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Towards unification of national vegetation classifications: A comparison of two methods for analysis of large data sets

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Abstract. In European phytosociology, national classifications of corresponding vegetation types show considerable differences even between neighbouring countries. Therefore, the European Vegetation Survey project urgently needs numerical classification methods for large data sets that are able to produce compatible classifications using data sets from different countries. We tested the ability of two methods, TWINSPAN and COCKTAIL, to produce similar classifications of wet meadows (*Calthion*, incl. *Filipendulenion*) for Germany (7909 relevés) and the Czech Republic (1287 relevés) in this respect.

In TWINSPAN, the indicator ordination option was used for classification of two national data sets, and the extracted assignment criteria (indicator species) were applied crosswise from one to the other national data set. Although the data sets presumably contained similar community types, TWINSPAN revealed almost no correspondence between the groups derived from the proper classification of the national data set and the groups defined by the assignment criteria taken from the other national data set. The reason is probably the difference in structure between the national data sets, which is a typical, but hardly avoidable, feature of any pair of phytosociological data sets. As a result, the first axis of the correspondence analysis, and consequently the first TWINSPAN division, are associated with different environmental gradients; the difference in the first division is transferred and multiplied further down the hierarchy.

COCKTAIL is a method which produces relevé groups on the basis of statistically formed species groups. The user determines the starting points for the formation of species groups, and groups already found in one data set can be tested for existence in the other data set. The correspondence between the national classifications produced by COCKTAIL was fairly good. For some relevé groups, the lack of correspondence to groups in the other national data set could be explained by the absence of the corresponding vegetation types in one of the countries, rather than by methodological problems.

Keywords: *Calthion*; COCKTAIL; Czech Republic; European Vegetation Survey; Germany; Phytosociological data base; TWINSPAN; Wet meadow.

Nomenclature: Ehrendorfer (1973).

Introduction

Despite the traditionally active international contacts among European vegetation scientists, vegetation classification in Europe has mainly developed on a national basis. Classical schemes of vegetation classification (e.g. Tüxen 1937; Oberdorfer 1957) had regional validity only, and researchers in adjacent areas often produced different schemes which were compatible only to a minor degree. Restriction to a national scale and quite a mismatch of national classifications has dominated European phytosociology up to the present. Still, the strategy of the Working Group for European Vegetation Survey is to encourage the development of national vegetation survey programmes (Mucina et al. 1993). There are several reasons for this situation, in particular the traditional limitation of expert knowledge to national territories and the restricted availability of the bulk of relevant data which is only partly accessible abroad.

In some cases, the national approach results in low compatibility of classifications, even between neighbouring countries with similar vegetation. This may be exemplified by the *Molinio-Arrhenatheretea* meadow classification in Germany (Dierschke 1995, 1997) and Austria (Ellmauer & Mucina 1993; Ellmauer 1994). Both German and Austrian classifications are based on extensive data analysis but they differ considerably from association to order level. Although this is not always stated explicitly, such differences in demarcation of syntaxa are mainly caused by different methodological approaches of the authors (Mucina 1997). For example, German classifications of *Calthion* s.str. meadows are largely based on character species and define only a few associations or association-level communities (10 in both Oberdorfer 1983 and Pott 1995), whereas the Czech classification (Blažková & Balátová-Tuláčková in Moravec et al. 1995) is based on diagnostic species combinations and distinguishes 16 associations in a territory 4.5 times smaller than Germany. A similar situation is encountered for tall-forb communities of the *Filipendulenion* suballiance (eight types in

Oberdorfer 1983, five in Pott 1995 and 10 in Blažková & Balátová-Tuláčková in Moravec et al. 1995).

Our paper is an attempt to overcome such methodological differences by applying clearly defined classification methods to vegetation data from two different countries. The primary motivation is to find methods which would allow a common vegetation classification for Europe to be produced. Since the current development of the European Vegetation Survey (Rodwell et al. 1995) is mainly proceeding bottom-up, unifying existing separate national classifications, rather than top-down, starting from one (presently non-existent) pan-European data set, the problem of unifying individual classifications is an important one. The problem is even more far-reaching: once a vegetation classification for the whole of Europe is created, the necessity will emerge to adapt the system to adjacent territories, such as Siberia.

For the purposes of the European Vegetation Survey project, large regional or national vegetation data bases were established in several centres across Europe, using common data standards and the TURBOVEG package as a data base management software (Hennekens 1996; Schaminée & Hennekens 1995). A divisive classification method implemented in the TWINSPAN program (Hill 1979), available in the TURBOVEG package, is commonly accepted as an appropriate tool to classify relevés in large data sets (Rodwell 1990 et seq.; Schaminée et al. 1995). In a comparative study with three other methods, based on subsets of 400 relevés each, TWINSPAN yielded satisfying classification results (Bruelheide & Jandt 1997), but the method has not yet been tested in a large international comparison. Apart from TWINSPAN, there are also other methods for the classification of large vegetation data sets, such as COCKTAIL (Bruelheide 1995, 2000), which uses combinations of species groups to define vegetation units. These two methods were included in the study, because they are used in the European Vegetation Survey. Apart from this, we are not aware of other programs which would allow classification of several thousand relevés and, at the same time, would provide transferable assignment criteria (cf. Bruelheide & Jandt 1997).

The objective of our study is to test the ability of TWINSPAN and COCKTAIL to recognize comparable vegetation types in different national classifications. As two national data sets, we used relevés of wet meadows (*Calthion,* incl. *Filipendulenion*) from Germany and the Czech Republic, two neighbouring countries with roughly similar abiotic environment and flora. We expected that, in principle, the two methods would produce similar classification results in both data sets, but also that they would reveal differences in their ability to detect corresponding vegetation types in different data sets.

Methods

Data sets

We compiled two computerized data sets of phytosociological relevés of the alliance *Calthion* (incl. *Filipendulenion*), one from Germany and one from the Czech Republic. The German data set consisted of 7909 relevés from 481 tables, and apart from *Calthion*, it also included several relevés of *Caricion davallianae, Molinion,* and some other wet meadow types. The Czech data set included only relevés assigned to the *Calthion* alliance by the authors of the original papers and includes 1287 relevés from 109 tables. These two data sets are henceforth referred to as ‘entire’ data sets. They may be considered representative in terms of territorial coverage, and they most probably include nearly the whole range of compositional variation in the *Calthion* meadows of both countries. Still, they are far from being complete; we estimate that they include about 70 % of all published relevés and 50 % of all existing relevés. Cryptogams were deleted from both data sets as they were not recorded in all relevés. Herb-layer plants, juvenile individuals of woody plants, and occasionally recorded shrubs were fused into one layer. Species taxonomy and nomenclature were standardized, using the concept of broad species and species aggregates as defined in Ehrendorfer (1973). It should be emphasized that both data sets possessed several faults which are quite typical of large phytosociological data bases: some regions were over-sampled and others were not sampled at all; the large number of researchers involved in sampling could contribute to severe recording bias; the relevés greatly varied in sampling date; the plot size was roughly standardized, but still varied over a limited range. The variation in cover scales was no problem, because the study only made use of presence/absence data.

Apart from performing comparisons between national classifications, an important issue for the European Vegetation Survey is how nationally defined vegetation types behave when the data set is extended to a larger geographical scale. For this purpose, both data sets were combined into one, the ‘total’ data set, thus comprising 9196 relevés.

Since no pre-selection of data within the tables mentioned above was performed, the Czech and especially the German data set probably contained outliers (abnormal relevés), which are known to strongly influence the classification results (van der Maarel 1982). Therefore, we prepared a more homogeneous data set by deleting relevés whose affinity to wet meadows was poor in floristic terms. We compiled a list of 103 character or diagnostic species of the order *Molinietalia* and subordinated syntaxa, making use of standard handbooks

(Oberdorfer 1983; Moravec et al. 1995). Then all relevés with less than eight character/diagnostic species were excluded from each data set. These 'reduced' data sets contained 6405 relevés for Germany and 1221 relevés for Czechia.

TWINSPAN classifications

TWINSPAN (Hill 1979) is a divisive classification method which allocates samples to groups by successive dichotomization based on Correspondence Analysis (CA). Since the currently used algorithm by Hill (1979) has been found to use lax convergence criteria for extracting eigenvalues, which results in classification instability (Oksanen & Minchin 1997), we employed an improved version, which was adapted to a capacity of 9999 relevés by S.M. Hennekens. Our tests of both versions revealed only minor differences in classification results. The relative importance of the gradient associated with the first TWINSPAN division was determined by calculating CA eigenvalues for the two data sets using the CANOCO 4 package (ter Braak & Šmilauer 1998), which has been corrected to avoid the instability reported by Oksanen & Minchin (1997). To determine what environmental gradients underlay the ordination axes, mean Ellenberg indicator values (Ellenberg et al. 1992) for light, temperature, continentality, moisture, reaction, and nutrients were calculated for all relevés and correlated to the relevé scores on the ordination axes.

TWINSPAN was run on the entire and reduced data sets of Germany, Czechia and the total (fused) data set. The indicator ordination option was used. It yields results almost identical to the default option, called refined ordination (Hill 1979; Bruelheide & Jandt 1997), but has the advantage of providing assignment criteria which can be applied crosswise to the data sets. The assignment criteria, which are indicator species and assignment thresholds, can be considered as simple discriminant functions or mapping keys. Whether a relevé is assigned to the negative or positive group is decided by summing up negative (–1) and positive (+1) indicator species and comparing the result with the threshold. Indicator species and thresholds were extracted from the TWINSPAN output files using personally designed programs. Such programs were also used for applying them to the data sets and for evaluating the results. TWINSPAN classification was run without pseudospecies, i.e. only presence data were used, to the 3rd level, yielding $2 + 4 + 8$ groups. Minimum group size for division was 10; maximum number of indicator species was set to the possible maximum of 15. The assignment criteria produced by the indicator ordination of each national data set were applied crosswise to the other national data set and to the total data set in order to find out whether the assignment criteria are transferable, or in other words, to check how well groups distinguished in different data sets match. The ϕ-coefficient (Fleiss 1981: 59-60; Bortz et al. 1990: 327) was calculated as a measure of correspondence between groups based on the indicator ordination and groups based on assignment criteria transferred from the other data set. The ϕ-coefficient is equivalent to the correlation coefficient but allows for evaluating categorical data. It ranges between –1 and + 1.

The comparison of the two TWINSPAN classifications involved comparisons among three hierarchical levels. This is necessary because the same vegetation type in different data sets may be formed on different hierarchical levels. For example, the first classification's 3rd level species may be the same as the second classification's 2nd level species. Therefore, we included 14 $(2 + 4 + 8)$ groups in each comparison. Additionally, we examined whether correspondence of groups occurred between the 1st to 3rd level and the 4th level $(2 + 4 + 8 + 16$ groups).

COCKTAIL classifications

The program COCKTAIL (Bruelheide 1995, 2000) produces groups of species whose joint occurrence is more frequent than expected in the case of random species distribution in the relevé data set. An important feature is that the user pre-selects a starting species or a small starting species group. This pre-selection, to some extent, determines the final composition of the species group. In an optimization algorithm, further species are added to the starting group on the basis of their u-value, which is a test parameter measuring a species' concentration in a group of relevés based on its departure from a Gaussian distribution. Only those species whose concentration in the relevés belonging to the species group is higher than in the rest of the data set are added to the species group. The u-value depends on (1) the difference in species frequency between the relevés belonging to the species group and the other relevés, (2) the size of the data set, and (3) the proportion of relevés belonging to the species group (Bruelheide 1995, 2000; Bruelheide & Jandt 1995). The size of a species group is determined by the threshold u-value, chosen by the user: the lower the threshold, the more species are included in a group. The number of species from a species group that a relevé must contain in order to belong to this species group is also defined statistically in such a way that always fewer relevés belong to a species group than would be expected if the species of the group were distributed randomly among the relevés (Bruelheide 1995, 2000; Bruelheide & Jandt 1995).

Once a species group is formed, other species groups may be formed using the same algorithm, independently

Table 1. ϕ-correlation matrix of TWINSPAN results for assignment criteria derived from the **German** data set, applied to the **Czech** data set; based on the **entire Czech** data set (n = 1287). Values > | 0.500 | are shaded.

TWINSPAN				Units based on species groups from the **Czech** data set (*n* = 1287).....															
	Level			1st		2nd				3rd									
		Group		**0**	**1**	**00**	**01**	**10**	**11**	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
			n	756	531	108	648	109	422	12	96	282	366	64	45	323	99
	1st	**0**	1106	0.106	–0.106	–0.015	0.112	0.123	–0.184	–0.147	0.038	–0.142	0.255	0.093	0.077	–0.132	–0.110
		1	181	–0.106	0.106	0.015	–0.112	–0.123	0.184	0.147	–0.038	0.142	–0.255	–0.093	–0.077	0.132	0.110
	2nd	**00**	83	–0.121	0.121	0.012	–0.125	0.352	–0.082	–0.025	0.022	–0.131	–0.018	–0.046	0.587	–0.123	0.055
		01	1023	0.164	–0.164	–0.020	0.173	–0.108	–0.108	–0.111	0.020	–0.043	0.231	0.107	–0.291	–0.039	–0.128
.....		**10**	176	–0.094	0.094	0.018	–0.102	–0.121	0.170	0.150	–0.036	0.150	–0.251	–0.091	–0.076	0.140	0.072
Identified		**11**	5	–0.075	0.075	–0.019	–0.063	–0.019	0.089	–0.006	–0.018	–0.033	–0.039	–0.014	–0.012	–0.036	0.216
by species	3rd	**000**	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
groups		**001**	83	–0.121	0.121	0.012	–0.125	0.352	–0.082	–0.025	0.022	–0.131	–0.018	–0.046	0.587	–0.123	0.055
from the		**010**	985	0.236	–0.236	0.002	0.231	–0.082	–0.199	–0.099	0.039	–0.008	0.264	0.118	–0.264	–0.102	–0.184
German		**011**	38	–0.199	0.199	–0.053	–0.166	–0.053	0.240	–0.017	–0.050	–0.081	–0.110	–0.040	–0.033	0.164	0.156
data set		**100**	176	–0.094	0.094	0.018	–0.102	–0.121	0.170	0.150	–0.036	0.150	–0.251	–0.091	–0.076	0.140	0.072
		101	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		110	5	–0.075	0.075	–0.019	–0.063	–0.019	0.089	–0.006	–0.018	–0.033	–0.039	–0.014	–0.012	–0.036	0.216
		111	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

of each other, starting with different user-determined initial species groups. Different species groups may be used for structuring a phytosociological table. However, some relevés may belong to more than one species group, and this fact implies that there are many possible options for arranging the table (Bruelheide & Jandt 1997). This stage requires subjective decisions, but the decision-making procedure is repeatable due to the stringent application of formal logic (Bruelheide 1997).

COCKTAIL classifications were performed on both the reduced and entire data sets. Species groups as assignment criteria from each national data set were applied crosswise from one data set to the other. Correspondence between the groups from the proper analysis of each national data set and the groups resulting from the application of the other data set's assignment criteria was evaluated by the ϕ-coefficient as described above.

Results

TWINSPAN classifications

Table 1 shows the TWINSPAN classification results for the entire Czech data set, when units based on indicator species groups from the Czech data set are compared with units based on indicator species groups from the German data set. Only two comparisons displayed considerable correlation indicated by a ϕ-value exceeding 0.5. There was almost no correspondence between units based on the Czech and on the German assignment criteria, i.e. the Czech units were not reproduced by the German assignment criteria. Furthermore, the German criteria were not even able to break the Czech data set down into smaller units. From the total of 1287 relevés 985 relevés still remained in one group on the third level. Some third-level units (101 and 111) remained empty, indicating that no Czech relevé matched the German criteria for these groups.

Table 2. ϕ-correlation matrix of TWINSPAN results for assignment criteria derived from the **Czech** data set, applied to the **German** data set; based on the **entire German** data set (n = 7909). Values > | 0.500 | are shaded.

TWINSPAN				Units based on species groups from the **German** data set (*n* = 7909).....															
	Level			1st		2nd				3rd									
		Group		**0**	**1**	**00**	**01**	**10**	**11**	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
			n	6475	1434	1412	5063	1382	52	16	1396	4736	327	1238	144	52	0
	1st	0	3233	0.146	–0.146	–0.191	0.269	–0.135	–0.058	–0.037	–0.187	0.334	–0.173	–0.115	–0.071	–0.058	0.000
		1	4676	–0.146	0.146	0.191	–0.269	0.135	0.058	0.037	0.187	–0.334	0.173	0.115	0.071	0.058	0.000
	2nd	00	104	–0.012	0.012	0.068	–0.064	0.014	–0.009	–0.005	0.069	–0.053	–0.024	0.011	0.009	–0.009	0.000
		01	3129	0.149	–0.149	–0.208	0.286	–0.139	–0.056	–0.036	–0.204	0.348	–0.168	–0.119	–0.073	–0.056	0.000
.....		10	1350	0.214	–0.214	0.308	–0.074	–0.209	–0.037	–0.020	0.312	–0.037	–0.089	–0.195	–0.062	–0.037	0.000
Identified		11	3326	–0.308	0.308	–0.045	–0.211	0.294	0.086	0.053	–0.051	–0.304	0.240	0.264	0.118	0.086	0.000
by species	3rd	000	12	–0.058	0.058	–0.018	–0.032	0.059	–0.003	–0.002	–0.018	–0.028	–0.008	0.055	0.019	–0.003	0.000
groups		001	92	0.008	–0.008	0.079	–0.056	–0.006	–0.009	–0.005	0.080	–0.046	–0.023	–0.008	0.003	–0.009	0.000
from the		010	1279	–0.095	0.095	–0.203	0.085	0.102	–0.023	–0.020	–0.202	0.121	–0.091	0.114	–0.021	–0.023	0.000
Czech		011	1850	0.255	–0.255	–0.063	0.256	–0.250	–0.045	–0.025	–0.061	0.297	–0.115	–0.236	–0.066	–0.045	0.000
data set		100	447	0.115	–0.115	–0.096	0.169	–0.113	–0.020	–0.011	–0.095	0.184	–0.045	–0.105	–0.033	–0.020	0.000
		101	903	0.169	–0.169	0.434	–0.210	–0.165	–0.029	–0.016	0.438	–0.177	–0.073	–0.155	–0.049	–0.029	0.000
		110	2684	–0.307	0.307	–0.138	–0.136	0.312	–0.005	0.039	–0.143	–0.226	0.228	0.279	0.128	–0.005	0.000
		111	642	–0.025	0.025	0.159	–0.147	–0.010	0.165	0.028	0.156	–0.159	0.038	–0.007	–0.009	0.165	0.000

Table 3. ϕ-correlation matrix of TWINSPAN results for assignment criteria derived from the **German** data set, applied to the **total** data set; based on the total data set (n = 9196). Values > | 0.500 | are shaded.

TWINSPAN				Units based on species groups from the **total** data set (*n* = 9196).....													
	Level			1st		2nd				3rd							
		Group		**0**	**1**	**00**	**01**	**10**	**11**	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
			n	8485	711	1672	6813	686	25	16	1656	6281	532	595	91	25	0
	1st	**0**	7581	0.627	−0.627	0.217	0.191	−0.615	−0.113	0.019	0.216	0.200	−0.040	−0.570	−0.217	−0.113	0.000
		1	1615	−0.627	0.627	−0.217	−0.191	0.615	0.113	−0.019	−0.216	−0.200	0.040	0.570	0.217	0.113	0.000
	2nd	**00**	1495	0.128	−0.128	0.752	−0.584	−0.125	−0.023	0.095	0.745	−0.504	−0.092	−0.116	−0.044	−0.023	0.000
		01	6086	0.405	−0.405	−0.412	0.610	−0.397	−0.073	−0.058	−0.407	0.554	0.039	−0.368	−0.140	−0.073	0.000
.....		**10**	1558	−0.614	0.614	−0.212	−0.187	0.625	−0.007	−0.019	−0.211	−0.196	0.040	0.579	0.221	−0.007	0.000
Identified		**11**	57	−0.107	0.107	−0.037	−0.032	−0.007	0.581	−0.003	−0.037	−0.033	0.004	−0.004	−0.008	0.581	0.000
by species	3rd	**000**	16	0.012	−0.012	0.034	−0.023	−0.012	−0.002	0.437	−0.013	−0.028	0.012	−0.011	−0.004	−0.002	0.000
groups		**001**	1479	0.127	−0.127	0.751	−0.584	−0.124	−0.023	0.046	0.749	−0.503	−0.093	−0.115	−0.044	−0.023	0.000
from the		**010**	5721	0.371	−0.371	−0.366	0.548	−0.364	−0.067	−0.054	−0.361	0.637	−0.240	−0.337	−0.128	−0.067	0.000
German		**011**	365	0.059	−0.059	−0.090	0.115	−0.058	−0.011	−0.008	−0.089	−0.239	0.692	−0.053	−0.020	−0.011	0.000
data set		**100**	1414	−0.550	0.550	−0.200	−0.159	0.561	−0.005	−0.018	−0.199	−0.175	0.049	0.606	−0.018	−0.005	0.000
		101	144	−0.255	0.255	−0.059	−0.103	0.261	−0.007	−0.005	−0.059	−0.085	−0.024	−0.012	0.722	−0.007	0.000
		110	57	−0.107	0.107	−0.037	−0.032	−0.007	0.581	−0.003	−0.037	−0.033	0.004	−0.004	−0.008	0.581	0.000
		111	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The match was even worse when Czech assignment criteria were applied to the German data set (Table 2). No ϕ-value exceeded 0.5; the maximum was 0.438. The German indicator species themselves were not able to subdivide the 11 group at the 3rd level, resulting in an empty 111 unit. This behaviour is quite remarkable, because minimum group size was set to 10. Therefore, the column of group 11, with 52 relevés, could have been expected to divide into two parts, which was not the case. The reason is 'misclassification' by TWINSPAN, meaning a deviation between the first so-called refined ordination, based on CA, and the indicator species ordination. For example, a relevé which was placed in the negative group by the refined ordination was assigned to the positive group by the indicator ordination. On each classification level, only 0 to 2 % of the relevés are misclassified. Regarding one level only, the misclassification is not severe, but errors are multiplied from level to level, because all previous assignment criteria have to be applied. For example, the classification of the 111 group at the 3rd level makes use of the 0-1, 10-11 and 110-111 criteria.

Our expectation that more correlations would be encountered using more hierarchical levels proved to be untrue. When the 4th level units were included in Table 1 (not shown), maximum ϕ increased to just 0.640 (with five more values above 0.5). In Table 2, the maximum only increased to 0.466. Another result of including the 4th level was an increase in empty groups, both as an effect of misclassification (two additional empty columns each in Tables 1 and 2) and as an effect of mismatching assignment criteria (9 and 1 additional empty rows in Table 1 and 2, respectively).

The correspondence between the two classifications was much higher when the data set which provided allocation criteria was a large subset of the data set to which the criteria were applied. This can be demonstrated with Table 3, where the assignment criteria from the entire German data set were applied to the total data set, 86 % of which was made up by the German relevés.

Table 4. ϕ-correlation matrix of TWINSPAN results for assignment criteria derived from the **Czech** data set, applied to the **total** data set; based on the total data set (n = 9196). Values > | 0.500 | are shaded.

TWINSPAN				Units based on species groups from the **total** data set (*n* = 9196).....													
	Level			1st		2nd				3rd							
		Group		**0**	**1**	**00**	**01**	**10**	**11**	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
			n	8485	711	1672	6813	686	25	16	1656	6281	532	595	91	25	0
	1st	**0**	3989	0.151	−0.151	−0.199	0.268	−0.145	−0.046	−0.026	−0.197	0.360	−0.216	−0.128	−0.068	−0.046	0.000
		1	5207	−0.151	0.151	0.199	−0.268	0.145	0.046	0.026	0.197	−0.360	0.216	0.128	0.068	0.046	0.000
	2nd	**00**	212	0.017	−0.017	−0.014	0.023	−0.016	−0.008	−0.006	−0.014	0.041	−0.038	−0.014	−0.008	−0.008	0.000
		01	3777	0.147	−0.147	−0.196	0.263	−0.141	−0.044	−0.024	−0.195	0.351	−0.206	−0.124	−0.066	−0.044	0.000
.....		**10**	1459	0.126	−0.126	0.428	−0.300	−0.123	−0.023	−0.018	0.432	−0.233	−0.099	−0.114	−0.043	−0.023	0.000
Identified		**11**	3748	−0.246	0.246	−0.117	−0.047	0.238	0.063	0.040	−0.122	−0.190	0.291	0.214	0.100	0.063	0.000
by species	3rd	**000**	24	−0.025	0.025	−0.024	0.006	0.026	−0.003	−0.002	−0.024	0.012	−0.013	0.030	−0.005	−0.003	0.000
groups		**001**	188	0.027	−0.027	−0.006	0.022	−0.026	−0.008	−0.006	−0.006	0.039	−0.036	−0.026	−0.007	−0.008	0.000
from the		**010**	1561	0.007	−0.007	−0.212	0.191	−0.003	−0.024	−0.019	−0.210	0.235	−0.111	0.006	−0.022	−0.024	0.000
Czech		**011**	2216	0.163	−0.163	−0.040	0.135	−0.160	−0.029	−0.011	−0.039	0.197	−0.140	−0.148	−0.056	−0.029	0.000
data set		**100**	511	0.070	−0.070	−0.026	0.065	−0.069	−0.013	−0.010	−0.025	0.085	−0.046	−0.064	−0.024	−0.013	0.000
		101	948	0.098	−0.098	0.534	−0.410	−0.096	−0.018	−0.014	0.537	−0.344	−0.084	−0.089	−0.034	−0.018	0.000
		110	3007	−0.260	0.260	−0.162	−0.016	0.262	0.013	0.004	−0.163	−0.155	0.278	0.232	0.118	0.013	0.000
		111	741	0.003	−0.003	0.067	−0.057	−0.022	0.092	0.064	0.060	−0.077	0.046	−0.015	−0.022	0.092	0.000

Table 5. Eigenvalues (Eig) and correlation coefficients of the first and second Correspondence Analysis axis with Ellenberg indicator values for Light (L), Temperature (T), Continentality (C), Moisture (M), Reaction (R) and Nutrients (N). Calculations are based on the reduced datasets. *** = $P < 0.001$, ** = $P < 0.01$, * = $P < 0.05$, n.s. = not significant.

	Eig	L	T	C	M	R	N
Germany							
Axis 1	0.349	0.222***	– 0.051***	0.029*	– 0.154***	0.164***	– 0.428***
Axis 2	0.320	0.280***	– 0.261***	– 0.068***	0.873***	– 0.424***	– 0.624***
Czechia							
Axis 1	0.253	–0.141***	0.650***	0.493***	– 0.055$^{\text{n.s.}}$	0.696***	0.525***
Axis 2	0.219	0.203***	– 0.181***	– 0.221***	– 0.661***	– 0.020$^{\text{n.s.}}$	– 0.174***

Most units derived from German assignment criteria corresponded to units derived from the total data set, as indicated by ϕ-values > 0.5 in the diagonal of Table 3. With a maximum ϕ of 0.752, the two units were still far from a complete match. In contrast, the Czech assignment criteria derived from only 14 % of the total data set yielded the same lack of correspondence with the units derived from the total data set (Table 4) as with the units derived from the German data set (Table 2). Obviously, the size of the subset on which the assignment criteria are based strongly influences the degree of correspondence.

A pre-selection of relevés using strict floristic criteria for belonging to the *Calthion* resulted in slightly higher correlations (not shown). In the reduced Czech data set, only three ϕ-values exceeded 0.5 with a maximum ϕ of 0.553. The reduced German data set reached a maximum ϕ of 0.618 with one more value above 0.5. No higher ϕ-values were encountered on the 4th level, where empty groups occurred due to misclassifications and mismatching assignment criteria, similarly to Tables 1 and 2.

Visual inspection of the TWINSPAN indicator species revealed that the first divisions reflected different gradients in each of the national data sets. The following survey of the indicator species refers to the reduced data sets in which slightly better correspondence was achieved, since most of the outliers had been removed. The following indicator species occurred at the first division level:

German data set
negative indicators:
Achillea millefolium agg., *Alopecurus pratensis, Bellis perennis, Cerastium fontanum* agg., *Festuca pratensis, Plantago lanceolata, Taraxacum officinale* agg., *Trifolium pratense, T. repens*
positive indicators:
Carex nigra, Cirsium palustre, Galium palustre agg., *G. uliginosum.*

Czech data set
negative indicators:
Agrostis canina, A. tenuis, Briza media, Carex nigra, C. paniculata, Cirsium palustre, Festuca rubra agg., *Galium uliginosum, Juncus filiformis, Luzula campestris* agg., *Myosotis palustris* agg., *Potentilla erecta, Viola palustris*
positive indicators:
Cirsium oleraceum, Lysimachia nummularia.

From knowledge of these species' habitat preferences, we infer that the first division in the German data set reflects a moisture gradient from mesic to wet sites, whereas in the Czech data set, the first division is associated with the gradient from base-poor to base-rich soils. This interpretation is supported by the Ellenberg indicator value analysis (Table 5). In the German data set, the first CA ordination axis is mainly associated with nutrients, but is also significantly correlated with moisture. In the Czech data set, the first axis mainly reflects the variation in soil reaction and temperature, and it is not correlated with moisture. The second axes in both data sets mainly reflect the moisture gradient, but differ in the other gradients associated with it.

COCKTAIL classifications

Unlike TWINSPAN, COCKTAIL classifications for each of the national data sets produced very similar results both for extraction of species groups from each data set and for crosswise application of the groups between the data sets. Since the classifications obtained

Table 6. ϕ-correlation matrix of COCKTAIL results for assignment criteria derived from the **German** data set, applied to the **Czech** data set; based on the entire **Czech** dataset (n = 1287). Group numbers are identical with columns in Table 9. Values > \| 0.500 \| are shaded.

COCKTAIL			Units based on species groups from the **Czech** data set (n = 1287).....													
	Group		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		n	24	91	46	39	24	67	66	107	24	46	158	68	151	376
	1	27	0.943	–0.006	–0.004	–0.004	–0.003	–0.005	0.018	0.012	–0.003	–0.004	–0.008	–0.005	0.008	–0.013
	2	91	–0.006	1,000	–0.008	–0.008	–0.006	–0.010	–0.010	–0.013	–0.006	–0.008	–0.015	–0.010	–0.015	–0.024
	3	68	–0.005	–0.010	0.821	0.384	0.045	–0.009	–0.009	–0.011	–0.005	–0.007	–0.013	–0.009	–0.013	–0.021
.....	4	17	–0.003	–0.005	–0.004	0.659	–0.003	–0.004	–0.004	–0.005	–0.003	–0.004	–0.007	–0.004	–0.006	–0.010
Identified by	5	24	–0.003	–0.006	–0.004	0.062	0.916	–0.005	–0.005	–0.006	–0.003	–0.004	–0.008	–0.005	–0.008	–0.012
species groups	6	119	–0.007	–0.013	–0.009	–0.009	–0.007	0.748	–0.011	0.453	–0.007	–0.009	–0.018	–0.012	–0.017	–0.028
from the	7	94	–0.006	–0.012	–0.008	–0.008	–0.006	–0.010	0.824	0.270	0.015	–0.008	–0.016	–0.010	–0.015	–0.025
German	8	25	–0.003	–0.006	–0.004	–0.004	–0.003	–0.005	–0.005	0.481	–0.003	–0.004	–0.008	–0.005	–0.008	–0.013
data set	9	24	–0.003	–0.006	–0.004	–0.004	–0.003	–0.005	–0.005	0.013	0.958	–0.004	–0.008	–0.005	–0.008	–0.012
	10	97	–0.006	–0.012	–0.009	–0.008	–0.006	–0.010	–0.010	–0.013	–0.006	0.656	–0.016	–0.010	–0.016	0.261
	11	251	–0.010	–0.020	–0.014	–0.013	–0.010	–0.017	–0.017	–0.021	–0.010	–0.014	0.773	–0.017	–0.009	0.275
	12	43	–0.004	–0.008	–0.006	–0.005	–0.004	–0.007	–0.007	–0.009	–0.004	–0.006	–0.011	0.794	–0.010	–0.017
	13	175	–0.008	–0.016	–0.012	–0.011	–0.008	–0.014	–0.014	–0.018	–0.008	0.011	–0.003	0.200	0.883	–0.021
	14	232	–0.010	–0.019	–0.013	–0.012	–0.010	–0.016	–0.016	–0.020	–0.010	–0.013	–0.025	0.000	–0.008	0.760

Table 7. ϕ-correlation matrix of COCKTAIL results for assignment criteria derived from the **Czech** data set, applied to the **German** data set; based on the entire **German** data set (n = 7909). Group numbers are identical with columns in Table 8. Values > | 0.500 | are shaded.

COCKTAIL			Units based on species groups from the **German** data set (*n* = 7909).....															
	Group		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		n	44	571	241	237	146	264	390	591	610	87	189	230	747	61	1145	2356
	1	0	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	2	384	-0,009	0,808	-0,040	-0,040	-0,031	-0,042	-0,051	-0,064	-0,065	-0,024	-0,035	-0,039	-0,073	-0,020	-0,093	-0,147
	3	205	-0,012	-0,046	0,920	-0,029	-0,022	-0,030	-0,037	-0,046	-0,047	-0,017	-0,026	-0,028	-0,053	-0,014	-0,067	-0,106
.....	4	107	0,006	-0,024	-0,014	0,634	-0,016	-0,016	-0,027	-0,033	-0,034	-0,012	-0,018	-0,020	-0,038	-0,010	-0,048	-0,076
Identified	5	289	0,022	-0,054	-0,035	0,495	0,689	-0,006	-0,044	-0,055	-0,056	-0,021	-0,030	-0,034	-0,063	-0,017	-0,080	-0,127
by species	6	262	-0,004	-0,046	-0,033	-0,028	-0,010	0,969	-0,042	-0,053	-0,054	-0,020	-0,029	-0,032	-0,060	-0,016	-0,076	-0,121
groups	7	184	-0,012	-0,043	-0,018	-0,027	-0,021	-0,029	0,670	-0,044	-0,045	-0,016	-0,024	-0,027	-0,050	-0,014	-0,063	-0,101
from the	8	261	-0,004	-0,035	-0,033	-0,032	-0,025	-0,034	-0,042	0,631	-0,053	-0,019	-0,029	-0,032	-0,060	-0,016	-0,076	-0,120
Czech	9	1202	-0,032	-0,064	-0,067	-0,074	-0,058	-0,079	0,242	0,331	0,683	-0,035	-0,066	-0,073	-0,137	-0,037	-0,174	-0,276
data set	10	85	-0,008	-0,029	-0,011	-0,018	-0,014	-0,019	-0,024	-0,030	-0,030	0,977	-0,016	-0,018	-0,034	-0,009	-0,043	-0,068
	11	0	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	12	77	0,010	-0,023	0,020	-0,017	-0,014	-0,018	-0,023	-0,028	-0,029	-0,010	-0,016	0,519	-0,032	-0,009	-0,041	-0,065
	13	256	0,025	-0,040	-0,003	-0,032	-0,025	-0,034	-0,042	-0,052	-0,053	-0,019	0,051	-0,032	0,481	-0,016	-0,069	-0,119
	14	59	-0,006	-0,024	-0,015	-0,015	-0,012	-0,016	-0,020	-0,025	-0,025	-0,009	-0,014	-0,015	-0,028	0,983	-0,036	-0,056
	15	1135	-0,002	-0,109	-0,070	-0,072	-0,056	-0,076	-0,093	-0,116	-0,118	-0,043	-0,033	-0,071	-0,127	-0,036	0,950	-0,254
	16	3403	0,021	-0,115	-0,132	-0,153	-0,119	-0,161	-0,198	-0,247	-0,251	-0,092	0,130	0,093	0,175	-0,071	-0,321	0,741

using the reduced data sets differed only slightly from the results obtained using the entire data sets, only the latter are presented in tables. High correspondence between the assignment criteria of both countries is documented in Tables 6 and 7 where high ϕ-values are concentrated on the diagonal. The only deviation was that relevé groups 1 and 11 of the German classification could not be identified by the species groups extracted from the Czech data set (Table 7) because the species groups corresponding to these relevé groups did not exist in the Czech data.

Floristic differentiation in the entire national data sets is presented in Tables 8 and 9, alongside attempts to create phytosociological tables from the species groups extracted from one national data set and applied to the other national data set. Three species and relevé groups were found that roughly correspond to the abandoned wet meadows of the *Filipendulenion* suballiance. The *Valeriana officinalis* group was only distinguished in the German data set (Table 8, column 1); it corresponds to the *Valeriano-Filipenduletum* Sissingh in Westhoff et al. 1946 and the *Valeriano-Polemonietum caerulei* Rosskopf 1971. In Czechia, the former association occurs only in the extreme northwest and is mostly characterized by *Valeriana procurrens*, which is a subatlantic species from the *V. officinalis* aggregate. The latter association has not been reported in Czechia. The presence of *Euphorbia palustris* in the *Valeriana officinalis* group indicates that relevés of subcontinental tall-forb meadows from the lower reaches of large rivers (*Veronico longifoliae-Lysimachion vulgaris*) were also included. The *Carex gracilis* group and the *Chaerophyllum hirsutum* group (Table 8, columns 2-3, Table 9, columns 1-2) were found in both the German and the Czech data sets. The former indicates transitions from the *Filipendulenion* to the *Phragmito-Magnocaricetea*, whereas the latter includes montane *Filipendulenion* communities that largely correspond to the *Chaerophyllo hirsuti-Filipenduletum* Niemann et al. 1973. No relevé group could be clearly identified with the widely recognized association *Filipendulo-Geranietum palustris* Koch 1926, as it is mostly negatively differentiated.

For the *Calthion* s. str. (*Calthenion*), three corresponding groups were distinguished in each of the national data sets, and the fourth group was found in the German data set only. The *Cirsium oleraceum* group indicates base-rich soils and includes the *Angelico-Cirsietum oleracei* Tüxen 1937, *Cirsietum rivularis* Nowiński 1927 and some related associations (Table 8, columns 4-6; Table 9, columns 3-5). On the contrary, the *Cirsium palustre* group is typical of base-poor soils and corresponds to the group of associations including *Crepido-Juncetum acutiflori* Oberdorfer 1957, *Angelico-Cirsietum palustris* Balátová-Tuláčková 1973, and *Polygono-Cirsietum palustris* Balátová-Tuláčková 1974 (Table 8, columns 7-10; Table 9, columns 6-9). The *Senecio aquaticus* group is found only in the German data set and is not reproduced in the Czech data set. This group corresponds to the *Senecioni-Brometum racemosi* Tüxen et Preising 1951 ex auct. (Table 8, column 11), which is a low-altitudinal subatlantic community not occurring in Czechia. The last species group typical of the *Calthion* is the *Caltha palustris* group, which includes several species with a rather large ecological range. Species from this group often co-occurred with those from the *Cirsium oleraceum* and *Cirsium palustre* groups and, in phytosociological terms, they may be best termed as the *Calthion* character (or differential) species. In both national data sets, there was a relevé group lacking the previous species groups and solely characterized by the *Caltha palustris* group (Table 8, columns 12-13; Table 9, columns 10-11). These relevés may be unequivocally assigned to the *Calthion* alliance, but their classification into associa-

Table 8. Synoptic table produced by COCKTAIL. Assignment criteria were derived from the **German** dataset, then applied to the entire **German** dataset (*n* = 7909) and to the entire **Czech** dataset (*n* = 1287). Occurences of species in relevés that are relevant for assigning these relevés are shaded.

COCKTAIL species groups from the German data set... =Assignment key G		**... applied to the German data set**																**... applied to the Czech data set**															
	Number of relevés	44	571	241	237	146	264	390	591	610	87	189	230	747	61	1145	2356	0	27	91	68	17	24	119	94	25	24	11	94	248	43	172	230
Name of group Required species	Number of unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Valeriana officinalis	Valeriana officinalis agg.	V	+	I	+	r	r	r	r	r	r	r	r	r	.	r	r	.	.	r	.	I	.	.	r	.	r	.	.	r	.	r	r
group	Geranium palustre	IV	r	.	r	r	r	r	r	r	.	.	.	r	.	r	r	.	II	r	II	II	r	r	+	r	+	.	+	I	.	I	I
2 out of 4	Polemonium caeruleum	II	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Euphorbia palustris	I	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex gracilis	Carex gracilis	I	IV	r	+	I	r	+	+	+	+	II	+	I	.	r	+	.	V	+	II	II	II	r	I	II	I	.	+	I	.	+	I
group	Phalaris arundinacea	II	IV	r	r	r	r	r	r	r	r	r	.	r	r	r	+	.	V	r	.	I	.	r	r	.	.	.	r	r	.	r	r
2 out of 6	Glyceria maxima	r	III	r	.	r	r	.	r	r	r	r	r	r	.	.	r	.	II	.	.	.	.	.	.	.	.	.	.	.	.	r	r
	Iris pseudacorus	II	II	r	r	r	r	r	r	r	.	.	.	r	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Thalictrum flavum	+	II	.	r	r	.	r	r	r	.	r	r	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
	Peucedanum palustre	+	II	.	r	r	.	r	r	r	r	.	r	r	.	r	r	.	+	.	.	.	.	r	.	.	.	.	r	.	.	.	r
Chaerophyllum hirsutum	Chaerophyllum hirsutum	+	r	IV	+	r	r	r	r	r	r	.	+	r	I	r	r	.	+	IV	II	I	I	I	I	I	I	.	I	I	II	I	I
group	Cardamine amara	.	r	IV	r	.	.	r	r	r	.	.	r	r	.	r	r	.	r	III	.	+	.	.	r	I	.	.	.	r	.	.	r
2 out of 8	Stellaria alsine	.	+	III	.	r	r	+	r	+	r	r	r	r	r	.	r	.	.	III	.	.	.	r	r	+	.	+	r	r	.	r	r
	Chrysosplenium oppositifolium	.	.	II	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
	Ranunculus aconitifolius	.	.	II	.	.	.	r	r	r	.	.	+	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
	Epilobium obscurum	.	.	II	.	.	.	r	r	r	.	.	.	.	.	.	r	.	+	II	r	.	.	I	I	I	.	.	+	+	.	r	r
	Stellaria nemorum	.	r	II	.	.	.	r	.	r	.	.	.	.	.	r	r	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.
	Chrysosplenium alternifolium	.	.	I	.	.	.	.	r	.	.	.	.	r	.	.	r	.	.	I	.	.	.	.	.	.	.	.	.	r	.	r	.
Cirsium oleraceum	Cirsium oleraceum	III	I	+	V	V	V	r	I	+	II	I	r	II	I	II	I	.	IV	II	IV	V	V	+	I	I	I	+	r	II	r	II	II
group	Geum rivale	I	r	I	V	V	V	+	+	r	+	r	+	I	I	r	r	.	I	+	V	V	IV	I	+	r	r	+	I	+	II	+	r
2 out of 3	Cirsium rivulare	r	r	r	I	II	II	.	r	.	.	.	r	r	.	r	r	.	.	+	II	I	II	r	.	.	.	I	I	+	.	+	r
Cirsium palustre	Lotus uliginosus	I	II	III	IV	II	II	V	V	V	V	III	II	II	II	I	II	.	+	I	I	+	I	III	III	II	IV	I	I	I	+	I	+
group	Cirsium palustre	I	II	III	III	II	I	V	V	IV	V	I	III	III	II	I	I	.	II	II	III	I	III	V	V	V	V	IV	IV	III	II	III	II
3 out of 5	Juncus effusus	I	II	III	II	I	+	IV	III	IV	IV	I	II	I	r	r	II	.	III	IV	IV	II	II	V	V	V	V	IV	II	II	II	II	II
	Galium palustre agg.	II	III	III	I	I	+	IV	III	III	II	I	II	I	.	r	I	.	II	III	II	II	II	IV	IV	IV	III	I	II	I	r	+	I
	Juncus acutiflorus	r	+	I	+	r	r	III	III	III	III	I	II	I	.	r	+	.	.	r	.	.	.	I	+	+	I	.	.	.	.	.	.
Senecio aquaticus	Ranunculus auricomus agg.	r	I	r	I	I	I	r	I	r	I	IV	+	+	I	+	+	.	III	III	IV	IV	IV	IV	IV	III	V	V	IV	IV	IV	IV	III
group	Senecio aquaticus	.	I	r	r	+	I	r	I	I	I	IV	r	+	.	r	+	.	r	.	.	.	.	r	+	r	.	V	r	.	.	.	.
2 out of 4	Bromus racemosus	.	r	r	+	+	+	r	+	r	+	III	r	r	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Fritillaria meleagris	r	+	.	r	.	.	.	r	r	.	II	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caltha palustris	Carex nigra	I	I	II	IV	II	I	V	IV	III	III	II	V	IV	r	+	II	.	I	II	IV	.	III	V	IV	II	IV	V	V	III	I	II	I
group	Caltha palustris	III	IV	IV	IV	I	I	IV	IV	II	II	III	IV	IV	r	r	I	.	IV	IV	IV	III	II	V	V	II	III	II	IV	IV	I	II	II
3 out of 8	Galium uliginosum	II	II	III	IV	II	II	IV	IV	II	IV	I	IV	IV	II	I	I	.	III	III	V	III	III	V	V	III	V	V	V	V	IV	III	II
	Crepis paludosa	II	+	III	III	+	I	III	III	+	II	II	II	II	I	r	r	.	+	III	IV	I	II	III	II	.	III	+	II	II	III	II	I
	Valeriana dioica	+	I	II	IV	+	I	III	II	r	I	+	III	III	r	r	r	.	+	I	III	.	II	IV	II	r	III	III	III	II	r	I	r
	Scirpus sylvaticus	II	I	II	II	I	I	II	III	II	II	I	II	II	r	+	I	.	IV	IV	IV	III	III	III	V	III	IV	III	III	IV	II	III	II
	Carex panicea	.	I	I	IV	I	I	III	III	I	II	I	IV	III	+	+	I	.	+	I	III	I	III	IV	III	+	V	IV	IV	III	II	III	+
	Dactylorhiza majalis	+	r	I	III	I	+	II	II	r	I	I	I	II	r	r	r	.	r	r	II	.	II	I	I	.	I	II	I	I	.	+	.
Agrostis canina	Agrostis canina	+	I	I	r	r	r	IV	I	II	+	I	III	+	r	r	I	.	r	I	II	.	.	IV	II	r	II	III	IV	+	+	I	+
group	Viola palustris	r	r	II	+	r	.	IV	+	I	+	r	IV	r	.	r	+	.	.	II	I	.	r	IV	I	I	II	I	IV	I	I	+	+
2 out of 6	Epilobium palustre	I	+	II	r	+	r	III	I	II	r	r	II	r	r	r	r	.	r	I	II	.	r	III	+	II	I	+	III	r	.	r	r
	Carex echinata	.	r	+	r	r	r	III	r	+	r	r	III	r	.	r	r	.	.	+	I	.	r	III	r	r	+	I	III	r	r	+	r
	Eriophorum angustifolium	+	+	+	+	.	r	II	+	+	r	r	III	+	.	r	+	.	.	+	II	.	r	III	r	r	I	.	II	r	.	r	r
	Carex canescens	.	r	+	r	.	.	II	r	I	.	r	II	r	r	r	r	.	.	+	+	+	.	II	r	+	.	.	II	r	.	r	r
Heracleum sphondylium	Dactylis glomerata agg.	II	r	I	+	I	IV	r	r	r	III	+	.	r	IV	IV	+	.	I	I	+	.	III	r	+	.	II	.	r	r	III	III	I
group	Veronica chamaedrys	+	r	I	I	I	III	+	I	+	III	I	+	+	V	III	r	.	II	I	III	II	IV	II	II	I	IV	IV	II	II	V	V	I
3 out of 10	Achillea millefolium agg.	I	r	r	I	I	II	r	+	+	IV	I	r	+	IV	IV	I	.	+	I	II	I	IV	II	II	I	IV	III	II	II	V	IV	I
	Heracleum sphondylium	I	r	I	+	I	III	r	r	r	III	I	r	r	III	III	r	.	II	I	r	+	IV	+	+	r	III	I	+	+	IV	III	+
	Trisetum flavescens	I	r	r	+	I	III	r	r	r	III	+	r	r	III	III	r	.	+	r	+	I	III	r	r	r	III	I	r	r	III	II	r
	Leucanthemum vulgare agg.	.	r	r	+	II	III	r	+	r	III	I	r	+	IV	III	+	.	I	r	r	.	III	+	r	.	III	II	+	+	I	III	r
	Galium mollugo agg.	II	+	+	r	I	III	r	r	r	II	r	r	r	III	III	r	.	I	+	r	+	II	r	r	.	+	+	.	r	II	II	+
	Anthriscus sylvestris	+	r	r	r	r	II	r	r	r	I	+	.	r	III	II	r	.	+	+	.	I	I	r	r	r	I	+	r	r	r	I	r
	Arrhenatherum elatius	I	r	r	+	+	II	r	r	r	II	r	.	r	II	III	r	.	+	r	.	+	II	.	.	.	.	.	.	r	r	II	r
	Crepis biennis	r	r	.	r	r	I	.	r	r	r	r	r	r	II	II	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Geranium sylvaticum	Geranium sylvaticum	.	r	II	r	r	r	r	r	r	+	.	r	r	IV	r	r	.	r	II	I	I	II	r	r	.	I	.	+	r	IV	+	I
group	Hypericum maculatum	I	r	r	+	r	r	+	+	r	II	.	+	r	IV	I	r	.	.	+	+	.	II	I	I	I	II	.	I	I	IV	II	I
2 out of 5	Phyteuma spicatum	.	.	r	.	r	r	.	r	.	r	.	r	r	IV	r	r	.	.	r	.	+	r	r	.	r	r	+	.	r	III	r	r
	Poa chaixii	.	.	r	r	r	r	r	r	r	r	.	.	r	II	r	r	.	.	r	.	.	.	r	.	.	.	.	r	r	II	.	+
	Cardaminopsis halleri	.	.	+	.	.	.	.	r	.	r	.	.	r	r	.	r	.	.	+	r	I	r	r	.	.	.	.	r	r	IV	.	+

tions is problematic due to the lack of association character species. In the present tables, they are best classified as the central association of the alliance (Dierschke 1981).

Apart from the above species groups, three other groups are shown in Tables 8 and 9 that correspond to other high-rank grassland syntaxa, i.e. the *Agrostis canina* group (*Caricion fuscae*), *Heracleum sphondylium* group (*Arrhenatherion*), and *Geranium sylvaticum* group (*Polygono-Trisetion*). These groups indicate transitions from the *Calthion* to the syntaxa mentioned.

A large number of relevés remained unclassified, particularly in the German data set, amounting to 30 % of the entire data set, but this was because we just performed an initial classification with only a few species groups to demonstrate the method. Apart from the groups presented in Tables 8 and 9, we found roughly 20 more groups which would produce a much finer classification. In a regional study of a large variety of montane

Table 9. Synoptic table produced by COCKTAIL. Assignment criteria were derived from the Czech dataset, then applied to the entire Czech dataset (*n* =1287) and to the entire German dataset (*n* = 7909). Occurences of species in relevés that are relevant for assigning these relevés are shaded.

COCKTAIL species groups from the Czech data set =Assignment key C		... applied to the Czech set														... applied to the German set													
	Number of relevés	24	91	46	39	24	67	66	107	24	46	158	68	151	376	384	205	107	289	262	184	261	1202	85	77	256	59	1135	303
Name of group	Number of unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Required species																													
Carex gracilis	Carex gracilis	V	+	II	I	II	+	I	I	I	+	I	r	+	I	V	r	+	+	r	+	I	+	+	r	I	.	r	I
group	Phalaris arundinacea	V	r	.	+	.	r	r	.	.	r	.	.	r	r	IV	+	r	r	r	r	r	r	r	.	r	r	r	+
2 out of 3	Glyceria maxima	II	.	.	.	.	.	.	.	.	.	.	.	r	r	IV	r	.	r	r	.	r	r	r	r	r	.	.	r
Chaerophyllum hirsutum	Chaerophyllum hirsutum	+	IV	II	I	I	I	I	+	I	I	I	II	I	I	r	IV	+	r	r	+	+	r	r	I	+	I	r	r
group	Stellaria alsine	.	III	.	.	.	r	r	+	.	r	.	.	r	r	+	IV	.	r	r	I	+	+	r	+	r	r	.	r
2 out of 6	Cardamine amara	r	III	.	r	.	.	r	r	.	.	r	.	.	r	r	IV	r	r	.	r	r	r	.	r	r	.	r	r
	Epilobium obscurum	+	II	r	r	.	+	II	I	r	+	+	.	r	r	.	II	.	.	.	r	r	r	.	.	.	.	.	r
	Chrysosplenium alternifolium	.	I	.	.	.	.	.	.	.	.	r	.	r	.	.	II	.	.	.	.	r	.	.	.	r	.	.	r
	Stellaria nemorum	.	+	.	.	.	.	.	.	.	.	.	.	r	.	r	II	.	.	.	.	.	r	.	.	.	.	r	r
Cirsium oleraceum	Cirsium oleraceum	IV	II	V	IV	V	r	I	I	I	+	II	r	II	II	I	+	V	V	V	+	+	+	II	+	II	I	II	I
group	Geum rivale	I	+	V	V	IV	I	+	+	r	I	+	II	+	+	r	I	V	V	V	+	+	+	+	I	I	I	r	+
2 out of 3	Cirsium rivulare	.	+	II	II	II	r	.	r	.	r	+	.	I	r	r	.	I	II	II	.	.	r	.	r	r	.	r	r
Cirsium palustre	Juncus effusus	III	IV	IV	III	II	V	V	V	V	III	III	II	II	II	II	III	II	I	+	IV	III	IV	IV	II	+	+	r	I
group	Cirsium palustre	II	II	III	II	III	V	V	V	V	IV	III	III	II	II	II	III	III	II	I	V	V	V	V	III	III	II	I	II
3 out of 5	Galium palustre agg.	II	III	I	II	II	IV	IV	IV	III	II	I	r	+	I	III	III	I	I	+	IV	III	IV	II	II	I	.	r	I
	Lotus uliginosus	r	I	I	r	I	III	III	III	III	+	I	I	I	+	II	III	IV	III	II	V	V	V	V	III	III	II	I	II
	Juncus acutiflorus	.	r	.	.	.	+	+	+	I	.	.	.	.	.	+	I	I	r	r	III	IV	III	III	I	I	.	r	+
Caltha palustris	Caltha palustris	IV	IV	V	II	II	V	V	III	III	V	V	I	II	II	IV	III	V	II	II	V	V	II	II	V	V	+	r	II
group	Galium uliginosum	III	III	V	IV	III	V	V	IV	V	V	V	IV	III	III	II	III	V	III	II	V	V	III	IV	V	V	II	I	II
3 out of 4	Scirpus sylvaticus	IV	IV	V	II	III	V	V	II	IV	IV	V	I	III	II	II	II	IV	I	I	III	IV	II	II	IV	IV	+	+	I
	Crepis paludosa	r	III	IV	II	II	IV	II	+	III	III	III	III	II	I	+	III	V	II	I	V	V	I	II	IV	IV	II	r	+
Agrostis canina	Eriophorum angustifolium	.	+	II	+	+	III	+	II	+	III	r	.	r	+	r	r	+	r	r	II	r	I	r	III	+	.	r	+
group	Carex echinata	.	+	I	I	+	III	r	II	+	II	r	r	+	+	r	r	r	r	r	III	r	I	r	III	r	.	r	+
2 out of 6	Agrostis canina	.	I	I	II	.	IV	I	III	II	IV	r	I	+	I	I	I	r	r	r	IV	I	II	+	III	r	r	r	I
	Viola palustris	.	II	I	I	r	IV	II	II	II	IV	I	I	+	I	r	II	+	r	.	IV	+	II	+	III	+	.	r	+
	Epilobium palustre	.	I	I	I	+	III	+	II	I	II	+	.	r	I	r	II	+	+	r	III	I	II	r	II	+	r	r	+
	Carex canescens	.	+	+	+	.	II	r	I	.	II	r	.	r	+	r	+	r	r	.	II	r	I	.	II	.	.	r	r
Heracleum sphondylium	Achillea millefolium agg.	r	I	I	II	IV	II	II	II	IV	I	I	V	IV	II	r	r	I	I	II	r	r	+	IV	r	+	IV	IV	I
group	Veronica chamaedrys	II	I	III	II	IV	II	II	II	IV	II	II	V	IV	I	r	I	I	I	III	I	I	+	III	+	I	V	III	r
3 out of 9	Heracleum sphondylium	II	I	r	+	IV	+	+	r	III	I	+	III	III	+	r	I	r	I	III	r	r	r	III	r	r	III	III	r
	Dactylis glomerata agg.	II	I	+	+	III	.	+	r	II	r	r	III	III	+	r	I	+	I	IV	r	r	r	III	.	r	IV	IV	+
	Trisetum flavescens	+	r	+	+	III	r	.	r	III	r	+	III	II	r	r	r	r	I	III	r	r	r	III	+	r	III	III	r
	Leucanthemum vulgare agg.	I	r	r	+	III	+	r	r	III	+	+	I	III	+	r	r	r	I	III	r	+	r	III	+	+	IV	III	+
	Campanula patula	+	r	r	.	III	r	r	r	II	.	r	II	II	r	.	.	r	r	I	.	r	.	r	.	r	+	I	r
	Galium mollugo agg.	II	+	r	r	II	r	r	r	+	.	.	II	II	+	r	+	r	I	III	r	r	r	II	r	r	III	III	r
	Arrhenatherum elatius	r	r	.	+	I	.	.	.	.	.	r	r	II	r	r	r	r	+	II	r	r	r	II	.	r	II	III	r
Geranium sylvaticum	Cirsium heterophyllum	.	+	r	.	+	+	r	+	II	+	r	V	+	I	.	.	.	.	.	r	.	r	.	+	r	.	r	r
group	Hypericum maculatum	.	+	r	+	II	I	I	I	II	I	+	IV	I	I	r	+	+	+	r	+	+	r	II	+	r	IV	I	r
2 out of 6	Geranium sylvaticum	r	II	II	+	II	+	r	r	I	+	r	III	r	I	r	II	r	r	r	+	r	r	+	+	r	IV	r	r
	Cardaminopsis halleri	.	+	r	+	r	r	.	.	.	.	r	II	.	r	.	+	.	.	.	.	.	r	r	.	r	+	.	r
	Phyteuma spicatum s.str.	.	r	.	r	r	.	.	r	r	.	.	II	r	r	.	r	.	r	.	.	r	r	r	.	r	IV	r	r
	Poa chaixii	.	r	.	.	.	.	.	r	.	.	.	I	.	r	.	r	r	r	r	r	.	r	r	.	r	II	r	r

grassland communities (Bruelheide 1995), 24 species groups were sufficient to reduce the number of unclassified relevés to 2.1 % of the data set.

Discussion

Lack of correspondence in the TWINSPAN classifications

The groups produced by TWINSPAN with assignment criteria from one national data set showed almost no correspondence with the groups produced with assignment criteria from the other national data set, neither for the entire nor the reduced data set. Even when the German and Czech data were combined into one data set, TWINSPAN was unable to detect similarities when the assignment criteria were based on a small national subset. There are two possible reasons why the assignment criteria are not transferable between national data sets: either vegetation types in the two neighbouring countries are completely different and not comparable, or TWINSPAN fails to reveal corresponding groups in different data sets, despite the fact that these groups do exist.

Even if the immense variation within a broadly defined vegetation type like the *Calthion* on the scale of countries is taken for granted, it is very unlikely that there are no common vegetation types at all. For Germany and Czechia, many phytosociological studies have repeatedly reported several associations to occur in both countries (cf. Oberdorfer 1983 and Balátová-Tuláčková in Rybníček et al. 1984). Obviously, the lack of correspondence is a methodological problem of TWINSPAN.

TWINSPAN uses one-dimensional correspondence analysis (CA) ordination to divide the data set into two subsets. Successively, a new CA is made for each subset, and new divisions are performed according to sample positions on the ordination axis. In this algorithm, two features of TWINSPAN may be responsible for causing correspondence between two classifications to be lacking:

1. The CA-based division does not properly reflect the data structure. Van Groenewoud (1992) reported that with artificial data of rather simple structure, the splitting rule of TWINSPAN overrode the necessity of keeping closely related samples together. The results were particularly unstable when the first two orthogonal gradients were of the same length. The same result for CA was reported by Minchin (1987). Oksanen & Minchin (1997) showed that a great deal of instability in TWINSPAN is due to lax convergence criteria in the algorithm used to estimate the CA eigenvalues and predicted that more stringent criteria would eliminate the instability. We used the improved TWINSPAN version and found the difference between this and the previous version to be of minor influence.

2. Assuming that the TWINSPAN algorithm works properly, another explanation must be sought for why the two data sets are classified in an incompatible way, even though traditional phytosociologists could identify several vegetation types common to both countries. This explanation may be the sensitivity of TWINSPAN to differences in data set structure: in our case, the first CA axes in both data sets differed in underlying environmental gradients.

The first gradient detected by the CA ordination may be strongly influenced by a relevé group from extreme environments present in the data set. If two data sets consisted of relevés from roughly identical environments, but one of them additionally contained several relevés from e.g. extremely cool sites, the first axis in this data set might reflect the temperature gradient, while in the other data set, where relevés from such sites were absent, the first axis might be associated with some other gradient. This situation is more likely to occur if the first and second gradients are of similar length, i.e. their eigenvalues are close, as is the case in our data sets.

Once the data sets are divided differently into two subsets according to their first axes, the differences increase down the hierarchy, resulting in incompatible end groups. This would probably occur even if the first axis in one data set corresponded to the second or higher axis in the other data set, because the second CA gradient as detected in the whole data set need not always be found in the CAs of the first-level subsets. The larger one of the two subsets can still reflect the second gradient of the whole data set, whereas the smaller one can be dominated by another gradient, possibly because the important relevés of the second gradient have been allocated characterizing only a minor part of the second gradient. Even if such relevé allocation occurred in only a single subset of either of the data sets, the consequence would be a severe decrease in correspondence between the two classifications. It is also possible that neither of the two subsets in one or both data sets would reflect the second gradient. As a result, completely different classifications were obtained from data sets containing a large proportion of vegetation types which are considered identical by classical phytosociology.

Differences are amplified by the tendency in TWINSPAN to misclassify a certain amount of relevés on each hierarchical level. This effect has proved to be problematic when working with assignment criteria on more than three levels.

Balancing data sets: a remedy for TWINSPAN classification?

Assuming that the TWINSPAN classification incompatibility probably results from differences in data set structure, the solution to the problem should be sought in balancing the data sets. However, phytosociology almost exclusively works with unbalanced data sets like ours, and we are not aware of an appropriate method which would allow a reasonable balancing of data sets consisting of real data. Let us discuss some balancing options:

1. Balancing by size. Our entire and reduced German data sets were 6.1 and 5.2 times larger than the corresponding entire and reduced Czech data sets, respectively; consequently, the total data set classification was strongly biased towards the German classification. It would have been possible to reduce the German data set to the size of the Czech set by random selection. However, taking into account that Germany is 4.5 times larger than Czechia, the total data set would have to be considered as biased towards the Czech classification in this case. In addition, the proportion of the areas actually occupied by *Calthion* meadows in the two countries is unknown. Apart from the immense effort involved in the repeated random selections which would have to be done before stable results would be obtained, this balancing by size would not solve the problem of balancing the different representation of vegetation types in the data sets. Even if the field sampling was done by systematic or random design, according to the area covered by *Calthion* meadows in both countries, the different abundance of corresponding vegetation types in each country would result in different classifications.

2. Balancing by vegetation types. In this case, an *a priori* definition of all vegetation types involved would be necessary (cf. Bruelheide & Jandt 1997), and resulting classifications would be based on a circular argument.

The problem would not be solved even with data sets involving all existing relevés from both countries. For example, a certain community may comprise 1/10 of the relevés in the German data set, but only 1/100 in the Czech data set, just because it is more common in Germany or sampled more often by German phytosociologists.

3. Balancing by outlier exclusion. The structure of data sets selected from large data bases is strongly dependent on the selection method. Our entire data sets differed in this respect: the German data set consisted of a larger selection of wet meadow relevés, while in the Czech data set only relevés assigned to *Calthion* by the original authors were included. Therefore, in the reduced data sets, we attempted to balance the data sets by defining our study object by the presence of a minimum number of eight out of 103 arbitrarily chosen diagnostic species. By applying such a definition, we hoped to exclude most of the deviating relevés. Comparing the classifications of the entire and reduced data sets we found more unequal divisions in the former. For example, the first-level division of the entire German data set based on German assignment criteria produced groups of 6475 and 1434 relevés (Table 2). In contrast, the reduced data set shows a more equal division into groups of 2716 and 3689 relevés. Another feature is lower ϕ-values for the entire data sets than for the reduced data sets. For example, Table 2 shows no value above 0.5, whereas the corresponding analysis of the reduced data set yields two values. We conclude that outlier exclusion improved the correspondence between two classifications, but only to a minor extent.

Features of the COCKTAIL classifications

In contrast to TWINSPAN which seems to produce classifications only valid in a particular data set which are not transferable to other data sets, the method implemented in the COCKTAIL program permits the user more freedom in looking for species groups and their combinations reported from previous studies. In this way, analyses of new data sets may be easily linked to already existing classifications. Our results also show that COCKTAIL can easily detect species groups and communities present in one data set and not in the other, such as the *Senecio aquaticus* group or the *Senecioni-Brometum racemosi* community, which occurs in Germany and not in the Czech Republic, and the *Valeriana officinalis* group or the *Valeriano-Filipenduletum* community, which is well-known from Germany but in Czechia is only rarely reported from the western areas adjacent to the German border (Balátová-Tuláčková in Rybníček et al. 1984).

Unlike many other algorithms, COCKTAIL proved to be fairly unaffected by outliers. This was demonstrated by only marginal differences in classifications based on the reduced or entire data sets. Another important property of the COCKTAIL classification is that some relevés which do not belong to any of the species groups used for classification, remain unclassified. On the one hand, this is an advantage of the method (Bruelheide & Jandt 1997), because only floristically well characterized relevés are assigned to groups, forming ‘cores’ of vegetation types. On the other hand, several vegetation types recognized in the traditional phytosociological studies may remain outside the classification, as they are only defined by one species and not by a species group, such as the *Caricetum cespitosae.* This is also the case for communities defined by dominance (e.g. *Scirpetum sylvatici),* because the species group method is based on presence/absence only. Furthermore, all vegetation types which are solely negatively characterized, such as basal communities, cannot be detected by the COCKTAIL method.

Conclusion

The European Vegetation Survey project is currently in the stage of gathering computerized data, and there is an urgent need for the development and unification of the survey methods, including numerical analysis of large data sets. We have found that the widely used program TWINSPAN, when applied to different national data sets of the same vegetation type, may produce results only valid in a particular data set which are not transferable to other data sets. As TWINSPAN is currently the only classification method used in TURBOVEG (the standard EVS software package for data storage and analysis), there is a danger that the national vegetation survey projects in different countries may result in a number of incompatible classifications. An alternative classification method may be COCKTAIL (Bruelheide 1995, 2000), a fundamental feature of which is the ability to produce national classifications which are comparable and transferable between countries. However, some aspects of COCKTAIL need further improvement, e.g. the preselection of the starting species groups.

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References

Bortz, J., Lienert, G.A. & Boehnke, K. 1990. *Verteilungsfreie Methoden in der Biostatistik.* Springer, Berlin.

Bruelheide, H. 1995. Die Grünlandgesellschaften des Harzes und ihre Standortsbedingungen. Mit einem Beitrag zum Gliederungsprinzip auf der Basis von statistisch ermittelten Artengruppen. *Diss. Bot.* 244: 1-338.

Bruelheide, H. 1997. Using formal logic to classify vegetation. *Folia Geobot. Phytotax.* 32: 41-46.

Bruelheide, H. 2000. A new measure of fidelity and its application to defining species groups. *J. Veg. Sci.* 11: 167-178.

Bruelheide, H. & Jandt, U. 1995. Survey of limestone grassland by statistically formed groups of differential species. *Coll. Phytosoc.* 23: 319-338.

Bruelheide, H. & Jandt, U. 1997. Demarcation of communities in large databases. *Phytocoenologia* 27: 141-159.

Dierschke, H. 1981. Zur syntaxonomischen Bewertung schwach gekennzeichneter Pflanzengesellschaften. In: Dierschke, H. (ed.) *Syntaxonomie. Ber. Int. Symp. Int. Vereinig. Vegetationsk. Rinteln* 1980: 109-122.

Dierschke, H. 1995. Syntaxonomical survey of *Molinio-Arrhenatheretea* in Central Europe. *Coll. Phytosoc.* 23: 387-399.

Dierschke, H. 1997. *Molinio-Arrhenatheretea* (E1). Kulturgrasland und verwandte Vegetationstypen. Teil 1: *Arrhenatheretalia*. Wiesen und Weiden frischer Standorte. In: Dierschke H. (ed.) *Synopsis der Pflanzengesellschaften Deutschlands* 3, pp. 1-74, Floristisch-soziologische Arbeitsgemeinschaft, Göttingen.

Ehrendorfer, F. (ed.) 1973. *Liste der Gefäßpflanzen Mitteleuropas.* 2nd ed. G. Fischer, Stuttgart.

Ellenberg, H., Weber, H.E., Düll, R., Wirth, W., Werner, W. & Paulißen, D. 1992. Zeigerwerte von Pflanzen in Mitteleuropa. 2nd ed. *Scripta Geobot.* 18: 1-258.

Ellmauer, T. 1994. Syntaxonomie der Frischwiesen (*Molinio-Arrhenatheretea* p.p.) in Österreich. *Tuexenia* 14: 151-168.

Ellmauer, T. & Mucina, L. 1993. *Molinio-Arrhenatheretea.* In: Mucina, L., Grabherr, G. & Ellmauer, T. (eds.) *Die Pflanzengesellschaften Österreichs. Teil I. Anthropogene Vegetation,* pp. 297-401. G. Fischer, Jena/Stuttgart/New York.

Fleiss, J.L. 1981. *Statistical methods for rates and proportions*. 2nd ed. John Wiley & Sons, New York, NY.

Hennekens, S.M. 1996. *TURBO(VEG). Software package for input, processing, and presentation of phytosociological data.* IBN-DLO, Wageningen & University of Lancaster.

Hill, M.O. 1979. *TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* Cornell University, Ithaca, NY.

Minchin P.R. 1987. Simulation of multidimensional community patterns: towards a comprehensive model. *Vegetatio* 83: 97-110.

Moravec, J., Balátová-Tuláčková, E., Blažková, D., Hadač, E., Hejný, S., Husák, Š., Jeník, J., Kolbek, J., Krahulec, F., Kropáč, Z., Neuhäusl, R., Rybníček, K., Řehořek, V. & Vicherek, J. 1995. Rostlinná společenstva České republiky a jejich ohrožení (Red list of plant communities of the Czech Republic and their endangerment). 2nd ed. *Severočes. Přír*. Suppl. 1995: 1-206.

Mucina, L. 1997. Classification of vegetation: Past, present and future. *J. Veg. Sci.* 8: 751-760.

Mucina, L., Rodwell, J.S., Schaminée, J.H.J. & Dierschke, H. 1993. European Vegetation Survey: current state of some national programmes. *J. Veg. Sci*. 4: 429-439.

Oberdorfer, E. 1957. *Süddeutsche Pflanzengesellschaften.* G. Fischer, Jena.

Oberdorfer, E. (ed.) 1983. *Süddeutsche Pflanzengesellschaften. Teil III. Wirtschaftswiesen und Unkrautgesellschaften*. 2nd ed. G. Fischer, Jena.

Oksanen, J. & Minchin, P.R. 1997. Instability of ordination results under changes in input data order: explanations and remedies. *J. Veg. Sci.* 8: 447-454.

Pott, R. 1995. *Die Pflanzengesellschaften Deutschlands.* 2nd ed. E. Ulmer, Stuttgart.

Rodwell, J.S. (ed.) 1990. *British plant communities 1. Woodlands and scrub*. Cambridge University Press, Cambridge.

Rodwell, J.S., Pignatti, S., Mucina, L. & Schaminée, J.H.J. 1995. European Vegetation Survey: Update on progress. *J. Veg. Sci*. 6: 759-762.

Rybníček, K., Balátová-Tuláčková, E. & Neuhäusl, R. 1984. Přehled rostlinných společenstev rašelinišť a mokřadních luk Československa. *Stud. ČSAV* 8/84: 1-124. (In Czech.)

Schaminée, J.H.J. & Hennekens, S.M. 1995. Update on the installation of Turboveg in Europe. *Ann. Bot. (Roma)* 53: 159-161.

Schaminée, J.H.J., Stortelder, A.H.F. & Westhoff, V. 1995. *De vegetatie van Nederland 1. Inleiding tot de plantensociologie: grondslagen, methoden en toepassingen*. Opulus Press, Uppsala.

ter Braak, C.J.F. & Šmilauer, P. 1998. *CANOCO reference manual and user's guide to Canoco for Windows. Software for Canonical Community Ordination (version 4).* Centre of Biometry, Wageningen.

Tüxen, R. 1937. Die Pflanzengesellschaften Nordwestdeutschlands. *Mitt. Florist.-Soziol. Arbeitsgem. Niedersachsen* 3: 1-170.

van der Maarel, E. 1982. On the manipulation and editing phytosociological and ecological data. *Vegetatio* 50: 71-76.

van Groenewoud, H. 1992. The robustness of Correspondence, Detrended Correspondence and TWINSPAN Analysis. *J. Veg. Sci.* 3: 239-246.

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