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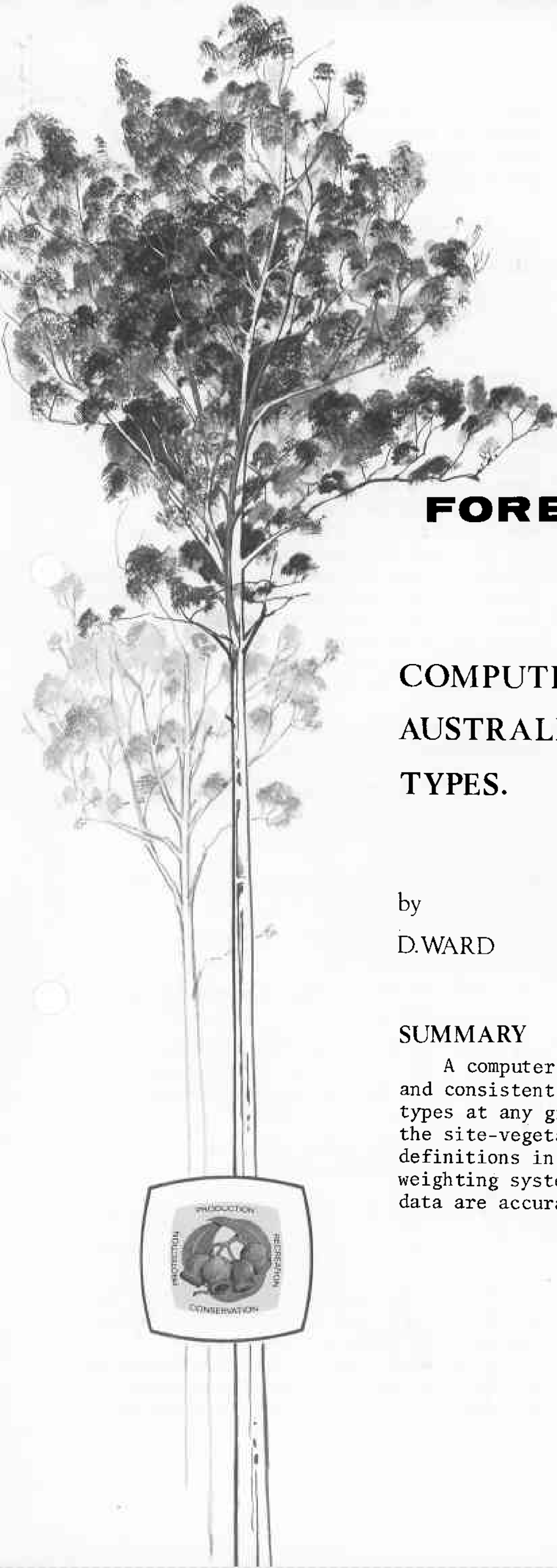

**FORESTS DEPARTMENT**
*OF WESTERN AUSTRALIA*

# COMPUTER SORTING OF WESTERN AUSTRALIAN SITE - VEGETATION TYPES.

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## SUMMARY

A computer program, GURU, was devised as an objective and consistent way of identifying the site-vegetation types at any given survey point. Verbal definitions of the site-vegetation types are converted to numerical definitions in the form of a control matrix, and a weighting system is incorporated to ensure that the data are accurately assessed.

## INTRODUCTION

Native vegetation can be used as an indicator of edaphic characteristics (Tansley, 1920; Cajander, 1926). Although vegetation rarely changes abruptly, but rather gradually along a number of environmental gradients, it is sometimes practical to divide these vegetational continua into discrete segments. In a study of the northern jarrah forest of Western Australia, Havel (1975 a and b), identified certain environmental gradients by principal component analysis of native vegetation data, and on the basis of his results defined different site-vegetation types, each designated by a letter of the alphabet. These site-vegetation types have potential use in land-use planning since they represent a relatively rapid way of assessing site characteristics such as fertility, drainage and soil structure. Site assessment entails a vegetation survey of the area, classification of the survey points into site-vegetation types, and finally mapping of the site-vegetation types. Classification has until now been done by a person experienced in plant taxonomy and ecology and familiar with the site-vegetation types. This is, however, time-consuming and hence expensive, particularly when the set of floral survey data is large. A computer program, GURU, was developed to cope with the task.

## METHOD

Firstly the verbal definitions of the site-vegetation types must be translated into numbers. For the northern jarrah forest region this translation took the form of an 80 x 21 control matrix (Appendix 1). The rows of the matrix represent the species likely to occur in any survey of the region, and the columns represent the site-vegetation types. The elements of the matrix take the values +1, 0 or -1, according to whether each species is positive, neutral or negative evidence of each site-vegetation type.

Bias can arise, however, in interpretation of the matrix. To take an extreme case as an example, if a certain species is positive evidence of only 2 site-vegetation types, then its presence is stronger evidence in favour of those types than if it were positive evidence for 15 out of the 21 types. Similarly, if a particular site-vegetation type has more positive indicator species than another type, then it is likely consistently to get a higher score.

A weighting system is therefore incorporated into GURU to correct both these sources of bias. When the control matrix has been read in, the program calculates two more rows and columns, showing the marginal totals of the positive and negative elements respectively. The score of any survey point with regard to any site-vegetation type is the sum of the abundances of all positive species in that type and the number of types of which that species is positive evidence, less the sum of the abundances of all negative species present weighted in a similar fashion. This system will work for presence-absence data or abundance scores. Since in the case of the northern jarrah forest the abundance scores ranged from 0 (absent) to 5 (highly abundant), the weighted contributors to the score for each type could, in the logical extreme cases, range from -5 to +5.

The weighting system can be expressed mathematically as follows.

$$S_j = \sum_{i=1}^{p} \frac{\alpha_i \varepsilon_{ij}}{\varepsilon_{ik} \varepsilon_{mj}}$$

Where $S_j$ is the weighted score for the jth type ($j = 1, \ldots q$)

$p$ is the number of species considered

$\alpha_i$ is the abundance score of the ith species

$\varepsilon_{ij}$ is the element of the control matrix for the ith species and the jth site-vegetation type (-1, 0, or +1)

$q$ is the number of site-vegetation types

$$k = q + 2 - (\varepsilon_{ij} + 1) / (\varepsilon^2_{ij} + 1)$$

$$m = p + 2 - (\varepsilon_{ij} + 1) / (\varepsilon^2_{ij} + 1)$$

The control matrix can, of course, be altered in size and content to suit other regions with different species and site-vegetation types. Once the weighting system is grasped, the program becomes self-explanatory; a listing is given in

Appendix 2. Data are read in for one survey point at a time, with species observations punched across the cards.

To test the reliability of classification using GURU, data of native species abundances at various sites within Yarragil Catchment, Western Australia, were analysed and site-vegetation types were allocated to the sites. Some of the abundance data are given in Appendix 3, and part of the computer classification in Appendix 4. The results agreed with field assessments made of the site-vegetation types, confirming the accuracy of both Havel's original description of the site-vegetation types and GURU classification.

## DISCUSSION

Apart from the time-saving aspect of classification by computer, it is valuable to have an entirely objective and consistent method of classifying survey points according to previously defined site-vegetation types. Whilst those who sort by inspection and personal judgement are no doubt skilled, it would be contrary to human experience if there were not slight differences in interpretation between different individuals and even drift within the same individual with passing time. The program can cope with changes; the control matrix can be adjusted at any time to include more site-vegetation types or more species, or to alter the evidence value of any species in the light of better knowledge of its distribution. In contrast with the conventional method of classification, however, these changes will be deliberate rather than unconscious, and a record will remain of the contents of the previous matrix.

## CONCLUSIONS

Computer classification of survey points according to their site-vegetation type is not only possible, but is completely objective and consistent. Where large amounts of data have been collected, for example with the object of mapping site-vegetation types over large areas, computer classification is possibly the only feasible method.

## REFERENCES

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# APPENDIX 1

## Part of GURU control matrix

| Species | Site-vegetation types A | B | C | D | E | F | G | H | J | L | M | O | P | Q | R | S | T | U | W | Y | Z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acacia alata | -1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Acacia extensa | 0 | 0 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -1 | +1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 |
| Adenanthos barbigera | -1 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 |
| Adenanthos obovata | 0 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Agonis linearifolia | -1 | -1 | +1 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Astartea fascicularis | +1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Baeckea camphorosmae | -1 | 0 | 0 | 0 | +1 | -1 | -1 | 0 | 0 | -1 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | +1 | -1 |
| Banksia grandis | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | +1 | +1 | 0 | 0 | +1 | +1 | 0 | 0 | -1 | 0 |
| Banksia littoralis | +1 | -1 | 0 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -1 | -1 |
| Borya nitida | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Bossiaea aquifolium | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | +1 | -1 | -1 | -1 | -1 |
| Bossiaea ornata | -1 | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | 0 | +1 | +1 | +1 | -1 | +1 | +1 | +1 | -1 | -1 | -1 | +1 |
| Casuarina fraserana | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | 0 | -1 | -1 | +1 | +1 | -1 | -1 | 0 | 0 | -1 | -1 | -1 | -1 |
| Casuarina humilis | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | -1 | -1 |
| Chorizema ilicifolium | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 | 0 | 0 | -1 | -1 | -1 |
| Conospermum stoechadis | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| Clematis pubescens | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | -1 | +1 | 0 | -1 | +1 | +1 | -1 | -1 | -1 |
| Dampiera alata | -1 | 0 | 0 | +1 | +1 | -1 | -1 | -1 | 0 | -1 | 0 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | +1 | -1 |
| Daviesia pectinata | -1 | -1 | -1 | 0 | 0 | 0 | -1 | +1 | -1 | -1 | -1 | -1 | 0 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | -1 |

# APPENDIX 2

## Listing of GURU program

```
      PROGRAM GURU (INPUT,OUTPUT,TAPE2=INPUT,TAPE3=OUTPUT)
C.GURU READS IN ABUNDANCE DATA (ABUN) ON BOTANICAL SPECIES IN A NUMBER
C.OF PLOTS.  IT MATCHES EACH PLOTS CHARACTERISTICS AGAINST NTYPE SITE-VEGE
C.TATION TYPES
C.AND GIVES EACH TYPE A SCORE ACCORDING TO PRESENCE AND ABUNDANCE OF
C.SPECIES PROVIDING POSITIVE OR NEGATIVE EVIDENCE OF THE PLOT BELONGING
C.TO THAT TYPE. THE SPECIES ABUNDANCE IS WEIGHTED ACCORDING TO A CONTROL
C.MATRIX (KODE).
      REAL SCORE(25),ABUN(100)
      INTEGER KODE(27,102),TITLE(16),TYPES(25),FMT(8)
C.NTYPE VEGETATION TYPES (UP TO 25)
C.NSPEC SPECIES (UP TO 100)
C.KODE MUST BE DIMENSIONED (NTYPE+2,NSPEC+2)
C.NFIRST IS THE NUMBER WHICH WILL BE PRINTED BESIDE THE FIRST PLOT.
      READ(2,111) (TITLE(J),J=1,16),(TYPES(K),K=1,25),(FMT(L),L=1,8)
     *,NSPEC,NTYPE,NPLOT,NFIRST
111   FORMAT(16A5/25A2/8A10/4I5)
      WRITE(3,1)(TITLE(J),J=1,16),(TYPES(K),K=1,25)
  1   FORMAT(1H1,5X,16A5/1HO,5X,*PLOTS*,25A5)
      JO=NTYPE+1
      KO=JO+1
      LO=NSPEC+1
      MO=LO+1
C.SET LAST TWO COLUMNS AND ROWS OF KODE TO ZERO, THEN USE THEM TO TOTAL
C.PLUSES AND MINUSES IN EACH SPECIES AND TYPE.
      DO 100 J=1,NSPEC
      DO 100 K=JO,KO
      KODE(K,J)=0
 100  CONTINUE
      DO 101 K=1,NTYPE
      DO 101 J=LO,MO
      KODE(K,J)=0
 101  CONTINUE
C.READ IN CONTROL MATRIX
      DO 200 J=1,NSPEC
      READ(2,2) (KODE(K,J),K=1,NTYPE)
  2   FORMAT (25I2)
      DO 300 L=1,NTYPE
      IF(KODE(L,J))10,300,11
 10   KODE(KO,J)=KODE(KO,J)+1
      KODE(L,MO)=KODE(L,MO)+1
      GOTO 300
 11   KODE(JO,J)=KODE(JO,J)+1
      KODE(L,LO)=KODE(L,LO)+1
 300  CONTINUE
 200  CONTINUE
      DO 400 J=1,NPLOT
      DO 500 K=1,NTYPE
      SCORE(K)=0.0
 500  CONTINUE
      READ(2,FMT) (ABUN (K),K=1,NSPEC)
      DO 600 L=1,NSPEC
      DO 700 M=1,NTYPE
      IF(KODE(M,L)) 12,700,13
 12   N=KO
      NN=MO
      GOTO 14
 13   N=JO
      NN=LO
 14   SCORE(M)=SCORE(M)+FLOAT(KODE(M,L))*ABUN(L)/FLOAT(KODE(M,NN)*KODE(
     *N,L))
 700  CONTINUE
 600  CONTINUE
C.ROUND SCORES TO TWO PLACES
      DO 800 I=1,NTYPE
      IF(SCORE(I).EQ.0.0)GOTO 800
      SCORE(I)=SCORE(I)+.005*(SCORE(I)/ABS(SCORE(I)))
 800  CONTINUE
      KPLOT=J+NFIRST-1
      WRITE(3,4) KPLOT,(SCORE(K),K=1,NTYPE)
  4   FORMAT(6X,I3,1X,21F5.2)
 400  CONTINUE
      STOP
      END
```

## APPENDIX 3

Abundances of indicator species at 7 sample sites in Yarragil Catchment

| Species | Sample point 1 | 4 | 41 | 45 | 136 | 408 | 538 |
|---|---|---|---|---|---|---|---|
| Acacia browniana | | | | | | | 2 |
| Agonis linearifolia | | | | 3 | | | |
| Astartea fascicularis | | | | | | | |
| Banksia grandis | | | 4 | | | | |
| Banksia littoralis | | | | | | 2 | |
| Bossiaea ornata | 1 | | | | | | |
| Casuarina fraserana | | | 3 | | | | |
| Clematis pubescens | 2 | | | | | | |
| Dryandra nivea | | | 4 | | 4 | | 3 |
| Eucalyptus calophylla | 4 | 4 | | 4 | 1 | 1 | 1 |
| Eucalyptus marginata | 3 | 1 | 5 | 1 | 2 | 1 | 4 |
| Eucalyptus patens | 4 | | | 1 | 3 | 4 | |
| Eucalyptus rudis | | | | 3 | | | |
| Hakea ceratophylla | 1 | | | | | | |
| Hakea lissocarpha | | | | | 3 | | 2 |
| Hakea varia | | | | | | | |
| Hibbertia lineata | | | | | | | |
| Hypocalymma angustifolium | | | | | 4 | | |
| Kingia australis | 1 | | | | | | |
| Lasiopetalum floribundum | 3 | 5 | 4 | | | | |
| Leptospermum ellipticum | 1 | | | | | | |
| Leucopogon capitellatus | | | | | | | 3 |
| Leucopogon propinquus | | | | | | | 1 |
| Macrozamia riedlei | 4 | 3 | | | | | 4 |
| Melaleuca affin. incana | | | | | | 2 | |
| Melaleuca affin. scabra | | | | | | 2 | |
| Persoonia longifolia | 1 | | 2 | | | | 3 |
| Phyllanthus calycinus | | | 2 | 2 | | | 4 |
| Pteridium esculentum | 4 | 4 | | 3 | | | |
| Xanthorrhoea preissii | | 3 | | 2 | 4 | 4 | 3 |
| Xanthorrhoea gracilis | | | | | 4 | 2 | 2 |
| Havel's site-vegetation type (GURU allocation) | U | T | S | C | W | A | Z |

## APPENDIX 4

Scores allotted by GURU to each possible site-vegetation type at 7 sample sites in Yarragil Catchment. Scores are based on abundance data. Figures in boxes denote the site-vegetation type at each site.

| Sample site | Site-vegetation types | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | J | L | M | O | P | Q | R | S | T | U | W | Y | Z |
| 1 | .09 | .02 | .04 | .11 | .04 | -.02 | -.04 | -.03 | -.01 | .02 | .08 | .06 | .03 | .16 | .08 | .15 | .23 | .35 | .13 | .04 | .08 |
| 4 | -.03 | .01 | -.01 | .06 | -.02 | -.03 | -.02 | -.03 | -.01 | -.05 | .05 | .03 | -.01 | .13 | .06 | .18 | .27 | .19 | .13 | -.03 | .06 |
| 41 | -.09 | .02 | -.04 | .02 | .04 | .06 | -.02 | .04 | .03 | -.03 | .01 | .25 | .24 | .03 | .07 | .28 | .21 | .02 | .01 | -.04 | .07 |
| 45 | .18 | .01 | .22 | .06 | -.02 | -.03 | -.02 | -.04 | .02 | -.03 | -.01 | .02 | -.01 | .11 | .05 | .02 | .11 | .14 | -.11 | -.02 | .05 |
| 136 | -.04 | -.01 | .03 | .14 | .05 | .01 | -.01 | .10 | .02 | .14 | .08 | .11 | .09 | .14 | .06 | .01 | .07 | .07 | .17 | .07 | .05 |
| 408 | .24 | -.03 | .16 | .10 | -.03 | -.03 | -.02 | .03 | -.01 | .04 | -.01 | .04 | .04 | .08 | -.01 | -.02 | .06 | .07 | .10 | -.03 | -.01 |
| 538 | -.09 | .01 | -.05 | .07 | .02 | .03 | -.02 | .06 | -.01 | .02 | .13 | .16 | .13 | .18 | .22 | .22 | .19 | .10 | .08 | -.01 | .23 |