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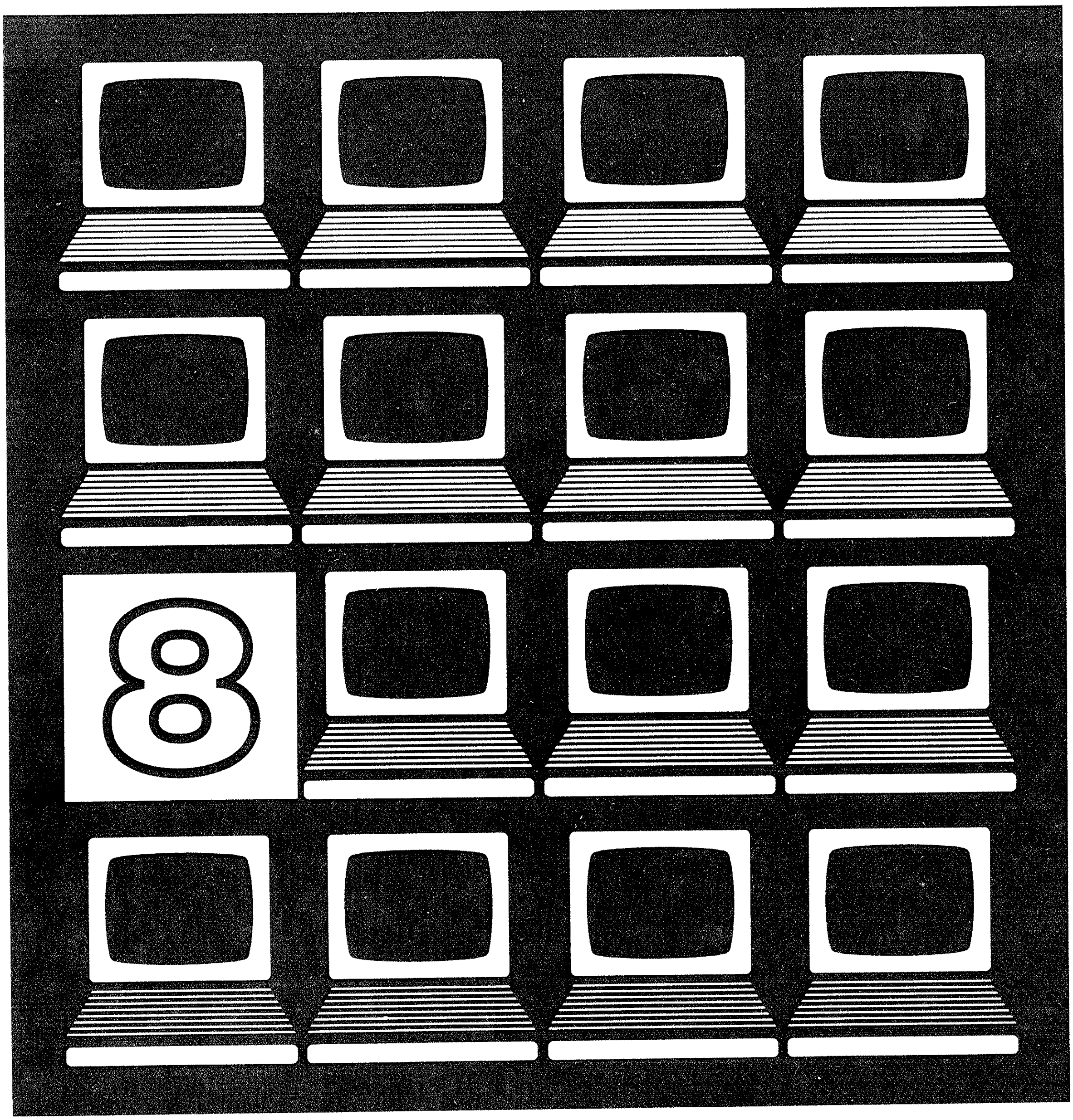
The Microcomputer Scientific Software Series 8

The SYCOOR Users Manual

Edgar E. Gutiérrez-Espeleta and Gary Brand



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The Microcomputer Scientific Software Series 8: The SYCOOR Users Manual

Edgar E. Gutiérrez–Espeleta and Gary J. Brand

This manual describes how to use a microcomputer program that implements Bakuzis' (1959) Method of Synecological Coordinates (MSC). Background information about the method is first provided to help you understand what is needed to use the program and interpret its results. The current version of SYCOOR (short for SYnecological COORdinates) is a BASIC computer program that runs on a Macintosh™ microcomputer. But SYCOOR does not have the typical Macintosh™ "look and feel," based heavily on the use of pull-down menus, windows, dialog boxes, a mouse to make selections, and the ability to interrupt the program to activate desk accessories or other programs and windows. Rather, you make selections from menus or answer simple questions by entering your response from the keyboard. Because our primary objective is to provide a way for MSC to be more easily used and better understood, we chose a simpler interface that can be more readily converted to other computers.

THE METHOD OF SYNECOLOGICAL COORDINATES

The edaphic and climatic environment, strongly influenced by biotic interactions and human and natural disturbance, determines to a large degree the distribution of plant communities across a landscape. Several ordination techniques have been used to distinguish plant communities and thereby infer, either directly or indirectly, their associated environments (Jongman *et al.* 1987). Knowing more about these environments can help us better predict vegetative change and manage accordingly.

The Method of Synecological Coordinates (Bakuzis 1959) uses relative indicator values of those species occurring together to estimate the operational environment (described by moisture, nutrients, heat, and light factors). The principal advantage of MSC over ordination methods is its foundation based on prior ecological knowledge of species' environmental adaptations. Therefore, MSC provides an ecosystem space in terms of matter and energy, not a species-composition space with imaginary axes (the first, the second, and third) that are subsequently related to combinations of environmental measurements (Bakuzis and Kurmis 1978).

Originally developed in 1959 (Bakuzis 1959, Bakuzis and Kurmis 1978) for Minnesota forest plants, MSC has also been applied to tree and shrub species in Michigan (Brand 1985), in one Holdridge Life Zone and one transitional belt in Costa Rica (Gutiérrez–Espeleta 1991, Gutiérrez–Espeleta and Mize 1993), and to trees in New England (Hershey and Befort, in press). It is similar to weighted averaging discussed by Gauch (1982) and attributed to Ellenberg (1948), Whittaker (1948), Curtis and MacIntosh (1951), and Rowe (1956). Weighted averaging is a mathematically simple approach requiring only species' abundances and weights. Assigned weights (synecological coordinates in the terminology of Bakuzis or indicator values in the terminology of Ellenberg) for all species occurring together are multiplied by their respective abundances and accumulated. This total, divided by the sum of the individual species' abundances, produces a weighted average abundance (score) for the site. Alternatively, scores for species can be computed by using weights assigned to sites. MSC differs slightly from the above in that a weighted average presence is usually calculated (equivalent to using abundance = 1 when present and = 0 when absent).

In MSC, weights are assigned to each species according to its prevailing occurrence under

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conditions of competition (i.e. not necessarily ideal conditions but an average value for a niche), on a relative scale from 1 (lowest intensity) to 5 (highest intensity) along moisture (M), nutrient (N), heat (H), and light (L) axes. Each factor represents a complex of interacting environmental conditions.

There are two components of the method: calibration and application. The purpose of calibration is to adjust preliminary coordinates to more accurately reflect the regional environmental preferences of a species. Once synecological coordinates have been adjusted, they can be applied in particular sites of interest. Calibration is not required when previously adjusted coordinates are available. A list of plant species present at each site sampled is needed for both calibration and application.

Calibration

To develop coordinates in a new area, initial values for each species' moisture, nutrient, heat, and light requirements are needed. Initial values are derived from descriptions of the plant's habitat found in the literature and then adjusted based on the species composition of sampled sites. The following steps produce adjusted synecological coordinates:

1) Define the sampling frame or study unit (SU), i.e. the area of study (e.g., forest types, regions, or some other class).
2) Define the size and number (K) of sites to sample. Note: In this paper we discuss a site as though it were a single entity. Some sample designs may use a number of subplots scattered across a site. If this is the case, then each of the K sites will contain subplots, which are combined.
3) Locate the K sites so that the **different** environments encountered in the SU are **well represented.**
4) At each site, record each species present (multiple occurrences of species in subplots are recorded as a single occurrence for the site).
5) From all sites, make a list of all species found and assign each species a unique identification code.
6) For each species, assign a synecological coordinate representing the species' adaptations to, or requirements for, moisture (M), nutrients (N), heat (H), and light (L). These values can be obtained from the literature or from an ecologist familiar with the environmental requirements of the species.
7) Compute the weighted average presence for each site using the assigned coordinates as weights. Use 1 if the species is present and 0 if it is absent.
8) Compute another weighted average presence, but this time for each species. Use the weighted average for each site (computed in step 7) as the weight and presence/absence of the species at each site.
9) Adjust the species' assigned values according to the approach outlined in Appendix A. The premise behind the adjustment approach is that all species with "real" coordinates of 2, for example, should occur on similar sites. If a species initially assigned a value of 4 occurs most often on these sites, then its coordinate should be changed to 2.

Application

The following steps are used when species coordinates do not need adjustment:

1) Define the sampling frame or study unit (SU), i.e. the area of study (e.g., forest types, regions, or some other class).
2) Define the size and number (K) of sites to sample. As above, each of the K sites may contain subplots, which are combined.
3) Locate the K sites so that the objectives for sampling the SU are met.
4) At each site, record each species present (multiple occurrences of species in subplots are recorded as a single occurrence for the site).
5) From all sites, make a list of all species found and assign each species a unique identification code.
6) Compute the weighted average presence for each site using the previously adjusted coordinates as weights. Use 1 if the species is present and 0 if it is absent.
7) Compute another weighted average presence, but this time for each species. Use the weighted average for each site (computed in step 6) as the weight and presence/absence of the species at each site. These computations are used to produce ecographs (see below).

In addition to describing the environment of sites through site coordinates (step 6), MSC provides information on the ecological requirements or adaptations of species to environmental factors through ecographs. Ecographs represent the species' synecological distribution, i.e. the proportion of sites with particular site coordinates containing the species. Of the six possible bivariate combinations, the combinations moisture-nutrient and heat-light are the most important (fig. 1). They are called the edaphic and climatic fields, respectively. For example, the edaphic field ecograph for jack pine (*Pinus banksiana*) shows that at least 70 percent of the sites with both a moisture and nutrient site coordinate of less than 2 contained jack pine (fig. 1). However, Bakuzis (1959) did not find jack pine on any sites where moisture was greater than 3.2 or nutrients greater than 3. Calculations from step 7 are needed to produce ecographs.

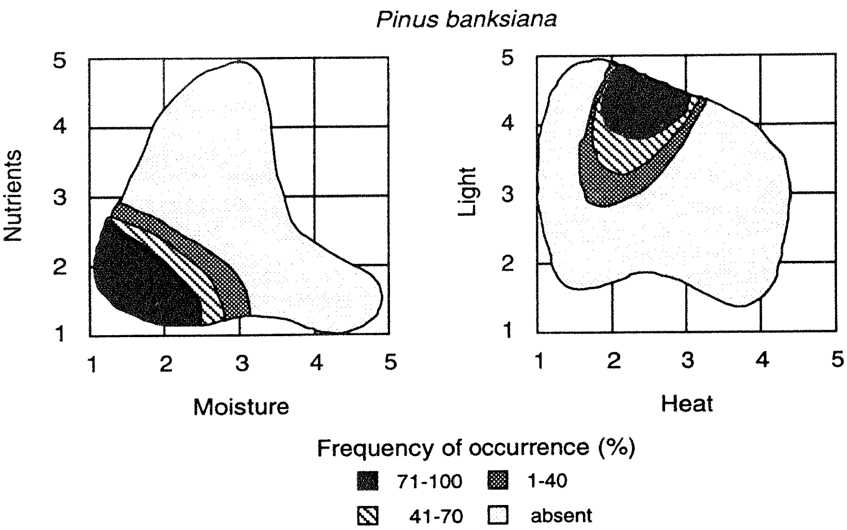

Figure 1.—*An example ecograph for the edaphic and climatic fields for* Pinus banksiana *(Bakuzis and Kurmis 1978).*

A DESCRIPTION OF SYCOOR

SYCOOR is a user-friendly, menu-driven computer program. After presenting an information screen, SYCOOR asks if the maximum number of species (initially 200) and sites (initially 50) should be changed. Enter a "y" or "n" and press "return" to answer the question. Increasing the values may cause the program to run out of memory. See the section on **Hardware and Software Requirements** for instructions on how to increase the memory allocated to SYCOOR.

The main menu (fig. 2) is presented next and provides program control. Enter the number of the option you desire and press "return." The program may also be terminated by entering "stop" in response to a yes or no question or by entering "-1" as a menu selection and then pressing "return."

Option 1—enter data from the keyboard

Data can be entered from the keyboard. Keyboard entry is most appropriate for small data sets. Data required consist of: an identifier for the study unit, the number of sites, the number of different species found and their synecological coordinates, and a list of species found at each site.

```
Do you want to:

   1 - enter data from the keyboard?
   2 - read data from a file?
   3 - edit data?
   4 - print data?
   5 - calculate synecological coordinates?
   6 - save the data in matrix format?
   7 - adjust provisional coordinates?
   8 - save calculations?
   9 - draw ecographs?
  10 - quit?

Which do you want ( 1 to 10 ; or -1 to stop SYCOOR)?
```

Figure 2.—*SYCOOR's main menu.*

Option 2—read data from a file

You can also read data from previously created files. Two file formats can be used for the input data: an ASCII file stored in COMPOSE readable format and a pair of ASCII files stored in matrix format. COMPOSE readable format is a highly structured format that can also be read by one of the Cornell Ecology programs called COMPOSE (Mohler 1987). COMPOSE produces files that are acceptable for TWINSPAN (Hill 1979a) and DECORANA (Hill 1979b), two programs often used to analyze vegetation data. Depending on how your data are formatted, you will need to select different submenus (fig. 3).

COMPOSE format files

Figure 4 shows the two forms of COMPOSE format that SYCOOR can read. Both forms consist of a header block, a data block, a species code block, and a site code block. The data block, which contains the list of species and the sites on which each occurred, begins on line three for COMPOSE format files (table 1). Standard order (this example file has the name SAMPS) lists the species and then the site on which it occurs. Transpose order (this example file has the name SAMPT) lists the site followed by one of the species found there. It is important that the largest species number and the largest site number match the numbers of species and sites, respectively, listed on the first line. SYCOOR considers any abundance value greater than zero to mean the species is present. The line following the last data entry contains a zero entered in columns 1 to 3. The species code block is next and consists of multiple lines of 10, eight character codes per line. No spaces are entered between codes if the code consists of eight characters. Codes are expected to be in the numerical order of the species numbers. The site code block is formatted identically.

Matrix format files

Matrix format files are less structured and are particularly appropriate if the data have been stored as a spreadsheet. Matrix format (fig. 5) requires two files saved in comma-separated-value format. The first file (this example file is SAMP.DAT) contains data on the occurrence of the species on the sites. Its first line contains the number of species

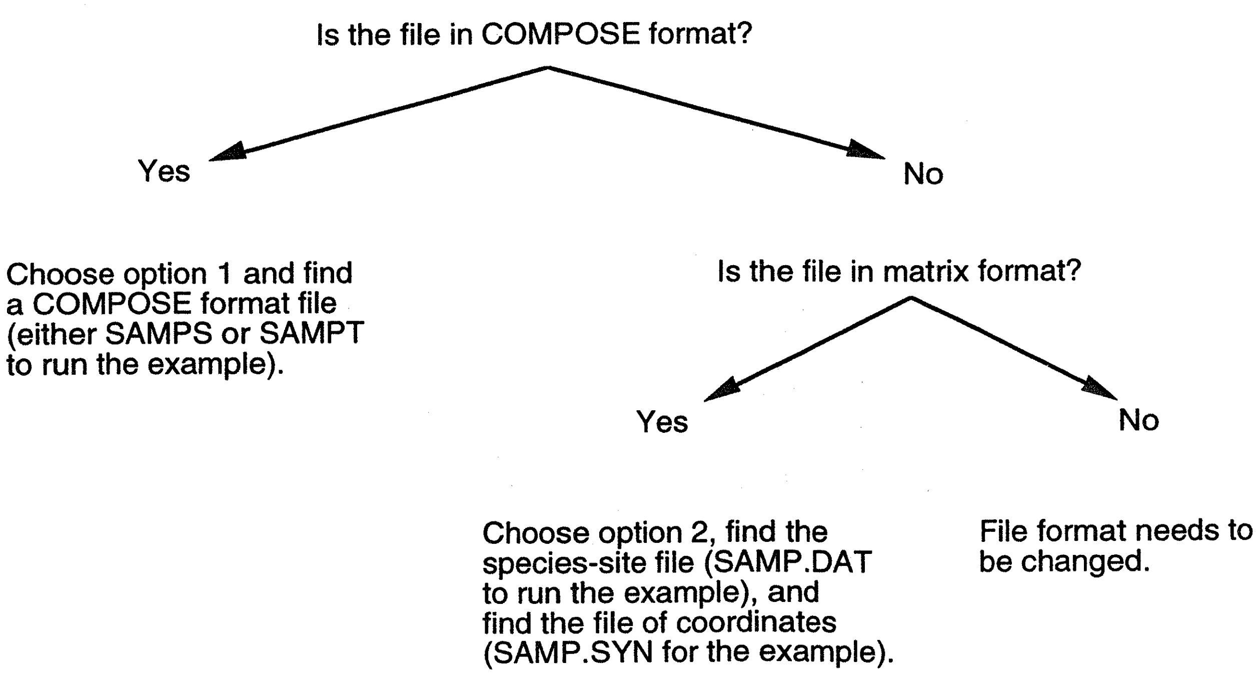

Figure 3.—*Guide to responses needed after selecting main menu option 2.*

Standard order

```
            1         2         3         4         5         6         7         8[a]
12345678901234567890123456789012345678901234567890123456789012345678901234567890[a]
  113   24 Plants from aspenS                                             SC     **
(I3,10X,I3,10X,F6.2)                                                      1
  1 ABIEBALS    1 128          .80 4 2 1 2 1992
  1 ABIEBALS    2 199          .20 4 2 1 2 1992
  1 ABIEBALS    3 2TOLAST      .60 4 2 1 2 1992
  1 ABIEBALS    4 321         1.00 4 2 1 2 1992
  1 ABIEBALS    5 81           .60 4 2 1 2 1992
  1 ABIEBALS    6 HOVLAND     1.00 4 2 1 2 1992
  1 ABIEBALS    7 PORTBRK      .80 4 2 1 2 1992
  1 ABIEBALS    8 THUR2       1.00 4 2 1 2 1992
  2 ACERRUBR    1 128          .20 2 2 3 3 1992
  2 ACERRUBR    9 129          .80 2 2 3 3 1992
  2 ACERRUBR    2 199          .20 2 2 3 3 1992
...
112 VIBUTRIL    1 128          .40 3 3 3 3 1992
112 VIBUTRIL    4 321          .40 3 3 3 3 1992
112 VIBUTRIL   10 470          .20 3 3 3 3 1992
112 VIBUTRIL   21 82           .20 3 3 3 3 1992
113 VICIAMER    1 128          .20 3 3 4 3 1992
113 VICIAMER    4 321          .40 3 3 4 3 1992
000
ABIEBALSACERRUBRACERSAC2ACERSPICACTAPACHACTARUBRALNURUGOAMELSPP.AMPHBRACANEMQUIN
APOCANDRAQUICANAARALNUDIARALRACEASARCANAASTEMACRATHYFILIBETUPAPYBOTRVIRGCARPCARO
CELASCANCLINBORECOMPPERECOPTGROECORATRIFCORNALTECORNCANACORNRACECORNRUGOCORNSTOL
CORYAMERCORYCORNCRYPCANADESMGLUTDIERLONIDIRCPALUDRYOSPINEPIGREPEEQUIARVEEQUIPRAT
EQUISYLVFRAGVESCFRAGVIRGFRAXNIGRFRAXPENNGALIBOREGALITRI2GAULPROCGYMNDRYOHEPAAMER
LATHOCHRLATHVENOLINNBORELONICANALONIHIRSLYCOANNOLYCOCLAVLYCOCOMPLYCOOBSCMAIACANA
MELALINEMITENUDAOSMOCLAYOSTRVIRGPARTQUINPEDICANAPETAPALMPICEGLAUPINUBANKPINUSTRO
POLYPUBEPOPUBALSPOPUGRANPOPUTREMPRENALBAPRUNPENSPRUNSEROPRUNVIRGPTERAQUIQUERMACR
QUERRUBRRHUSRADIRIBEAMERRIBEHIRTROSAACICRUBUIDAERUBUPARVRUBUPUBERUDBLACISALIHUMI
SANIMARISMILRACESMILSTELSMILTRIFSOLIFLEXSORBAMERSPIRALBASTREROSESYMPALBUTARAOFFI
THALDIOITILIAMERTRIEBORETRILGRANULMUAMERUVULGRANUVULSESSVACCANGUVACCMYRTVIBULENT
VIBURAFIVIBUTRILVICIAMER
128     199     2TOLAST 321     81      HOVLAND PORTBRK THUR2   129     470
D9      FRI1    PILLAG2 THUR1   THUR4   TOMAHAWKTUE1    TUE3    WED1    TUE2
82      THUR3   WED3    WED2
```

[a]*This row is not part of the data file; it is used as an aid to understanding its format.*

(Figure 4 continued on next page)

Figure 4.—*Two forms of COMPOSE readable format that are used by SYCOOR. In the first form, data are ordered by species (standard order); and in the second form, data are ordered by plot (transpose order).*

followed by the number of sites. Site codes (name or identifier for the site) are listed on the second line. A blank field precedes the first site code to facilitate alignment of the site codes with their respective species presence lists when viewed in a spreadsheet program. Each subsequent line contains a species code and indicates whether the species is present (1) or absent (0) on each site. If abundance values appear instead of simply a one or zero, SYCOOR will convert all values greater than zero to one. The second file (this example file is SAMP.SYN) contains the species code and synecological coordinates for each species listed in the first file. The order and codes of the species in the two files must be the same.

Option 3—edit data

Changes can be made in the synecological coordinates assigned to a species or in the species assigned to a site. The number associated with the species is used to identify the species that will have its coordinates changed. Likewise, the site number is used to designate which site needs to have different species assigned to it. Changing species assigned to a site can be tedious because all species occurring on the site need to be entered.

Option 4—print data

Obtain a printed copy of the data by selecting option 4. A list of species present on the sites or a list of the synecological coordinates for each species can be printed.

(Figure 4. continued)

Transpose order

```
         1         2         3         4         5         6         7         8a
12345678901234567890123456789012345678901234567890123456789012345678901234567890a
  113   24 Plants from aspenT                                          TC     **
(I3,10X,I3,10X,F6.2)                                                   1
  1 128          1 ABIEBALS    .80 4 2 1 2 1992
  1 128          2 ACERRUBR    .20 2 2 3 3 1992
  1 128          3 ACERSPIC    .40 3 2 2 1 1992
  1 128          4 ACTAPACH    .20 3 4 2 1 1992
  1 128          5 ACTARUBR    .40 3 3 2 1 1992
  1 128          6 ALNURUGO    .20 5 2 1 4 1992
  1 128          7 ANEMQUIN    .80 4 3 3 4 1992
  1 128          8 APOCANDR    .40 1 2 3 5 1992
  1 128          9 ARALNUDI    .80 2 2 2 3 1992
  1 128         10 ASTEMACR    .80 2 2 2 3 1992
...
 24 WED3        32 RUBUPUBE   1.00 4 2 1 1 1992
 24 WED3       112 RUDBLACI    .40 4 5 4 3 1992
 24 WED3        33 SANIMARI    .80 2 3 3 3 1992
 24 WED3        88 SOLIFLEX    .20 3 5 3 1 1992
 24 WED3       113 TARAOFFI    .40 2 2 3 5 1992
 24 WED3        35 THALDIOI    .40 2 3 3 3 1992
 24 WED3        60 TILIAMER    .20 2 5 4 1 1992
 24 WED3        76 ULMUAMER    .60 3 5 4 2 1992
 24 WED3        54 UVULSESS    .40 2 4 3 1 1992
000
ABIEBALSACERRUBRACERSPICACTAPACHACTARUBRALNURUGOANEMQUINAPOCANDRARALNUDIASTEMACR
ATHYFILIBETUPAPYCORYCORNDIERLONIEQUIPRATEQUISYLVFRAGVIRGGALIBOREGALITRI2GYMNDRYO
LATHOCHRLATHVENOLONICANALONIHIRSMAIACANAMITENUDAPETAPALMPOPUTREMPRENALBAPTERAQUI
ROSAACICRUBUPUBESANIMARISTREROSETHALDIOIVIBURAFIVIBUTRILVICIAMERAMELSPP.AQUICANA
ASARCANACLINBORECORNCANACORNSTOLDRYOSPINEQUIARVEFRAXNIGRPOPUBALSPRUNVIRGRIBEHIRT
TRIEBORETRILGRANUVULGRANUVULSESSACERSAC2BOTRVIRGLYCOOBSCQUERRUBRRHUSRADITILIAMER
CARPCAROCOPTGROECORATRIFLYCOCLAVOSMOCLAYCORYAMERHEPAAMERPICEGLAUPINUSTROSYMPALBU
VACCANGUCORNALTERIBEAMERRUBUIDAESPIRALBAULMUAMERVIBULENTCOMPPEREEPIGREPEGAULPROC
LYCOCOMPMELALINEPINUBANKPRUNPENSSALIHUMIFRAGVESCPOLYPUBESOLIFLEXAMPHBRACCORNRUGO
OSTRVIRGQUERMACRRUBUPARVDESMGLUTPARTQUINSMILRACELYCOANNOSORBAMERLINNBOREPEDICANA
SMILSTELVACCMYRTCELASCANDIRCPALUSMILTRIFARALRACEPRUNSEROPOPUGRANCORNRACEFRAXPENN
CRYPCANARUDBLACITARAOFFI
128     129     199     2TOLAST 321     470     81      82      D9      FRI1
HOVLAND PILLAG2 PORTBRK THUR1   THUR2   THUR3   THUR4   TOMAHAWKTUE1    TUE2
TUE3    WED1    WED2    WED3
```

[a]*This row is not part of the data file, it is used as an aid to understanding its format.*

Option 5—calculate synecological coordinates

Three tables are produced with this option. SYCOOR table 1 (Appendix B) shows the average synecological coordinates for each site. These values are often the primary reason for using MSC because they provide estimates of the environmental factors at the site. SYCOOR table 2 (Appendix B) lists for each species the mean coordinates for all sites on which the species was found. Values in this table are used when adjusting the coordinates to local conditions. These means also give an idea of where the species is found in ecosystem space (as defined by M, N, H, and L). Also needed to adjust coordinates to local conditions are the average site scores for sites that contain species with an initial coordinate of 1, 2, 3, 4, or 5. These averages are provided in the last table, SYCOOR table 3 (Appendix B). The calculations and adjustment process are further explained in Appendix A. The tables may be printed if desired.

Option 6—save the data in matrix format

The data can be saved in matrix format as a species-site data file and a species synecological coordinate data file. Default names consist of your data file's name and the extension ".dat" or ".syn" for the two files, respectively. You may choose different names if you wish.

Option 7—adjust initial coordinates

When using MSC in a new region or with species that have estimated coordinates, you may need to adjust the initial coordinates. SYCOOR uses the results presented

Table 1.—*Description of the COMPOSE data format*

Line	Column	Description
Header Block		
1	1–5	number of species (right justified)
	6–10	number of sites (right justified)
	11–70	optional comment or name for the data set
	71	"S" if standard order or "T" if transpose order
	72	"C"
	77–78	"**"
2	1–20	"(I3,10X,I3,10x,F6.2)"
	70	"1"
Data Block		
1 –...	1–3	species number (right justified) if standard order or site number (right justified) if transpose order
	5–12	code corresponding to number in columns 1–3
	14–16	site number (right justified) if standard order or species number (right justified) if transpose order
	18–25	code corresponding to number in columns 14–16
	27–32	abundance of the species
	34	moisture value
	36	nutrient value
	38	heat value
	40	light value
	42–80	optional comment
last	1–3	"000" (zeroes)
Species Code Block		
1	1–8	code for first species
	9–16	code for second species
	...	
	73–80	code for tenth species
2		repeat for the remaining species codes
Site Code Block		
1	1–8	code for first site
	9–16	code for second site
	...	
	73–80	code for tenth site
2		repeat for the remaining site codes

Presence/Absence data.

```
 113 , 24
   ,128     ,199      ,2TOLAST ,321      ,81        ,HOVLAND ,...,THUR3    ,WED3     ,WED2
ABIEBALS, 1 , 1 , 1 , 1 , 1 , 1 ,..., 0 , 0 , 0
ACERRUBR, 1 , 1 , 1 , 1 , 1 , 0 ,..., 0 , 0 , 0
ACERSAC2, 0 , 1 , 1 , 0 , 0 , 1 ,..., 0 , 0 , 0
ACERSPIC, 1 , 1 , 1 , 1 , 0 , 1 ,..., 0 , 0 , 0
ACTAPACH, 1 , 0 , 0 , 0 , 0 , 0 ,..., 0 , 0 , 0
ACTARUBR, 1 , 0 , 0 , 1 , 0 , 0 ,..., 1 , 0 , 0
...
VIBURAFI, 1 , 0 , 0 , 1 , 0 , 0 ,..., 0 , 0 , 1
VIBUTRIL, 1 , 0 , 0 , 1 , 0 , 0 ,..., 0 , 0 , 0
VICIAMER, 1 , 0 , 0 , 1 , 0 , 0 ,..., 0 , 0 , 0
```

Synecological coordinates.

```
ABIEBALS, 4 , 2 , 1 , 2
ACERRUBR, 2 , 2 , 3 , 3
ACERSAC2, 3 , 5 , 3 , 1
ACERSPIC, 3 , 2 , 2 , 1
ACTAPACH, 3 , 4 , 2 , 1
ACTARUBR, 3 , 3 , 2 , 1
...
VIBURAFI, 2 , 2 , 3 , 3
VIBUTRIL, 3 , 3 , 3 , 3
VICIAMER, 3 , 3 , 4 , 3
```

Figure 5.—*Matrix readable format used by SYCOOR. The first file contains the presence/absence data. Species synecological coordinates are read from a file with a format like the second list.*

in SYCOOR tables 2 and 3 to adjust coordinates for each species that has occurred on a minimum number of sites. Initially, the minimum is set at 5. You are asked if the minimum should be changed. This minimum number of occurrences for a species is also used in options 8 and 9. Coordinate adjustment is an iterative process. You are asked if the maximum number of iterations (default is 20) or the convergence criterion (default is .05) should be changed. Convergence occurs when the difference between successive averages listed in the last line of SYCOOR table 3 is less than the convergence criterion for all factors. The new coordinates can be shown on the screen or printed and, if desired, saved to a file. Choosing option 5 will produce new tables based on the adjusted scores.

Option 8—save calculations

Save the site coordinates to a file (given extension ".sc") by choosing this option. In addition, data needed to prepare ecographs can be saved to a file (extension ".eco"). Again you may choose a different file name. Ecograph data are saved for each species that occurs on a minimum number of sites. As in option 7, you are asked if the minimum should be changed. The coordinates for each site at which the species is found are written to the file. Therefore, a separate program or statistical package can calculate the selected species' frequency of occurrence for various coordinate classes, i.e. data needed to produce ecographs.

Option 9—draw ecographs

Edaphic and climatic ecographs are shown on the screen with this option (fig. 6). Ecographs are shown only for species observed on the specified minimum number of sites. Again, you are asked if you want to change the minimum.

Option 10—quit

This option terminates the program. If the current data have not been saved, you have another chance to save the data.

HARDWARE AND SOFTWARE REQUIREMENTS

SYCOOR is written in True BASIC™ and is now available for the Macintosh™ computer. As distributed, SYCOOR requires 600 KB of

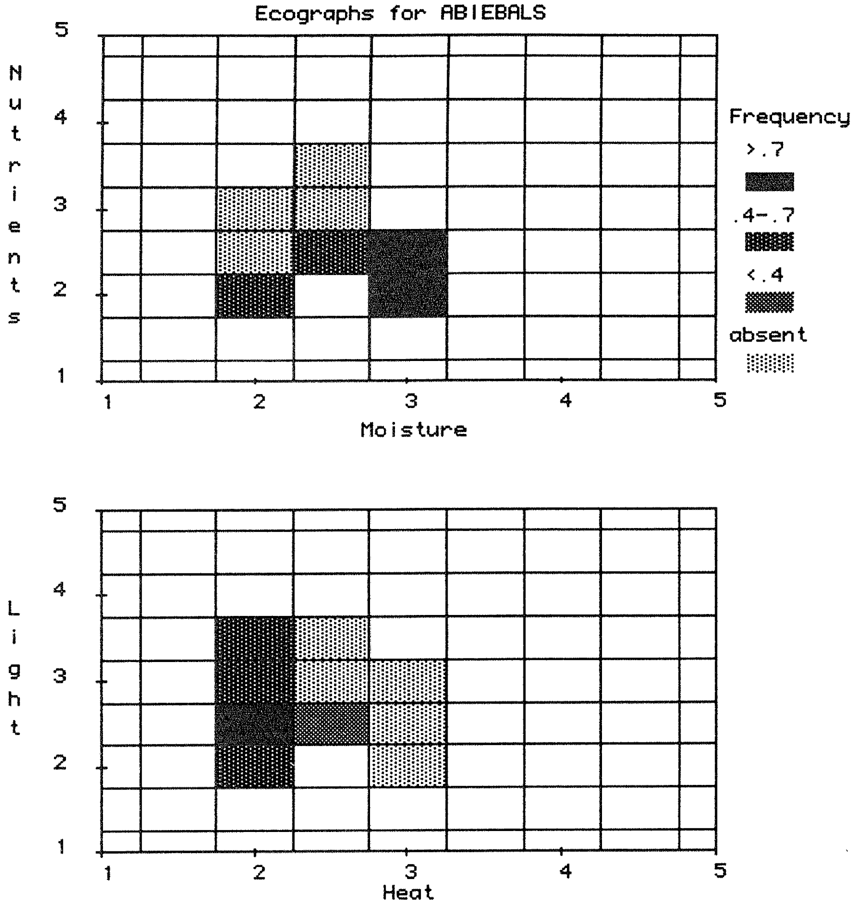

Figure 6.—*The edaphic and climatic ecographs produced by SYCOOR for balsam fir, using the example data.*

free memory to run and 150 KB of disk storage. A Macintosh compatible printer is required to print the tables.

Increasing the default maximum number of species and sites will increase the memory requirements of SYCOOR. For example, a maximum of 300 species and 300 sites requires about 2 MB of free memory. Generally, if the product of the number of species times the number of sites is less than 90,000, it will run with 2 MB of memory. You can change the memory allocated to SYCOOR at the Finder by selecting SYCOOR, choosing Get Info from the File menu, and changing the Current Memory Size. Your Macintosh™ manuals give additional help for changing the memory allocated to programs.

To make changes in the program, you will need the True BASIC™ language system.

AVAILABILITY OF THE PROGRAM

Obtain SYCOOR source code, application, and sample data files by sending a 3.5-inch diskette to:

Modeling—SYCOOR
North Central Forest Experiment Station
1992 Folwell Avenue
St. Paul, MN 55108

The sample data files contain the same data as used in this manual. SAMPS is the data file in COMPOSE standard format. SAMPT is in transpose order. SAMP.DAT (species-site data) and SAMP.SYN (synecological coordinates) contain the same data stored in matrix format.

We welcome your suggestions for improving SYCOOR.

ACKNOWLEDGMENT

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APPENDIX A—THE MATHEMATICS OF SYNECOLOGICAL COORDINATES

SYCOOR performs a series of calculations using the presence of species on sites and values of the synecological coordinates for those species. Species synecological coordinates represent four environmental factor complexes: moisture (M), nutrients (N), heat (H), and light (L). These integer species values range from 1 to 5. Site synecological coordinates provide semi-quantitative indices of the four environmental factors based on the presence of plants within the community. Because computations are identical for each environmental factor, we will show the mathematics as if there were only one factor. Actual arrays used in SYCOOR account for all four factors.

Let P_{ik} represent the presence of species i on site k. The total number of species identified is I, and the total number of sites is K. P_{ik} equals 1 if species i is present on site k; otherwise P_{ik} equals 0. S_i represents the synecological coordinate (value) of species i for our environmental factor. C_k is the site synecological coordinate for site k. Then:

$$C_k = \frac{\sum_{i=1}^{I} P_{ik} \cdot S_i}{\sum_{i=1}^{I} P_{ik}} \qquad [1]$$

SYCOOR's table 1 (Appendix B) shows values of C_k.

Ecographs show the distribution of C_k for those sites containing a given species. The environments in which a species occurs more frequently are often assumed to provide more favorable conditions for the species. Another way to show which environments are more favorable is to compute the mean site coordinate of those sites in which the species is found. Let MC_i represent the mean site coordinate for species i. Then:

$$MC_i = \frac{\sum_{k=1}^{K} P_{ik} \cdot C_k}{\sum_{k=1}^{K} P_{ik}} \qquad [2]$$

Results of equation [2] are displayed in SYCOOR's table 2 (Appendix B).

One of the key benefits of SYCOOR is its ability to adjust species synecological coordinates. Initial values are adjusted using the numbers found in SYCOOR's tables 2 and 3 (Appendix B). SYCOOR table 3 shows how many species (v) had initial values (coordinates) of 1, 2, 3, 4, or 5 and the average MC of those species. Let V_{is} equal 1 if S_i equals s; otherwise V_{is} equals 0. Also let MR_s represent the average MC for species with an initial value of s. Then:

$$MR_s = \frac{\sum_{i=1}^{I} V_{is} \cdot MC_i}{\sum_{i=1}^{I} V_{is}} \qquad [3]$$

An adjustment of S_i is needed if MC_i is not like other species with the same species synecological coordinate. For example, if species i has a coordinate of 1 but it does not occur on sites with the same community coordinates as other species that have coordinates of 1, then it probably has an incorrect synecological coordinate. SYCOOR uses linear interpolation to adjust the species coordinates. To adjust S_i, SYCOOR finds the value of MR_s closest to MC_i in SYCOOR table 3. SYCOOR chooses the s associated with this MR_s and sets the adjusted value of S_i to s. When few species with a particular s occur, there is meager evidence for the average community coordinate associated with s. Therefore, SYCOOR does not use MR_s when less than 5 percent of the species have a species coordinate of s. The adjustment/calculation cycle is repeated until the difference in successive values of MR_s is less than the convergence criterion (default value is .05). Note that MR_s for each factor must converge before the cycle ends. Iterations may also end if a maximum number of cycles has been completed (20 is the default). Synecological coordinates presented in Bakuzis and Kurmis (1978) and Brand (1985) are the result of one iteration.

APPENDIX B—SYCOOR OUTPUT TABLES

The following tables are produced by SYCOOR with Option 5, using the example data set presented in the body of the paper and provided on the distribution disk:

SYCOOR information for SU: SAMPS Date: 03/15/93

Table 1. Site synecological coordinates (i = no. of species per site).

Site	(i)	ID	Moisture	Nutrient	Heat	Light
1	(38)	128	2.45	2.29	2.11	2.97
2	(37)	199	2.62	2.62	2.14	2.38
3	(35)	2TOLAST	2.80	2.46	1.97	2.14
4	(37)	321	2.22	2.22	2.24	3.14
5	(30)	81	1.87	1.93	2.13	3.67
6	(30)	HOVLAND	2.90	2.37	1.97	2.40
7	(29)	PORTBRK	2.76	2.14	1.79	2.66
8	(19)	THUR2	2.53	2.53	2.26	2.53
9	(43)	129	2.67	2.53	2.21	2.58
10	(34)	470	2.62	2.68	2.44	2.71
11	(29)	D9	2.69	2.76	2.21	2.07
12	(36)	FRI1	2.25	2.86	2.64	2.72
13	(27)	PILLAG2	2.11	2.74	2.78	2.89
14	(10)	THUR1	2.20	2.30	2.30	2.50
15	(33)	THUR4	2.55	3.24	2.88	2.39
16	(23)	TOMAHAWK	2.22	2.04	2.17	3.00
17	(30)	TUE1	2.27	3.07	2.83	2.60
18	(24)	TUE3	1.92	2.21	2.42	3.04
19	(22)	WED1	2.18	3.23	2.86	2.27
20	(26)	TUE2	2.54	3.69	3.00	1.85
21	(30)	82	2.17	2.13	2.23	3.60
22	(35)	THUR3	1.89	2.26	2.34	3.60
23	(29)	WED3	2.31	3.10	2.90	2.93
24	(16)	WED2	2.06	3.12	3.12	3.12

Table 2. Mean site synecological coordinates by species
(k = plots where that species was present).

Species #(k)		Moisture	Nutrient	Heat	Light
1 (8)	ABIEBALS	2.52	2.32	2.08	2.73
2 (16)	ACERRUBR	2.35	2.57	2.40	2.69
3 (9)	ACERSAC2	2.53	2.92	2.50	2.31
4 (10)	ACERSPIC	2.52	2.36	2.12	2.64
5 (2)	ACTAPACH	2.56	2.41	2.16	2.78
6 (6)	ACTARUBR	2.33	2.35	2.26	3.10
7 (4)	ALNURUGO	2.28	2.34	2.28	3.22
8 (18)	AMELSPP.	2.34	2.55	2.40	2.84
9 (7)	AMPHBRAC	2.21	2.91	2.80	2.81
10 (18)	ANEMQUIN	2.39	2.58	2.37	2.68
11 (5)	APOCANDR	2.38	2.21	2.09	3.10
12 (1)	AQUICANA	2.67	2.53	2.21	2.58
13 (20)	ARALNUDI	2.38	2.57	2.37	2.73
14 (1)	ARALRACE	2.54	3.69	3.00	1.85
15 (3)	ASARCANA	2.53	2.77	2.52	2.74
16 (20)	ASTEMACR	2.38	2.49	2.31	2.75
17 (10)	ATHYFILI	2.57	2.61	2.30	2.56
18 (5)	BETUPAPY	2.61	2.48	2.18	2.64
19 (3)	BOTRVIRG	2.57	3.19	2.67	2.21
20 (1)	CARPCARO	2.80	2.46	1.97	2.14
21 (3)	CELASCAN	2.43	2.99	2.68	2.41
22 (9)	CLINBORE	2.49	2.47	2.19	2.58
23 (1)	COMPPERE	1.87	1.93	2.13	3.67
24 (1)	COPTGROE	2.80	2.46	1.97	2.14
25 (1)	CORATRIF	2.80	2.46	1.97	2.14
26 (5)	CORNALTE	2.43	3.02	2.66	2.36
27 (8)	CORNCANA	2.55	2.40	2.15	2.64
28 (2)	CORNRACE	2.19	3.11	3.01	3.03
29 (4)	CORNRUGO	2.24	2.84	2.69	2.69
30 (7)	CORNSTOL	2.57	2.43	2.17	2.71
31 (4)	CORYAMER	2.17	2.66	2.58	3.07
32 (22)	CORYCORN	2.37	2.56	2.37	2.74
33 (1)	CRYPCANA	2.31	3.10	2.90	2.93
34 (2)	DESMGLUT	2.32	3.22	2.89	2.37
35 (15)	DIERLONI	2.33	2.44	2.32	2.86
36 (4)	DIRCPALU	2.38	3.31	2.89	2.28
37 (3)	DRYOSPIN	2.75	2.55	2.13	2.35
38 (1)	EPIGREPE	1.87	1.93	2.13	3.67
39 (2)	EQUIARVE	2.65	2.58	2.17	2.48
40 (1)	EQUIPRAT	2.45	2.29	2.11	2.97
41 (3)	EQUISYLV	2.59	2.56	2.15	2.47
42 (2)	FRAGVESC	2.21	2.50	2.44	3.16
43 (20)	FRAGVIRG	2.35	2.55	2.39	2.84
44 (10)	FRAXNIGR	2.62	2.77	2.37	2.38
45 (2)	FRAXPENN	2.19	3.11	3.01	3.03
46 (10)	GALIBORE	2.31	2.44	2.37	3.03
47 (17)	GALITRI2	2.41	2.51	2.30	2.72
48 (3)	GAULPROC	1.89	2.13	2.30	3.44
49 (6)	GYMNDRYO	2.64	2.44	2.11	2.58
50 (11)	HEPAAMER	2.31	2.80	2.61	2.60
51 (7)	LATHOCHR	2.26	2.47	2.39	3.15
52 (7)	LATHVENO	2.27	2.33	2.28	3.09
53 (1)	LINNBORE	1.89	2.26	2.34	3.60
54 (6)	LONICANA	2.64	2.34	2.04	2.54
55 (4)	LONIHIRS	2.59	2.33	2.07	2.66

(Table 2 continued on next page)

table 2 continued...

Species #(k)	Moisture	Nutrient	Heat	Light
56 (1) LYCOANNO	2.76	2.14	1.79	2.66
57 (2) LYCOCLAV	2.51	2.25	2.07	2.57
58 (1) LYCOCOMP	1.87	1.93	2.13	3.67
59 (4) LYCOOBSC	2.72	2.49	2.03	2.31
60 (19) MAIACANA	2.38	2.49	2.31	2.75
61 (1) MELALINE	1.87	1.93	2.13	3.67
62 (9) MITENUDA	2.65	2.55	2.19	2.54
63 (6) OSMOCLAY	2.48	3.02	2.64	2.38
64 (6) OSTRVIRG	2.32	3.14	2.83	2.45
65 (1) PARTQUIN	2.11	2.74	2.78	2.89
66 (1) PEDICANA	1.89	2.26	2.34	3.60
67 (7) PETAPALM	2.53	2.34	2.10	2.78
68 (2) PICEGLAU	2.56	2.29	2.10	2.77
69 (1) PINUBANK	1.87	1.93	2.13	3.67
70 (1) PINUSTRO	2.22	2.22	2.24	3.14
71 (1) POLYPUBE	2.69	2.76	2.21	2.07
72 (1) POPUBALS	2.67	2.53	2.21	2.58
73 (1) POPUGRAN	2.18	3.23	2.86	2.27
74 (19) POPUTREM	2.38	2.51	2.34	2.82
75 (4) PRENALBA	2.43	2.33	2.09	2.79
76 (2) PRUNPENS	2.02	2.03	2.18	3.63
77 (1) PRUNSERO	1.92	2.21	2.42	3.04
78 (20) PRUNVIRG	2.36	2.67	2.47	2.76
79 (13) PTERAQUI	2.34	2.38	2.25	2.89
80 (5) QUERMACR	2.12	2.82	2.76	3.05
81 (13) QUERRUBR	2.24	2.82	2.64	2.77
82 (6) RHUSRADI	2.31	2.68	2.51	2.79
83 (1) RIBEAMER	2.62	2.68	2.44	2.71
84 (7) RIBEHIRT	2.43	2.76	2.53	2.74
85 (10) ROSAACIC	2.25	2.39	2.36	3.11
86 (8) RUBUIDAE	2.18	2.49	2.48	3.12
87 (3) RUBUPARV	2.64	2.46	2.13	2.59
88 (20) RUBUPUBE	2.44	2.60	2.37	2.68
89 (1) RUDBLACI	2.31	3.10	2.90	2.93
90 (3) SALIHUMI	1.97	2.11	2.24	3.62
91 (12) SANIMARI	2.34	2.68	2.51	2.90
92 (3) SMILRACE	2.31	3.02	2.83	2.63
93 (1) SMILSTEL	1.89	2.26	2.34	3.60
94 (1) SMILTRIF	2.55	3.24	2.88	2.39
95 (5) SOLIFLEX	2.47	3.17	2.76	2.37
96 (1) SORBAMER	2.76	2.14	1.79	2.66
97 (1) SPIRALBA	2.62	2.68	2.44	2.71
98 (14) STREROSE	2.45	2.46	2.23	2.68
99 (3) SYMPALBU	2.09	2.20	2.27	3.45
100 (1) TARAOFFI	2.31	3.10	2.90	2.93
101 (11) THALDIOI	2.34	2.87	2.62	2.67
102 (8) TILIAMER	2.35	3.12	2.80	2.53
103 (11) TRIEBORE	2.55	2.68	2.31	2.45
104 (3) TRILGRAN	2.61	2.59	2.27	2.57
105 (5) ULMUAMER	2.41	3.17	2.87	2.60
106 (8) UVULGRAN	2.47	3.00	2.60	2.36
107 (13) UVULSESS	2.39	2.78	2.51	2.59
108 (5) VACCANGU	2.08	2.28	2.32	3.34
109 (2) VACCMYRT	1.90	2.23	2.38	3.32
110 (1) VIBULENT	2.62	2.68	2.44	2.71
111 (14) VIBURAFI	2.30	2.64	2.51	2.83
112 (4) VIBUTRIL	2.36	2.33	2.26	3.10
113 (2) VICIAMER	2.33	2.25	2.17	3.05

SYCOOR information for SU: SAMPS Date: 03/15/93

Table 3: Average mean site synecological coordinates by initial species coordinate values (v = total number of species).

Initial value	Moisture(v)	Nutrient(v)	Heat(v)	Light(v)
1	2.18 (28)	2.14 (10)	2.14 (20)	2.49 (32)
2	2.32 (27)	2.45 (51)	2.26 (36)	2.59 (14)
3	2.45 (36)	2.62 (25)	2.47 (34)	2.86 (33)
4	2.59 (21)	2.86 (5)	2.70 (20)	2.88 (16)
5	2.28 (1)	2.97 (22)	2.44 (3)	3.29 (18)
Average	2.37	2.58	2.38	2.79

Gutiérrez-Espeleta, Edgar E.; Brand, Gary J.
1993. **The microcomputer scientific software series 8: the SYCOOR users manual**. Gen. Tech. Rep. NC-160. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 15 p.

Describes how to use SYCOOR, an interactive Macintosh program written in BASIC for computing and adjusting synecological coordinates. Site synecological coordinates are indices of moisture, nutrients, heat, and light computed from lists of plant species present at the site. Graphs of a species' distribution in moisture-nutrient and heat-light space are also displayed by the program.

KEY WORDS: Synecological coordinates, environmental factors, weighted averaging, species indicator values, BASIC program.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.

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