1 2 3 4 FREQUENCY = 1
VECTOR 17 : 5 2 4 3 1 FREQUENCY = 4

SET CONTAINS 5 VARIABLE(S). INFORMATION QUANTITIES:

- 1. JOINT INFORMATION = 409.047
2. MUTUAL INFORMATION = 358.378
3. EQUIVOCATION INFORMATION = 50.670
4. MULTIPLE OF ENTROPY = 575.254
5. MULTIPLE OF JOINT ENTROPY = 216.876

VARIABLE 2 HAS RANK 1 (INTERACTION INFORMATION = 125.336)

JOINT FREQUENCIES

VECTOR 1 : 2 5 3 4 FREQUENCY = 4
VECTOR 2 : 4 3 2 1 FREQUENCY = 8
VECTOR 3 : 4 2 1 5 FREQUENCY = 4
VECTOR 4 : 2 1 4 5 FREQUENCY = 2
VECTOR 5 : 1 3 2 5 FREQUENCY = 6
VECTOR 6 : 3 2 1 4 FREQUENCY = 6
VECTOR 7 : 1 5 3 4 FREQUENCY = 6
VECTOR 8 : 5 2 1 4 FREQUENCY = 3

VECTOR 9 : 2 1 5 4 FREQUENCY = 10
 VECTOR 10 : 2 5 1 4 FREQUENCY = 4
 VECTOR 11 : 2 1 3 4 FREQUENCY = 2
 VECTOR 12 : 3 5 4 1 FREQUENCY = 4
 VECTOR 13 : 2 3 5 4 FREQUENCY = 8
 VECTOR 14 : 2 3 5 1 FREQUENCY = 3
 VECTOR 15 : 4 5 2 3 FREQUENCY = 5
 VECTOR 16 : 5 2 3 4 FREQUENCY = 1
 VECTOR 17 : 5 4 3 1 FREQUENCY = 4

SET CONTAINS 4 VARIABLE(S). INFORMATION QUANTITIES:

-
1. JOINT INFORMATION = 280.292
 2. MUTUAL INFORMATION = 233.042
 3. EQUIVOCATION INFORMATION = 47.251
 4. MULTIPLE OF ENTROPY = 449.918
 5. MULTIPLE OF JOINT ENTROPY = 216.876

VARIABLE 4 HAS RANK 2 (INTERACTION INFORMATION = 110.402)

JOINT FREQUENCIES

VECTOR 1 : 2 5 4 FREQUENCY = 8
 VECTOR 2 : 4 3 1 FREQUENCY = 8
 VECTOR 3 : 4 2 5 FREQUENCY = 4
 VECTOR 4 : 2 1 5 FREQUENCY = 2
 VECTOR 5 : 1 3 5 FREQUENCY = 6
 VECTOR 6 : 3 2 4 FREQUENCY = 6
 VECTOR 7 : 1 5 4 FREQUENCY = 6
 VECTOR 8 : 5 2 4 FREQUENCY = 4
 VECTOR 9 : 2 1 4 FREQUENCY = 12
 VECTOR 10 : 3 5 1 FREQUENCY = 4
 VECTOR 11 : 2 3 4 FREQUENCY = 8
 VECTOR 12 : 2 3 1 FREQUENCY = 3
 VECTOR 13 : 4 5 3 FREQUENCY = 5
 VECTOR 14 : 5 4 1 FREQUENCY = 4

SET CONTAINS 3 VARIABLE(S). INFORMATION QUANTITIES:

-
1. JOINT INFORMATION = 164.739
 2. MUTUAL INFORMATION = 122.640
 3. EQUIVOCATION INFORMATION = 42.099
 4. MULTIPLE OF ENTROPY = 326.315
 5. MULTIPLE OF JOINT ENTROPY = 203.675

VARIABLE 1 HAS RANK 3 (INTERACTION INFORMATION = 94.796)

JOINT FREQUENCIES

VECTOR 1 : 5 4 FREQUENCY = 14
 VECTOR 2 : 3 1 FREQUENCY = 11
 VECTOR 3 : 2 5 FREQUENCY = 4
 VECTOR 4 : 1 5 FREQUENCY = 2
 VECTOR 5 : 3 5 FREQUENCY = 6
 VECTOR 6 : 2 4 FREQUENCY = 10
 VECTOR 7 : 1 4 FREQUENCY = 12
 VECTOR 8 : 5 1 FREQUENCY = 4
 VECTOR 9 : 3 4 FREQUENCY = 8
 VECTOR 10 : 5 3 FREQUENCY = 5

VECTOR 11 : 4 1 FREQUENCY = 4

SET CONTAINS 2 VARIABLE(S). INFORMATION QUANTITIES:

1. JOINT INFORMATION = 58.720
2. MUTUAL INFORMATION = 27.844
3. EQUIVOCATION INFORMATION = 30.876
4. MULTIPLE OF ENTROPY = 208.782
5. MULTIPLE OF JOINT ENTROPY = 180.939
VARIABLE 3 HAS RANK 4 (INTERACTION INFORMATION = 27.844)

JOINT FREQUENCIES

VECTOR 1 : 4 FREQUENCY = 44
VECTOR 2 : 1 FREQUENCY = 19
VECTOR 3 : 5 FREQUENCY = 12
VECTOR 4 : 3 FREQUENCY = 5

SET CONTAINS 1 VARIABLE(S). INFORMATION QUANTITIES:

1. JOINT INFORMATION = 20.656
2. MUTUAL INFORMATION = 0.000
3. EQUIVOCATION INFORMATION = 20.656
4. MULTIPLE OF ENTROPY = 90.247
5. MULTIPLE OF JOINT ENTROPY = 90.247
VARIABLE 5 HAS RANK 5

3.5.2 Program WEIGHSCP

P1: Variables are given weights according to sum of squares, cross products, multiple correlation, or specific variance depending on the option chosen. Input is from an Arrangement 2 disk file of the covariance or cross product matrix.

P2: cov1411 (created in program CORRELATION from data in EX41221)

19.66667 13.83333 -1.499998
16 -5.166667
5.571427

P3: PROGRAM WEIGHSCP

=====

PRODUCTS FILE: cov1411, VOLUME c:\qb45\works
WEIGHTS FILE: weights, VOLUME c:\qb45\works
NUMBER OF VARIABLES: 3
WEIGHTING OPTION: MULTIPLE CORRELATION

PRODUCTS MATRIX

19.667 13.833 -1.500
13.833 16.000 -5.167
-1.500 -5.167 5.571

SUMMARY
 VARIABLE RANK MULTIPLE CORRELATION

VARIABLE	RANK	MULTIPLE CORRELATION
1	2	0.293
2	1	0.802
3	3	0.000

3.6 Cluster recognition

3.6.1 Program ALC

P1: Average Link Clustering is performed on a similarity matrix. Similarity values are expected in the 0 and 1 range. The data file is Arrangement 2. The cluster descriptors are stored on file for input in program TREE which draws the dendrogram on screen.

P2: cos1722

```

1.000 0.472 0.156 0.242 0.315 0.000
      1.000 0.896 0.970 0.618 0.342
            1.000 0.941 0.289 0.060
                  1.000 0.595 0.379
                        1.000 0.931
                              1.000
  
```

The cos1722 matrix is created by program CORRELATION using data file EX1721. The raw data are in:

<i>Environmental sensitivity class</i>	<i>Percent of sites in ecogroup</i>					
	1	2	3	4	5	6
<i>Low</i>	0	50	82	59	13	0
<i>Medium</i>	100	29	13	16	22	0
<i>High</i>	0	21	5	25	65	100

P3:

PROGRAM ALC

=====

SIMILARITIES FILE: cos1722, VOLUME c:\qb45\works
 NUMBER OF INDIVIDUALS: 6

CLUSTERING PASS # 1

NUMBER OF OBJECTS IN FUSION GROUP: 2
 AVERAGE SIMILARITY: 0.970
 OBJECTS:

2 4

CLUSTERING PASS # 2

NUMBER OF OBJECTS IN FUSION GROUP: 2
AVERAGE SIMILARITY: 0.931
OBJECTS:
5 6

CLUSTERING PASS # 3

NUMBER OF OBJECTS IN FUSION GROUP: 3
AVERAGE SIMILARITY: 0.926
OBJECTS:
2 4 3

CLUSTERING PASS # 4

NUMBER OF OBJECTS IN FUSION GROUP: 5
AVERAGE SIMILARITY: 0.419
OBJECTS:
2 4 3 5 6

CLUSTERING PASS # 5

NUMBER OF OBJECTS IN FUSION GROUP: 6
AVERAGE SIMILARITY: 0.396
OBJECTS:
1 2 4 3 5 6

DENDROGRAM DATA STORED IN FILE den1722, VOLUME c:\qb45\works

3.6.2 Program SLC

P1: Single Link Clustering is performed on distances or similarity values input from an Arrangement 2 file. Dendrogram data are stored in the TREE file for input in program TREE which draws the dendrogram on screen.

P2: dist1711 (generated from data in ex4221)

0.000	5.831	6.557	7.681	4.243	13.784	15.556
	0.000	1.000	2.236	6.481	9.274	11.225
		0.000	2.000	7.280	9.434	11.358
			0.000	8.544	8.062	10.630
				0.000	12.728	13.342
					0.000	4.472
						0.000

P3: PROGRAM SLC

=====
SIMILARITY (OR DISTANCE) FILE:dist1711, VOLUME c:\qb45\works
DENDROGRAM DATA IN FILE: tree1711, VOLUME c:\qb45\works
ORDER OF DENDROGRAM: 7
INPUT MATRIX OPTION: DISTANCES

```
CLUSTERING PASS 1
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
DISTANCE AT FUSION:      1.000
INDIVIDUALS: 2 3
```

```
CLUSTERING PASS 2
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 3
DISTANCE AT FUSION:      2.000
INDIVIDUALS: 2 3 4
```

```
CLUSTERING PASS 3
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
DISTANCE AT FUSION:      4.243
INDIVIDUALS: 1 5
```

```
CLUSTERING PASS 4
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
DISTANCE AT FUSION:      4.472
INDIVIDUALS: 6 7
```

```
CLUSTERING PASS 5
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 5
DISTANCE AT FUSION:      5.831
INDIVIDUALS: 2 3 4 1 5
```

```
CLUSTERING PASS 6
-----
NUMBER OF INDIVIDUALS IN FUSION GROUP: 7
DISTANCE AT FUSION:      8.062
INDIVIDUALS: 2 3 4 1 5 6 7
```

RUN PROGRAM TREE, USING FILE tree1711, VOLUME c:\qb45\works TO PLOT THE DENDROGRAM.

3.6.3 Program SSA

P1: Sum of squares clustering is performed on a distance matrix stored in an Arrangement 2 file. Dendrogram data are stored in the TREE file.

P2: DIST1711 (see listing in Section 3.6.2)

P3:

PROGRAM SSA

=====

DISTANCES FILE: dist1711, VOLUME c:\qb45\works

NUMBER OF OBJECTS: 7

CLUSTERING PASS 1

NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
FUSION SUM OF SQUARES: 0.500
INDIVIDUALS: 2 3

CLUSTERING PASS 2

NUMBER OF INDIVIDUALS IN FUSION GROUP: 3
FUSION SUM OF SQUARES: 3.333
INDIVIDUALS: 2 3 4

CLUSTERING PASS 3

NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
FUSION SUM OF SQUARES: 9.000
INDIVIDUALS: 1 5

CLUSTERING PASS 4

NUMBER OF INDIVIDUALS IN FUSION GROUP: 2
FUSION SUM OF SQUARES: 10.000
INDIVIDUALS: 6 7

CLUSTERING PASS 5

NUMBER OF INDIVIDUALS IN FUSION GROUP: 5
FUSION SUM OF SQUARES: 66.400
INDIVIDUALS: 1 5 2 3 4

CLUSTERING PASS 6

NUMBER OF INDIVIDUALS IN FUSION GROUP: 7
FUSION SUM OF SQUARES: 247.429
INDIVIDUALS: 1 5 2 3 4 6 7

DENDROGRAM DATA STORED IN FILE tree1731, VOLUME c:\qb45\works
RUN PROGRAM TREE TO PLOT THE DENDROGRAM!

3.6.4 Program TRGRPS

P1: A deterministic answer is supplied in answer of the proposition that a collection is divided into R groups along natural discontinuities. If R groups cannot be found, the quest continues for R-1 groups, R-2 groups, ... until a specified control condition is satisfied. The input data contains distance values from an Arrangement 2 file. Dendrogram data are stored on file.

P2: Input is DISTRAW4, a distance matrix whose elements are computed by METRICS from the 2 x 80 raw data matrix below. \mathbf{x}_1 and \mathbf{x}_2 are co-ordinate sets:

x_1	195	255	175	232	123	192	114	170	226	165
	212	221	278	257	319	334	373	332	368	380
	403	421	468	431	406	465	479	478	526	540

531	632	682	626	615	681	652	656	695	733
728	668	627	689	610	600	641	576	552	505
588	488	469	429	361	295	355	575	381	412
365	404	430	460	451	462	571	615	625	675
611	683	729	805	830	791	855	844	891	931
911	932	859	862	926					

X ₂	125	178	195	222	238	258	317	310	330	380
	392	448	421	491	481	534	507	583	555	595
	579	541	584	621	638	682	641	614	609	628
	679	668	655	612	595	597	569	521	529	574
	487	491	443	418	410	372	347	320	328	299
	269	258	189	209	142	129	208	641	342	379
	378	414	400	390	430	449	96	74	120	156
	179	213	261	260	270	331	345	401	380	440
	491	152	103	164	176					

```

P3: PROGRAM TRGRPS
DISTANCE FILE:dist4
ORDER OF DISTANCE MATRIX: 85
MINIMUM GROUP SIZE EXPECTED: 4
NUMBER OF GROUPS TO BE FORMED: 4
INITIAL NEIGHBOURHOOD RADIUS: 20.24846
RADIUS INCREMENT: .359
  4 GROUPS FORMED
MAXIMUM NEIGHBOURHOOD RADIUS= 76.25258
GROUP 1
  1  2  4  6  8  7
    9  56  3  10  11  12
    14  15  16  19  20  21
    22  18  17  23  27  28
    26  24  25  29  30  58
    31  32  33  34  35  36
    37  38  42  39  41  40
    13  43  45  46  47  48
    49  51  50  52  44  55
    57  5  53  54
GROUP 2
  59  61  60  63  62  64
    65  66
GROUP 3
  67  68  69  71  70  72
    73  74  75  76  77  79
    78  80  81
GROUP 4
  82  85  83  84
ELAPSED TIME= 244.7422 SECONDS

```

3.7 Trend seeking

3.7.1 Programs CONA, LATTICE, LATGRAPHS

p1: Canonical contingency table analysis is performed. The options include CONA proper, RECIPROCAL ORDERING, and CONA with two weighting options. Should the groups (row or column categories) have unequal sizes,

run program ADJUST before running CONA! Adjust takes the raw contingency scores from file and the block sizes, also from file, and computes the adjusted contingency table scores. The latter are stored on file for use by program CONA. The primary data file is Arrangement 1 and entry is by row with same considerations of data dimensions as under ADJUST. Separate files are created for Eigenvalues, canonical scores, and lattice information for input in program LATTICE, which generates tables of partitioned deviations, and in program PLOT or STEREO which generate 2-d and 3-d scattergrams. Run program LATGRAPHS after LATTICE to obtain screen plots of the deviations profiles. The user must be familiar with file names and data dimensions found in the PRINTDA file of CONA and LATTICE.

P2a: Program ADJUST

The first data file is ex1751f based:

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

The second data file is ex1751n is based on this

$$\begin{bmatrix} 140 & 200 & 110 \\ 126 & 180 & 99 \\ 98 & 140 & 77 \end{bmatrix}$$

P3a: PROGRAM ADJUST

```
=====
CONTINGENCY TABLE FILE:ex1751f, VOLUME c:\qb45\works
BLOCK SIZE FILE:ex1751n, VOLUME c:\qb45\works
NUMBER OF ROWS: 3
NUMBER OF COLUMNS: 3
```

ADJUSTED OCCUPANCY COUNTS:

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

ADJUSTED OCCUPANCY COUNTS STORED IN FILE ex1751a, VOLUME c:\qb45\works

P4b: PROGRAM CONA

=====
 CONTINGENCY TABLE FILE:ex1751a, VOLUME c:\qb45\works
 NUMBER OF ROWS: 3
 NUMBER OF COLUMNS: 3
 WEIGHTING OPTION: NO WEIGHTING (CONCENTRATION ANALYSIS PROPER).

ROW TOTALS

 88.882 87.604 171.514

COLUMN TOTALS

 92.525 119.963 135.512

GRAND TOTAL = 348.000

RELATIVE FREQUENCIES BY COLUMN

 COLUMN 1
 0.0187 0.7679 0.2135
 COLUMN 2
 0.0756 0.1176 0.8067
 COLUMN 3
 0.5762 0.0180 0.4058

RELATIVE FREQUENCIES BY ROW

 ROW 1
 0.0194 0.1021 0.8785
 ROW 2
 0.8110 0.1611 0.0279
 ROW 3
 0.1152 0.5643 0.3206

SCALAR PRODUCT MATRIX

 0.259 -0.210 -0.036
 -0.210 0.390 -0.128
 -0.036 -0.128 0.117

CANONICAL CORRELATIONS AND LEVELS OF INFLUENCE

 CAN VAR 1 R(X,Y) = 0.7490 LEVEL = 195.221 OR 73.20%
 (CUMULATIVE = 73.20)
 CAN VAR 2 R(X,Y) = 0.4531 LEVEL = 71.456 OR 26.80%
 (CUMULATIVE = 100.00)

TEST FOR COMPOSITIONAL HETEROGENEITY AMONG THE 9 BLOCKS

 CHI SQUARE = 266.677
 DEGREES OF FREEDOM = 4
 RANK = 2

ROW CANONICAL SCORES

 SET 1
 -1.080 1.626 -0.271
 SET 2
 -1.322 -0.572 0.978

COLUMN CANONICAL SCORES

```

-----
SET  1
    1.563      -0.145      -0.939
SET  2
   -0.564       1.371      -0.829

```

EIG ADJUSTED SCORES -- ROWES

```

-----
SET  1
   -0.4104     0.6180     -0.1030
SET  2
   -0.3442     -0.1489     0.2544

```

EIG ADJUSTED SCORES -- ROWES

```

-----
SET  1
    0.6401     -0.0596     -0.3843
SET  2
   -0.1503     0.3658     -0.2212

```

ROW CANONICAL SCORES ARE STORED IN FILE rows, VOLUME c:\qb45\works
COLUMN CANONICAL SCORES ARE STORED IN FILE cols, VOLUME c:\qb45\works
EIGENVALUES (SQUARED CANONICAL CORRELATIONS) ARE STORED IN FILE eig,
VOLUME c:\qb45\works
LATTICE INFORMATION IS STORED IN FILE lat, VOLUME c:\qb45\works
!!! NOTE: RUN PROGRAM LATTICE TO COMPLETE THE ANALYSIS !!!

P3c: PROGRAM LATTICE

=====

INPUT FILES ARE lat AND eig VOLUME c:\qb45\works

DEVIATIONS TABLES (LATTICES):

```

=== TABLE  1
   -29.883     3.606     26.277
    44.352    -5.352    -39.000
   -14.469     1.746     12.723

```

```

=== TABLE  2
    7.980    -25.173     17.193
    3.403    -10.734     7.331
   -11.382    35.906    -24.524

```

```

=== SUM OF ALL TABLES
   -21.904    -21.567     43.470
    47.755    -16.086    -31.669
   -25.851     37.652    -11.801

```

GRAPHS IN FILE: GRP.lat, VOLUME c:\qb45\works

P4d PROGRAM LATGRAPHS (graphs are drawn on screen).

LATTICE ROWS PLOTTED

DATA FILE: c:\qb45\works\grp.lat

NUMBER OF LATTICES: 2

NUMBER OF ROWS: 3

NUMBER OF COLUMNS: 3

3.7.2 Program EIGENAN

P1: Eigenvalues and Eigenvectors are computed for a square symmetric matrix. The data file is an Arrangement 2 half or full product matrix or distance matrix. If the input products matrix is a dual matrix, the elements in the Eigenvectors are component scores, identical to those computed in PCAR from the primary data.

P2: cov41221a (computed from ex41221 as a dual matrix in METRICS)

8.06	1.75	1.30	-0.03	5.85	-7.46	-9.46
	1.11	1.32	0.99	0.37	-2.27	-3.27
		1.70	1.37	-0.25	-2.22	-3.22
			1.70	-1.91	-0.22	-1.89
				6.63	-5.84	-4.84
					8.68	9.35
						13.35

P3: PROGRAM EIGENAN

=====

INPUT FILE:cov41221d, VOLUMEc:\qb45\works

ORDER OF cov41221d = 7

MATRIX

8.06	1.75	1.30	-0.03	5.85	-7.46	-9.46
1.75	1.11	1.32	0.99	0.37	-2.27	-3.27
1.30	1.32	1.70	1.37	-0.25	-2.22	-3.22
-0.03	0.99	1.37	1.70	-1.91	-0.22	-1.89
5.85	0.37	-0.25	-1.91	6.63	-5.84	-4.84
-7.46	-2.27	-2.22	-0.22	-5.84	8.68	9.35
-9.46	-3.27	-3.22	-1.89	-4.84	9.35	13.35

EIGEN UNDERWAY

VECTOR ADJUSTED BY OPTION: 2

EIGENVALUE 1 = 32.55746 OR 78.94995 % (CUM. 78.94994 %)

VECTOR:

2.7577 0.7788 0.7104 0.1696 1.9040 -2.8344 -3.4861

EIGENVALUE 2 = 7.235595 OR 17.5459 % (CUM. 96.49584 %)

VECTOR:

-0.3935 0.6653 0.9713 1.2943 -1.7275 0.1898 -0.9996

EIGENVALUE 3 = 1.445051 OR 3.504165 % (CUM. 100 %)

VECTOR:

-0.5489 0.2445 0.5058 -0.0137 0.1523 -0.7811 0.4411

EIGENVALUES IN FILE EIGEN eig, VOLUME c:\qb45\works

SCORES IN FILE SCORES\$; 0 ;NEV\$

RUN PROGRAM plot OR stereo FOR SCATTERGRAM.

JOB REQUIRED 41.57031 SECONDS

3.7.3 Program MDSCAL

P1: Metric co-ordinates are computed from proximity data. Two data files are involved: one holds the external sample distance matrix (Arrangement 2) and the other optionally an Arrangement 1 file of the co-ordinates of a fixed a priori configuration (entered by axes). If the a priori configuration option is not chosen, the starting configuration is an arbitrary set of random numbers generated in the program. The user must specify the dimensionality (t) of the final configuration. This should be an integer number one higher than the desired dimensionality. The final internal configuration co-ordinates are stored in the PRINTDA file and also stored in an Arrangement 1 file readable by other programs.

P2: Example 15.1.1 A mountain transect with 20 plots laid at 200 meter intervals. The number of trees per plot are recorded:

	<i>Low elevation</i>										<i>High elevation</i>									
<i>Plot</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Species</i> A	40	45	50	47	41	35	25	20	15	13	10	7	5	2	2	2	2	0	0	0
B	10	16	22	37	40	45	42	40	36	30	25	20	16	13	7	3	2	1	0	0
C	0	2	5	11	13	17	25	31	41	51	58	60	51	40	35	28	25	20	14	10
D	0	0	1	1	1	2	5	8	12	15	19	26	35	52	60	66	60	49	36	30

Program METRICS generates the distances dist1511.

P3:

PROGRAM MDSCAL

=====

EXTERNAL DISTANCES FILE:dist1511, VOLUME c:\qb45\works

ORDER OF DISTANCE MATRIX: 20

DIMENSIONALITY OF FINAL SOLUTION: 3

STARTING CONFIGURATION OPTION: 2

INTERNAL DISTANCE OPTION: 1

ITERATION 1

STRESS VALUE = 36.333771%

GRADIENT LENGTH: 0.347411

(OLD STRESS)-(LAST STRESS) = 6.744191%

ITERATION 2

STRESS VALUE = 29.589579%

GRADIENT LENGTH: 0.201572

(OLD STRESS)-(LAST STRESS) = 1.593375%

ITERATION 3

STRESS VALUE = 27.996202%
GRADIENT LENGTH: 0.078185

(OLD STRESS)-(LAST STRESS) = 0.499091%

ITERATION 4

STRESS VALUE = 27.497112%
GRADIENT LENGTH: 0.060756

(OLD STRESS)-(LAST STRESS) = 0.402439%

ITERATION 5

STRESS VALUE = 27.094673%
GRADIENT LENGTH: 0.103884

(OLD STRESS)-(LAST STRESS) = 0.849578%

ITERATION 6

STRESS VALUE = 26.245096%
GRADIENT LENGTH: 0.121797

(OLD STRESS)-(LAST STRESS) = 3.712784%

ITERATION 7

STRESS VALUE = 22.532312%
GRADIENT LENGTH: 0.451018

(OLD STRESS)-(LAST STRESS) = 6.041601%

ITERATION 8

STRESS VALUE = 16.490711%
GRADIENT LENGTH: 0.346979

(OLD STRESS)-(LAST STRESS) = 3.477190%

ITERATION 9

STRESS VALUE = 13.013521%
GRADIENT LENGTH: 0.536770

(OLD STRESS)-(LAST STRESS) = 3.802992%

ITERATION 10

STRESS VALUE = 9.210528%
GRADIENT LENGTH: 0.319669

(OLD STRESS)-(LAST STRESS) = 2.036245%

ITERATION 11

STRESS VALUE = 7.174283%
GRADIENT LENGTH: 0.499496

(OLD STRESS)-(LAST STRESS) = 1.597909%

ITERATION 12

STRESS VALUE = 5.576375%
GRADIENT LENGTH: 0.304920

(OLD STRESS)-(LAST STRESS) = 0.854067%

ITERATION 13

STRESS VALUE = 4.722308%
GRADIENT LENGTH: 0.436948

(OLD STRESS)-(LAST STRESS) = 0.784837%

ITERATION 14

STRESS VALUE = 3.937470%
GRADIENT LENGTH: 0.236364

(OLD STRESS)-(LAST STRESS) = 0.718650%

ITERATION 15

STRESS VALUE = 3.218821%
GRADIENT LENGTH: 0.468309

(OLD STRESS)-(LAST STRESS) = 0.523250%

ITERATION 16

STRESS VALUE = 2.695571%
GRADIENT LENGTH: 0.206461

(OLD STRESS)-(LAST STRESS) = 0.202114%

ITERATION 17

STRESS VALUE = 2.493457%
GRADIENT LENGTH: 0.205572

(OLD STRESS)-(LAST STRESS) = 0.162143%

ITERATION 18

STRESS VALUE = 2.331314%
GRADIENT LENGTH: 0.227226

(OLD STRESS)-(LAST STRESS) = 0.114450%

ITERATION 19

STRESS VALUE = 2.216864%

GRADIENT LENGTH: 0.138591

(OLD STRESS)-(LAST STRESS) = 0.294180%

ITERATION 20

STRESS VALUE = 1.922685%
GRADIENT LENGTH: 0.221464

(OLD STRESS)-(LAST STRESS) = 0.074666%

ITERATION 21

STRESS VALUE = 1.848019%
GRADIENT LENGTH: 0.114575

(OLD STRESS)-(LAST STRESS) = 0.040933%

ITERATION 22

STRESS VALUE = 1.807086%
GRADIENT LENGTH: 0.147486

(OLD STRESS)-(LAST STRESS) = 0.036017%

ITERATION 23

STRESS VALUE = 1.771068%
GRADIENT LENGTH: 0.081668

(OLD STRESS)-(LAST STRESS) = 0.167999%

ITERATION 24

STRESS VALUE = 1.603069%
GRADIENT LENGTH: 0.191050

(OLD STRESS)-(LAST STRESS) = 0.043851%

ITERATION 25

STRESS VALUE = 1.559218%
GRADIENT LENGTH: 0.061743

(OLD STRESS)-(LAST STRESS) = 0.039954%

ITERATION 26

STRESS VALUE = 1.519263%
GRADIENT LENGTH: 0.181556

(OLD STRESS)-(LAST STRESS) = 0.044082%

ITERATION 27

STRESS VALUE = 1.475181%
GRADIENT LENGTH: 0.064596

(OLD STRESS)-(LAST STRESS) = 0.015382%

ITERATION 28

STRESS VALUE = 1.459800%
GRADIENT LENGTH: 0.066939

(OLD STRESS)-(LAST STRESS) = 0.013900%

ITERATION 29

STRESS VALUE = 1.445900%
GRADIENT LENGTH: 0.071857

(OLD STRESS)-(LAST STRESS) = 0.012042%

ITERATION 30

STRESS VALUE = 1.433858%
GRADIENT LENGTH: 0.078011

(OLD STRESS)-(LAST STRESS) = 0.010880%

ITERATION 31

STRESS VALUE = 1.422977%
GRADIENT LENGTH: 0.083327

(OLD STRESS)-(LAST STRESS) = 0.010678%

ITERATION 32

STRESS VALUE = 1.412300%
GRADIENT LENGTH: 0.048254

(OLD STRESS)-(LAST STRESS) = 0.052972%

ITERATION 33

STRESS VALUE = 1.359328%
GRADIENT LENGTH: 0.255684

(OLD STRESS)-(LAST STRESS) = 0.066928%

ITERATION 34

STRESS VALUE = 1.292400%
GRADIENT LENGTH: 0.090925

(OLD STRESS)-(LAST STRESS) = 0.010963%

ITERATION 35

STRESS VALUE = 1.281436%
GRADIENT LENGTH: 0.044913

(OLD STRESS)-(LAST STRESS) = 0.010456%

ITERATION 36

STRESS VALUE = 1.270980%
GRADIENT LENGTH: 0.066790

(OLD STRESS)-(LAST STRESS) = 0.006473%

ITERATION 37

STRESS VALUE = 1.264507%
GRADIENT LENGTH: 0.047075

(OLD STRESS)-(LAST STRESS) = 0.004977%

ITERATION 38

STRESS VALUE = 1.259529%
GRADIENT LENGTH: 0.053875

(OLD STRESS)-(LAST STRESS) = 0.004601%

ITERATION 39

STRESS VALUE = 1.254929%
GRADIENT LENGTH: 0.055924

(OLD STRESS)-(LAST STRESS) = 0.004564%

ITERATION 40

STRESS VALUE = 1.250365%
GRADIENT LENGTH: 0.056033

(OLD STRESS)-(LAST STRESS) = 0.004509%

ITERATION 41

STRESS VALUE = 1.245856%
GRADIENT LENGTH: 0.056427

(OLD STRESS)-(LAST STRESS) = 0.004441%

ITERATION 42

STRESS VALUE = 1.241415%
GRADIENT LENGTH: 0.056539

(OLD STRESS)-(LAST STRESS) = 0.004456%

ITERATION 43

STRESS VALUE = 1.236958%
GRADIENT LENGTH: 0.056708

(OLD STRESS)-(LAST STRESS) = 0.004404%

ITERATION 44

STRESS VALUE = 1.232555%
GRADIENT LENGTH: 0.056967

(OLD STRESS)-(LAST STRESS) = 0.004450%

ITERATION 45

STRESS VALUE = 1.228105%
GRADIENT LENGTH: 0.057161

(OLD STRESS)-(LAST STRESS) = 0.004455%

ITERATION 46

STRESS VALUE = 1.223650%
GRADIENT LENGTH: 0.057441

(OLD STRESS)-(LAST STRESS) = 0.004521%

ITERATION 47

STRESS VALUE = 1.219130%
GRADIENT LENGTH: 0.057530

(OLD STRESS)-(LAST STRESS) = 0.004581%

ITERATION 48

STRESS VALUE = 1.214548%
GRADIENT LENGTH: 0.057786

(OLD STRESS)-(LAST STRESS) = 0.004646%

ITERATION 49

STRESS VALUE = 1.209903%
GRADIENT LENGTH: 0.057878

(OLD STRESS)-(LAST STRESS) = 0.004758%

ITERATION 50

STRESS VALUE = 1.205145%
GRADIENT LENGTH: 0.058001

(OLD STRESS)-(LAST STRESS) = 0.004843%

THE MAXIMUM NUMBER OF ITERATIONS HAS BEEN REACHED! LAST STRESS = 1.200302%

FINAL CONFIGURATION

AXIS 1

-0.1447	-0.1285	-0.0855	-0.1313	-0.1288	-0.0819
-0.0782	-0.0729	-0.0167	-0.0363	-0.0507	-0.0324

```

    0.0359    0.0824    0.1217    0.1540    0.1342    0.1465
    0.1608    0.1522
  AXIS  2
    -0.3221   -0.3051   -0.2791   -0.1974   -0.1868   -0.1687
    -0.0949   -0.0703   -0.0331    0.0321    0.0693    0.0922
    0.1082    0.1303    0.1589    0.1851    0.2145    0.2171
    0.2211    0.2286
  AXIS  3
    -0.1119   -0.0689   -0.0768   -0.0825   -0.0347   -0.0431
    -0.0562   -0.0066   -0.0027   -0.0355   -0.0053    0.0337
    -0.0023   0.0664    0.0634    0.0669    0.0733    0.0634
    0.0651    0.0943

```

FINAL CONFIGURATION SCORES STORED IN FILE scores VOLUME c:\qb45\works
 Elapsed time= 160.9297 seconds

3.7.4 Program PCAR

P1: Principal Components Analysis is performed on data entered by variable on an Arrangement 1 file. Component coefficients are computed for variables and component scores for relevés. The latter are stored in a separate Arrangement 1 file by components.

P2: ex41221 (given in Section 3.1.1).

P3: PROGRAM PCAR

```

=====
COORDINATE FILE:ex41221, VOLUME c:\qb45\works
NUMBER OF ROWS (VARIABLES): 3
NUMBER OF COLUMNS (INDIVIDUALS): 7
OPTION: VARIANCE,COVARIANCE

```

VARIANCE, COVARIANCE MATRIX

```

-----
    19.667    13.833    -1.500
    13.833    16.000    -5.167
    -1.500    -5.167     5.571

```

SUBROUTINE EIGEN: EIGENVECTORS ADJUSTED TO UNIT LENGTH.

```

-----
EIGENVALUE 1 =      32.5574 OR  78.95% (CUMULATIVE  78.95%)
EIGENVECTOR:   0.730  0.662 -0.167

```

```

EIGENVALUE 2 =       7.2356 OR  17.55% (CUMULATIVE  96.50%)
EIGENVECTOR:   0.531 -0.396  0.750

```

```

EIGENVALUE 3 =       1.4450 OR   3.50% (CUMULATIVE 100.00%)
EIGENVECTOR:  -0.430  0.636  0.640

```

COMPONENT SCORES:

```

-----
SET 1 :
```

```

-2.758    -0.779    -0.710    -0.170    -1.904    2.834
 3.486

SET 2 :
 0.394    -0.665    -0.971    -1.294    1.728    -0.190
 1.000

SET 3 :
 0.549    -0.244    -0.506    0.014    -0.152    0.781
-0.441

```

COMPONENT SCORES STORED IN TEXT FILE scores, VOLUME c:\qb45\works

3.7.5 Program REGRESSION

P1: Regression analysis is performed on one or more factor variables (X) and one response variable (Y). Option is available for polynomial regression. Two input files are required: the X file (Arrangement 1) and the Y file (Arrangement 3). Data entry in the X file is by variable. The user chooses the rejection probability (alpha) and corresponding F value for the degrees of freedom displayed on the screen by the program.

P2: ex1321x is file for X₁, X₂ and ex1321Y for Y.

Temperature X ₁ (°C)	Light level X ₂ (nE cm ⁻² sec ⁻¹)	Photosynthetic rate Y (mg CO ₂ cm ⁻² hr ⁻¹)
5	5	1
7	30	6
8	10	2
10	10	3
10	30	10
8	5	2

P4a: PROGRAM REGRESSION

```

=====
FILE X (INDEPENDENT VARIABLES): ex1321x, VOLUME c:\qb45\works
FILE Y (DEPENDENT VARIABLE): ex1321y, VOLUME c:\qb45\works
OPTION SELECTED: 1
NUMBER OF OBSERVATIONS: 6
T VALUE AT DF = 4 IS 2.776

```

ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
---------------------	----------------	------	-------------	---

REGRESSION	16.05556	1	16.05556	1.53113
RESIDUAL	41.94444	4	10.48611	
TOTAL	58.00000	5		

 COEFFICIENT OF DETERMINATION = 0.27682

REGRESSION COEFFICIENTS

 B(0) = -3.55556 B(1) = 0.94444

Y AND Y-HAT VALUES, AND RESIDUALS

Y	Y-HAT	RESIDUAL
1.00000	1.16667	0.16667
6.00000	3.05556	2.94444
2.00000	4.00000	2.00000
3.00000	5.88889	2.88889
10.00000	5.88889	4.11111
2.00000	4.00000	2.00000

LOWER AND UPPER CONFIDENCE LIMITS FOR B-VALUES

 B(0)
 B(1) -1.17436 3.06325

LOWER AND UPPER CONFIDENCE LIMITS, Y-HAT AND Y VALUES

Y-HAT	Y
-6.17308	12.60516
-1.18205	15.93806
0.33013	11.70957
0.28307	13.59401
0.28307	20.59401
0.33013	11.70957

P4b: PROGRAM REGRESSION

=====

FILE X (INDEPENDENT VARIABLES): ex1321x, VOLUME c:\qb45\works
 FILE Y (DEPENDENT VARIABLE): ex1321y, VOLUME c:\qb45\works
 OPTION SELECTED: 2
 NUMBER OF OBSERVATIONS: 6
 T VALUE AT DF = 3 IS 3.182

 X VARIABLE* MEAN VARIANCE

1	8.00000	3.60000
2	15.00000	140.00000

*IF OP=3 THEN X1=X AND X2=X^2

SSCP MATRIX- CORRECTED FOR MEANS

 18.00000 35.00000

35.00000 700.00000

INVERSE OF SSCP

0.06154 -0.00308
-0.00308 0.00158

ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	D.F.	MEAN SQUARE	F
REGRESSION	52.58901	2	26.29451	14.57839
RESIDUAL	5.41099	3	1.80366	
TOTAL	58.00000	5		

COEFFICIENT OF DETERMINATION = 0.90671

REGRESSION COEFFICIENTS

	VALUE	STANDARDIZED	T	VIF
B(0)	-3.42198			
B(1)	0.47692	0.26569	1.43152	1.10769
B(2)	0.24044	0.83530	4.50057	1.10769

Y AND Y-HAT VALUES, AND RESIDUALS

Y	Y-HAT	RESIDUAL
1.00000	0.16484	0.83516
6.00000	7.12967	1.12967
2.00000	2.79780	0.79780
3.00000	3.75165	0.75165
10.00000	8.56044	1.43956
2.00000	1.59560	0.40440

LOWER AND UPPER CONFIDENCE LIMITS FOR B-VALUES

B(0)		
B(1)	-0.58319	1.53703
B(2)	0.07044	0.41044

LOWER AND UPPER CONFIDENCE LIMITS, Y-HAT AND Y VALUES

Y-HAT	Y
-3.39558	3.72525
3.61463	10.64471
0.85714	4.73847
0.68810	6.81520
5.29398	11.82689
-0.84029	4.03150

P4c: PROGRAM REGRESSION

```

=====
FILE X (INDEPENDENT VARIABLES): ex1321x, VOLUME c:\qb45\works
FILE Y (DEPENDENT VARIABLE): ex1321y, VOLUME c:\qb45\works
OPTION SELECTED: 3
NUMBER OF OBSERVATIONS: 6
T VALUE AT DF = 3 IS 3.182

```

```

-----
X VARIABLE*  MEAN      VARIANCE
-----
1           8.00000    3.60000
2          67.00000   856.79999
*IF OP=3 THEN X1=X AND X2=X^2

```

```

SSCP MATRIX- CORRECTED FOR MEANS
-----
      18.00000    276.00000
      276.00000   4284.00000

```

```

INVERSE OF SSCP
-----
      4.57692    -0.29487
     -0.29487     0.01923

```

```

ANOVA TABLE
-----
SOURCE OF      SUM OF      MEAN      F
VARIATION      SQUARES    D.F.     SQUARE
-----
REGRESSION     16.82681    2      8.41341    0.61303
RESIDUAL       41.17319    3     13.72440
TOTAL          58.00000    5

```

```

-----
COEFFICIENT OF DETERMINATION = 0.29012

```

```

REGRESSION COEFFICIENTS
-----
      VALUE      STANDARDIZED    T      VIF
-----
B(0)      3.22439
B( 1 )    -0.92308    -0.51423    -0.11647    82.38448
B( 2 )     0.12179     1.04674     0.23707    82.38448

```

```

Y AND Y-HAT VALUES, AND RESIDUALS
-----
      Y      Y-HAT      RESIDUAL
-----
      1.00000    1.65386    0.65386
      6.00000    2.73078    3.26922
      2.00000    3.63462    1.63462
      3.00000    6.17306    3.17306
     10.00000    6.17306    3.82694
      2.00000    3.63462    1.63462

```

```

-----
LOWER AND UPPER CONFIDENCE LIMITS FOR B-VALUES
-----

```

```

B(0)
B( 1 )      -26.14239      24.29623
B( 2 )      -1.51293      1.75652

```

LOWER AND UPPER CONFIDENCE LIMITS, Y-HAT AND Y VALUES

Y-HAT		Y	
-9.98218	13.28991	-15.56378	17.56378
-4.33204	9.79360	-7.74208	19.74207
-3.23642	10.50565	-11.64450	15.64450
-2.10882	14.45495	-11.40662	17.40662
-2.10882	14.45495	-4.40662	24.40662
-3.23642	10.50565	-11.64450	15.64450

3.8 Accessory programs

3.8.1 Program ADJUST

P1: Contingency table entries are adjusted to equal block size. The adjusted data are written in disk file to be read by CONA. The data file is Arrangement 1 and data entry is from two disk files: raw contingency table entries and the block sizes. Entry is by row or column in both, which ever has the lesser dimension.

See Section 3.7.1 for example.

3.8.2 Program CONVERTER

P1: Random access and sequential files are converted into opposite kind. The data file is Arrangement 1. The full matrix is entered by row.

P2: EX 41221 (see data in Section 3.7.4)

P3:

Input data file: c:\qb45\works\ex41221 is sequential.
Output data file c:\qb45\works\ex41221R is random access.

3.8.3 Program INVDET

P1: A square symmetric matrix is inverted and its determinants are found. The data file is Arrangement 2.

P2: cov1041 (see Section 3.4.7).

P3:

PROGRAM INVDET

=====

INPUT FILE: cov1041, VOLUME c:\qb45\works

ORDER: 3

12.52178 -1.07844 -52.36088
-1.07844 8.53511 -26.65244
-52.36088 -26.65244 840.43408

INVERSE OF MATRIX:

0.12071 0.04300 0.00888
0.04300 0.14535 0.00729
0.00888 0.00729 0.00197

DETERMINANT = 53538.43750

3.8.4 Program PLOT

P1: Scattergram is plotted and the graph is stored on file. The file name starts with KEP and is BMP type. Data entry is by axis from an Arrangement 1 co-ordinate file. User specifies the axes to be plotted. The horizontal axis must have the smaller numerical label. The co-ordinates and vital run information are shown in the PRINTDA file. An option is available to generate prime number series for co-ordinates on first plotted axis.

P2: scor1632 (created in MDSCAL, Section 3.7.3).

P3: PROGRAM PLOT

=====

COORDINATES FILE, VOLUME y

Graph in file; kepplt.BMP

 COORDINATES
POINT AXIS 1 AXIS 2

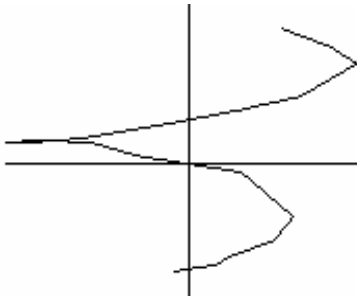
1 .053 .326
2 .079 .287
3 .098 .241
4 .064 .162
5 .030 .135
6- .010 .102
7- .070 .062
8- .101 .049
9- .117 .053
10- .095 .057
11- .063 .051

12-	.037	.023
13	.028-	.022
14	.059-	.126
15	.048-	.183
16	.020-	.225
17	.015-	.237
18	.011-	.245
19	.001-	.250
20-	.013-	.260

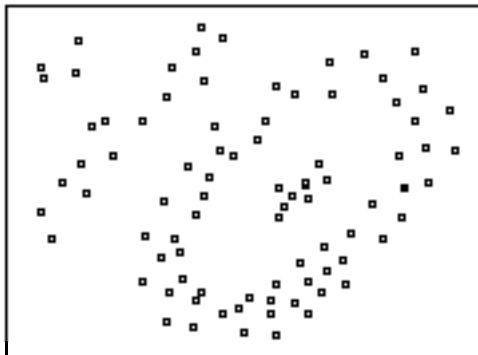
Intersection of axes is at X= 1.e-9 AND Y= 9.e-9
 Minimum and maximum, horizontal axis:-.1166777 and 9.8252591e-2
 Minimum and maximum, vertical axis:-.25959839 and .32641431
 HORIZONTAL AXIS IS AXIS 1
 SEQUENCE OF POINTS (LEFT TO RIGHT) IS:
 9 8 10 7 11 12 20 6 19 18 17 16 13 5 15
 1 14 4 2 3
 VERTICAL AXIS IS AXIS 2

SEQUENCE OF POINTS (BOTTOM TO TOP) IS:
 20 19 18 17 16 15 14 13 12 8 11 9 10 7 6
 5 4 3 2 1

P4a: Horizontal axis first axis. Sequence begins in first quadrant, ends in third.



P4b: Edited plot of the data listed under P3, Section 3.6.4. Data and graph adapted from Orlóci (1978).



3.8.5 Program STEREO

P1: Stereograms are drawn from a co-ordinate file (Arrangement 1). This file must contain co-ordinates on 3 axes. Input is by axis. The stereograms are stored on file under file name that contains KEP and is BMP type.

P2: score1532 (same as in Section 3.8.4).

P3: PROGRAM STEREO

```
-----  
Input data in file:scor1632  
Number of data points: 20  
Graph size changed by 0 %  
Range of variable 1 = .21493029  
Range of variable 2 = .5860127  
Range of variable 3 = .3157059  
Order on axis 1 :  
 9 8 10 7 11 12 20 6 19 18 17 16 13 5 15 14 1 4 2 3  
Order on axis 2 :  
 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
```

Data

```
2.3069473 2.6613477 2.92557 2.4575919 1.994692 1.457829  
.62887297 .20668437 0 .30165005 .7334492 1.0872197 1.9627277  
2.3870178 2.2417852 1.8665631 1.7921467 1.7369468 1.6065792  
1.4080532 0 2.92557 2.92557 0 0 2.92557 2.92557 0  
3.3 3.080361 2.8166782 2.374972 2.2224996 2.0370121  
1.8104966 1.7384058 1.7583686 1.7852644 1.747378 1.5923336  
1.3353019 .75288938 .43234976 .19306102 .12575543  
8.2776397e-2 .05150873 0 0 0 3.3 3.3 0 0 3.3 3.3  
2.3450823 2.2985044 2.3332422 2.6543303 2.80692 2.7736261  
2.3943567 1.9970224 1.242862 .58255118 .22718557 0  
7.2860307e-2 .44551763 .60586756 .60697475 .46791833  
.53498691 .39686795 .3346885 0 0 0 0 2.80692 2.80692  
2.80692 2.80692
```

SPREAD COEFFICIENTS

```
2.92557 3.3 2.80692
```

VIEWPOINTS

```
1.287 2.112  
1.287 1.287  
10.89 9.9
```

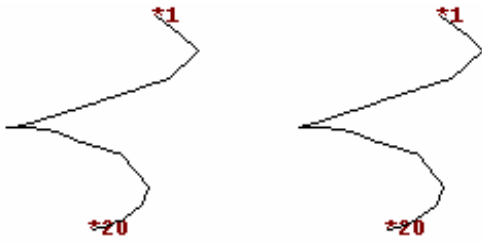
STEREO COORDINATES

```
2.5868635 7.860449  
3.0290304 8.308316  
3.3723725 8.6474129  
2.8348699 8.068975  
2.2404442 7.4539558  
1.5162068 6.7342777  
.44339074 5.7108781  
-.03591317 5.2788234  
-.16580704 5.2279064  
.24596054 5.6993336
```

.72165505	6.2040773
1.0872197	6.5872197
1.9672792	7.4617223
2.43394	7.8987489
2.2980343	7.7494312
1.9007729	7.3520758
1.8148261	7.2777863
1.7601931	7.2175699
1.6186662	7.0874633
1.4118915	6.8857324
0	5.5
2.92557	8.42557
2.92557	8.42557
0	5.5
-.44692197	4.7665896
3.4945777	8.7080893
3.4945777	8.7080893
-.44692197	4.7665896
3.8524513	3.8524513
3.5601434	3.5601434
3.2337882	3.2337882
2.725622	2.725622
2.54736	2.54736
2.2933153	2.2933153
1.9580354	1.9580354
1.8397743	1.8397743
1.819096	1.819096
1.813425	1.813425
1.7571869	1.7571869
1.5923336	1.5923336
1.3356273	1.3356273
.73010647	.73010647
.38199988	.38199988
.12848923	.12848923
7.3619242e-2	7.3619242e-2
2.0560748e-2	2.0560748e-2
4.7803662e-3	4.7803662e-3
-.04080828	-.04080828
0	0
0	0
3.3	3.3
3.3	3.3
-.44692197	-.44692197
-.44692197	-.44692197
3.9990318	3.9990318
3.9990318	3.9990318

Stereogram file:kepscor1632.BMP
19990609 15:42:08

P4: The stereo pair below is for stereo viewing at scale as give. See explanations under P5 in section 3.8.4.



3.8.6 Program TRANSPOSE

P1: A full matrix stored in a disk file is transposed. The transposed matrix is stored on file under a user selected name.

P2: ex41221 (see Section 3.1.1).

p3: PROGRAM TRANSPOSE

```
=====
INPUT FILE: ex41221, VOLUME c:\qb45\works
( 3 ROWS AND 7 COLUMNS)
OUTPUT FILE IS data, VOLUME NAMED c:\qb45\works
TRANSPOSE OF INPUT MATRIX
```

```
-----
26.000  28.000  18.000
29.000  31.000  14.000
29.000  31.000  13.000
29.000  33.000  13.000
30.000  27.000  19.000
35.000  38.000  15.000
39.000  36.000  15.000
```

3.8.6 Program TREE

P1: A dendrogram is drawn from data in a TREE file created by program SSA, ALC or SLC. The graph is not stored. To capture it on the "clipboard", press appropriate keys on the keyboard while the program holds the graphics screen.

P2: Tree 17.3.1 (created in SSA from EX 4.2.2.1)

P3: PROGRAM TREE

=====

DENDROGRAM FILE: tree1731, VOLUME c:\qb45\works

NUMBER OF OBJECTS: 7

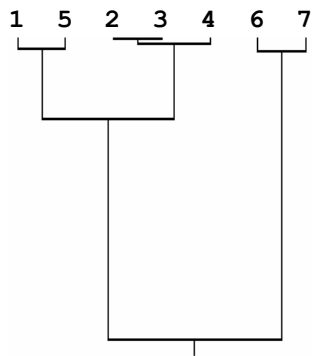
HORIZONTAL SEQUENCE:

1 5 2 3 4 6 7

DISSIMILARITY VALUES (VERTICALLY FROM TOP DOWN):

0.500 3.333 9.000 10.000 66.400 247.429

P4: Figure captured (PrintScr key) from scree:



Glossary

Executable program: code translated into machine language and linked with all needed library functions to stand alone as an application.

Dynamic array: its dimensions expand as needed in the program.

Individual: the unit object on which variables are measured; a relevé which describes the object; a vector (relevé) whose elements are kept conterminous in the data file.

Order of a symmetric matrix: the number of rows (columns) in the matrix.

Primary data file: a user-created data file.

Random access: data positions accessible in any sequence; adjacency does not rule the sequence of progress in reading from it or writing onto.

Rank of a matrix: latent dimensionality, related to the number of non-zero latent roots (Eigenvalues).

Relevé: a record in which an individual object's description is stored; a description of any kind; a vector whose elements are kept conterminous in the data file.

Sequential file: units are read or written in order starting with the first; no position can be stepped over.

Start-up dialogue: the initial conversation of user and program as the run gets under way.

Variable: a character that varies; varying values describing the states of a

Key references

- Feoli, E. and L. Orłóci (eds.) 1991. Computer Assisted Vegetation Analysis. Kluwer Academic Publishers, London. -- a broad account of advances in a changing field and exposition of views that characterise the changes.
- Morrison, D.F. 1976. Multivariate Statistical Analysis. 2nd ed. McGraw-Hill, New York. – intermediate level text for general users with familiarity in linear algebra and univariate statistics.
- zOrłóci, L. 1971. Information theory techniques for classifying plant communities. In: G. P. Patil, E. C. Pielou and W. E. Waters (eds.), Statistical Ecology, Vol. 3, pp. 259-270. Pennsylvania State University Press, University Park.
- Orłóci, L. 1978. Multivariate Analysis in Vegetation Research. 2nd ed. W. Junk, The Hague. – a monograph of the field as it was in the 1970s.
- Orłóci, L. 1991. Entropy and Information. Ecological Computations Series: Vol. 3. SPB Academic Publishing, The Hague. -- detailed account of techniques, examples of application and a computer program.
- Orłóci, L. 1991. CONAPACK: A program for Canonical Analysis of Classification Tables. Ecological Computations Series: Vol. 4. SPB Academic Publishing, The Hague. -- detailed account of techniques, examples of application and a computer program.
- Orłóci, L. 1991. On character-based community analysis: choice, arrangement, comparison. In: Feoli, E. and L. Orłóci (eds.) Computer Assisted Vegetation Analysis, pp. 81-93. Kluwer Academic Publishers, London.
- Orłóci, L. 1993. The complexities and scenarios of ecosystem analysis. In: G. P. Patil and C. R. Rao, Multivariate Environmental Statistics, pp.421-430, North Holland/Elsevier, New York.
- Orłóci, L. and M. Orłóci. 1995. Sampling and Data Analysis. Mimeographed, London. – lecture notes for a 300 level course in biology.

- Orlóci, L., C. R. Rao and W. M. Stiteler (eds.) 1980. Multivariate methods in Ecological Work. ICP, Fairland, Maryland.
- Orlóci, L. and M. Orlóci. 1991. Edge detection in vegetation: Jornada revisited. In: Feoli, E. and L. Orlóci (eds.) Computer Assisted Vegetation Analysis, pp. 373-385. Kluwer Academic Publishers, London.
- Pillar, De Patta V. and L. Orlóci. 1993. Character-based Vegetation Analysis: the Theory and an Application Program. Ecological Computations Series (ECS): Vol. 5. SPB Academic Publishing bv, The Hague, The Netherlands. -- arguments in favour of character-based analysis and description of a very fast computer program in C.
- Wildi, O. and L. Orlóci. 1996 Numerical Exploration of community Patterns. 2nd. ed. SPB Academic Publishing, The Hague.

BACK COVER

Although the brute power of the main frame super machines is unmatched, the conveniences that the personal computer offers in low-cost yet superbly efficient and versatile computing are irresistible. The four dozen or so programs described in this manual should help the user to take advantage of a PC in instructional computing.

The programs allow selective access to specific tasks, yet the program structures permit linkages through standard output and input. The programs are in versions of run-time BASIC.