# ФИТОСОЦИОЛОГИЯТА КАТО НАУКА И НЕЙНОТО ПРАКТИЧЕСКО ПРИЛОЖЕНИЕ (Обзор)

# PHYTOSOCIOLOGY AS A SCIENCE AND ITS PRACTICAL APPLICATION IN VARIOUS FIELDS (Review)

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**Abstract**

Phytosociology is a science devoted to the study and classification of plant communities which are the smallest fundamental vegetation units. It is a relatively young discipline that has been developing since the beginning of the 20th century. Both its theoretical matter and methodology are utilizable in various other applied sciences, especially in landscape architecture. Its practical application results from the wide scope of vegetation studies (e.g. studies on the composition of plant communities, their diversity, distribution, and dynamics, as well as their relationships with environmental conditions, and human impact).

The paper presents the use of phytosociological knowledge in various branches of science, e.g. in landscape architecture, forestry, land and water resource management, agriculture, grassland management, environmental protection and nature conservation.

**Key words:** phytosociology, plant communities, landscape architecture.

## INTRODUCTION

Many scientists have considered phytosociology to be a branch of phytogeography (Scamoni, 1967), geobotany (Fukarek, 1967), ecology (Matuszkiewicz, 2001) or vegetation science (Pott, 2011). Nowadays, it is a science that deals with research of plant communities and the use of knowledge of them in various fields (Wysocki and Sikorski, 2009). It has its roots in the studies of the 19th century plant geography pioneers.

Development of phytosociology can be divided into three periods that have been characterized by different approaches to vegetation. In the 19th century the physiognomic approach to vegetation dominated, however it was replaced with the floristic approach at the beginning of the 20th century (Fukarek, 1967; Pott, 2011), followed by the phytosociological approach further in that century.

The most dynamic phase of the development of phytosociology is dated to the 1913-1925, thanks to the Swiss botanist J. Braun-Blanquet, who described the basics of vegetation classification system, methods of distinguishing of plant communities according to floristic criteria, as well as methods of phytocoenoses analysis. Braun-Blanquet's approach to vegetation have fundamentally differed from the earlier approaches: the physiognomic and floristic one (Dzwonko, 2007; Géhu, 2011). The system he established, improved by following scientists, is still in use today. At the same time, in Europe and all over the world, other phytosociological schools employing different methods, started to develop. Still, the main European research centre at the time was the research station founded by Braun-Blanquet in Montpellier - *Station Internationale de Géobotanique Méditerranéenne et Alpine* (SIGMA) – Dzwonko, 2007.

Since the fifties of the 20th century, phytosociology has been developing rapidly, thanks to, among others, the most remarkable Braun-Blanquet's student and associate - R. Tüxen. Owing to his work the second European phytosociological research centre was established in Germany. Tüxen's greatest accomplishments were: his contribution to the development of phytosociological cartography and establishment of the concept of potential natural vegetation. He was the first to compile the syntaxonomic description of all plant communities of a large region (north-west Germany), which subsequently became the model for various similar monographs - e.g. Oberdorfer's study of Southern Germany's vegetation (1977-1992), the study of Austria's vegetation by Mucina et al. (1993), Rodwell's study of Great Britain's vegetation (1991-2000) and the study of Poland's vegetation by Matuszkiewicz (2001).

In the 1939, an international phytosociological society was founded. It was ultimately named the *International Association for Vegetation Science* (IAVS) in the 1982 and nowadays consists of several committees and working groups that focus on large, international research projects (Dzwonko, 2007). Undoubtedly, it has popularized studies of vegetation. Its huge contribution to the modern phytosociology was the issuing of an *International Code of Phytosociological Nomenclature* (Weber et al., 2000).

## PHYTOSOCIOLOGY – FIELD OF STUDY AND OBJECTIVES

The field of study of phytosociology is Earth's vegetation. This concept is defined as the entire flora and vegetation that occurs on Earth (Matuszkiewicz, 2011). The basic unit of vegetation, in phytosociology, is the plant community – a phytocoenosis, that becomes an essential object of research of this science. Phytocoenosis is a concrete, existing plant community, which is a component of a particular ecosystem (biocoenosis). Being a part of an ecosystem, phytocoenosis is related to it and reveals connections to other elements of this system, e.g. to the abiotic components of the environment, fauna, microorganisms and human activity (Matuszkiewicz, 2011).

Phytosociology as a science deals with, among others, composition of plant communities, description and differentiation of plant associations, impact of environmental factors that determine the occurrence of plant communities (synecology), development of plant associations in the time perspective (dynamic or successional phytosociology), distribution of plant communities (synchorology), and hierarchical classification of plant associations – syntaxonomy (Fukarek, 1967).

## RESEARCH METHODS USED IN PHYTOSOCIOLOGY

The fundamental phytosociological method used to investigate any homogeneous plant community is a phytosociological relevé. It consists of a set of analytic data on phytocoenosis (a list of all the species that have been recorded – each species with its qualitative and quantitative attributes: abundance – dominance assigned) and its habitat. Certain conditions must be met in order to perform a proper relevé. These are: selection of an adequate area of the relevé, its shape and size, the time it is performed, as well as consideration of the seasonal aspects of vegetation. In order to identify syntaxonomical unit, the data of relevés (of sufficient number of similar plots) should be summarised in the form of synthesis table, which is then rearranged according to the syntaxonomical classification. Such data is the subject of further, statistical analysis (Wysocki and Sikorski, 2009). Afterwards, the identified association is described according to its analytic and synthetic characteristics.

## PRACTICAL APPLICATION OF PHYTOSOCIOLOGY IN LANDSCAPE ARCHITECTURE

Landscape architecture is an artistic, scientific, and professional discipline that similarly to phytosociology, has been developed relatively recently, at the turn of the 20th century. As a science, it involves devising theoretical basis and practical methods of landscape design (Siewniak and Mitkowska, 1998). The main materials used in landscape design are: vegetation, water features and urban components.

When considering a landscape architect's field of activity, it is important to take into account various factors that contribute to the character and quality of a landscape, both natural ones, e.g. land relief, soil, climate, or vegetation, and anthropogenic ones, such as: local culture, tradition and social needs. Therefore, landscape architecture is a multi-disciplinary field, which incorporates aspects of other sciences, e.g. botany, ecology, phytosociology, horticulture, earth sciences (geology, geography), architecture, civil engineering, and psychology.

The main field of activity of the landscape architect is a design of various types of green spaces (gardens, parks, recreation facilities, etc.), their conservation or revitalization. Landscape architecture can also involve different activities connected to landscape, e.g.: spatial planning, sustainable development, nature conservation or environmental protection. Phytosociological knowledge is a significant contribution to all those fields.

The conservation and environment protection issues have became important in various fields since the so-called 'Earth Summit 1992' - The United Nations Conference on Environment and Development, which was held in Rio de Janeiro from 3 June to 14 June 1992. As the result of the summit, most of the world's governments committed themselves to obey the rules of sustainable development, including the conservation of biodiversity – through ratification of the 'Convention on Biological Diversity' [1760 UNTS 79; 31 ILM 818 (1992)]. In addition, member states of the European Union have made similar commitments through ratification of the 'Bern Convention on the Conservation of European Wildlife and Natural Habitats' (ETS 104) and the obligation to implement the Council Directive 92/43/EEC on the

Conservation of natural habitats and of wild fauna and flora (OJ L. 206/7), to their legal systems. Since then, proper management of natural resources and their conservation, which includes biological diversity conservation, has became a major principle in landscape architecture.

Phytosociological knowledge allows the landscape architect to design green spaces in harmony with habitat, natural vegetation of the area, and local landscape, which is consistent with the sustainable development idea.

Furthermore, phytosociological methods are widely used for habitat investigation of the site inventory, which should precede any design or planning process. Vegetation is an adequate indicator for estimation of the environmental conditions. Most plants have precise habitat requirements and therefore, their occurrence or presence in plant communities allows to estimate both the environmental conditions of a given area and the anthropogenic changes it has undergone (Wysocki and Sikorski, 2009). This method, called phytoindication, is quicker, easier, and cheaper to use in comparison with laboratory analysis. It is used to measure environmental conditions such as: soil pH, soil moisture content, soil nitrogen content, and other (Bacieczko et al., 2005). In this method, a scale of indicator values (a list of plant species along with corresponding points, which specify their response to a given ecological factor) is used, which was compiled for the first time by Ellenberg (1950). Most often this scale is used to measure soil characteristics (fertility, moisture, pH, texture, organic matter, salinity, heavy metals contamination) and climate factors (light, temperature, continentality). Estimation of habitat conditions can be carried out on the basis of a simple list of species or a phytosociological relevé. Indicator values of particular species are then summed up and the arithmetic mean is calculated.

Habitat conditions may be estimated on the basis of plant communities that occur within a given area. Most plant communities are related to specific habitat types and have narrower ecological amplitudes than particular plant species (Wysocki and Sikorski, 2009).

Environmental conditions can be also evaluated with potential natural vegetation maps, which represent hypothetical final succession stages on a given area, provided that no further changes of abiotic environment will occur. Such maps present habitat's biotic potential, species diversity of a given area, including information about the occurrence of rare and protected species, vegetation spatial structure and vegetation dynamics, the degree of phytocoenoses degeneration and intensity of anthropogenic impact on the environment. Thus, they constitute an excellent instrument for planning and design processes (Dzwonko, 2007).

Beside the site inventory process, phytosociological methods are used for the valuation of natural resources. They work out better than floristic methods (list of species) because as a result they provide multiple additional data, e.g. information about quantity relations between plant species of a given area, spatial structure of plant communities, naturalness or degeneration degree of vegetation, succession stages, and appropriate vegetation conservation practices when such are needed.

Moreover, phytosociological methods form a tool necessary to evaluate the environment's condition used for an environmental impact assessment, which is often mandatory while implementing projects that may have an impact on the environment. In the European Union, the obligation to conduct an environmental impact assessment is established in the following directives: Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (OJ L. 26/1), Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (OJ L 197) and, indirectly, in Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora OJ L. 206/7). The environment impact assessment reports are prepared by environment protection experts, as well as by the landscape architects.

Plants are the fundamental material in the landscape architect's design process and, therefore, a proper plant selection is the groundwork of every design. According to the sustainable development principles, the basis of the plant selection, especially for large landscape projects, should be the native species. Phytosociological knowledge is helpful when creating a plant selection that fits the local climate and habitat conditions (Bacieczko et al., 2005). Knowing the habitat type and corresponding syntaxonomic vegetation unit, along with its characteristic combination of plant taxa, is useful when creating a plant selection for areas that are degraded or hard to reclaim (Wysocki and Sikorski, 2009). In most cases, it is difficult to avoid using non-native plant species, mainly because of their ornamental value. Phytosociological knowledge allows the landscape architect to avoid introducing invasive species, which could in short time spread and dominate the area.

Furthermore, evaluation of natural absorption of plant communities (an indicator, which determines acceptable number of people for a given plant community that will not bring any changes to the environment) on a phytosociological basis is helpful for planning of recreation areas. Consequently, through proper landscape detailing, it allows to minimize damages caused by the land use (Wysocki and Sikorski, 2009).

## PRACTICAL APPLICATION OF PHYTOSOCIOLOGY IN VARIOUS OTHER DISCIPLINES

Vegetation is a highly integrated component of the environment and landscape, which reflects the outcomes of anthropogenic influence better than any other element and, therefore, results and conclusions of phytosociological research have practical value for various, applied sciences, besides landscape architecture. The basis of their use is the fact that every plant association suits precise habitat relations, thus it may be used as a precise indicator of habitat conditions. The knowledge of potential natural vegetation, which expresses the natural production potential of a given habitat, is extremely important (Fukarek, 1967; Faliński, 1997).

Forestry was the first discipline, in which phytosociology quickly became useful. The basic criteria of silviculture is such selection of tree species for a given habitat, that would not reduce the habitat's production capability, but would help to eliminate existing damages and, at the same time, would be the most efficient for timber production (Fukarek, 1967). For the forestry needs, forest type schemes (classification of forest types according to the site factors, put in order alongside with an increasing potential productivity) have been applied on a phytosociological basis. Such classification is less detailed than the phytosociological one (one forest type often involves several, sometimes distinct rank, syntaxa), however both systems are highly compliant (Dzwonko, 2007; Wysocki and Sikorski, 2009). As a consequence phytosociology has became the base of the forest management. When planting a particular forest field plots, the corresponding vegetation unit is being taken into account (Scamoni, 1967).

Second field, in which the results of the phytosociological research have been taken into consideration, is agriculture. In this area, Ellenberg's research (1950) on indicator value of various plant species, proved to be the most important. On the basis of the analysis of field's weed communities, a selection of crop type and crop rotation may be reasonably planned. Site conditions evaluation, based on ecological indicator values, provides more information than physicochemical analysis alone. Beside data on soil chemical properties (e.g. pH, nitrogen, and organic matter content), soil moisture content, and soil physical properties (texture), it provides information on climate factors (insolation, temperature), which is essential for crop cultivation (Bacieczko et al., 2005). Furthermore, analysis of species composition of weed plant communities allows to estimate soil biological activity, as well as soil structure and consistency (Scamoni, 1967).

Estimation of habitat conditions on the basis of ecological indicator values has been also used in the grassland management. For the needs of the grassland science, soil moisture conditions analysis, and soil pH measurement is the most useful. In addition, analysis of the indicator values for soil nitrogen content and temperature, is valuable for grassland management. After the soil water conditions of a given area are evaluated, lands utility for grazing may be determined and, if needed, guidelines on land improvement (e.g. drainage, irrigation) may be given (Scamoni, 1967).

Moreover, phytosociological knowledge may be useful for determination of forage value for the grassland science. Estimation of quantity of the hay yield does not reflect the yield's quality, which is dependent on hay's composition, particularly on the contribution of the valuable pasture species. Yet, through phytosociological analysis of the yield, supported by calculation of the mass of its components, proper estimation of yield's quality may be done. Phytosociological knowledge has also contributed to the development of a new classification of grassland types, according to which particular grassland types refer to higher phytosociological syntaxa – classes, orders, and alliances (Fukarek, 1967; Wysocki and Sikorski, 2009). Phytosociological knowledge is also helpful for planning the composition of a grassland mixture.

Another discipline, in which phytosociology is used, is the aquaculture. In this field, phytosociological methods are helpful for classifying the types of bodies of water. The analysis of aquatic, reed bed, and shoreline vegetation provides information on the depth, pH, mobility, and fertility of water. When the environmental characteristic of a given body of water is known, an estimation on its utility value may be done and fish farming may be planned properly (Bacieczko et al., 2005).

Phytosociological knowledge is also useful for water resource management, particularly when planning any land improvement, such as drainage or irrigation, and evaluation of its effectiveness. In

case of raising or lowering of the groundwater level is planned, it should be examined which of the existing plant communities are dependent (and how heavily) on the groundwater level, as well as on its quality and mobility. Such estimation enables to both plan necessary land improvement practices, and evaluate impact of those actions on crop productivity and impact on the neighbourhood areas. After the land improvement project is executed, its results may be monitored through investigation of the plant communities' dynamics. Any river engineering and hydromodification works should be approached in a similar manner (Fukarek, 1967; Scamoni, 1967).

Phytosociological knowledge is also helpful for the rehabilitation of degraded areas. In case of reforestation of large areas, it is advised to take the current 'open' plant community into consideration, which will provide hints on the tree and shrub species selection (Scamoni, 1967). When covering spoil tips, landfill sites, railway and motorway embankments with turf, it is worth to use mixtures that include synanthropic species (Bacieczko et al., 2005).

Results of phytosociological research, as well as phytosociological methods themselves, are extremely important for modern nature conservation. They are used for the description and inventory of the areas of environmental value, sometimes as maps of current vegetation, which are created for the protected areas. Phytosociological research enables to indicate areas predestined to be protected because of the occurrence of rare or endangered plant communities. It is also helpful when making recommendations on conservation practices for various types of protected areas (Dzwonko, 2007).

Phytosociological methods are necessary for ecological monitoring of the areas of protected vegetation. Considering the commitments derived by European Union law, ecological monitoring allows to evaluate the condition of conservation of species of Community interest and quality of habitat conservation. Moreover it enables to observe changes that occur in the composition of plant communities, as well as changes of their temporal and spatial distribution. The relevé data collected from the same plot on a regular basis, allows to both precisely document condition of vegetation and estimate the rate and direction of changes that occur in the pytocoenoses. Thereafter, such data makes it possible to conclude from on the origin of those changes and on the effectiveness of the implemented conservation practices. Furthermore, the collected data enables to counteract the negative effects if such are noticed, to undertake specific protective actions, as well as to predict the response of the investigated environment components to further changes in the environment (Dzwonko, 2007).

What attests the great significance of phytosociology for nature conservation is the fact that it has been addressed within large international programmes: the Coordination of Information on the Environment (CORINE) and the Natura 2000 Networking Programme. Phytosociological classification is the basis of the recognition of habitats within these programmes.

## SUMMARY

1. Phytosociology, despite being a relatively young science that originated in the beginning of the 20th century, has very quickly developed both practically and theoretically within Europe, America, and afterwards around the world. Its research methods have evolved simultaneously within different scientific centres, e.g. in Switzerland, Germany, and Scandinavia.

2. Theoretical concepts of phytosociology have applications in various fields: in silviculture, agriculture, grassland science, aquaculture, land management, water resource management, as well as in environment protection and nature conservation. They also have exceptional applications in landscape architecture, particularly in:

- site inventory and environmental resources valuation, which precedes any planning or design activity,
- selection of plant species, which are used in the planting scheme (of an open space, a garden, a park, a road embankment) and for degraded areas development,
- evaluation of the condition of environment,
- nature conservation and environment protection,
- evaluation of natural absorption of plant communities present in recreation facilities,

3. Phytosociology is taught as an academic subject in various scientific centres and universities in Europe, including Poland. It is a part of various Natural Sciences courses, e.g. Biology course, Environment Protection course, or Agriculture course. For many years it has been an important course in the higher education of students of Landscape Architecture at the Faculty of Environmental Management and Agriculture of West Pomeranian University of Technology in Szczecin, which determines the formation of an appropriate profile of a Landscape Architecture graduate.

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