AN APPLICATION OF ORDINATION TO THE IDENTIFICATION OF FOREST TYPES*

M.D. SWaine & J.B. HALL**

Department of Botany, University of Ghana, Legon, Ghana.

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Introduction

Multivariate methods have been applied by many authors to data from tropical forest: in Malaysia (Ashton 1964, Austin & Greig-Smith 1972, Swaine 1973), South America (Hatheway 1969), Solomon Isles (Greig-Smith, Austin & Whitmore 1967) and Australia (Webb, Tracey, Williams & Lance 1970, Williams, Lance, Webb & Tracey 1973). These investigations have shown the value of such methods in extracting meaningful gradients and vegetation types in forest which is too complex for satisfactory classification by more traditional methods. Little attention, however, has hitherto been paid to the problem of identifying forest type subsequently investigated forest stands (Greig-Smith 1969).

Divisive monothetic techniques such as association analysis (Williams & Lambert 1969) produce a dichotomous hierarchical classification in which division at each level in the hierarchy is based on the presence or absence of single key species. It is thus ostensibly possible to identify a stand by searching for the species used in division. Such a classification will only be meaningful if natural vegetation types each possess at least one constant and faithful species; in practice, however, it is usually found that constant species are not faithful and faithful species are not constant (Poore 1955, Hall & Swaine in press). Both in taxonomy (Sneth & Sokal 1973) and phytosociology (Lambert, Meacock, Barrs & Smartt 1973) it is now generally recognized that a polythetic approach to classification is preferable.

* Nomenclature follows Hutchinson & Dalziel (1954–72) except where authorities are given.
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Ordination procedures use all species, and are therefore fully polythetic, but the resulting ordination must be partitioned if a classification is desired.

Available objective partitioning methods (Noy-Meir 1973, Hill, Bunce & Shaw 1975) suffer from various drawbacks (Hall & Swaine in press). In our classification of closed forest in Ghana (Hall & Swaine in press) we have been guided by one of these methods: ‘indicator species analysis’ (Hill et al. 1975), but have divided the ordination (Fig. 1) empirically, using also independent information on climate, soils, forest structure, and experience, to delimit geographically coherent forest types.

Identification procedure

Variation in forest composition is largely continuous, but there is some evidence of clustering in the ordination (Fig. 1) and lines of division were drawn in such a way as to separate these clusters. By comparison of Fig. 1 with Table 1 it may be seen that axis 1 of the ordination is responsive to mean annual rainfall. Axis 6 is used to separate a group of forests at high elevations, but is not exclusively concerned with altitude; in other parts of the ordination it is related to rainfall, rock type, and the occurrence of occasional ground fires (Hall & Swaine in press).

During our survey of forest in Ghana we made complete lists of vascular plants in 155 sample plots, each of 0.0625 (1/16) ha, distributed throughout the forest zone; ordination used the 749 species found in four or more plots. The ordination method adopted: ‘reciprocal averaging’ (Hill 1973), yields species and stand ordinations related in such a way that any stand score is proportional to the mean score.
of the species which occur in it:

\[ y = mx + c \]

where \( y \) is the stand score, \( x \) the mean score of the constituent species, and \( m \) and \( c \) are the usual regression constants whose values can readily be determined graphically from the results of a few of the ordinated stands. Testing of several plot records showed that the mean species score for a random list of about 30 species does not differ significantly from the mean species score for the whole list (usually comprising 70-150 species).

To identify a forest stand, it is necessary merely to list any 30 species encountered, calculate mean species scores on the two axes of the ordination diagram, convert the values obtained to plot scores using the regression equation, and to use these as coordinates to find the corresponding forest type on the ordination diagram. (Alternatively, the axes of the ordination diagram can be scaled in units of mean species score.) This method of identification by 'coordinate estimation' has, in contrast to those requiring a search for indicators, the considerable advantage that plant identifications need not be made in the field. The number of people who can name most plants accurately in a particular area of tropical forest is quite small, but any investigator can make a collection of leafy shoots which may then be sent to an expert for the names on which forest-type identification can be made.