# Vegetace České republiky

## 1 Travinná a keříčková vegetace

# Vegetation of the Czech Republic

## 1. Grassland and Heathland Vegetation

Milan Chytrý (editor) a kolektiv

ACADEMIA
PRAHA 2007

KATALOGIZACE V KNIZE – NÁRODNÍ KNIHOVNA ČR

Vegetace České republiky. 1, Travinná a keříčková
vegetace = Vegetation of the Czech Republic. 1,
Grassland and heathland vegetation / Milan Chytrý (editor)
a kolektiv. – Vyd. 1. – Praha : Academia, 2007. – 528 s. ;
barev. il.
ISBN 978-80-200-1462-7

581.524/.526 * 581.526.45 * 581.526.4:582.093/.095 *
(437.3)
- vegetace – Česko
- luční rostlinná společenstva – Česko
- stepní rostlinná společenstva – Česko
- křovinná společenstva – Česko
- monografie

581 – Obecná botanika [2]

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ISBN 978-80-200-1462-7

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Milan Chytrý

## The development and current state of phytosociological research in the Czech Republic

The classification of plant communities using relevés, i.e. the lists of plant species including data on their quantitative representation in small plots, has a long tradition in Central Europe, dating back to the first decades of the $20^{th}$ century. The basic methodological principles of phytosociology were formulated by the Swiss plant ecologist Josias Braun-Blanquet (1921, 1928). Braun-Blanquet's methods spread quickly in a number of European countries. The first pioneering studies in the former Czechoslovakia were carried out e.g. by Jaromír Klika, Vladimír Krajina, Rudolf Mikyška, Pavel Sillinger and Alois Zlatník in the 1920s and 1930s. They focussed on classification and inventory of plant communities and provided a good overview of major vegetation types, summarized by Jaromír Klika in the annotated lists of plant communities of Czechoslovakia and Central Europe (Klika in Klika & Novák 1941: 53–71, Klika & Hadač 1944, Klika 1948, 1955). These lists were elaborated to the level of phytosociological alliance and neither included associations – the fundamental units of vegetation classification. However, they were compiled at approximately the same time as the foremost representatives of European phytosociology, Josias Braun-Blanquet and Reinhold Tüxen, attempted to make an analogous list of the vegetation of Central Europe (Braun-Blanquet & Tüxen 1943). Czech vegetation scientists thus contributed significantly to the formation of the basic classification scheme of European vegetation.

After World War II, the newly established Geobotanical Laboratory and later Institute of Botany of the Czechoslovak Academy of Sciences in Průhonice became the centre of phytosociological research on Czechoslovak vegetation. The team led by Rudolf Mikyška, which included distinguished scientists such as Jaroslav Moravec, Robert Neuhäusl and Zdenka Neuhäuslová, studied Czechoslovak vegetation within the framework of an ambitious project aimed at mapping reconstructed natural vegetation. The map was published as a book with explanatory text (Mikyška et al. 1968) and map sheets at the scale of 1 : 200 000. Besides vegetation mapping, which contributed a great deal to the knowledge on the diversity of natural forest vegetation, research into other types of plant communities also progressed markedly in the 1960s. Jan Jeník, Charles University, Prague, focussed on alpine and subalpine vegetation, while Slavomil Hejný and Karel Kopecký from the Institute of Botany in Průhonice studied aquatic, wetland and synanthropic vegetation types. University and academic centres in Brno also contributed to this kind of research: Jiří Vicherek studied various types of grassland and wetland vegetation, Emilie Balátová-Tuláčková investigated meadows and Kamil Rybníček mires. The results obtained in this period appeared in a new overview of plant communities at the level of phytosociological alliances and classes (Holub et al. 1967).

Since the 1960s phytosociological classification of vegetation has been routinely implemented as an approach to inventory in institutions engaged in environmental protection and botanical research of selected areas. Further major contributions to the knowledge of plant communities in various regions within the Czech Republic were published by the above-mentioned authors as well as Denisa Blažková, František Grüll, Emil Hadač, Miroslava Husová, Vladimír Jehlík, Jiří Kolbek, Jarmila Kubíková, Antonín Pyšek, Jaroslav Rydlo, Jaromír Sofron, Tomáš Sýkora, Miloslav Toman and others. At the beginning of the 1980s the knowledge of plant communities of the Czech Republic was sufficiently detailed to allow the compilation of the first overview of vegetation units at the level of association (Moravec et al. 1983a; the second, updated edition was published in 1995). The second edition contains 665 associations, 150 alliances, and 44 classes. Although this overview played a key role in the synthesis of current knowledge and remains the only complete survey of vegetation units in the Czech Republic at the level of associations, it has a number of shortcomings. The specification of many vegetation units included in the overview is rather ambiguous and their characteristics are too brief to be sufficient for identification. Attempts were made to eliminate these shortcomings by adding more detailed descriptions to all associations in the series entitled *Vegetation Survey of the Czech Republic*, edited by Jaroslav Moravec. However, even this series did not provide the necessary baseline data of a modern survey, i.e. tables with floristic composition of vegetation units and distribution maps. The volumes that have been published so far (Moravec 1998, Moravec et al. 2000, Husová et al. 2002, Neuhäuslová 2003) deal only with forest vegetation.

Since the 1990s phytosociological classification has acquired increasing importance in Europe, particularly in the connection with the adoption of the Habitats Directive (92/43/EEC). The Habitats Directive implemented the principle that the selection of protected areas should proceed on the basis of the representative distribution of endangered habitats. Vegetation is the most suitable component for the typification of terrestrial habitats and phytosociology thus seems to be a suitable method for habitat classification. Being based on the detailed analyses of species composition of plant communities, phytosociology is also crucial for biodiversity protection. Therefore, the phytosociological system was adopted in the corrected form in the European schemes of habitat classifications such as EUNIS (Davies & Moss 1997; http://eunis.finsiel.ro/eunis/habitats.jsp). The European systems of habitat classification were adapted to the needs of the Czech Republic and interpreted in the *Habitat Catalogue of the Czech Republic* (Chytrý et al. 2001a), which became the starting point for the national mapping of habitats within the Natura 2000 project from 2001 to 2004.

## The "Vegetation of the Czech Republic" project

The demand by environment protection agencies for consistent and well-documented systems of vegetation classification led in the 1990s to the implementation of modern national projects of vegetation classification in some European countries, e.g., Great Britain (Rodwell 1990–2000), Austria (Mucina et al. 1993b), the Netherlands (Schaminée et al. 1995–1999), Slovakia (Valachovič et al. 1995, Jarolímek et al. 1997, Valachovič 2001), Germany (Dierschke 1996 et seq.) and the German federal state of Mecklenburg-Vorpommern (Berg et al. 2004). These projects have the following features in common: thorough revision of previously described vegetation units on the basis of a critical reassessment of large relevé data sets; documentation of accepted associations using species composition tables; the detailed revision of the nomenclature of vegetation units; and the compilation of the distribution maps of phytosociological associations within the area in question. Research teams have shared their experiences from these projects with vegetation scientists from other European countries at the annual meetings of the European Vegetation Survey working group that have been held every year since 1992 (Mucina et al. 1993c, Rodwell et al. 1995). This working group has also produced the European synopsis of vegetation units at levels ranging from classes to alliances (Mucina 1997a, Rodwell et al. 2002).

Despite a long tradition of phytosociological research and a good level of documentation of vegetation, the Czech Republic did not possess the modern classification of vegetation. In 1995 a decision was made to start to work on a new monograph entitled *Vegetation of the Czech Republic*. The initial, partial goal was to generate the Czech National Phytosociological Database which would contain the representative sample of relevés from different habitats and regions of the Czech Republic in an easily accessible electronic format (Chytrý & Rafajová 2003). Such relevés existed but were scattered in a number of scientific books, articles, theses, unpublished research reports, inventory surveys of protected areas, field books and other written materials maintained by different botanists. Thanks to Professor John S. Rodwell from Lancaster University (UK) and Stephan M. Hennekens from Alterra – Green World Research in Wageningen (The Netherlands), we were able to use know-how from the British and Dutch vegetation classification projects from the very beginning of our work on the database. In 1995–1997, John Rodwell arranged a series of courses to acquaint with the principles of phytosociological database management and particularly with the computer program TURBOVEG (Hennekens 1995, Hennekens & Schaminée 2001). The author of this program Stephan M. Hennekens kindly provided it to Czech users free of charge. TURBOVEG was prepared for use in Central Europe in cooperation with colleagues from Austria (Ladislav Mucina, Harald Niklfeld, Walter Gutermann) and Slovakia (Milan Valachovič, Ivan Jarolímek) and in 1996 it was made accessible to all vegetation scientists in the Czech Republic (Chytrý 1996). In February 1997 Masaryk University in cooperation with John Rodwell organized a TURBOVEG training course in Brno for colleagues and students from the Czech Republic and Slovakia. Subsequently, a network of local TURBOVEG coordinators was established, which covered all major botanical institutions in the Czech Republic.

Financial support from the Czech Science Foundation has enabled the employment of a database administrator since 1999. This position was occupied by Marie Rafajová (1999–2003), Ilona Knollová (2003–2005) and Štěpánka Králová (since 2005). Professional database management and contributions from a number of co-workers from Masaryk University, the Institute of Botany of the Academy of Sciences of the Czech Republic and other institutions resulted in the fast population of the database (Chytrý & Rafajová 2003). By the end of 2005, the database included a total of 72,476 relevés, recorded on the territory of the Czech Republic in the period from 1922 to 2005. The database is thus probably third largest in the world following the Dutch and French databases (Ewald 2001).

Besides the creation of the relevé database, the preparation of the monograph *Vegetation of the Czech Republic* also necessitated the development and testing of methods for vegetation classification using large data sets. In the case of data sets with tens of thousands of relevés, standard methods developed for classification of smaller data sets are not suitable or do not allow the potential of these data to be fully exploited. In addition, there has been only very limited experience with how various shortcomings in data quality affect the analysis of large relevé data sets. It was therefore necessary to perform various methodological studies. One of the challenges was to establish a method of selection of relevés from the database which would prevent the negative impact on the resultant classification caused by the uneven distribution of relevés within the Czech Republic (Knollová et al. 2005). For vegetation classification on the basis of a phytosociological database, we selected the Cocktail method (Bruelheide 1995, 2000). This method creates explicit definitions of vegetation units which allow an unambiguous assignment of every relevé to these units. It thus allows matching of newly obtained relevés to the units of established classification. The Cocktail method underwent comprehensive testing and modifications and was extended with a procedure that enabled the assignment of relevés to vegetation units based on similarity (Kočí et al. 2003, Tichý 2005). Attention was also devoted to the testing and development of statistical methods to determine species fidelity to vegetation units (Chytrý et al. 2002, Tichý & Chytrý 2006), an important criterion in the determination of diagnostic species and the presentation of vegetation classification in tables. Chytrý & Tichý (2003) calculated species fidelities to vegetation classes and alliances of the current standard vegetation classification of the Czech Republic (Moravec et al. 1995), using data from the Czech National Phytosociological Database. Based on this analysis, they were able to evaluate the quality of delimitation of vegetation units. This work was used as a guideline for identification of (1) which vegetation units from the current classification should be adopted in the new classification system and (2) which should be eliminated or modified. Since 1998 all methods of analysis of phytosociological data used in the project have been included in the computer program JUICE (Tichý 2002), which has become a tool for the comprehensive analysis of phytosociological data and is currently being used by a number of individuals and institutions in many countries worldwide.

The preparation of the first volume of the monograph *Vegetation of the Czech Republic* was supported by the Czech Science Foundation (GAČR) grant no. 206/02/0957 (2002–2004). The project was managed at the former Department of Botany (now Department of Botany and Zoology), Masaryk University, Brno, with the Institute of Botany of the Academy of Sciences of the Czech Republic acting as a cooperating institution. Besides the authors of the treatments of individual syntaxa, the project involved several colleagues without whose contributions this book would never have been completed. Lubomír Tichý developed software tools for the comprehensive analysis of phytosociological data. Ilona Knollová managed the phytosociological database and prepared the data sets for analysis. Zdenka Otýpková and Katrin Karimová were involved in editing of the database. Jiří Danihelka produced a database for automatic conversion of species taxonomy and nomenclature used in the TURBOVEG program to those used in the *Key to the Flora of the Czech Republic* and also undertook a detailed linguistic revision of the Czech text. Ondřej Hájek prepared all the maps used in this book and took part in the preparation of the predictive distribution models. Klára Kubošová developed the statistical models used for the prediction of potential distribution. Jiří Rozehnal was responsible for the design of graphs and provided the hardware and software support. The final editing of the manuscript and publication of this book were supported by the grants nos. GAČR 206/05/0020, GAČR 206/06/0659 and MSM 0021622416.

## The hierarchy of the system of plant communities

The European phytosociological school recognizes four main hierarchical levels (ranks) of phytosociological units (syntaxa), which differ by the endings of their Latin names. The ranks, arranged from the lowest to the highest, are as follows: association (ending *-etum*), alliance (*-ion*), order (*-etalia*) and class (*-etea*). Apart from syntaxa of these main ranks, there are also syntaxa of supplementary ranks, subassociation (*-etosum*), suballiance (*-enion*), suborder (*-enalia*) and subclass (*-enea*). The nomenclature of these syntaxa is governed by the *International Code of Phytosociological Nomenclature* (ICPN; hereafter referred to as the Code; Weber et al. 2000).

We believe that a simple hierarchy is convenient for the practical use of a system of vegetation units on the national level. Therefore, we only use four hierarchical ranks in the presented system, namely class, alliance, association and variant. Classes, alliances and associations are frequently used in practice to identify various vegetation types. We do not use orders as they are not of great significance on the national level, and because classes usually contain a manageable number of alliances, which do not need to be arranged hierarchically by introducing yet another classification rank. Moreover, the application of orders has often not stabilized, since their meaningful definition would require the revision of the respective vegetation classes throughout their distribution range; this has not yet been possible with the current level of knowledge of the diversity of European vegetation. We also do not use suballiances, suborders or subclasses. Until now suballiances have been used in the Czech Republic for only a few alliances (Moravec et al. 1995). However, we do consider it suitable to use classification units below the rank of association in order to express internal variability. Subassociations could be suitable for this purpose, but the problem is that for many associations, there are plenty of subassociations described that have rather limited, local validity, overlap each other and are defined according to mutually incompatible criteria. Based on analysis of the variability of relevés within a given association we have attempted in the present work to define two to four major subtypes inside the associations. Often these subtypes could not be unambiguously identified with the described subassociations, and thus named correctly according to the Code. We therefore used the variant as a classification unit at the hierarchical level below the association, because its nomenclature, unlike that of subassociation, is not governed by the Code. This means that *ad hoc* names can be used irrespective of the units described previously. We do not distinguish variants for relatively homogeneous associations with small internal variability.

For the purpose of the coding of vegetation units in maps and databases, all vegetation units used are given unique codes, which simultaneously reflect their rank in the classification hierarchy, e.g. TBB03, or TBB03a, respectively. The meaning of these abbreviations is as follows:

- The first letter indicates the formation group according to the *Habitat Catalogue of the Czech Republic* (Chytrý et al. 2001a) and is selected to reflect the name of the formation group. For instance, the letter A denotes alpine vegetation while the letter T indicates vegetation of secondary grasslands and heathlands;
- The second letter is presented in the alphabetical order and indicates the class within the formation group;
- The third letter is also given in alphabetical order and indicates the alliance within the class;
- The two-digit number indicates the association within the alliance;
- The small letter provided in alphabetical order indicates the variant within the association.

## The concept of associations and other vegetation units

The variability of species composition in plant communities is usually continuous: clearly defined vegetation units are rather rare in nature. However, vegetation classification is important for practical purposes, e.g. for habitat inventory and mapping. Classification can be performed using several alternative approaches, of which none can be declared the best. The classification in the monograph *Vegetation of the Czech Republic* largely adopted traditional vegetation units used in the last edition of the list of plant communities of the Czech Republic (Moravec et al. 1995), in the vegetation overviews of neighbouring countries (Mucina et al. 1993b, Schaminée 1995–1999, Pott 1995, Valachovič et al. 1995 et seq., Matuszkiewicz 2001, Schubert et al. 2001, Borhidi 2003, Berg et al. 2004) and in the pan-European overviews (Mucina 1997a, Rodwell et al. 2002). We did not aim at the formation of a new classification but at a critical review of the current classification, to which Czech and Central European users are accustomed. The main goals of this revision, based on analysis of large relevé data sets, were as follows: (1) to eliminate overlaps in the definitions of the currently distinguished vegetation units, (2) to exclude from the syntaxonomic system units with poor floristic differentiation, which are difficult to recognize both in the field and in the databases, and (3) to adapt the definitions of the vegetation units of the Czech Republic to concepts accepted in neighbouring countries, provided they are not in conflict with the variability of the vegetation occurring on the territory of the Czech Republic.

The large relevé data sets can be classified using methods of unsupervised or supervised classification (Ejrnæs et al. 2004). Unsupervised classification algorithms seek the main gradients in species composition, more significant discontinuities and relatively homogeneous relevé groups within the relevé data sets. The use of these algorithms yields the division of the relevés into groups which is dependent only on the information contained in the data set. The most commonly used methods of unsupervised classification include TWINSPAN (Hill 1979) and cluster analysis (Legendre & Legendre 1998, Podani 2000). Different variants of these algorithms as well as different data transformations provide slightly different results. However, the majority of them reflect the variability inside the data set quite well. The main disadvantage of unsupervised classification is that the result is always unique for the given set of relevés. If the data set is partially altered, e.g. by the addition of newly obtained relevés, the classification may change considerably and some of the relevés that have been assigned to a particular group during the classification of the original set will be assigned to a different group during the classification of the altered set. Unsupervised classifications thus do not ensure the stability of vegetation classification of large areas. The project *Vegetation of the Czech Republic* employed unsupervised classifications in pilot studies to identify the main gradients within individual vegetation types on the territory of the Czech Republic and neighbouring countries (e.g. Havlová et al. 2004, Botta-Dukát et al. 2005). However, the final version of the classification was generated using a supervised classification method.

Supervised classifications use external predefined criteria of what the individual vegetation types should look like. These criteria are independent of the data set being classified. The vegetation classification at the level of associations in the project *Vegetation of the Czech Republic* was performed using the supervised classification method Cocktail (Bruelheide 1995, 2000). This method imitates the traditional phytosociological classification approach using the sociological groups of species. It was tested with various data sets and slightly modified in comparison with its original version (Bruelheide & Chytrý 2000, Kočí et al. 2003, Lososová 2004). Based on large sets of relevés, Cocktail quantifies species co-occurrence rates and generates sociological groups from species with a strong tendency to occur together in relevés. When sociological groups are to be generated, the initial species of the groups can be selected subjectively so as to characterize the traditional vegetation units well. However, the assignment of other species to a particular group is subjected to a statistical check to indicate whether one species matches the group better than others. Sociological groups are named after one of the group's species. The next phase delimits the vegetation units by means of formal definitions with the logical operators AND, OR or NOT. These definitions determine which sociological groups must be present or absent in a relevé in order this relevé can be assigned to the particular vegetation unit. We produced Cocktail definitions of associations but not of the vegetation units of other ranks. The testing of the Cocktail method revealed that a large number of traditional associations could not be defined purely by floristic composition, without considering dominance of some species (Kočí et al. 2003). As a result, the formal definitions include the dominance of selected individual species, in addition to the presence/absence of sociological species groups. For example, the Cocktail definition of the association *Angelico sylvestris-Cirsietum oleracei* has the following form:

> **Group *Caltha palustris*** AND **Group *Cirsium oleraceum*** NOT **Group *Cirsium rivulare*** NOT *Carex cespitosa* cover > 25 % NOT *Filipendula ulmaria* cover > 25 %.

This means that a relevé is assigned to the association if it contains both the *Caltha palustris* sociological group and the *Cirsium oleraceum* group and, at the same time, it does not contain the *Cirsium rivulare* group nor the species *Carex cespitosa* with the cover higher than 25% nor the species *Filipendula ulmaria* with the cover higher than 25%. The sociological group is considered to be represented in the relevé if the relevé contains at least half of all species of the group. The overview of sociological species groups used in the first volume of *Vegetation of the Czech Republic* is provided in Table 1 (page 22). The formal definitions of associations were elaborated in such a way that the groups of relevés specified by them matched as much as possible the traditionally distinguished associations. In the course of the elaboration of formal definitions attempt was made to formally define all associations included in the latest list of vegetation units of the Czech Republic (Moravec et al. 1995) and some associations not yet reported from the Czech Republic but recognized in neighbouring countries. It was shown that many associations mentioned by Moravec et al. (1995) overlap in their delimitations while others cannot be defined at the national scale at all due to their poor floristic differentiation. As a result, the number of associations recognized in the monograph *Vegetation of the Czech Republic* is lower than in the list by Moravec et al. (1995). However, the accepted associations are clearly defined and well recognizable. Thus, the Cocktail method prevents the inflation of vegetation units (Pignatti 1968), i.e. the description of an increasing number of associations which are usually of limited local validity or have poor differentiation as compared with the previously described associations.

It should be emphasized that associations defined by the Cocktail method are defined subjectively, i.e. like the associations in the traditional phytosociological classification. However, they have one major advantage compared with traditional classification: they are defined using unambiguous criteria which allow the consistent assignment of any relevé to the particular association. They can therefore serve as a suitable basis for computer expert systems, i.e. programs that will compare every submitted relevé with the formal definitions of associations and assign it to the particular association.

An important property of the Cocktail method is that some relevés, particularly those consisting of mainly generalist species, are not assigned to any association and thus remain unclassified. Up to 50–70% of relevés usually remained unclassified in our tests. This feature reflects traditional phytosociological experience that the majority of vegetation stands occurring in the field cannot be assigned to associations. However, in some practical applications of phytosociological classification, e.g. in vegetation mapping, it is not desirable that some stands are not assigned to classification units. We have therefore developed a two-step classification. In the first step, the relevés are assigned to associations according to formal definitions. In the second step, the relevés that have not been assigned to any association by formal definitions are compared with the species composition of groups of relevés that have already been assigned to individual associations and subsequently assigned to the most matching association (Kočí et al. 2003, Tichý 2005).

The adopted concept of alliances and classes relies particularly on the statistical analysis of the quality of the delimitation of alliances and classes described by Moravec et al. (1995) that was performed by Chytrý & Tichý (2003) on the basis of the data from the Czech National Phytosociological Database. The analysis evaluated not only the sharpness of each unit, i.e. the number and the quality of its diagnostic species, but also the uniqueness of the unit, i.e. the degree of overlap of the particular vegetation unit with other vegetation units. As an auxiliary criterion, the major alliances and classes accepted in the vegetation overviews of neighbouring countries and international overviews were also taken into account.

## The technical procedure of defining associations and other vegetation units

The set of 53,097 relevés from the Czech Republic available in the Czech National Phytosociological Database on 1 July 2002 was used to generate sociological groups of species and formal definitions using the Cocktail method. This set was elaborated to contain as many different vegetation types as possible. It thus includes not only grassland and low-shrub vegetation, but also relevés of anthropogenic, aquatic, wetland, chasmophytic, shrub and forest vegetation. First, a total of 636 relevés recorded using plots of unusually large or small size (Chytrý & Otýpková 2003) were eliminated from the data set. This applied to any plots < 50 m$^2$ or > 1000 m$^2$ for forests, < 10 m$^2$ or > 100 m$^2$ for shrub vegetation and < 4 m$^2$ or > 100 m$^2$ for herbaceous vegetation. This was followed by the elimination of 12,740 relevés that had not been assigned to syntaxa at least at the level of the class according to the standard national list (Moravec et al. 1995) or that lacked geographical localization with an accuracy of at least one geographical minute. All other data analyses were performed in the JUICE program (Tichý 2002), unless stated otherwise.

The geographical distribution of the remaining relevés was relatively uneven: some territories were surveyed sufficiently, with quite a large number of relevés available, while fewer or no relevés at all were available from other territories (Chytrý & Rafajová 2003). We therefore performed a stratified selection of relevés to ensure that no vegetation type was represented by a high number of relevés from a small area and that the formation of sociological groups was not affected by locally specific coincidences of species occurrence (Knollová et al. 2005). Stratification was performed in a geographical grid with cells sized 1.25 minutes of longitude × 0.75 minutes of latitude, i.e. approximately 1.5 × 1.4 km. If two or more relevés assigned by their authors to the same association fell in the same grid cell, only one of them was selected. The selection preferred relevés with a record of the moss layer and more recent relevés. If there were still some relevés of the same record date left, one of them was selected at random. This stratified selection generated a data set containing 21,794 relevés, which was used to generate sociological species groups, test the Cocktail definitions of associations and perform other analyses.

All records of juvenile trees and shrubs in the herb layer were deleted from the stratified data set because some authors recorded them while others did not. The multiple records of the identical species in the tree and shrub layers were combined. Similarly, the records of low shrubs or high herbs recorded in the herb layer by some authors and in the shrub layer by others (e.g. *Calluna vulgaris*, *Cotoneaster* spp., *Daphne mezereum*, *Prunus fruticosa*, *Reynoutria* spp., *Rosa gallica*, *Rubus* spp. and *Sambucus ebulus*) were also combined in one layer. The same approach was applied to lianas recorded in the tree, shrub and herb layers (e.g. *Clematis vitalba*, *Hedera helix*, *Humulus lupulus* and *Solanum dulcamara*). As a result, all the species were represented only once in the final data.

Bryophytes, foliose and fruticose lichens and macroscopic algae were maintained in the data set although they were not recorded in all relevés. This fact could lead in some cases to underestimating the significance of these plants in the formation of species groups. Therefore the species groups were formed with particular emphasis on vascular plants since these are recorded in all relevés.

The taxonomic concepts and nomenclature of species and subspecies were standardized according to standard works for vascular plants (Kubát et al. 2002), bryophytes (Kučera & Váňa 2003) and lichens (Vězda & Liška 1999). The names of vascular plants that do not occur in the Czech Republic mostly follow Ehrendorfer (1973), provided there is no contradiction in the taxonomic concept accepted in this publication and in Kubát et al. (2002). Narrowly defined species or subspecies were unified into a broader concept in all cases where most relevés contained determinations of broadly defined species or when the data on narrowly defined species were likely to contain errors. In cases when the *Key to the Flora of the Czech Republic* (Kubát et al. 2002) specifies species aggregates, these aggregates (agg.) were used for broadly defined species. In other cases, the broader species concepts were defined particularly for the purpose of the monograph *Vegetation of the Czech Republic* and marked with the name of a particular species and abbreviation s. lat. (*sensu lato*). These species are listed in the Czech version of the text (page 25). Broader species concepts were used in the analysed data set. If statistical analysis of this data set determined some broadly conceived species as diagnostic, constant or dominant of an association, and it is known that some narrowly conceived species grows in this association, the species list contains the broader species concept, followed by the narrower concept in brackets.

The resultant set of 21,794 relevés was used to generate sociological species groups with the Cocktail method (Bruelheide 1995, 2000), which included a few modifications described by Kočí et al. (2003). The degree of co-occurrence was calculated for each species using the phi coefficient of association (Sokal & Rohlf 1995, Chytrý et al. 2002). When the phi coefficient between two species was high, indicating a strong interspecific association that exceeded the association of each of these two species to any other species, these two species were used as the basis of a sociological group. The next step tested the association between the common occurrence of these two species and the occurrence of the other species. Based on the strength of this association, third species was added to group. It was a species with strong (usually the strongest) association with the relevés containing both species previously included in the sociological group. The species with the strongest association was not included in the sociological group in the cases when it had already been included in another group or when its frequency (i.e. the number of occurrences in the data set) differed by an order of magnitude from those of the species already included in the sociological group. In such cases, species with the second or third strongest association was included in the group. This was done because incorporation of either too rare or too common species would lead to the formation of heterogeneous sociological groups. In the next steps, the association between relevés containing at least half of the species included in the sociological group on the one hand and the occurrence of other individual species on the other was calculated. On the basis of this calculation, another species with a strong association was added to the group and the process continued in the same way. The generation of sociological groups usually stopped when they contained 3–5 species, because larger groups usually appeared too heterogeneous.

Sociological groups and dominances of selected species were used to generate logical definitions of associations, in which the requirements regarding the occurrence of groups or species dominances were linked via the logical operators AND, OR, and NOT (Bruelheide 1997). The definitions of associations were generated stepwise so that the group of relevés assigned to a particular association using its logical definition overlapped the group of relevés included in this association by the relevé authors as much as possible. These two groups of relevés were compared after every modification of the logical definition using the phi coefficient. Finally, the definition was selected that was as close to the traditional subjective delimitation of association as possible. However, at the same time, the requirement that relatively simple definitions are maintained, without too many criteria, was applied. If the definitions assigned some relevés of forest vegetation to some grassland or heathland associations, these relevés were automatically excluded.

In the definitions of associations marginal overlap was allowed, i.e. some relevés could be assigned to more than one association at the same time. These relevés were compared with the groups of relevés that had already been assigned to each of these associations unambiguously. The comparison was based on the Frequency-Positive Fidelity Index (FPFI; Tichý 2005), which took account of the similarity of species composition between the relevés to be assigned and the respective group of relevés, positively weighting the species with the diagnostic value for the particular group of relevés. Every relevé subjected to comparison was then assigned to the group of relevés (association) that it best matched according to the FPFI index.

Variants, i.e. lower vegetation units inside the associations, were defined using an unsupervised classification method – cluster analysis performed separately for each group of relevés assigned to the individual associations. The cluster analysis was calculated using the PC-ORD 4 program (McCune & Mefford 1999), with the chord distance as a measure of dissimilarity and the beta-flexible linkage method with the coefficient $\beta = -0.25$. The clusters obtained were interpreted subjectively with respect to their ecological interpretation. Generally, two or three (occasionally four) clusters at the highest hierarchical level were interpreted as variants. If the clusters distinguished in this way showed only indistinctive floristic differentiation or did not have an unambiguous ecological interpretation, no variants in the particular association were differentiated.

Associations were grouped into alliances and classes on the basis of the subjective evaluation of their mutual similarity, following the Central European phytosociological tradition. In some cases, this evaluation was supported by cluster analysis or ordination of several related associations.

## Nomenclature of plant communities

The nomenclature of plant communities in continental Europe usually adheres to the rules implemented in the *International Code of Phytosociological Nomenclature* (Weber et al. 2000). Also in monograph *Vegetation of the Czech Republic*, the Code was accepted as the nomenclature authority. The individual nomenclature solutions partly follows those adopted in previous nomenclature revisions (particularly Mucina et al. 1993b, Rennwald 2000, Berg et al. 2004), but predominantly they are based on the independent revision of the Czech and international syntaxonomic literature. Many vegetation units have been given names different from those used in the latest list of plant communities of the Czech Republic (Moravec et al. 1995) because this overview contains not only correct names but sometimes also invalid names or names that have never been described.

All names used in the monograph *Vegetation of the Czech Republic* were checked in the publications containing their original description so that we could ensure that all the accepted names are valid. However, it is possible that a different, older and valid name will be found for some of the syntaxa in the vast body of phytosociological literature in the future, and this name will have to be accepted as the correct name.

Apart from the adopted name, which is the most likely correct name, the text also provides frequent synonyms such as legitimate younger names of the same syntaxon and illegitimate names. The list of synonyms is not exhaustive but it is limited particularly to the synonyms used by Moravec et al. (1995) and in the vegetation monographs of neighbouring countries such as Germany (Oberdorfer 1993a, b, Pott 1995, Dierschke 1996 et seq., Rennwald 2000, Schubert et al. 2001), Austria (Mucina et al. 1993b), Poland (Matuszkiewicz 2001), Slovakia (Valachovič et al. 1995 et seq., Stanová & Valachovič 2002) and Hungary (Borhidi 2003). All synonyms older than the respective accepted name include a reference to the article or paragraph of the Code (indicated as §) according to which the name has to be rejected as being ineffective, invalid or illegitimate. This is not included in case of the names younger than the accepted one because such names are not usable on the basis of the priority principle. The most frequent reasons of rejecting a name are listed below:

**§ 1** – The name has not been published in a printed publication, it is therefore rendered ineffective (*nomen ineditum*)

**§ 2b** – The name has not been published with a sufficient original diagnosis (*nomen nudum*). Sufficient original diagnosis means: (1) in the case of associations, at least one relevé or constancy table if published before 1978 or at least one relevé if published after 1978; (2) in the case of the units of a higher rank, a bibliographically unambiguous reference to the valid name of the syntaxon of the closest subordinate principal rank and since 1980 also with the list of diagnostic species

**§ 3a** – The name has been merely cited as a synonym by its author

**§ 3b** – The name has been suggested as provisional by its author

**§ 3c** – The syntaxonomic rank of the vegetation unit has not been indicated

**§ 3d** – The rank of the syntaxon did not correspond to the rank of the Code or it is an association of the Uppsala School published before 1936

**§ 3e** – The syntaxonomic rank did not correspond to the form of the name

**§ 3f** – The name-giving taxa were not indicated in the original diagnosis

**§ 3g** – The name was published after 1978 and it is not clear from which taxon name(s) it has been formed

**§ 5** – The name was published after 1978 without indication of the nomenclature type

**§ 29** – The syntaxon has been renamed because another taxon characterizes it better

**§ 31** – The name is a younger homonym, i.e. it is spelled like a previously and validly published name

**§ 33** – The name is one of the homonyms of equal age but another of these homonyms was adopted by other earlier authors

**§ 34a** – The name contains an epithet in the nominative case that indicates a geographical, ecological or morphological property, e.g. *Fagetum sudeticum* or *Vaccinietum myrtilli subalpinum*

**§ 34c** – The name was formed from more than two taxon names

**§ 36** – Due to earlier misinterpretations, the name was often used in a false sense that excludes its type (*nomen ambiguum*); it may therefore be proposed for rejection as *nomen ambiguum rejiciendum propositum*

**§ 37** – The type relevé of the association is so incomplete or complex that it cannot be assigned to any one of the currently distinguished associations (*nomen dubium*)

**§ 43** – The taxon providing the name of the syntaxon was determined erroneously

Besides the above-mentioned reasons, synonymy may also include the names that are often quoted in the literature and attributed to a particular author who neither created nor used the name. Such cases occur surprisingly often and are called *phantoms* according to Mucina (in Mucina et al. 1993a: 19–28).

Another synonymy problem concerns pseudonyms, i.e. the names of syntaxa used with the original author citation or with reference to it but misinterpreted by later authors. If these names are used more frequently, we also place them in synonymy, referring to the misinterpreting author, preceded by the word *sensu*, and followed by the name of the author of the original description (after the word *non*). For example, the author citation 'sensu Šmarda 1961 non Tüxen 1937' means that Šmarda used Tüxen's name for a syntaxon other than that originally described by Tüxen. If more authors used a certain name in a manner different from that of the original description, the abbreviation *auct. non* is used instead of the name of the misinterpreting author.

There are many cases when the correct form of the accepted name differs from that given in the original diagnosis. As a result, every accepted name in the monograph *Vegetation of the Czech Republic* is accompanied by its original wording attached after the abbreviation 'Orig.', including the original wording of the author citation if this was indicated in the original diagnosis. The accepted names of associations and alliances that contained only the genus name(s) in the original diagnosis were supplemented with species epithets in accordance with Recommendation 10C of the Code. One exception applies to the associations and alliances whose original diagnosis contains more than one species of the genus used in the name, and it is not therefore clear from which species name the name of the syntaxon was formed. In the cases that only one of these species is indicated in the list of diagnostic species or has much higher constancy or cover as compared with the other species, the former species is considered as name-giving and included in the name of the syntaxon. In other cases, when it is not clear which is the name-giving species, only the genus name is used and the list of species that can potentially provide the name is placed in brackets after the original wording of the name. The names of classes composed of two taxon names are usually left without species epithets in accordance with established tradition while the names of classes formed from the name of a single species are supplemented with the species epithet.

For practical reasons in some cases, we also used the modified form of names which is subject to approval by the Nomenclature Commission of the International Association for Vegetation Science. The form used is considered here as the proposal to modify the name. This concerns *nomina inversa* and *nomina mutata*. According to Article 42 of the Code, *nomina inversa* are the names of syntaxa in which, as compared with the original diagnosis, the order of the names of taxa was changed so that the dominant taxon or the taxon of the higher layer is in the second place. According to Article 45, *nomina mutata* replace syntaxon names which were originally formed from the names of taxa not used in the recent taxonomic and floristic literature, with syntaxon names that include the names of taxa that are in accordance with the contemporary taxonomic literature. The names of taxa that were not accepted in common taxonomic and nomenclature sources used in the Czech Republic over the last 30 years (Ehrendorfer 1973, Smejkal 1981, Neuhäuslová & Kolbek 1982, Dostál 1982, 1989, Hejný et al. 1988 et seq., Kubát et al. 2002) were generally replaced by names of taxa accepted in the *Key to the Flora of the Czech Republic* (Kubát et al. 2002). In order to facilitate work with synonyms, we provide the conversion of the old taxon name to the name from the *Key* in brackets after the original form of the syntaxon name. We also introduce this conversion in cases when the name of the syntaxon maintains a different taxon name than that used in the *Key*.

## Phytosociological tables and the determination of diagnostic, constant and dominant species of vegetation units

Species composition of associations defined by the Cocktail method was compared in synoptic tables, which included groups of similar associations. Each table contains the percentage frequency of the occurrence of species in relevés assigned to individual associations. Tables do not contain all available relevés that can be assigned to the particular association; instead, they only show the relevés of the stratified set of 21,794 relevés of all vegetation types of the Czech Republic (see above) that were assigned to individual associations with the help of Cocktail definitions. The use of relevés from the stratified data set limited potential distortion of the data due to local oversampling of some sites. If some associations had less than 10 relevés assigned to them, additional relevés were added such that the number 10 was attained, provided they were available and complied with the Cocktail definition.

In this stratified data set fidelity of each species to each association, i.e. the occurrence concentration of species in relevés of the particular association, was calculated. Fidelity expresses the diagnostic value of the species for a particular association. Species with high fidelity can be considered diagnostic, i.e. character species or differential species. Fidelity was determined with the phi coefficient, which was used as a measure of the statistical association between the occurrence of species and the relevés assigned to the particular phytosociological association. Since the value of the phi coefficient depends on the ratio of the number of relevés belonging to the particular association to the total number of relevés, and each association is represented by a different number of relevés (Chytrý et al. 2002), the relative number of relevés of each association was virtually equalized to 1% of the total number of all relevés in the stratified data set (Tichý & Chytrý 2006). For comparison with the target association, relevés of all vegetation types were retained in this stratified data set. As a result, diagnostic species determined in this manner have general validity in comparison with all other vegetation types of the Czech Republic. Species with a phi coefficient above 0.25 were considered diagnostic for a particular association while species with a phi coefficient above 0.50 were termed highly diagnostic. These thresholds were determined subjectively in order to obtain practical numbers of diagnostic species, i.e. not too many or too few. After virtual equalization of the number of relevés in an association, the phi coefficient may reach a high value even in cases where fidelity of a particular species to a particular association is not statistically significant. This occurs in cases when the particular association before equalization is represented by a small number of relevés. Therefore, in addition to the phi coefficient for each species and association, the statistical significance of the fidelity prior to equalization was calculated using the Fisher's exact test (Chytrý et al. 2002). Based on this calculation, species whose occurrence concentration in relevés of the particular association did not differ from random at a level of significance of $P < 0.001$ were not included in a group of diagnostic species although they showed a high phi coefficient value. The fidelity of bryophytes and lichens, which were not recorded in all relevés, was calculated only on the basis of the subset of relevés in which these plants were recorded. Diagnostic species are marked with green in synoptic tables while highly diagnostic species are marked in a dark green colour. These species are also introduced in the lists of diagnostic species in the textual descriptions of associations; highly diagnostic species are printed in bold.

Diagnostic species determined in the above-mentioned manner were also used to assess the quality of the definition of individual associations using the Cocktail method. Associations that had no diagnostic species, i.e. those difficult to distinguish floristically, were not accepted in the proposed system of vegetation units.

In addition to diagnostic species, species frequently occurring in vegetation stands (constant species) and species with high cover (dominant species) are also important for sufficient characterization of phytosociological associations. These species were determined using the same data set with which diagnostic species were determined. Constant or highly constant species were those with a frequency over 40% or 80%, respectively. Dominant species and highly dominant species were those that occurred with a cover value exceeding 25% at least in 5% and 10% of relevés, respectively. However, in cases of associations with few relevés only, species occurring as dominants in a single relevé were not included in the list of dominant species, even though this single dominant occurrence corresponded to more than 5 or 10% of relevés. In the case of bryophytes and lichens, constant and dominant species were only determined on the basis of relevés in which these plants had been recorded.

Diagnostic and constant species of the alliances and classes were determined in the same way as those of the associations, based on the relevés assigned to all the subordinate associations. As these groups of species are only based on the data from the Czech Republic, they have a local validity for the national territory. If vegetation diversity across the entire geographic range of particular classes and alliances was taken into account, the lists of diagnostic and constant species would probably be modified to some extent. In alliances with a single association recognized in the Czech Republic, we consider their diagnostic and constant species to be identical with those of the association. The same principle applies for classes with a single alliance. We did not determine dominant species of classes and alliances, because different associations assigned to them often have different dominant species.

Highly constant and highly dominant species are printed in bold in the text. Synoptic tables contain a list of diagnostic species in the first part, followed by a list of species with frequency of at least 10% in all relevés of a particular table or at least 20% in one or more associations of the table. Less frequent and non-diagnostic species were omitted due to space limitation.

## Graphic calibration of associations

Ellenberg indicator values (Ellenberg et al. 1992), altitudinal range and the cover of the herb layer for each association were illustrated in box-and-whiskers plots, which provide an overview of the habitat requirements and the physiognomy of individual associations. These plots were formed on the basis of relevés from the stratified selection, i.e. from the relevés used for making synoptic tables. They illustrate the median (i.e. the horizontal line in the middle of the box), lower and upper quartiles, i.e. the interval accomodating 50% of the observed values (box), and 5% and 95% percentiles, i.e. the interval containing 90% of the observed values (whiskers). The background of each graph contains the median (the coloured horizontal line) and the inter-quartile range (the colour strip) for all associations of the grassland and heathland vegetation of the Czech Republic, allowing a comparison of the values between individual graphs that use different scales on the vertical axis. Whether the respective variable in the individual associations has higher, lower or nearly equal values as the other types of grassland and heathland vegetation can be derived from the comparison of the positions of the boxes and colour strips.

Ellenberg indicator values in the ordinal scale express the relationship of plant species to light, temperature, continentality, humidity, soil reaction and nutrients. This scale contains twelve degrees in the case of humidity and nine degrees for other variables. Although the applicability and interpretations of Ellenberg indicator values have been repeatedly challenged in the recent literature (Schaffers & Sýkora 2000, Wamelink et al. 2002), their main advantage is that they allow to compare large numbers of relevés with regard to environmental factors that cannot usually be determined on the basis of short-term measurements. The major disadvantage is the ordinal character of Ellenberg indicator values, which limits the usability of basic arithmetic operations. However, the values in a data set with a larger number of species tend to behave like continuous variables and calculations of arithmetic means from the values of species for a relevé are often used as a rough estimate of site conditions (ter Braak & Barendregt 1986, Ertsen et al. 1998, Schaffers & Sýkora 2000). Ellenberg values of all represented vascular plants were used to calculate the unweighted arithmetic mean for each relevé of the stratified data set that was assigned by the Cocktail definitions to individual associations. Species which were lacking or not assigned a particular indicator value in the Ellenberg tables were omitted. Thus we obtained indicator values for each relevé and illustrated their distribution in the box-and-whiskers plots.

Altitudes were taken directly from the accompanying relevé data. If there was no indication of altitude, this was derived from the digital hypsometric map in the geographical information system ArcGIS 8.3 (www.esri.com).

Data on percent cover of the herb layer were also taken from the relevés. Relevés that did not contain this information were not used in the graphical presentation.

## Distribution maps of associations*

The distribution of individual associations was mapped in a geographical grid with cells of 5 minutes of geographical longitude × 3 minutes of latitude, i.e. approximately 6 × 5.5 km. The grid was derived from the standard grid of the Central European mapping of flora and fauna, with the basic cells divided into quadrants.

The source data used to make maps included all relevés of non-forest vegetation that were contained in the Czech National Phytosociological Database by 15 December 2005 and localized using geographical coordinates with an accuracy greater than 1 geographical minute. The total number of relevés used was 51,940. The relevés from this data set were compared with the formal definitions of associations formed by the Cocktail method. They were compared not only with the definitions of associations of grassland and heathland vegetation but also with definitions of associations of other treeless vegetation types, such as mires, reed beds, tall-sedge vegetation and chasmophytic vegetation, which will be described in the next volumes of the monograph *Vegetation of the Czech Republic*. This parallel comparison enabled to identify all overlaps in the association delimitations. If any relevé was assigned to more than one association, its final assignment was decided on the basis of the similarity calculation using the FPFI index (Tichý 2005) and the relevé was assigned to the

*Elaborated by M. Chytrý, K. Kubošová & O. Hájek.

association whose species composition it best matched.

The distribution maps prepared on the basis of available relevés used different symbols for those sites where only old relevés were available (recorded up to 1975) and sites with relevés recorded after this date. The maps provide a reliable overview of distribution in the case of rare associations, for which the majority of sites are well known and phytosociologically documented (e.g. associations of alpine vegetation). They are also reasonably reliable for associations that are abundant but represent vegetation types which have been popular among phytosociologists and extensively sampled in the Czech Republic (e.g. dry grasslands). However, in the case of some widespread associations (e.g. meadows), the maps of existing relevé localities provide an incomplete picture of the real distribution. We believe that publication of these incomplete maps may stimulate further research aimed at filling the gaps in the presently known distribution. In future these maps will be regularly updated with the use of new relevés obtained for the Czech National Phytosociological Database and published online.

To provide further information about the distribution of the associations, the maps of relevé localities of some of the associations were supplemented with the estimate of their potential distribution. The estimate was based on the statistical predictive model which quantified the relationship between the occurrence probability of a particular association and the explanatory environmental variables that were available in the form of digital maps for the territory of the Czech Republic. The models used the following explanatory variables: altitude, soil acidity, average temperature (annual, January and June) and annual precipitation. The values of these variables were obtained for each relevé by the overlaying of the respective digital maps with geographical coordinates of the relevés. The overlay was performed in the geographical information system ArcGIS 8.3 (www.esri.com). In order to minimize the effect of the local oversampling of certain areas, the stratified set of 21,794 relevés (see above) was used for modelling. From this data set, the relevés complying with the Cocktail definition of each association were selected for modelling.

Since the dependent variable, i.e. the presence or absence of the association at the particular site, is binary, predictive modelling used the generalized linear model (GLM) with binomial distribution and the logistic linking function logit. In cases when the binary dependent variable did not have a binomial distribution, the quasi distribution was used (McCullagh & Searle 2001). Regression coefficients were estimated using the maximum likelihood method and their significance was tested using the likelihood ratio test. The selection of variables proceeded from the full model with all explanatory variables. The variables shown to be significant and to contribute to the increased predictive ability of the model were selected stepwise. In this process, each association obtained an equation with the estimated regression coefficients; this equation was used to predict the probability of occurrence at the sites with no data available. The probability of the occurrence of a particular association in a range of $<0, 1>$ was obtained using the inverse logistic transformation of the linear predictor values calculated from regression equations.

The generalized index $R_N^2$ (generalized R-square) was used (Cox & Snell 1989) to verify the predictive abilities of the models. If the $R_N^2$ value was higher than 0.8, the model was considered highly predictive. Equations with an $R_N^2$ value of 0.7 to 0.8 were also accepted, showing slightly lower but still good predictive ability. The predictive abilities of models were low particularly in cases when available relevés did not provide a representative coverage of the range of ecological factors linked to the occurrence of the association in question. Associations with less than 50 available relevés were not modeled at all; similarly, some models based on a larger number of relevés but providing meaningless predictions according to the expert judgement were also rejected. For some associations, two to three alternative models were developed, of which the model that seemed to best reflect the biological reality was subjectively selected.

Probabilities of occurrence, calculated from individual models, were plotted on grid maps provided they were higher than a subjectively selected threshold. However, they were only plotted at sites where grasslands or heathlands currently occur according to the digital map of CORINE land cover. In such a way the observed distribution was supplemented with the estimate of the potential distribution. The symbols used in the maps are as follows: ● sites with relevés recorded after 1975; ○ sites with no relevés recorded after 1975 but with relevés recorded earlier; • sites with no relevés but with a high probability of occurrence of the association according to the predictive model.

## On the practical application of the present phytosociological system

Vegetation can be classified in many different ways and the system presented here is just one of them. Its main advantage is that it is supported by the analysis of phytosociological data and provides unambiguous criteria for inclusion of particular vegetation stands or relevés in associations. It does not aspire to classify every existing stand of vegetation but defines the cores of associations, which are usually characterized by the occurrence of ecologically specialized species. This reflects the common experience that phytosociological systems work well with relatively homogeneous stands that contain specific combinations of species with a narrow ecological range, but at the same time leave a large proportion of vegetation stands existing on the landscapes unclassified. Still it is possible to quantify the similarity of any vegetation stand to the cores of the associations and assign it to the most similar association, if necessary.

The identification of associations included in the proposed classification can be performed using the computer expert system available at www.sci.muni.cz/botany/vegsci/vegetace.php. This expert system runs in the environment of the JUICE program and uses relevés exported from the TURBOVEG program as input data. In order to ensure the correct function of the expert system, relevés intended for automatic assignment to associations should be exclusively from non-forest vegetation. Formal definitions of grassland and heathland associations prepared with the Cocktail method and contained in the expert system were formed with an assumption that they will not be used for classification of forest vegetation (if they were, they could assign some forest relevés to non-forest associations, e.g. some dry pine forest relevés from acidic soils to heathland associations). Sometimes different relevés from a single relatively homogeneous vegetation stand are assigned to different associations by the expert system. Such stands should be interpreted as transitional between these associations. If the expert system assigns some of the relevés from a single vegetation stand to a particular association while others remain unassigned to any association, it means that the stand consists of patches with typical and less typical species composition with respect to the association core. Relevés that remained unassigned to any association can be compared by the expert system using the FPFI index with the total species composition of individual associations and subsequently assigned to the association that they best match. This kind of assignment can be interpreted as follows: although the relevé does not belong to the core of the particular association and is not typical of it, it is close or similar to it. In addition to the requirement that the relevé should match the particular association better than any other, it is also appropriate to determine the particular threshold value of similarity that the relevé must exceed in order to be assigned to the particular association. A large number of stands exist that are mainly composed of species with a broad ecological range or which contain unusual species combinations whose assignment to any association would be in conflict with phytosociological tradition. The determination of the threshhold value is subjective and depends on the user, who must decide how large deviations from the typical species composition he or she is willing to accept while assigning the relevé to a particular association.

With respect to the practical use of vegetation classification, one should realize that applicability of any classification is scale-dependent. The proposed classification was optimized for the territory of the Czech Republic. It is therefore possible that some associations that have been distinguished in it will not be clearly recognizable in broader Central European or European vegetation classification systems. However, it is also evident that in the case of strictly local vegetation description, e.g. in a small nature reserve, it may be more suitable to define *ad hoc* local vegetation units. Such units may be difficult to transpose into other territories or to larger scales but will provide a better description of local vegetation variability. Even so, it may be desirable to compare such local vegetation units with the national classification, e.g. by means of the assignment of relevés to associations by the expert system, and thus place local diversity patterns into a broader context.

## Acknowledgments

This project would never have been possible without the hundreds of enthusiastic Czech botanists who have enjoyed and continue to enjoy crawling along on their knees within the restricted areas of their relevés, searching for further plant species among blades of grass and tiny leaves in stands of vegetation. The enormous amount of field work performed over the last 80 years by these enthusiasts has made the Czech Republic one of the best explored countries in the world in terms of vegetation diversity.

The methodology of the project was established thanks to the support and inspiration of friends from the *European Vegetation Survey* working group. John S. Rodwell and Julian Dring (Lancaster, UK) shared their experience in the management of phytosociological databases with us at the beginning of the project. Stephan M. Hennekens (Wageningen, NL) provided us with the TURBOVEG program and was always willing to improve and modify this program according to our requirements, which were usually very demanding. Harald Niklfeld, Walter Gutermann (Vienna, AT), Ladislav Mucina (Stellenbosch, ZA), Milan Valachovič and Ivan Jarolímek (Bratislava, SK) cooperated with us on the development of a standard list of Central European plant species for the TURBOVEG database. Helge Bruelheide (Halle, DE) inspired us with his ideas to formalize the methods of traditional phytosociology and was always willing to discuss with us on the development and application of these new methods. Jason Holt (Brno, now Hinsdale, Montana, USA) and Zoltán Botta-Dukát (Vácrátót, HU) contributed to the development of the concept of statistical measurement of species fidelity. Jean-Paul Theurillat (Champex, CH) and Valentin Golub (Togliatti, RU) gave us advice on the syntaxonomic nomenclature and diversity of saline vegetation, respectively. Ms. Iva Adamová, the librarian at the former Department of Botany and now of the Department of Botany and Zoology, Masaryk University, helped us obtain difficult-to-access literature. Toby Spribille (Göttingen, DE) kindly made a thorough linguistic revision of the English texts in this book. Photographs of some vegetation types were provided, besides the authors of the treatments of individual syntaxa, by Vít Grulich, Viera Horáková, Záboj Hrázský, Jitka Kopáčová, Zdenka Otýpková, Jan Roleček, Jan Vaněk, Jiří Vicherek and Alena Vydrová. Many valuable comments on the previous version of the text were provided by the reviewer of this book, Ladislav Mucina (Stellenbosch). Last but not least, we want to thank all of the colleagues who supplied the national phytosociological database with relevés and cooperated in database compilation. These contributors are listed in the Czech version of this text (page 17).

## Czech-English glossary of basic keywords

| | |
|---|---|
| alpínský, -á, -é | alpine |
| asociace | association |
| Bílé Karpaty | White Carpathians |
| biotop, -y | habitat, -s |
| bohatý, -á, -é | rich |
| bor, -y | pine forest, -s |
| bučina, -y | beech forest, -s |
| bylina, -y | herb, -s |
| bylinný, -á, -é | herbaceous |
| Čechy | Bohemia |
| Česká republika | Czech Republic |
| Českomoravská vrchovina | Bohemian-Moravian Uplands |
| český, -á, -é | 1. Czech; 2. Bohemian |
| chladný, -á, -é | cool |
| chudý, -á, -é | poor |
| diagnostický, -á, -é | diagnostic |
| dominantní | dominant, dominating |
| doubrava, -y | oak forest, -s |
| dřevina, -y | woody plant, -s |
| druh, -y | species |
| druhová bohatost | species richness |

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|---|---|---|---|
| druhové složení | species composition | nížina, -y | lowland, -s |
| dubohabřina, -y | oak-hornbeam forest, -s | nízký, -á, -é | low |
| dynamika | dynamics | oceanický, -á, -é | oceanic |
| flyš | flysch | ohrožení | endangerment |
| fytocenologické snímky | relevés | olšina, -y | alder forest, -s |
| | | opadavý, -á, -é | deciduous |
| fytocenologický snímek | relevé | opuštěný, -á, -é | abandoned |
| | | orná půda | arable land |
| hadec, hadce | serpentine, -s | pahorkatina, -y | hilly (colline) landscape, -s |
| hluboký, -á, -é | deep | panonský, -á, -é | Pannonian |
| hojný, -á, -é | common | paseka, -y | forest clearing, -s |
| hora, -y | mountain, -s | pastvina, -y | pasture, -s |
| horský, -á, -é | montane | patro, -a | layer, -s |
| hospodářský význam | economic importance | písčina, -y | sand area, -s |
| jednoletá rostlina | annual plant | písečný, -á, -é | sand, sandy (*adj.*) |
| jehličnatý, -á, -é | coniferous | písek, písky | sand, -s |
| jižní | southern | plevel, -e | weed, -s |
| karpatský, -á, -é | Carpathian | počet druhů | number of species |
| Karpaty | Carpathians | podhorský, -á, -é | submontane |
| keř, -e | shrub, -s (*subst.*) | pokryvnost, -i | cover, -s |
| keřový, -á, -é | shrub (*adj.*) | pole | field, -s |
| keříček, keříčky | low shrub, -s (*subst.*) | Polsko | Poland |
| keříčkový, -á, -é | low-shrub (*adj.*) | porost, -y | stand, -s |
| klasifikace | classification | potok, -y | brook, -s |
| konstantní | constant | Praha | Prague |
| kontinentální | continental | prameniště | water spring, -s |
| kras | karst | převážně | mainly, mostly |
| Krkonoše | Giant Mountains | přirozený, -á, -é | natural |
| křovina, -y | scrub, shrubbery (*subst.*) | průměrný, -á, -é | average |
| křovinný, -á, -é | shrub, shrubby (*adj.*) | půda, -y | soil, -s |
| kyselý, -á, -é | acid, acidic | řád, -y | order, -s |
| Labe | Elbe | rákosina, -y | reed bed, -s |
| les), -y | forest, -s, woodland, -s (*subst.*) | Rakousko | Austria |
| | | rašeliniště | mire, -s |
| lesní lem, -y | forest fringe (saum) | řeka, -y | river, -s |
| lesní | forest, woodland (*adj.*) | rostlina, -y | plant, -s |
| lišejník, -y | lichen, -s | rostlinná společenstva | plant communities |
| louka, -y | meadow, -s | rostlinné společenstvo | plant community |
| lužní | riverine, floodplain (*adj.*) | rozšíření | distribution |
| Maďarsko | Hungary | rula, -y | gneiss, -es |
| malý, -á, -é | small | rybník, -y | fishpond, -s |
| mech, -y | moss, -es | sečený, -á, -é | mown |
| mechorost, -y | bryophyte, -s | sešlapávaný, -á, -é | trampled |
| mělký, -á, -é | shallow | severní | northern |
| město, -a | town, -s | širokolistý, -á, -é | broad-leaved |
| mírný, -á, -é | gentle, moderate | skála, -y | rock, -s (*subst.*) |
| Morava | Moravia | skalní | rock, rocky (*adj.*) |
| moravský | Moravian | skupina, -y (*abbrev.* skup.) | group, -s |
| nadmořská výška, -y | altitude, -s | | |
| narušovaný, -á, -é | disturbed | slanisko, -a | salt marsh, -es |
| Německo | Germany | slatina, -y | fen, -s |

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| sloupec, sloupce | columns, -s | třída, -y | class, -es |
| Slovensko | Slovakia | údolí | valley, -s |
| smrčina, -y | spruce forest, -s | území | territory, -ies |
| společenstvo, -a | community, -ies | úzkolistý, -á, -é | narrow-leaved |
| srážky | precipitation | vápenec, vápence | limestone, -s |
| stanoviště | habitat, -s | vápnitý, -á, -é | calcareous |
| strmý, -á, -é | steep | varianta, -y | variant, -s |
| stojatá voda, -y | standing water | vegetace | vegetation |
| strom, -y | tree, -s (*subst.*) | velký, -á, -é | large, big |
| stromový, -á, -é | tree (*adj.*) | vesnice | village, -s |
| střední | central | vlhkost | moisture |
| struktura, -y | structure, -s | vlhký, -á, -é | wet |
| subalpínský, -á, -é | subalpine | voda, -y | water, water bodies |
| suchý, -á, -é | dry | vodní | aquatic |
| Šumava | Bohemian Forest | vrchoviště | bog, -s |
| suť, sutě | scree, -s | vřesoviště | heathland, -s |
| svah, -y | slope, -s | východní | eastern |
| svaz, -y | alliance, -s | výchoz, -y | outcrop, -s |
| tabulka, -y | table, -s | vysokobylinný, -á, -é | tall-forb |
| tekoucí voda, -y | running water | vysoký, -á, -é | tall |
| teplomilný, -á, -é | thermophilous | vytrvalá rostlina | perennial plant |
| teplota, -y | temperature | vzácný, -á, -é | rare |
| teplý, -á, -é | warm | zamokřený, -á, -é | water-logged |
| tráva, -y | grass, -es | západní | western |
| travina, -y | graminoid, -s | zaplavovaný, -á | flooded |
| travinný, -á, -é | grassland (*adj.*) | živina, -y | nutrient, -s |
| trávník, -y | grassland, -s (*subst.*) | žula, -y | granite, -s |