THE CONCEPT OF STRUCTURE IN PHYTOSOCIOLGY WITH REFERENCES TO CLASSIFICATION OF PLANT COMMUNITIES*

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Introduction
In phytosociology the term 'structure' appears to refer prevalently to the spatial distribution pattern of biomass and representation of life forms which are expressed in different ways. The use of compound terms such as population structure, age structure, ecological structure, competitive structure, production structure, size-class structure, dynamic structure, are more or less common in the literature. In texts describing vegetation structure, we can find paragraphs dealing with physiognomy, species composition, synusiae, consortia, minimal area, species association, etc. In these texts only about one in two authors discuss cyclic changes, i.e. the periodicity of plant communities. In theoretical ecology, on the other hand, sets of differential equations describing dynamics of multipopulation systems are considered as appropriate models for community structure.

The 1966 Rinteln Symposium of the International Society for Vegetation Science (Tuxen 1970), was devoted to structure. However, no clear definitions of structure were given or explicit use made of this concept in the majority of the papers as has been pointed out already in reviews of the volume (e.g. Kuchler 1972). This has stimulated the thoughts to be presented here. I hope that my contribution will not be seen as just another terminological exercise, but rather as an attempt to show new ways to understanding vegetation phenomena.

The analysis of the basic phytosociological concept of structure is an inevitable condition for an objective evaluation of structural and organisational complexity (Organisationshöhle, Braun-Blanquet 1964) in plant communities. Furthermore, the approach to the 'biosystematics' of plant communities and the evaluation of a plant community's position in the economy of nature depends in many cases on the knowledge of a plant community's structure.

The concept of structure
In contemporary science we can observe a process of defining theoretical terms (sensu Carnap 1956) with relevance in several or in many scientific disciplines. Terms which are generally defined but without reference to any specific field of science add new insight into concepts implicit in the terms, thereby promoting the use of the universal methods of system analysis.

Structure of an abstract system has been defined as a set of elements and relationships (e.g. Antomonov 1969). Mathematically, we can conceive structure in the same way as an abstract system: a subset of the Cartesian product of a set of elements and of a set of relationships, i.e. \( S \subseteq E \times R \) (cf. Mesarović 1964). With regard to this definition and to various explicit and implicit definitions of structure in phytosociology and ecology (Bykov 1970, Descoings 1971, Gournot 1969, Knight & Loucks 1969, Mueller-Dombois & Ellenberg 1974, Odum 1962, Pielou 1972, Segal 1971, Shimwell 1971, Suganuma 1967, Vandermeer 1969, Westhoff 1967, Westhoff & van der Maarel 1973, Whittaker 1970), we can propose a relatively broad definition appropriate for phytosociology: the structure of any system is determined by (1) the presence of components which belong to defined classes, (2) the quantitative representation of these components, and (3) the relations among them including their connections and spatial arrangement. However, often the analysis and the description of structure is performed from different points of view. The same subject can thus be regarded as either a component (element), from one point of view, or as a structure, from another. If we accept the above definition, three families

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of phytosociological structural characteristics should be distinguished: (1) qualitative constituent; (2) quantitative constituent, and (3) relational. To put this division of structural characteristics into proper phytosociological perspective is an immediate objective of the present paper.

(1) Qualitative constituent characteristics of structure

Of the components which form plant communities taxa (usually species), life forms, ecoelements, geoelements, size classes, age classes are examples. Classifications based on presence/absence type similarity indices, such as Sørensen’s, Kulczynski’s and Jaccard’s, use only qualitative constituent characteristics (Češka 1966, Cheetham & Hazel 1969). Vegetation analysis based on taxa above the species level has been examined by van der Maarel (1972) and Dale & Clifford (1976). In the last mentioned paper, there was an interesting result in that the use of generic and subgeneric categories instead of species caused only little loss in classification interpretability.

(2) Quantitative constituent characteristics of structure

Representation of species with respect to different importance values describes the population structure of a community. Distributions of relative species abundance, biomass, or other importance values (Whittaker 1970, May 1975) and indices of dominance and diversity (De Jong 1975, Pielou 1975, Rejmánek 1975) appear to be most frequently used descriptors of population structure. The sequence of plant communities according to their species diversity values may exhibit a clearly interpretable pattern (Fig. 1). Use of equitability indices in the form of ratios of absolute diversity to maximum possible diversity is very frequent in recent research (e.g. Jacobs 1975). This is not correct, however, except in the rare case when the total number of species in the sampling universe is known (cf. Peet 1974).

Comparisons of population structures with respect to both qualitative and quantitative properties, are the subject of vegetation classifications based on resemblance functions (Orlóci 1975). Distribution of individuals in age classes form the age structure (Namkoong 1975). Similarly, quantitative representation of individuals in different categories according to diameter, volume or height forms the dimensional or size class structure (Schmelz & Lindsey 1965). Biological and ecological spectra (or ‘structures’) can be expressed with respect to importance values of life forms and ecoelements respectively.

(3) Relational characteristics of structure

Relations among the components of any system can be viewed at different levels with various difficulties, and they can be expressed by all sorts of techniques. Most accessible are the spatial relations, i.e. the spatial structure. Models of spatial structure can be divided into three groups, namely iconical, symbolic and quantitative numerical or graphical. Iconical models (the profile diagrams) are often used in descriptions of tropical vegetation. Symbolic models (e.g. diagrams by Dansereau & Arros 1959) can express selected qualitative constituent characteristics as well as others. Horizontal structure can also be expressed by the use of symbols (this is dominantly done in permanent sample