Compos Analysis Version 6.3 User's Guide

User's Guide version 6. 3, March 2010 to Compos Analysis 6.3 standard and 6.3 plus, 26 March 2010.

Smith Ecology Microsoft® Excel tool for Compositional Analysis

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References to the Compos Analysis software:

Smith, P. G. 2005. Compos Analysis, version 6.2 standard [software]. Smith Ecology Ltd., Abergavenny, UK.

Smith, P. G. 2005. Compos Analysis, version 6.2 plus [software]. Smith Ecology Ltd., Abergavenny, UK.

Reference to published paper introducing the software:

Smith, P. G. 2004. Automated log-ratio analysis of compositional data: software suited to analysis of habitat preference from radiotracking data. *Bat Research News*, **45**: 16.

This user guide is available on the World Wide Web and can be cited as follows:

Smith, P. G. 2010. *Compos Analysis version 6.3 user's guide.* Version 6.3. Smith Ecology Ltd., Ty Major, Forest Coal Pit, Abergavenny, NP7 7LH, UK. i + 22 pp. [WWW document]. URL http://www.smithecology.com/software.htm

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User's Guide for Compos Analysis 6.3 standard[1] and 6.3 plus (25 March 2010): a Smith Ecology Microsoft® Excel tool for Compositional Analysis.

QUICK START

A. Copy the files to a folder and check that the program works.

1. Copy the Excel workbook file "Compositional Analysis 6_3 std.xls" or "Compositional Analysis 6_3 plus.xls" and the Excel Add-In file "Comp Anal 6_3 std.xla" or "Comp Anal 6_3 plus.xla" into a folder on your PC or Mac. [*Check that the copies have the same filenames as the originals as just stated (i.e. ensure that filenames have not been cropped during copying). Note that if your computer is set to hide file extensions you will not see the ".xls" or ".xla" parts of the filenames. In this case do not add ".xls" or ".xla" to the names when these extensions are already there, but hidden from view.*]

2. Start Excel and open the workbook "Compositional Analysis 6_3 std (or plus)". (See item 4 under installation on page 3 below if you get a message about macros.) You must accept Enable Macros if asked.

3. For Excel 2007 select and click Compos Analysis from the Add-Ins menu. For Excel earlier than 2007 click once on the Compos Analysis dropdown menu that appears on the Worksheet Menu Bar. Then click once on "CompAn 6.3 std (or plus)" at the top of the menu.

4. You should see a message box appear headed Compos Analysis and stating that this is version 6.3. (If you get any other response see "trouble shooting during installation" on page 4.) Click "Cancel" and then "OK" on the next "Terminating" message box to exit from the program. [*If you click "OK" instead of cancel on the first message box you will get a message box stating that you have "Insufficient data". Clicking "OK" on this message box (the only option here) causes the program to exit.*]

5. This confirms that everything is set up correctly and the program works. If you got any errors see trouble shooting below.

B. Try running the program with some example data.

1. When the "Compositional Analysis 6_3 std (or plus)" workbook first opens the "TestResults" worksheet is selected. Now select the "Ph" worksheet. This contains some data that relate to examples from a pheasant study described by Aebischer *et al.* (1993b).

2. Select and copy cells C17 to H31.

3. Select the "Used" worksheet and paste the selected data here starting from cell A1.

4. Select the "Ph" worksheet. Scroll to cells C33 to H47 and select and copy this block of data.

5. Select the "Avail" worksheet and paste the selected data here starting from cell A1.

6. Click once on the Compos Analysis dropdown menu and click once on "CompAn 6.3 std" or "CompAn 6.3 plus" at the top of the menu.

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[1] Compos Analysis <u>standard</u> will handle up to 200 cases (e.g. animals) for up to 25 variables (e.g. habitat categories), while Compos Analysis <u>plus</u> will handle up to 2000 cases for up to 30 variables. A version with increased limits can be supplied if required. Compos Analysis <u>plus</u> is also capable of weighting the log-ratio differences by the square root of n observations, or by n observations, when n observations per case are entered in the "Weight" worksheet.

7. You will see the "Compos Analysis" headed message box stating that this is version 6.3. Click "OK".

8. You will see a message box headed "Compos Analysis: Input", stating "Cases = 13, Variables = 5" and inviting you to enter the number of iterations you require for randomization or to accept the default of "1000". Click "OK".

9. You will see a further "Compos Analysis: Input" message box. This one informs you that "Some 'used' values are zero." and invites you to enter a value to be used in place of zero or to accept the recommended default value of "0.01". Click "OK".

10. The "TestResults" worksheet will be automatically selected and the analysis will proceed to completion. During this time progress will be indicated on the Status bar below the worksheet tabs and on the worksheet. The date and time the analysis started will be shown on row 19 of the worksheet until the worksheet is rewritten with the final results.

11. Main results are output to the "TestResults" worksheet. Intermediate results are output to the worksheets "WilksValues", "ObsRawSSCP", "ObsMeanCorrectedSSCP", "ObsLRDs", "AvailRatios" and "UsedRatios". To save the results, either copy "TestResults" and any other worksheets you wish to save to a different workbook or save the current workbook using a different name. [N.B. In the latter case you may find multiple entries of "Compos Analysis" in the Tools Menu if you have more than one copy of the original workbook open simultaneously.]

12. You will observe that the results agree with those of the first pheasant example presented by Aebischer *et al*. (1993b). The results from this example are presented as Example 1 below. When you run "Compos Analysis" again, all results from the previous analysis will be cleared once you select "OK" at the first message box (i.e. the one where the version number is given). If you realise you meant to save data from the previous run first then select "Cancel" at this message box to exit from the macro without clearing any data from the previous analysis.

C. Users of "Compos Analysis +" may continue with the same example by repeating the analysis with weighting applied to adjust for differences in the number of radio locations obtained for each pheasant.

1. Select the "Ph" worksheet. Select cells A1 to B15 (or A17 to B31 or A33 to B47 - the example data is repeated against each set of habitat use/ availability data for convenience) and copy this block of data. This gives a (hypothetical) number of observations obtained from each pheasant, with pheasants 2, 4 and 5 having fewer observations than the others.

2. Select the "Weight" worksheet and paste the selected data here starting from cell A1.

3. Click once on the tools dropdown menu and click once on "Compos Analysis +" at the bottom of the menu.

4. Click "OK" at each of the following message boxes as in steps 7 to 9 above.

5. A dialogue box headed "Compos Analysis: weighting" will appear offering a choice of three radio button selections for weighting of cases.[2] "Weight by square root of n" is selected as the default. Select the required weighting option and click "OK". The analysis will then run to completion automatically.

6. The test results show that p-values obtained differ slightly but, with both weighted and unweighted data in this example, habitat use by pheasants was non-random and there is no difference in the ranking of habitats.

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[2] On the Apple Mac this dialogue box may appear in the bottom right hand corner of the screen.

7. To repeat the test without weighting the data, select the "Weight" worksheet, click the box at the top left corner of the worksheet (i.e. at the intersection of the column letters and row numbers), right click your mouse to get a menu, and left click on the "Clear Contents" item in the menu so obtained. Now that the "Weight" worksheet is clear of data, select "Compos Analysis +" again from the tools dropdown menu to repeat the analysis with no weightings applied.

INTRODUCTION

This tool for Compositional Analysis (Aitchison 1986) with randomization testing was written by Dr Peter G. Smith of Smith Ecology Ltd., Ty Major, Forest Coal Pit, Abergavenny, Monmouthshire, NP7 7LH, Wales, UK. Telephone: +44 (0) 1873 890055. E-mail peter@smithecology.com. The tool was first used, in an earlier version, by Smith (2000). The copyright in this software is held by Smith Ecology Ltd. The software must not be copied or distributed without the permission of Smith Ecology Ltd.

This compositional analysis tool requires Microsoft Excel. The tool comprises an application specific Excel Add-In (the file "Comp Anal 6_3 std.xla" or "Comp Anal 6_3 plus.xla") and an Excel workbook (the file "Compositional Analysis 6_3 std.xls" or "Compositional Analysis 6_3 plus.xls"). The Add-In is accessed as a library item by code in the Excel workbook to perform the analysis on data you copy into specific worksheets of the workbook.

Compositional Analysis is a technique that uses MANOVA to analyse two sets of data in which variables are represented as proportions. It is used to determine the statistical significance of differences and the rank order of differences between the variables.

SYSTEM REQUIREMENTS

This Add-In tool supports users of (on a PC) Excel Versions 95 (i.e. 7.0), 97, 2000, 2002 and 2007 on Windows 95/98, XP & Vista and (on an Apple Mac) Excel Version 10 on OS X or any compatible versions of Excel.

The first of the two pheasant examples presented by Aebischer *et al.* (1993b) is likely to take about:

4 seconds on a 2.6 GHz Pentium PC with 1 GB of RAM,

1 minute 13 seconds on a 100 MHz Pentium PC with 16 MB of RAM &

1 minute 3 seconds on an 800 MHz G4 (Power PC) Apple Mac with 512 MB of RAM.

BACKGROUND

This Add-In tool for Microsoft Excel implements fully the method for Compositional Analysis as described by Aebischer *et al.* (1993b). The significance of Wilk's lambda and of t-values is determined by randomization tests as recommended by Aebischer *et al.* (1993b) to overcome problems arising when the distribution of log-ratio differences is not multivariate normal. To avoid the need to always drop variables (e.g. habitat categories) or cases (e.g. animals) when availability of some habitats for some of the cases is zero, the method recommended by Aebischer *et al.* (1993b) in Appendix 2, option 3 is implemented, i.e. replacement of missing values in a particular residual log-ratio by the mean of all nonmissing values for that log-ratio, and then computation of a mean lambda by weighting each denominator-dependent value of lambda by the number of nonmissing values involved in its calculation, and determination of the level of significance by randomization. The plus version adds the option to weight the analysis to allow for differences in the number of observations recorded, and hence accuracy, for each case.

REVISION HISTORY

Compos Analysis standard

Version 5.0

This is the first Mac compatible release. Print warning if n non-missing cases is < 6 for any log-ratio difference. Restrict use to require number of cases >= number of variables since otherwise Lambda is not valid. Change to allow a ranked variable sequence string exceeding 255 characters to be output in the test results.

Version 5.1

Contact details were updated.

Version 6.0 (Trial version not for general release)

Improved reporting of errors detected in user data. Web address added to contact details.

Version 6.1

Change to code used in plus version only.

Version 6.2

Change to code used in plus version only.

Version 6.3

Change to allow macro to run in Excel 2007 (without altering code) and change to contact details for Smith Ecology Ltd as reported in first message when the macro is run. This version will not run in Excel 95.

Compos Analysis plus

Version 5.0+

The first plus version. This has limits of 2000 cases and 30 variables compared with 200 cases and 25 variables in the standard version.

Version 5.1+

This is the first release of a version with higher limits to the number of cases and variables handled compared with the standard product.

Version 6.0+ (Trial version not for general release)

As for the standard version and also the option to weight the log-ratio differences by the square root of n observations to allow for differences in numbers of observations (and hence differences in the accuracy of data) for each case.

Version 6.1+

Correction of error in calculation of the weighting introduced in the trial version 6.0, addition of option to weight by n observations (no transformation) and improved checking for errors in data presented in the "Weight" worksheet.

Version 6.2+

Change to text in dialog box for selection of weighting option. This was to reduce the number of characters, since when used on the Mac the last words of the final sentence were not showing.

Version 6.3+

Change to allow macro to run in Excel 2007 (without altering code) and change to contact details for Smith Ecology Ltd as reported in first message when the macro is run. This version will not run in Excel 95.

INSTALLATION

1. Installation of this software implies your acceptance of the terms of the end-user licence agreement which is held in a ".pdf" file (in Adobe Acrobat portable document format) accompanying this help file. (You will need Adobe Acrobat Reader, which is available free from the Adobe web site to read the file.)

2. Make backup copies of the four files supplied. The files are "CompAn help 6_3_0.pdf" (holding the text of the present User's Guide in Adobe PDF format), "Compan6_3* Licence.pdf" (which holds your end-user licence), "Compositional Analysis 6_3 std.xls" or "Compositional Analysis 6_3 plus.xls" (a Microsoft Excel workbook file) and "Comp Anal 6_3 std.xla" or "Comp Anal 6_3 plus.xla" (the file holding the software program that performs the compositional analysis).

3. Copy all the above files to a folder on your PC or Apple Mac, e.g. you may choose to use a folder named "CA", or "Compositional Analysis". Especially when copying to a Mac, ensure that the full file name of the Add-In is retained in the copy and, if not, rename it with the full name "Comp Anal 6_3 std" or "Comp Anal 6_3 plus". The file type of .xla may or may not be displayed on your computer depending on whether or not it is set to hide file types. If it is there, but hidden, do not add it again in the visible part of the name. Check the name of the workbook file too though its name is not critical for the software to work.

4. Open the supplied Excel workbook file in Excel. Depending on your system settings and on your version of Excel, when you open the workbook you may encounter an option to either disable or enable macros. You should select the option to "Enable Macros". Note that the macro is not digitally signed and in Excel 2002 if your security level is set to high the macro will be disabled as you open the workbook. If this is the case, change the security level to Medium by pointing to **Macro** on the **Tools** menu, click **Security**, click the **Security Level** tab and set the level to **Medium**. Then close the Compositional Analysis workbook, reopen it and click **Enable Macros** when asked upon loading. If you want Excel to automatically disable unsigned macros in the future, remember to change the security level back to High (though you would have to change back to Medium again to use "Compos Analysis"). Save the workbook in the form appropriate to your version of Excel.

5. In Excel 2007 your security settings can be accessed by clicking on the MS Office button (found at top left) and selecting "Excel Options" at the bottom right of the window that opens. Then select Trust Center/Trust Center Settings/Macro Settings. Here select the radio button for the option "Disable all macros with notification" and click OK and OK again. Excel will then invite you to Enable Macros for any Workbook you open that contains macros, such as the Compos Analysis Workbook. You must respond to Enable Macros or the program will not run.

6. The compositional analysis tool is now available by clicking the "Compos Analysis" dropdown menu that appears in an Add-In tab in Excel 2007 and for earlier versions appears on the Worksheet Menu Bar when the Workbook is opened and which is removed automatically when the Workbook is closed.

7. Now confirm the availability of the compositional analysis tool by clicking on the "CompAn 6.3 std (or plus)" item at the top of the Compos Analysis menu. This should

produce a message stating the version of the Compositional Analysis software. You will see this message every time you use the tool. The appearance of this message confirms that the tool is loaded correctly. Click OK. A message will then appear stating that Cases = 0, Variables = 0 and that the macro will terminate. This is normal and is because you have not yet set up any data for analysis as described below. Click OK and the macro will end. This completes the installation and your confirmation that the tool is working.

TROUBLESHOOTING DURING INSTALLATION

PC

If, upon selecting the "Compos Analysis" item on the Tools menu you get a **Microsoft Visual Basic** message - **Compile error: Sub or Function not defined**, or **Compile error: Can't find project or library**, or **Can't find project or library**, click **OK** (first click **Help**, then **OK** if you want instructions available on screen rather than following notes below). If using version 2000 or 2002 of Excel select **Reset** from the **Run** menu. Then, in any version of Excel, as you are now in the Visual Basic Editor rather than the workbook, select **References…** from the **Tools** menu and continue with locating "Comp Anal 6_3 std" or "Comp Anal 6_3 plus" as described in the appropriate paragraph below or in Excel Help. These instructions are likely to apply to Excel 97 too.

Excel version 7.0 (i.e. Excel 95) – needs version 6.2 of Compos Analysis or earlier version

If the compositional analysis tool is not available as described above and you are using version 7.0 of Excel, within the supplied Excel workbook, click the tab for the module named "Module1", then select "**References…**" from the **Tools** menu. If Comp Anal 6_2 is present in the list of references, but is given as "MISSING: Comp Anal_6_2.xla" then click on the box to the left of the entry to remove the tick and click OK. Then select "**References…**" from the **Tools** menu again. Now the invalid Comp Anal 6_2 entry should have gone from the list of references and you should then add the correct entry as follows. If Comp Anal 6_2 is not present in the "Available References" list, click the **Browse** button. This opens a "Browse" window. In the "Files of Type" box, select "Microsoft Excel Files (*.xl*; *.xls; *.xla; …)", then navigate to the folder to which you copied it, select it and click the **OK** button. You should see the option appear ready ticked (therefore not given as "MISSING") in the "Available References" list (possibly at the bottom initially) with the correct path given in the description box below. If it is not ticked then click on it such that a tick appears to the left of the Comp Anal 6_2 reference. Click the **OK** button. Return to the "TestResults" worksheet and save the Excel workbook to preserve the change. The "Compos Analysis" menu items should now work correctly. If not, then go back to **References** as described above and check that no Comp Anal 6_2 entry given as "MISSING" remains in the list of references. Sometimes more than one attempt is required to remove such references and if not removed the program will continue to look for the program at the invalid location.

Excel 2000 or 2002

If the compositional analysis tool is not available as described above and you are using version 2000 or 2002 of Excel, unless already in the **Visual Basic Editor**, then within the supplied Excel workbook select **Macro** from the **Tools** menu and select **Visual Basic Editor**. Then select **References…** from the **Tools** menu of the Visual Basic Editor. If Comp Anal 6_3 is present in the "Available References" list, but is given as "MISSING: Comp Anal_6_3.xla" then click on the box to the left of the entry to remove the tick and click OK. Then select "**References…**" from the **Tools** menu again. Now the invalid Comp Anal 6_3 entry should have gone from the "Available References" list and you should then add the correct entry as follows. If Comp Anal 6_3 is not present in the "Available References" list, click the **Browse** button. This opens an "Add Reference" window. In the "Files of Type" box, select "Microsoft

Excel Files (*.xls;*.xla)", then navigate to the folder to which you copied it, select it and click the **Open** button. You should see the option appear ready ticked (therefore not given as "MISSING") in the "Available References" list (possibly at the bottom initially) with the correct location given in the box below. If it is not ticked then click on it such that a tick appears to the left of the Comp Anal 6_3 reference. Click the **OK** button. Select **Microsoft Excel** from the **View** menu, or **Close and return to Microsoft Excel** from the **File** menu, to return to the workbook. Save the Excel workbook to preserve the change. The "Compos Analysis" menu items should now work correctly. If not, then go back to **References** as described above and check that no Comp Anal 6_3 entry given as "MISSING" remains in the "Available References" list. Sometimes more than one attempt is required to remove such references and if not removed the program will continue to look for the program at the invalid location.

Excel 2007

If the compositional analysis tool is not available as described above and you are using version 2007 of Excel, unless already in the **Visual Basic Editor**, then within the supplied Excel workbook select the **Developer** tab and select **Visual Basic**. Then select **References…** from the **Tools** menu of the Visual Basic Editor. If Comp Anal 6_3 is present in the "Available References" list, but is given as "MISSING: Comp Anal_6_3.xla" then click on the box to the left of the entry to remove the tick and click OK. Then select "**References…**" from the **Tools** menu again. Now the invalid Comp Anal 6_3 entry should have gone from the "Available References" list and you should then add the correct entry as follows. If Comp Anal 6_3 is not present in the "Available References" list, click the **Browse** button. This opens an "Add Reference" window. In the "Files of Type" box, select "Microsoft Office Excel Files (*.xlsm;*.xlam;*.xls;*.xla)", then navigate to the folder to which you copied it, select it and click the **Open** button. You should see the option appear ready ticked (therefore not given as "MISSING") in the "Available References" list (possibly at the bottom initially) with the correct location given in the box below. If it is not ticked then click on it such that a tick appears to the left of the Comp Anal 6_3 reference. Click the **OK** button. Select **Microsoft Excel** from the **View** menu, or **Close and return to Microsoft Excel** from the **File** menu, to return to the workbook. Save the Excel workbook to preserve the change. The "Compos Analysis" menu items should now work correctly. If not, then go back to **References** as described above and check that no Comp Anal 6_3 entry given as "MISSING" remains in the "Available References" list. Sometimes more than one attempt is required to remove such references and if not removed the program will continue to look for the program at the invalid location.

Apple Mac

If the compositional analysis tool is not available as described above and you are using Excel X on an Apple Mac, first ensure the Mac is a PowerPC G4 or compatible and that you have installed Mac OS X version 10.1 or later (though Compos Analysis 6_2 has also been shown to run on a blue & white G3 with Mac OS 9.2.2 and Office 2001 with Service Release 1 for Office installed). Check that the latest upgrades to OS X and Excel X or Office X are installed. You can find these on the internet or contact your supplier. You may have had an error message such as "error loading dll". If so you need to download the "VBA converter for Office v. X" or the "VBA converter for Excel v. X" from the internet and install it. Go to http://www.microsoft.com/mac/download to find this. The "Compos Analysis" menu items should now work correctly.

HOW TO USE THE COMPOSITIONAL ANALYSIS TOOL

First open the supplied Compositional Analysis Excel workbook file within Microsoft Excel. Be sure to notice the security warning about Macros being disabled and immediately respond by clicking Options and Enable this content (in Excel 2007). **Macros must be enabled when the workbook is first opened or you will have to close the workbook and open it again, this time enabling macros immediately.** The analysis will use the "Compos Analysis" macro supplied in the file Comp Anal 6_3.xla. This is run from within the Compositional Analysis Excel workbook either by clicking the "Compos Analysis" item on the Add-Ins menu (or the "Compos Analysis" dropdown menu for pre 2007 versions of Excel), or by selecting the "Compos_Analysis" macro available via the Developer/Macros menu (Tools/Macro menu pre 2007). Compos Analysis <u>standard</u> is set to handle up to 200 cases (e.g. animals) for up to 25 variables (e.g. habitat categories). Compos Analysis <u>plus</u> is set to handle up to 2000 cases for up to 30 variables. A version with increased limits can be supplied if required. In "Compos Analysis +" the option is provided to weight the log-ratio differences derived from each case of used and available compositions to allow for differences in the accuracy of data obtained for each case. The user enters the number of observations obtained for each case and the program weights the data by the square roots of these numbers as recommended by Aebischer *et al.* (1993b). A version providing weighting by some function other than the square root can be supplied if required.

Format of data in "Used", "Avail" and "Weight" worksheets

On running, the macro accesses "used" and "available" data from the "Used" and "Avail" worksheets within the Compositional Analysis Excel workbook. The data in these worksheets should be set up in a standard format (e.g. see worked examples below), i.e.: Cell A1 - Project name; Cell A2 - Source of data, e.g. study area (SA), minimum convex polygon (MCP), or radio location fix (Fix); Cells in row 2 from B2 - names of variables (e.g. habitat categories) [It is best to limit names to, say, 12 lower case characters for brevity and for clarity in output of final results.]; Cells in column A from A3 down - names of cases, e.g. identity of each animal.

The text entered in cell A1 of the "Used" worksheet will appear at the head of the "TestResults" worksheet. This should be the project title and should ideally not exceed a page width, though the maximum is usually 255 characters. Text indicating what is being compared with what is automatically appended to the project title at the head of the "TestResults" worksheet. This is derived from the A2 cells of the "Used" and "Avail" worksheets. The text '(used)' and '(available)' are appended to the text derived from each of these worksheets respectively, so that it is clear how the source data was set up. Hence, if the project title was given simply as 'Pheasants', the "TestResults" header text might read: 'Pheasants - MCP (used) vs. Study area (available)', assuming A2 of "Used" says 'MCP' and A2 of "Avail" says 'Study area'.

The data within the "Avail" and "Used" worksheets are percentage data, with each row nominally adding to 100% if you have included all original variables. However, after converting your data to percentages, you can drop variables not required before copying to the "Used" and "Avail" worksheets without the need to recalculate percentages, as ratios of habitat pairs would not be affected [as in the examples given in Aebischer *et al.* (1993b) and presented below]. Hence cases may total less than 100% if you have done this.

The standard version of "Compos Analysis" makes no use of the "Weight" worksheet. In the plus version, if weighting of cases is required, column 1 in the "Weight" worksheet should be set up similarly to the "Used" and "Avail" worksheets with the case number or name of each case. The number of observations for each case should be entered in column 2 from cell B3

down with one number for each case. Typically the number would be a positive integer, but the program will weight by the square root of any positive number given here. The program will report an error and terminate if any number <= zero is entered here. Text such as "n Observations" can be entered in cell B2. The rest of the worksheet should be empty.

Zeros in "Used" or "Avail" worksheets

Where any "available" data are zero or missing, the value(s) <u>must</u> be set to zero in the "Avail" worksheet. Where zero is set in the "Avail" worksheet Wilk's lambda is calculated as a weighted mean as recommended in Aebischer *et al.* (1993b). However, where any "used" data are zero the figure(s) may either be set to zero in the "Used" worksheet (recommended), or a small percentage can be substituted, e.g. 0.01, to be an order of magnitude less than existing non-zero values in either available or utilized data compositions [see Aebischer *et al.* (1993b)]. If "used" zeros are left as zeros, the macro will automatically determine an appropriate value to substitute for these "used" zeros in the calculations and will prompt the user to accept this as a default or to enter their own figure. The program will not replace the zeros on the "Used" worksheet itself but it will state the substitution value used in the report of results and will report the number of "used" zeros that are present and which correspond with nonzero "avail" values and hence were replaced in the calculations. Note that any "used" value that corresponds with a zero on the "avail" worksheet will be treated as missing in the analysis.

Ensure that ONLY the relevant data as demonstrated in the examples below is present in the "Avail" and "Used" worksheets so that the macro runs correctly. **DO NOT ADD OTHER DATA IN EXTRA ROWS OR COLUMNS**. Always include the appropriate number of variable (e.g. habitat category) labels in row 2. Case labels are optional and may be entered in column A (e.g. P1 to P13 in column A in the first worked example below, or 2 to 13 in column A in the second example below). Do not add any extra rows or columns of data that are not part of the required compositional analysis. Do not change the names of the worksheets supplied in the Compositional Analysis Excel workbook. TIP: Before entering data in the "Used" and "Avail" worksheets you can clear each worksheet's contents completely by, within each worksheet in turn, clicking the box at the top left corner of the worksheet (i.e. at the intersection of the column letters and row numbers), right clicking your mouse to get a menu, and left clicking on the "Clear Contents" item in the menu so obtained.

Caution! – Treatment of artificially small values in "Used" or "Avail" worksheets

Sometimes you may derive either "used" or "avail" data from a geographical information system (GIS) by, for example, calculating the total area of each habitat within a Minimum Convex Polygon or other outline that bounds the area deemed to be "used" or "available". If the boundary line just clips the edge of a habitat that is otherwise not represented within the defined area the total area of that habitat included may be extremely small – perhaps far smaller than the smallest unit recognised during data collection. If retained, such an artificially small value may further influence the data as the replacement value for any zeros in the "used" data is determined by reference to the smallest "used" or "avail" value present and will be an order of magnitude less than this. It is recommended that values that fall below the smallest unit recognised during data collection are either rounded up to the smallest recognised unit or replaced by zero as appropriate before commencing compositional analysis. This will avoid the potential for artificially small values to influence the analysis.

Starting the analysis

Once data is set up in the "Avail" and "Used" worksheets, click the "Compos Analysis" drop down menu and then the "CompAn 6.3 std (or Plus)" button. A message will appear stating the version number of the software. Click OK. The worksheets "TestResults", "WilksValues",

"ObsRawSSCP" (observed raw sums of squares and cross-products matrix), "ObsMeanCorrectedSSCP" (observed mean-corrected sums of squares and cross-products matrix), "ObsLRDs" (observed log-ratio differences), "AvailRatios" and "UsedRatios", holding output from any previous analysis will be cleared automatically to make way for the new results.

If you meant to save the results of the previous run click "Cancel" instead of "OK" at the first message box and the macro will exit without clearing any results from the previous analysis. If you wish to retain results from your previous analysis you should make a copy of what you require into other worksheet(s) or save them in a different workbook or text file before running the macro again with new data. If data has not been set up, or has not been set up correctly in the "Avail", "Used" and (for the plus version) "Weight" worksheets (but leave "Weight" clear if weighting is not required) an error message will appear explaining the problem and the macro will end. The seven results worksheets named above must be available for the macro to output its results for the current analysis.

Specifying the number of iterations you require

Assuming that the data in the "Avail" and "Used" worksheets appears to be OK, a dialogue box will appear asking you to set the number of iterations you require for randomization or to accept the default of 1000. With 1000 iterations (made up of the original data plus 999 permutations of the data) the smallest obtainable level of probability is $P <= .001$. The default is given as 1000 because Manly (1997) recommends that a minimum of 1000 iterations is used for tests at a significance level of .05. (TIP: If you are simply checking that the macro is working, then change the value to a small number, such as 10, so that the macro completes in a short time.)

Specifying a replacement value for zeros in "Used" values

Once you respond to the iterations dialogue box the macro will check for zeros among "used" values and, should there be any present, a new dialogue box will appear. This will show a recommended value (determined to be at least an order of magnitude less than the smallest non-zero value present in the "Used" and "Avail" worksheets) to automatically substitute for any zeros in the "used" values (though any "used" value that corresponds with a zero in "avail" will be treated as missing in the analysis). [See also comments under the heading "Caution – Treatment of artificially small values in "Used" or "Avail" worksheets" above.]This default may be accepted or an alternative value may be entered. Click OK to continue. Zeros will not actually be replaced in the "Used" worksheet, though the chosen value will be used as a substitute in the analysis and reported in the results.

Specifying weighting of cases

This option only appears in the plus version. In the standard version any data in the "Weight" worksheet is ignored. The plus version will not apply weightings if the "Weight" worksheet is empty. In the plus version, if the "Weight" worksheet contains data a dialogue box will appear asking the user to select one of three options: weight cases by the square root of n, weight by n or to apply no weighting to cases. If an option to apply weighting is selected, the program will read n observations for each case from the "Weight" worksheet and use these values or their square roots according to the user selection to weight each case during the analysis. The weights are applied during both the multivariate test for overall differences and the univariate tests (t-tests). The macro will report in the "TestResults" worksheet, on row 8, that the data were weighted and whether this was by n or the square root of n, or if weighting was not applied then row 8 will be clear.

For some studies the number of observations entered in the "Weight" worksheet would be the number of independent radio locations obtained from each animal. For studies in which

animals are tracked continuously, it could be the total number of minutes that each animal was tracked while engaged in the activity of interest.

Progress indicators

The analysis will now run to completion. The date and time the analysis started will be displayed in cell A19 of the "TestResults" worksheet. An increasing count will show on the status bar and on the screen (in cell B22 of the "TestResults" worksheet) indicating the number of iterations completed as the macro runs. Results will be output to the seven previously cleared worksheets as the macro runs.

Data that is output

The key test results are output to the "TestResults" worksheet. Wilk's lambda values from randomization are sorted into ascending order and the smallest 5% are output to the "WilksValues" worksheet. *** is placed in column B against the value calculated from the observed data, assuming this is within the lowest 5% of values determined by randomization. Matrices of raw and mean-corrected sums of squares of cross-products of log-ratio differences of observed data are output to the "ObsRawSSCP" and "ObsMeanCorrectedSSCP" worksheets respectively for each variable as denominator in turn. (Wilks lambda is derived as a ratio of the determinants of these matrices.) The observed log-ratio differences (for one set of variables as denominators only) are output to the "ObsLRDs" worksheet. Ratios of each pairing of "available" variables are output to the "AvailRatios" worksheet, while the equivalent ratios of "used" variables are output to the "UsedRatios" worksheet. Clearly log-ratios can be derived easily from these if required. (In the case of large numbers of variables – typically 16 or more - output of some of the intermediate results will be limited according to the number of columns available in the worksheets.)

The sorting of lambda values for output can take some time after the randomization iterations are complete. A message "PLEASE WAIT - sorting in progress" will display during this time and a counter will increment showing the percentage of the sort that is complete. In the "TestResults" worksheet, the simplified matrix of ranks is produced using the significance levels determined from randomization testing, but with the significance levels from t-tests on the OBSERVED data shown in parentheses where this differs.

Variables are presented in rank order above the simplified rank matrix. Variables are separated with > symbols, with those to the left being of higher rank (preference) than those to the right. Where there is a significant difference at $P < .05$ between two consecutively ranked variables, a >>> symbol is used. Where variables are of equal rank they are separated by the = symbol.

Worksheets holding example data from Aebischer *et al.* (1993b)

Four further worksheets are supplied. These are named "DskPh", "Ph", "DskSq" and "Sq". "DskPh" and "DskSq" hold the percentage data for Pheasant and Squirrel studies respectively as presented by Aebischer *et al.* (1993b). "Ph" and "Sq" are derived from this test data, but are arranged ready to copy appropriate blocks to the "Used" and "Avail" worksheets for test runs. Hypothetical values for n Observations have been included in "Ph" as an example of the layout of data that might be used for weighting of cases. To carry out analyses on the examples given in Aebischer *et al.* (1993b), simply copy and paste appropriate data from "Ph" or "Sq" to the "Avail" and "Used" worksheets. The results output to the "TestResults" worksheet for each of these example analyses (unweighted) is presented below. [Note that the simplified ranking matrix results for the second of the two squirrel examples presented by Aebischer *et al.* (1993b) in their table 5b, i.e. the Fix v. MCP comparison, is in error. Hence the results differ from those obtained by running the present compositional analysis tool. The error in the paper was due to mislabelling of variables in the original analysis of this example

by Aebischer *et al.* (1993b). The error does not apply to any of the overall results (lambda or randomization).] A beep will sound on completion of the macro.

Saving your results

Always copy and save results that are required into another file before carrying out another analysis. The macro can be stopped during an analysis at any time by pressing the Escape key.

CALCULATIONS FOR WEIGHTING OF CASES

The calculation of means and variances in an unweighted analysis uses in fact an implicit weighting of 1/(number of animals) that is the same for each animal. The weighted analysis can be viewed as replacing these equal values with ones that vary from animal to animal, and that are constructed as (individual weight)/(sum of weights). The formulae are given in Snedecor & Cochran (1980 pp 231 – 232), and in Draper & Smith (1981 pp. 108-115). When used, the weighting is applied throughout, i.e. for both Wilk's lambda and t-tests.

SAMPLE SIZES

As noted by Aebischer *et al.* (1993b), with reference to Siegel (1956), if values of a log-ratio difference all have the same sign, 6 is the minimum sample size required to show a significant difference from zero at *P* < .05 by randomization. Aebischer *et al.* (1993b) advise that for a comparison of utilized with available habitats, 6 radio-tagged animals constitute an absolute minimum. They recommend sample sizes above 10, and preferably above 30 animals, to represent a population adequately.

Missing values (zeros) in "Avail" have a direct effect on sample size. The effective sample size of each category of the log-ratio differences is 1 more than the number of degrees of freedom reported in the univariate test results. If the sample size of any one of these categories is less than 6 a warning message is included in the TestResults output on lines 20 and 21.

The program will not accept data with fewer cases than the number of variables as a valid Wilk's Lambda value could not then be determined.

An assumption that can affect the analysis is that compositions from different animals are equally accurate, which is untrue if numbers of radio locations vary widely from animal to animal (Aebischer *et al.* 1993b). The plus version of the program allows the number of observations per animal to be entered in the "Weight" worksheet. The square root of these numbers is then used to weight the log-ratio differences during the analysis as recommended by Aebischer *et al.* (1993b) to compensate for differences in sampling intensity.

COMPARISONS BETWEEN TREATMENTS

Typically the compositional analysis method is used to compare proportionate habitat use (in "Used") with proportionate habitat availability (in "Avail"). However, compositional analysis also allows testing for overall differences between habitat use by animals in two (or more) treatments in an ANOVA-like fashion, as shown by Aebischer *et al.* (1993a) in their Birkhäuser Verlag paper. Putting animals under treatment A in "Avail" and those under treatment B in "Used" will work ONLY if there is a natural pairing, e.g. the same animal has been subjected to both treatments (equivalent of a paired t-test). It will NOT work for the equivalent of an ordinary t-test. The present software allows for only two treatments to be included in such a test.

FURTHER ANALYSIS

The present software implements in full the analysis method presented in the 1993 Ecology paper (Aebischer *et al.* 1993b), but does not go further than that, except in that weighting of cases (animals) is implemented (in the plus version) as suggested but not carried out in the 1993 paper.

Testing for effects of factors (such as sex or season), whether main effects or their interaction, is not included in the program. However, variates containing the log-ratio differences are output as intermediate results (in the "ObsLRDs" worksheet). (Note that currently in the case of large numbers of variables – typically 16 or more - output of intermediate results to the "ObsLRDs" worksheet is limited according to the number of columns available in the worksheet.) These data could be entered into in a general statistics package to carry out further MANOVA analyses with factors entered as covariates. For a weighted analysis a variate containing the weights would also be required. This would be the data entered by the user in the "Weight" worksheet unless the user had specified the option to "weight cases by the square root of n" when generating the observed log-ratio differences, in which case the square roots of these values should be calculated as the weights variate for use in analyses within the general statistics package. It should be straightforward to obtain parametric statistics results in this manner where none of the variates contain missing data. Analyses would have to be carefully set up in an appropriate statistics package to obtain results by randomization as may be required when assumptions made for parametric tests are violated.

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APPENDIX 1: WORKED EXAMPLES

WORKED EXAMPLE 1 (Pheasants) [taken from an example presented by Aebischer *et al.* (1993b)]

The zeros in "Used" should be replaced with small values >0, such as 0.01, see above. This will be done automatically by the program if you leave them as zeros (see explanation above).

"Used" Worksheet

	A	B	C	D	E	F	G
1	Pheasants						
2	MCP	scrub	broad-leaf	conifer	grass	crop	
3	P1	19.6	1.97	0	0	78.4	
4	P2	20.58	14.7	0	0.4	64.31	
5	P3	8.32	5.73	0	58.9	27.03	
6	P4	8.78	23.86	0	12.24	55.1	
7	P5	4.41	30.29	10.32	54.98	0	
8	P6	5.43	30.52	10.11	53.94	0	
9	P7	4.34	31.24	11.02	53.39	0	
10	P8	8.66	38.71	0	52.61	0	
11	P9	9.64	53.16	0	37.17	0	
12	P10	11.72	8.82	0	79.44	0	
13	P11	14.36	32.56	0	53.05	0	
14	P12	9.7	10.95	0	79.33	0	
15	P13	5.53	20.08	4.11	70.28	0	

"Avail" Worksheet

	A	B	C	D	E	F	G
1	Pheasants						
2	Study area	scrub	broad-leaf	conifer	grass	crop	
3	P1	3.22	9.23	0.75	52.83	33.98	
4	P2	3.22	9.23	0.75	52.83	33.98	
5	P3	3.22	9.23	0.75	52.83	33.98	
6	P4	3.22	9.23	0.75	52.83	33.98	
7	P5	3.22	9.23	0.75	52.83	33.98	
8	P6	3.22	9.23	0.75	52.83	33.98	
9	P7	3.22	9.23	0.75	52.83	33.98	
10	P8	3.22	9.23	0.75	52.83	33.98	
11	P9	3.22	9.23	0.75	52.83	33.98	
12	P10	3.22	9.23	0.75	52.83	33.98	
13	P11	3.22	9.23	0.75	52.83	33.98	
14	P12	3.22	9.23	0.75	52.83	33.98	
15	P13	3.22	9.23	0.75	52.83	33.98	

Results generated by Worked Example 1 (Pheasants) as they appear in the TestResults worksheet.

NB: this analysis was run on a 2.6 GHz Pentium PC with 1 GB of RAM.

Pheasants - MCP (used) vs. Study area (available).
Multivariate (Wilk's lambda) test   Smith Ecology Compos Analysis 6.2 plus: test run created
22/06/2005 at 21:04:37   Time to complete (h:mm:ss): 0:00:04

Lambda =   0.0849
Chi Sq=   32.0591 d.f.= 4
P =   0.0000 P < .0001
Rand P =   0.0020

None of the 'Avail' values was zero. 19 'Used' values of 0% were replaced by 0.01.

Univariate tests (t-tests)

Numerator	scrub	scrub	scrub	scrub	broad-leaf	broad-leaf	broad-leaf	conifer	conifer	grass
Denominator	broad-leaf	conifer	grass	crop	conifer	grass	crop	grass	crop	crop
t-statistic	1.0905	3.2146	2.4989	6.0746	3.4310	2.8052	4.6793	-1.2032	1.8682	2.5256
d.f.	12	12	12	12	12	12	12	12	12	12
Mean	0.3785	3.2701	2.0965	6.5166	2.8916	1.7181	6.1381	-1.1736	3.2465	4.4200
StErr	0.3471	1.0173	0.8390	1.0728	0.8428	0.6125	1.3118	0.9754	1.7377	1.7501
Obs p value	0.2969	0.0074	0.0280	0.0001	0.0050	0.0159	0.0005	0.2521	0.0863	0.0266
Obs sig level	+	+++	+++	+++	+++	+++	+++	-	+	+++
Rand p value	0.3220	0.0120	0.0020	0.0020	0.0070	0.0040	0.0070	0.2430	0.1100	0.0410
Rand sig level	*	***	***	***	***	***	***	*	*	***
nCases	13									
nVariables	5									
Iterations	1000									

Matrix of means and standard errors

	scrub	**broad-leaf**	**conifer**	**grass**	**crop**
scrub		0.378 ± 0.347	3.270 ± 1.017	2.097 ± 0.839	6.517 ± 1.073
broad-leaf	-0.378 ± 0.347		2.892 ± 0.843	1.718 ± 0.612	6.138 ± 1.312
conifer	-3.270 ± 1.017	-2.892 ± 0.843		-1.174 ± 0.975	3.246 ± 1.738
grass	-2.097 ± 0.839	-1.718 ± 0.612	1.174 ± 0.975		4.420 ± 1.750
crop	-6.517 ± 1.073	-6.138 ± 1.312	-3.246 ± 1.738	-4.420 ± 1.750	

Ranked variable sequence (most to least used):   **scrub>broad-leaf>>>grass>conifer>crop**

>>> denotes a significant difference between two consecutively ranked variables

Simplified ranking matrix

	scrub	**broad-leaf**	**conifer**	**grass**	**crop**	**Rank**
scrub		+	+++	+++	+++	4
broad-leaf	-		+++	+++	+++	3
conifer	---	---		-	+	1
grass	---	---	+		+++	2
crop	---	---	-	---		0

Example of "Weight" worksheet that would be valid for use with the above example

"Weight" Worksheet

	A	B	C	D	E	F
1	Pheasants					
2	Case ID	n Observations				
3	P1	30				
4	P2	20				
5	P3	30				
6	P4	25				
7	P5	20				
8	P6	30				
9	P7	30				
10	P8	30				
11	P9	30				
12	P10	30				
13	P11	30				
14	P12	30				
15	P13	30				

Results generated by Worked Example 1 (Pheasants) when the weightings above are applied.

NB: this analysis was run on a 2.6 GHz Pentium PC with 1 GB of RAM.

Pheasants - MCP (used) vs. Study area (available).
Multivariate (Wilk's lambda) test   Smith Ecology Compos Analysis 6.2 plus: test run created
22/06/2005 at 20:02:01   Time to complete (h:mm:ss): 0:00:04

Lambda =   0.0852
Chi Sq=   32.0188   d.f.= 4
P =   0.0000   P < .0001
Rand P =   0.0010

None of the 'Avail' values was zero. 19 'Used' values of 0% were replaced by 0.01.
Log-ratio differences derived from each of the 13 cases were weighted by the square root of the corresponding n Observations.

Univariate tests (t-tests)

Numerator	scrub	scrub	scrub	scrub	broad-leaf	broad-leaf	broad-leaf	conifer	conifer	grass
Denominator	broad-leaf	conifer	grass	crop	conifer	grass	crop	grass	crop	crop
t-statistic	1.1020	3.2600	2.4556	6.2098	3.4652	2.7365	4.7689	-1.2660	1.9317	2.6248
d.f.	12	12	12	12	12	12	12	12	12	12
Mean	0.3843	3.2950	2.0527	6.6075	2.9107	1.6685	6.2233	-1.2422	3.3125	4.5548
StErr	0.3487	1.0107	0.8360	1.0641	0.8400	0.6097	1.3050	0.9813	1.7148	1.7353
Obs p value	0.2921	0.0068	0.0303	0.0000	0.0047	0.0180	0.0005	0.2296	0.0774	0.0222
Obs sig level	+	+++	+++	+++	+++	+++	+++	-	+	+++
Rand p value	0.3210	0.0050	0.0010	0.0010	0.0050	0.0050	0.0080	0.2450	0.0760	0.0280
Rand sig level	*	***	***	***	***	***	***	*	*	***
nCases	13									
nVariables	5									
Iterations	1000									

Matrix of means and standard errors

	scrub	broad-leaf	conifer	grass	crop
scrub		0.384 ± 0.349	3.295 ± 1.011	2.053 ± 0.836	6.608 ± 1.064
broad-leaf	-0.384 ± 0.349		2.911 ± 0.840	1.668 ± 0.610	6.223 ± 1.305
conifer	-3.295 ± 1.011	-2.911 ± 0.840		-1.242 ± 0.981	3.313 ± 1.715
grass	-2.053 ± 0.836	-1.668 ± 0.610	1.242 ± 0.981		4.555 ± 1.735
crop	-6.608 ± 1.064	-6.223 ± 1.305	-3.313 ± 1.715	-4.555 ± 1.735	

Ranked variable sequence (most to least used):   **scrub>broad-leaf>>>grass>conifer>crop**

>>> denotes a significant difference between two consecutively ranked variables

Simplified ranking matrix

	scrub	broad-leaf	conifer	grass	crop	Rank
scrub		+	+++	+++	+++	4
broad-leaf	-		+++	+++	+++	3
conifer	---	---		-	+	1
grass	---	---	+		+++	2
crop	---	---	-	---		0

WORKED EXAMPLE 2 (Pheasants) [taken from an example presented by Aebischer *et al.* (1993b)]

The zeros in "Used" should be replaced with small values >0, such as 0.01, see above. This will be done automatically by the program if you leave them as zeros (see explanation above).

"Used" Worksheet

	A	B	C	D	E
1	Pheasants				
2	Fix	scrub	broad-leaf	grass	
3	2	57	25.5	0	
4	3	47.6	14.3	4.8	
5	4	19.6	73.9	6.5	
6	5	6.7	45	8.3	
7	6	6.7	90	0	
8	7	0	53.3	0	
9	8	16.7	80	3.3	
10	9	6.7	78.3	15	
11	10	40.7	14.8	44.5	
12	11	39.3	14.3	46.4	
13	12	26.9	9.6	63.5	
14	13	13	37	22.2	

"Avail" Worksheet

	A	B	C	D	E
1	Pheasants				
2	MCP	scrub	broad-leaf	grass	
3	2	20.58	14.7	0.4	
4	3	8.32	5.73	58.9	
5	4	8.78	23.86	12.24	
6	5	4.41	30.29	54.98	
7	6	5.43	30.52	53.94	
8	7	4.34	31.24	53.39	
9	8	8.66	38.71	52.61	
10	9	9.64	53.16	37.17	
11	10	11.72	8.82	79.44	
12	11	14.36	32.56	53.05	
13	12	9.7	10.95	79.33	
14	13	5.53	20.08	70.28	

Results generated by Worked Example 2 (Pheasants) as they appear in the TestResults worksheet.

NB: this analysis was run on a 2.6 GHz Pentium PC with 1 GB of RAM.

Pheasants - Fix (used) vs. MCP (available).

Multivariate (Wilk's lambda) test   Smith Ecology Compos Analysis 6.2 plus: test run created 22/06/2005 at 21:07:06   Time to complete (h:mm:ss): 0:00:03

Lambda =	**0.3656**	
Chi Sq=	**12.0755**	**d.f.= 2**
P =	**0.0024**	**P < .01**
Rand P =	**0.0030**	

None of the 'Avail' values was zero. 4 'Used' values of 0% were replaced by 0.01.

Univariate tests (t-tests)

Numerator	scrub	scrub	broad-leaf
Denominator	broad-leaf	grass	grass
t-statistic	-0.4527	4.3687	3.3401
d.f.	11	11	11
Mean	-0.2795	2.8501	3.1296
StErr	0.6174	0.6524	0.9370
Obs p value	0.6596	0.0011	0.0066
Obs sig level	-	+++	+++
Rand p value	0.8710	0.0020	0.0040
Rand sig level	*	***	***
nCases	12		
nVariables	3		
Iterations	1000		

Matrix of means and standard errors

	scrub	**broad-leaf**	**grass**
scrub		-0.280 ± 0.617	2.850 ± 0.652
broad-leaf	0.280 ± 0.617		3.130 ± 0.937
grass	-2.850 ± 0.652	-3.130 ± 0.937	

Ranked variable sequence (most to least used):   **broad-leaf>scrub>>>grass**
>>> denotes a significant difference between two consecutively ranked variables

Simplified ranking matrix

	scrub	**broad-leaf**	**grass**	**Rank**
scrub		-	+++	1
broad-leaf	+		+++	2
grass	---	---		0

WORKED EXAMPLE 3 (Squirrels) [taken from an example presented by Aebischer *et al.*
(1993b)]

The zeros in "Used" should be replaced with small values >0, such as 0.01, see above. This
will be done automatically by the program if you leave them as zeros (see explanation above).

"Used" Worksheet

	A	B	C	D	E	F	G
1	Squirrels						
2	MCP	young	*Thuja*	larch	mature	open	
3	1	0	0	37.85	61.53	0.6	
4	2	60.01	0	1.88	35.53	2.57	
5	3	88.82	0	0	3.56	7.61	
6	4	19.73	0	29.49	41.6	9.18	
7	5	5.78	21.84	0	71.1	1.27	
8	6	24.02	0	7.88	35.99	32.1	
9	7	37.63	0.4	4.52	16.76	40.69	
10	8	62.57	0	0	30.4	7.01	
11	9	0.1	0	12.54	74.82	12.54	
12	10	30.32	0	10.2	35.86	23.61	
13	11	0	0	25.64	62.76	11.58	
14	12	0	0	27.55	67.52	4.91	
15	13	61.75	0	0	11.17	27.05	
16	14	0	0	33.99	61.14	4.86	
17	15	8.47	0	18.52	56.05	16.94	
18	16	0	0	18.83	50.62	30.53	
19	17	52.56	0	2.56	41.52	3.35	

"Avail" Worksheet

	A	B	C	D	E	F	G
1	Squirrels						
2	Study area	young	*Thuja*	larch	mature	open	
3	1	7.35	4.77	1.83	31.7	54.35	
4	2	7.35	4.77	1.83	31.7	54.35	
5	3	7.35	4.77	1.83	31.7	54.35	
6	4	7.35	4.77	1.83	31.7	54.35	
7	5	7.35	4.77	1.83	31.7	54.35	
8	6	7.35	4.77	1.83	31.7	54.35	
9	7	7.35	4.77	1.83	31.7	54.35	
10	8	7.35	4.77	1.83	31.7	54.35	
11	9	7.35	4.77	1.83	31.7	54.35	
12	10	7.35	4.77	1.83	31.7	54.35	
13	11	7.35	4.77	1.83	31.7	54.35	
14	12	7.35	4.77	1.83	31.7	54.35	
15	13	7.35	4.77	1.83	31.7	54.35	
16	14	7.35	4.77	1.83	31.7	54.35	
17	15	7.35	4.77	1.83	31.7	54.35	
18	16	7.35	4.77	1.83	31.7	54.35	
19	17	7.35	4.77	1.83	31.7	54.35	

Results generated by Worked Example 3 (Squirrels) as they appear in the TestResults worksheet.

NB: this analysis was run on a 2.6 GHz Pentium PC with 1 GB of RAM.

Squirrel - MCP (used) vs. Study area (available).
Multivariate (Wilk's lambda) test Smith Ecology Compos Analysis 6.2 plus: test run created
22/06/2005 at 21:08:52   Time to complete (h:mm:ss): 0:00:05

Lambda =   0.0681
Chi Sq=   45.6791 d.f.= 4
P =   0.0000 P < .0001
Rand P<=   0.0010

None of the 'Avail' values was zero. 24 'Used' values of 0% were replaced by 0.01.

Univariate tests (t-tests)

Numerator	young	young	young	young	Thuja	Thuja	Thuja	larch	larch	mature
Denominator	Thuja	larch	mature	open	larch	mature	open	mature	open	open
t-statistic	4.2712	-0.9797	-1.3137	0.6685	-5.3675	-11.0729	-5.8376	0.1541	2.6133	5.1572
d.f.	16	16	16	16	16	16	16	16	16	16
Mean	4.2427	-1.5061	-1.4003	0.6159	-5.7488	-5.6430	-3.6268	0.1058	2.1220	2.0162
StErr	0.9933	1.5373	1.0659	0.9213	1.0710	0.5096	0.6213	0.6867	0.8120	0.3909
Obs p value	0.0006	0.3418	0.2075	0.5133	0.0001	0.0000	0.0000	0.8795	0.0188	0.0001
Obs sig level	+++	-	-	+	---	---	---	+	+++	+++
Rand p value	0.0010	0.3460	0.2140	0.5110	0.0010	0.0010	0.0010	0.8750	0.0190	0.0010
Rand sig level	***	*	*	*	***	***	***	*	***	***
nCases	17									
nVariables	5									
Iterations	1000									

Matrix of means and standard errors

	young	Thuja	larch	mature	open
young		4.243 ± 0.993	-1.506 ± 1.537	-1.400 ± 1.066	0.616 ± 0.921
Thuja	-4.243 ± 0.993		-5.749 ± 1.071	-5.643 ± 0.510	-3.627 ± 0.621
larch	1.506 ± 1.537	5.749 ± 1.071		0.106 ± 0.687	2.122 ± 0.812
mature	1.400 ± 1.066	5.643 ± 0.510	-0.106 ± 0.687		2.016 ± 0.391
open	-0.616 ± 0.921	3.627 ± 0.621	-2.122 ± 0.812	-2.016 ± 0.391	

Ranked variable sequence (most to least used):   **larch>mature>young>open>>>Thuja**

>>> denotes a significant difference between two consecutively ranked variables

Simplified ranking matrix

	young	Thuja	larch	mature	open	Rank
young		+++	-	-	+	2
Thuja	---		---	---	---	0
larch	+	+++		+	+++	4
mature	+	+++	-		+++	3
open	-	+++	---	---		1

WORKED EXAMPLE 4 (Squirrels) [taken from an example presented by Aebischer *et al.* (1993b)]

The zeros in "Used" should be replaced with small values >0, such as 0.01, see above. This will be done automatically by the program if you leave them as zeros (see explanation above).

"Used" Worksheet

	A	B	C	D	E	F
1	Squirrels					
2	Fix	young	larch	mature	open	
3	1	0	29.55	70.45	0	
4	2	31.03	0	65.52	3.45	
5	3	70.59	0	5.88	23.53	
6	4	4.76	16.67	54.76	23.81	
7	5	3.57	0	89.29	3.57	
8	6	27.59	1.72	56.9	13.79	
9	7	18.52	0	70.37	11.11	
10	8	50	0	39.29	10.71	
11	9	0	12.5	62.5	25	
12	10	26.67	0	56.67	16.67	
13	11	0	20	70	10	
14	12	0	13.79	82.76	3.45	
15	13	86.67	0	10	3.33	
16	14	0	14.58	77.08	8.33	
17	15	6.9	10.34	67.24	15.52	
18	16	0	41.67	55	3.33	
19	17	32.61	4.35	47.83	15.22	

"Avail" Worksheet

	A	B	C	D	E	F
1	Squirrels					
2	MCP	young	larch	mature	open	
3	1	0	37.85	61.53	0.6	
4	2	60.01	1.88	35.53	2.57	
5	3	88.82	0	3.56	7.61	
6	4	19.73	29.49	41.6	9.18	
7	5	5.78	0	71.1	1.27	
8	6	24.02	7.88	35.99	32.1	
9	7	37.63	4.52	16.76	40.69	
10	8	62.57	0	30.4	7.01	
11	9	0.1	12.54	74.82	12.54	
12	10	30.32	10.2	35.86	23.61	
13	11	0	25.64	62.76	11.58	
14	12	0	27.55	67.52	4.91	
15	13	61.75	0	11.17	27.05	
16	14	0	33.99	61.14	4.86	
17	15	8.47	18.52	56.05	16.94	
18	16	0	18.83	50.62	30.53	
19	17	52.56	2.56	41.52	3.35	

Results generated by Worked Example 4 (Squirrels) as they appear in the TestResults worksheet.

NB: this analysis was run on a 2.6 GHz Pentium PC with 1 GB of RAM.

Squirrel - Fix (used) vs. MCP (available).

Multivariate (Wilk's lambda) test Smith Ecology Compos Analysis 6.2 plus: test run created 22/06/2005 at 21:11:27   Time to complete (h:mm:ss): 0:00:12

Weighted mean lambda =	**0.3445**	0.2517	0.5533	0.2874	0.3034
(Chi Sq=	18.1148 d.f.= 3	Warning: weighted mean lambda is most unlikely to conform to standard Chi Sq distribution.)			
(P =	0.0004 P < .001	)			
Rand P =	**0.0200**				

9 'Avail' values were zero, so treated as missing. 5 'Used' values of 0% where corresponding 'Avail' was nonzero were replaced by 0.01.

Univariate tests (t-tests)

Numerator	young	young	young	larch	larch	mature
Denominator	larch	mature	open	mature	open	open
t-statistic	1.5386	-3.9418	-1.4408	-2.4477	-1.5103	1.6062
d.f.	7	11	11	12	12	16
Mean	1.8326	-0.8848	-0.6438	-1.9854	-1.2514	0.5839
StErr	1.1911	0.2245	0.4469	0.8111	0.8285	0.3635
Obs p value	0.1678	0.0023	0.1775	0.0307	0.1568	0.1278
Obs sig level	+	---	-	---	-	+
Rand p value	0.2030	0.0040	0.1890	0.0120	0.1610	0.1470
Rand sig level	*	***	*	***	*	*
nCases	17					
nVariables	4					
Iterations	1000					

Matrix of means and standard errors

	young	**larch**	**mature**	**open**
young		1.833 ± 1.191	-0.885 ± 0.224	-0.644 ± 0.447
larch	-1.833 ± 1.191		-1.985 ± 0.811	-1.251 ± 0.829
mature	0.885 ± 0.224	1.985 ± 0.811		0.584 ± 0.364
open	0.644 ± 0.447	1.251 ± 0.829	-0.584 ± 0.364	

Ranked variable sequence (most to least used):   **mature>open>young>larch**
>>> denotes a significant difference between two consecutively ranked variables

Simplified ranking matrix

	young	**larch**	**mature**	**open**	**Rank**
young		+	---	-	1
larch	-		---	-	0
mature	+++	+++		+	3
open	+	+	-		2