

Syntaxonomic revision of the Pannonian grasslands of Austria – Part II: Vienna Woods (Wienerwald)

Syntaxonomische Revision der pannonischen Rasengesellschaften in Österreich – Teil II: Wienerwald

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Abstract

As second part of a series focusing on the Pannonian grasslands of Austria, we present a detailed classification of the grasslands of the Vienna Woods (Wienerwald). This region, although geographically belonging to the Alps, has strong floristic affinities to the Pannonian Basin. The eastern slopes of the Vienna Woods are a hotspot of xero-thermophytic vegetation and exhibit the highest vascular plant species richness in Austria at a scale of 3' × 5'. We used the TWINSpan classification of a large data set reported in the first part of this series as starting point. Relevés that were considered as misclassified at the level of alliances were manually re-arranged. From this table, an excerpt containing only the relevés of the Vienna Woods was used for the present study (1055 plots). We re-classified the relevés preliminary labelled as *Arrhenatherion* with another TWINSpan run. Clusters for which no ecological difference could be detected were merged. The final delimitation of associations and subassociations was achieved by adjusting their diagnostic species so as to get units that were most informative in terms of environmental conditions. All re-arrangements were based on the summarised cover of diagnostic species within individual relevés. As a result, the grasslands of the Vienna Woods are classified within 22 associations (plus two subassociations) belonging to ten alliances and four classes. Within the *Seslerio-Festucion pallentis*, a new association *Scorzonero austriacae-Caricetum humilis* is described. The semi-dry grasslands of the study area previously classified as *Onobrychido-Brometum* are described as new association *Filipendulo vulgaris-Brometum erecti* and assigned to the *Cirsio-Brachypodium*. The *Anthoxantho-Agrostietum tenuis* is reported for Austria for the first time, and its syntaxonomy is discussed within a broader geographical context.

Keywords: Austria, *Caricion davallianae*, *Festuco-Brometea*, *Molinio-Arrhenatheretea*, vegetation classification, *Violin caninae*.

Erweiterte deutsche Zusammenfassung am Ende des Textes

1. Introduction

In the first part of this series (WILLNER et al. 2013), we presented a numerical classification of the Pannonian grasslands of eastern Austria and southern Moravia using a data set of 3384 relevés. While this analysis provided a general picture of the floristic gradients and resulted in groups that were well interpretable in terms of site conditions, it was only a starting point for our envisaged aim of a syntaxonomic revision of the Pannonian grasslands of Austria at the level of associations and subassociations. Considering the enormous diversity of these grasslands, we decided to split the data set into regional subsets and elaborate a full classification for each of these subsets. The final step, which hopefully will be reached in a not too distant future, will be a synthesis of the regional classifications within a broader geographical context.

In this second part of the series, we present a detailed classification of the grasslands of the Vienna Woods (Wienerwald). This region, although geographically belonging to the Alps, has strong floristic affinities to the Pannonian Basin. The eastern slopes of the Vienna Woods are a hotspot of xero-thermophytic vegetation and exhibit the highest vascular plant species richness in Austria at the scale of the floristic mapping ($3' \times 5'$; NIKLFELD et al. 2008). Moreover, the grasslands of the Vienna Woods are among the best preserved ones in Austria (SUSKE et al. 2003), and due to extensive field work during the last decades they are also among the best documented ones.

The older phytosociological studies mostly focused on the dry grasslands along the eastern margin of the study area (WAGNER 1941, WENDELBERGER 1953, NIKLFELD 1964). KUYPER et al. (1978) published a few relevés of wet meadows from the Vienna Woods, and HUNDT & HÜBL (1983) presented the first study of mesic meadows in the region. Important contributions were also provided by KARRER (1985a, b). Since the 1980s, an impressive amount of data has been collected (largely in unpublished Master theses) but a consistent classification of these grasslands has not been achieved yet. With the declaration of the Vienna Woods as UNESCO Biosphere Reserve in 2005, and subsequent plans for a complete inventory and mapping of the area, establishing a functional classification of the grassland types of the Vienna Woods became an urgent task. At the same time, serious inconsistencies in the initial mapping of EU habitat types within the region were detected. Taken together, this gave the impetus to the present study and the whole series.

2. Study area

The Vienna Woods (Wienerwald) represent the north-eastern foothills of the Alps (Fig. 1), belonging to the geological units of the Flysch zone (in the north and west), and the Northern Limestone Alps (in the south-east), with some areas of "subalpine" molasse at the edges. The altitude ranges between 200 and 893 m a.s.l. Climatically and biogeographically, the Vienna Woods are a transition zone between the Central European and the Pannonian region. Mean annual temperature ranges from 6 to 10 °C, with the eastern slopes being among the warmest parts of Austria. The mean annual precipitation ranges from 600 mm at the eastern slopes to 900 mm on the highest peaks. About 60% of the Vienna Woods are covered by forests (mostly beech and oak-hornbeam forests). Nevertheless, the region is an important grassland area with a high diversity of dry, semi-dry, mesic, and wet grasslands.

The Vienna Woods are separated from the main body of the Northern Limestone Alps by a conspicuous valley running in east-west direction (Triesting-Gölsental). South of this valley, the Limestone Alps rapidly rise in height, and the alpine belt is reached on Mount

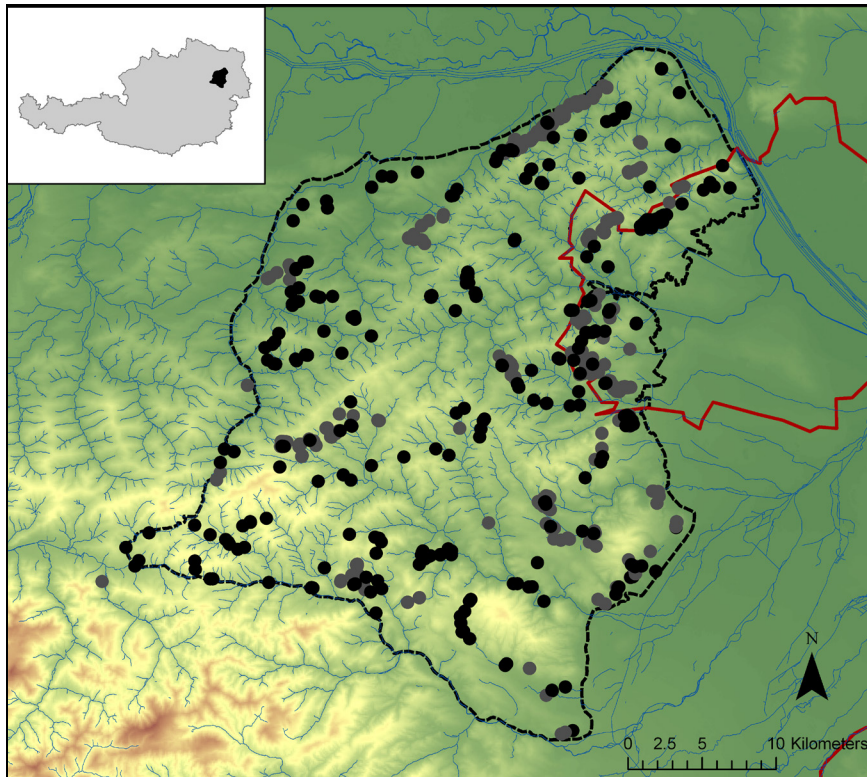


Fig. 1. Map of the study area with the location of the sample plots (grey: before 2005, black: 2005–2010). The dashed black line marks the border of the Biosphere Reserve Vienna Woods, the red lines are political borders of federal states.

Abb. 1. Karte des Untersuchungsgebiets und Lage der Vegetationsaufnahmen (grau: vor 2005, schwarz: 2005–2010). Die gestrichelte schwarze Linie markiert die Grenze des Biosphärenparks Wienerwald, die roten Linien sind Bundeslandgrenzen.

Schneeberg (2076 m a.s.l.), towering above the southern end of the Vienna Basin. The eastern part of the Gutenstein Alps and the Vienna Woods are subsumed as the forest ecoregion “Thermalalpen”, which is characterised by a Pannonian type of climate (KILIAN et al. 1994). The western border of this ecoregion is defined by the distribution limit of natural *Pinus nigra* forests. The name “Thermalalpen” refers to a line of hot springs (called “Thermalinie”) along the western margin of the Vienna Basin. In contrast to the Vienna Woods, the grasslands of the Gutenstein Alps are only poorly documented. The percentage of non-forest vegetation, however, is much lower in this area.

3. Material and methods

3.1 Field sampling

Between 2005 and 2010, more than 250 new relevés have been sampled in the Biosphere Reserve Vienna Woods for various projects. The major part was sampled in May and June 2010 for the Man & Biosphere project “Diversity and conservation value of the meadows and dry grasslands in the Bio-

sphere Reserve Vienna Woods”, which was led by the first author. The sampling design was semi-subjective as we used a stratified random selection of the grassland patches based on an unpublished GIS layer which included a rough classification of the grasslands within the Biosphere Reserve into six ecological types. Within each selected grassland patch, one or several relevé plots were located subjectively. We used a modified Braun-Blanquet scale solely based on cover (r: -0.2%, +: -1%, 1: -5%, 2a: -15%, 2b: -25%, 3: -50%, 4: - 75%, 5: -100%). Bryophytes and lichens could not be considered due to time and budget constraints.

3.2 Data preparation

The newly sampled data were combined with all available grassland relevés of the Pannonian region of Austria and adjacent areas, resulting in a data set of 3384 relevés (including 1055 from the Vienna Woods, 1664 from other parts of the Pannonian region of Austria, 98 from the Northern Limestone Alps of western Lower Austria and 567 from southern Moravia). We defined grasslands as all types of meadows, pastures and primary steppes. We also included fens but we excluded fringe vegetation and reed beds (see WILLNER et al. 2013 for details of the data set).

The taxonomic resolution of taxa was unified prior to the analysis (see WILLNER et al. 2013 for details). We excluded cryptogams from the analysis because they were determined in only 40% of the relevés. The most frequent cryptogam species were included in the table again after the numerical classification. Constancy values of the latter were calculated on the basis of the subset of relevés in which these plants were recorded. The taxonomy of species follows FISCHER et al. (2008) for vascular plants, FREY et al. (1995) for bryophytes and WIRTH (1995) for lichens.

3.3 Data analysis and table work

The total set of 3384 relevés was classified with TWINSpan (HILL 1979), resulting in 60 clusters (WILLNER et al. 2013). In the following, this classification is referred to as TPA (“TWINSpan classification of all Pannonian grasslands of Austria”). In the next step, clusters for which no ecological or geographical difference could be detected were merged, and relevés that were considered as misclassified at the level of alliances according to the summarised cover of the diagnostic species given in MUCINA et al. (1993) were manually re-arranged to the floristically and geographically most fitting cluster of the appropriate alliance. From this table, an excerpt containing only the relevés of the Vienna Woods was used for the present study. We re-classified the relevés preliminary labelled as *Arrhenatherion* with another TWINSpan run (cut levels: 0, 2, 5 and 25; minimum group size: 5; maximum level of divisions: 4) because the *Arrhenatherion* grasslands of the Vienna Woods corresponded to only two clusters in the TPA (clusters 32 and 34; see WILLNER et al. 2013) and a considerable number of relevés originally included in other clusters had been re-arranged to one of these two clusters. Again, clusters for which no ecological difference could be detected were merged.

The final delimitation of associations and subassociations was achieved by adjusting their diagnostic species so as to get units that were most informative in terms of environmental conditions. The association concept follows WILLNER (2006). Where appropriate, central associations were used in order to avoid definition gaps. This fine-tuning of the classification included further re-arrangement of individual relevés between clusters, the abandonment of some smaller clusters (i.e., all included relevés were re-arranged to other clusters) as well as the manual splitting of the heterogenous TPA cluster 30. All re-arrangements were based on the summarised cover of diagnostic species within individual relevés. A summarised cover of < 1% was considered as absence of the diagnostic species group (WILLNER 2011).

A species was considered as diagnostic for a syntaxon if its constancy ratio (CR) was ≥ 2 , i.e., if the constancy of the species in a unit was at least twice as high as in any other unit of the same rank within the next higher hierarchical level (DENGLER 2003). A species with $CR < 2$ was considered diagnostic if its total cover (= average cover taking also into account zero values) was $> 12\%$ and its total cover ratio (TCR) was ≥ 2 , i.e., if its total cover in this unit was at least twice as high as in any other unit of the same rank within the next higher hierarchical level (WILLNER et al. 2009). Species with constancy

< 20% were only exceptionally accepted as diagnostic. The diagnostic species of higher syntaxa were calculated on the basis of average values among the included basic units (associations and subassociations). Shared diagnostic species (i.e., species reaching the CR or TCR threshold in a group of two or more units against all other units of the same rank within the next higher hierarchical level) were also allowed, but usually the assignment as diagnostic species of a higher syntaxon was preferred. In a few cases, species marginally missing the CR or TCR threshold in the regional data set were nevertheless accepted as diagnostic based on the preliminary analysis of the more comprehensive data set used in part I of this series.

On the basis of the synoptic table, a simplified field determination key for the mapping of the distinguished vegetation units was developed, which can also be used for the assignment of new relevés. For the comparison of association 4.1 (*Anthoxantho-Agrostietum tenuis*) with pre-classified relevés from neighbouring countries, a DCA (detrended correspondence analysis) was performed using the CANOCO 4.5 program. All calculations and table manipulations were done with JUICE 7.0 (TICHÝ 2002).

4. Results and syntaxonomic discussion

4.1 TWINSPAN classification of mesic grasslands

The TWINSPAN classification of relevés preliminary classified as *Arrhenatherion* resulted in 13 clusters which are numbered with capital letters to avoid confusion with the TPA clusters (Table 1). Clusters A–C include ruderal *Arrhenatherum* meadows with *Elymus repens* and *Lolium perenne* grasslands. Most of these relevés were originally classified together with grasslands of the Danube floodplain (TPA cluster 33). Cluster D includes species-poor *Arrhenatherum* meadows on strongly fertilised soils, and cluster E meadows on fertilised and temporarily wet soils which are dominated by *Alopecurus pratensis* or *Poa trivialis* while *Arrhenatherum* is mostly absent. Both types were included in TPA cluster 34. Clusters F–G comprise nutrient-poor grasslands on moist and moderately acidic soils with *Agrostis capillaris*, *Carex pallescens* and *Viola canina*, which mostly originate from TPA cluster 35. Clusters H–I represent *Arrhenatherum* meadows on less fertilised and temporarily moist soils of the Flysch zone, which were included in TPA cluster 34, and clusters J–M comprise drier *Arrhenatherum* meadows on calcareous soils, which were mostly represented in TPA cluster 32.

4.2 Syntaxonomic overview

Altogether, 22 grassland associations are distinguished within the area of the Vienna Woods. Some of them, however, are very rare and represented by just a few relevés. In particular, the alliance *Festucion valesiaca* occurs only marginally in the Vienna Woods. The following overview shows the position of the associations in the syntaxonomic system. Classes and orders follow MUCINA et al. (1993) and GRABHERR & MUCINA (1993). The assignment of associations to alliances (All.) follows these references, too, except for *Seslerio-Festucion pallentis* and *Cirsio-Brachypodium* (see WILLNER et al. 2013 for a discussion of these units). The syntaxonomic position of association 4.1, which is reported for Austria for the first time, is discussed in section 4.4. Alliances are numbered consecutively, and associations are numbered with a two-digit code starting with the alliance number. Nomenclatural remarks are given in Appendix S1.

Table 1. TWINSpan classification of the mesic grasslands of the Vienna Woods. Only a selection of species diagnostic for one or several units is shown. Values are percentage constancies. When a species reaches a total cover of >12%, then the constancy is given in bold. Diagnostic species are highlighted in grey (species marked with * are diagnostic only against certain groups).

Tabelle 1. TWINSpan-Klassifikation der Frischwiesen im Wienerwald. Dargestellt ist eine Auswahl jener Arten, die diagnostisch für eine oder mehrere Gesellschaften sind. Stetigkeitswerte in Prozent (bei einer totalen Deckung von >12 % fett). Die diagnostischen Arten sind grau hervorgehoben (mit * gekennzeichnete Arten differenzieren nur gegen bestimmte Gruppen).

TWINSpan cluster	A	B-C	D	E	F-G	H-I	J-M
Number of relevés	3	17	122	39	90	89	74
TWINSpan hierarchy	1	1	1	1	0	0	0
	1	0	0	0	1	1	0
		1	0	0	1	0	
			1	0			
Peucedanum alsaticum	100	6	.	.	.	.	2
Falcaria vulgaris	67	12	.	.	.	.	4
Lolium perenne	.	47	10	10	3	4	7
Plantago major *	.	29	7	15	1	2	1
Cardaria draba	.	12	.	.	.	.	.
Elymus repens	67	59	8	3	7	2	5
Artemisia vulgaris	67	35	1	.	.	.	5
Convolvulus arvensis	33	47	16	3	4	7	15
Poa trivialis	.	18	66	72	25	13	6
Alopecurus pratensis	.	29	50	74	25	18	7
Ranunculus repens	.	24	22	49	3	2	.
Lysimachia nummularia *	.	.	13	41	21	13	1
Lychnis flos-cuculi *	.	.	11	28	24	13	1
Betonica officinalis	.	.	9	15	68	26	14
Carex pallescens *	.	.	4	36	65	2	.
Galium boreale	.	6	6	18	60	20	4
Agrostis capillaris	.	.	5	15	48	11	.
Knautia drymeia	.	6	7	.	32	8	.
Galium pumilum	.	.	.	5	21	6	3
Viola canina	.	.	.	3	17	4	.
Holcus lanatus	.	.	51	74	95	91	12
Cynosurus cristatus	.	6	24	54	73	49	3
Filipendula vulgaris *	.	6	27	38	82	71	20
Festuca rupicola	.	6	3	.	11	25	51
Onobrychis viciifolia	.	24	.	.	.	4	38
Bupthalmum salicifolium	.	.	.	.	4	6	23
Plantago media *	.	29	3	3	7	16	54
Centaurea scabiosa	.	53	2	.	3	8	53
Bromus erectus	.	18	21	.	78	87	91
Salvia pratensis	.	18	13	.	8	48	85
Primula veris	.	.	6	5	39	38	34
Ranunculus bulbosus	.	35	29	8	23	34	44
Arrhenatherum elatius	100	71	89	21	52	87	85

- Class *Festuco-Brometea* Br.-Bl. & Tx. 1943
- Order *Stipo-Festucetalia pallentis* Pop 1968
- All. (1) *Seslerio-Festucion pallentis* Klika 1931 corr. Zólyomi 1966
- (1.1) *Drabo aizoidis-Seslerietum albicantis* Mucina 1993
- (1.2) *Fumano-Stipetum eriocaulis* Wagner 1941 corr. Zólyomi 1966
- (1.3) *Scorzonero austriacae-Caricetum humilis* Willner ass. nov. (see below)
- Order *Festucetalia valesiacae* Br.-Bl. & Tx. 1943
- All. (2) *Festucion valesiacae* Klika 1931
- (2.1) *Stipo capillatae-Festucetum valesiacae* Sillinger 1930
- (2.2) *Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1959
- (2.3) *Medicagini-Festucetum valesiacae* Wagner 1941
- Order *Brometalia erecti* Koch 1926
- All. (3) *Cirsio-Brachypodion* Hadač & Klika 1944
- (3.1) *Polygalo-Brachypodietum* Wagner 1941
- (3.2) *Filipendulo vulgaris-Brometum* Hundt & Hübl ex Willner ass. nov. (see below)
- (3.3) *Euphorbio verrucosae-Caricetum montanae* Karrer 1985
- Class *Calluno-Ulicetea* Br.-Bl. & Tx. 1943
- Order *Nardetalia* Oberd. ex Preising 1949
- All. (4) *Violion caninae* Schwickerath 1944
- (4.1) *Anthoxantho-Agrostietum tenuis* Sillinger 1933
- Class *Molinio-Arrhenatheretea* Tx. 1937
- Order *Arrhenatheretalia* Tx. 1931
- All. (5) *Arrhenatherion* Koch 1926
- (5.1) *Ranunculo bulbosi-Arrhenatheretum* Ellmauer 1993
- (5.2) *Filipendulo vulgaris-Arrhenatheretum* Hundt & Hübl ex Ellmauer 1995
- (5.3) *Pastinaco-Arrhenatheretum* Passarge 1964
- (5.4) *Ranunculo repentis-Alopecuretum pratensis* Ellmauer 1993
- All. (6) *Cynosurion* Tx. 1947
- (6.1) *Plantagini-Lolietum* Beger 1932
- (6.2) *Cynosuro-Lolietum* Br.-Bl. & De Leeuw 1936
- Order *Molinietalia* Koch 1926
- All. (7) *Molinion* Koch 1926
- (7.1) *Succiso-Molinietum* (Kovács 1962) Soó 1969
- All. (8) *Calthion* Tx. 1937
- (8.1) *Cirsietum rivularis* Nowiński 1928
- (8.2) *Scirpetum sylvatici* Rałski 1931
- Order *Potentillo-Polygonetalia* Tx. 1947
- All. (9) *Potentillion anserinae* Tx. 1947
- (9.1) *Mentho-Juncetum inflexi* Lohmeyer ex Oberd. 1957
- Class *Scheuchzerio-Caricetea fuscae* Tx. 1937
- Order *Caricetalia davalliana* Br.-Bl. 1949
- All. (10) *Caricion davalliana* Klika 1934
- (10.1) *Caricetum davalliana* Dutoit 1924
- (10.2) *Junco subnodulosi-Schoenetum nigricantis* Allorge 1921

4.3 Description of the associations

In the following, all grassland associations of the Vienna Woods are described and their syntaxonomy is discussed. Synonyms are only given if they were used in MUCINA et al. (1993) or an important regional monograph. “Incl.” refers to syntaxonomic synonyms, i.e. valid names of associations that we include into more broadly defined associations. “Nom. corresp.” (*nomen correspondens*) refers to names of subassociations that have the same syntaxonomic content as the association described. Type relevés are given if they are located in the Vienna Woods. The regionally diagnostic and most frequent species are shown in a synoptic table (Table 2 in the supplement, for data sources see Appendix S2). Supra-regional diagnostic species are partly mentioned in the text. Newly sampled relevés are given in Tables 3–9 in the supplement (note that these relevés do not represent the “most typical” stands but document previously unsampled grassland patches; for additional header data see Appendix S3). In Appendix 1, a field determination key for the grassland types is presented (excluding units 2.3, 6.1, 6.2, 8.2 and 10.2 because their floristic composition could not be evaluated with certainty due to insufficient documentation in the data set). Alternatively to the full list of diagnostic species given in Table 2 in the supplement, this key may also be used for the assignment of new relevés. The correspondence between TWINSPAN clusters and the final classification is given in Table 10 in the supplement.

(1.1) *Drabo aizoidis-Seslerietum albicantis* Mucina 1993

(Table 2: 1)

(Incl. *Drabo lasiocarpae-Dianthetum neilreichii* Niklfeld 1993)

Typus: KARRER (1985a, Table 1, relevé 3) (holotypus).

On steep north-facing cliffs of the Vienna Woods, small patches of *Sesleria caerulea* grasslands can be found. Up to now, this community type has been documented from only three localities: Gießwände near Gießhübl, Mödlinger Klause, and Peilstein. The grasslands of this unit were included in three different TPA clusters: Cluster 1 (two relevés from Gießwände), cluster 7 (including relevés from all three localities as well as the *Fumano-Stipetum minutetosum setaceae*, which is described below) and cluster 12 (four relevés from Peilstein). According to MUCINA & KOLBEK (1993), the *Sesleria* grasslands of the Vienna Woods belong to two different associations: *Drabo aizoidis-Seslerietum* and *Drabo lasiocarpae-Dianthetum neilreichii*, the latter named after the steno-endemic *Dianthus plumarius* subsp. *neilreichii*, which occurs only in the surrounding of Mödling. In contrast to this concept, we consider all three localities as variants of only one association. The outlier position of some of its relevés in the TWINSPAN classification can be explained by the relatively small number of thermophilous species. However, put together, the unit shows a quite homogenous picture (Table 2 in the supplement). The *Fumano-Stipetum laserpitietosum sileris* described from the mountain Hohe Wand by NIKLFELD (1964) probably also belongs here. In Slovakia and the Czech Republic, a similar community type is known as *Saxifrago paniculatae-Seslerietum* (CHYTRÝ 2007, JANIŠOVÁ 2007). The relationship between the *Drabo aizoidis-Seslerietum* of the Vienna Woods and other submontane *Sesleria caerulea* grasslands in the Alps, the Carpathians and the Bohemian Massif needs further investigation.

(1.2) *Fumano-Stipetum eriocaulis* Wagner 1941 corr. Zólyomi 1966

(Table 2: 2–3, Table 3, Fig. 2)

Typus: WAGNER (1941, Assoziationstabelle 1, rel. 6) (lectotypus MUCINA & KOLBEK 1993).

The calcareous rocky grasslands on dry south-facing slopes of the Vienna Woods are known as *Fumano-Stipetum eriocaulis* (MUCINA & KOLBEK 1993). The herb layer is usually rather open, and in early spring many annual species can be found. The late-spring aspect is dominated by the feathery inflorescences of *Stipa eriocaulis*. This community type corresponds to the TPA clusters 8 and 9 (the latter being transitional towards the next association). Differential species against the *Poo badensis-Festucetum pallentis* of the Hainburg and Pavlov hills, which was also included in TPA cluster 8 (see WILLNER et al. 2013), are *Festuca stricta*, *Pulsatilla grandis*, *Globularia cordifolia*, *Galium lucidum*, *Leontodon incanus*, *Allium sphaerocephalon*, *Ononis pusilla* and *Polygonatum odoratum*. *Stipa eriocaulis* occurs in the Hainburg Hills but is absent from other localities of the *Poo badensis-Festucetum pallentis*. *Festuca stricta* subsp. *stricta*, which replaces *Festuca pallens* in this community, is regarded as an Austrian endemic (FISCHER et al. 2008). If the gravel grasslands of the southern Vienna Basin (TPA clusters 5–6) are included in the *Fumano-Stipetum eriocaulis* (SAUBERER & BUCHNER 2001), *Festuca stricta* subsp. *stricta* is an absolute character taxon of this association.

On south-facing rocky outcrops, pioneer grasslands can be found, which were described as subassociation (1.2a) *Fumano-Stipetum minuartietosum setaceae* by KARRER (1985a). This unit, which is only known from two localities (Mödlinger Klause, Hauerberg near Bad Vöslau), was included in TPA cluster 7. Differential species against the typical subassociation (1.2b) are: *Seseli austriacum*, *Hieracium glaucum*, *Euphorbia saxatilis*, *Minuartia setacea*, *Cardaminopsis petraea*, *Aethionema saxatile*, *Biscutella laevigata*, *Erysimum sylvestre*.



Fig. 2. Stand of the *Fumano-Stipetum eriocaulis* in the nature reserve “Glaslauerriegel-Heferlberg” near Gumpoldskirchen (Photo: N. Sauberer, 20 May 2012).

Abb. 2. Bestand des *Fumano-Stipetum eriocaulis* im Naturschutzgebiet „Glaslauerriegel-Heferlberg” bei Gumpoldskirchen (Foto: N. Sauberer, 20.05.2012).

(1.3) *Scorzonero austriacae-Caricetum humilis* Willner ass. nov. hoc loco

(Table 2: 4, Table 3, Fig. 3)

(Syn.: *Polygalo majoris-Brachypodietum* auct. non Wagner 1941)

Typus: WENDELBERGER (1953, rel. 14) (holotypus hoc loco).

Type relevé: G. Wendelberger, ca. 1950, Perchtoldsdorfer Heide, 48.12245° N, 16.25013°E, 320 m, E, 0–5°; plot size: 21.54 m²; cover of herb layer: 100%, cover of moss layer: 10%.

Bromus erectus 3, *Carex humilis* 3, *Anthyllis vulneraria* 2, *Dorycnium germanicum* 2, *Galium austriacum* 2, *Inula hirta* 2, *Sesleria caerulea* 2, *Anthericum ramosum* 1, *Bupleurum falcatum* 1, *Genista pilosa* 1, *Inula ensifolia* 1, *Leontodon incanus* 1, *Phyteuma orbiculare* 1, *Polygala amara* 1, *Rhytidium rugosum* 1, *Scabiosa canescens* 1, *Thesium linophyllum* 1, *Abietinella abietina* +, *Asperula cynanchica* +, *Asperula tinctoria* +, *Avenula pubescens* +, *Briza media* +, *Campanula glomerata* +, *Campylium stellatum* +, *Centaurea scabiosa* +, *Chamaecytisus ratisbonensis* +, *Daphne cneorum* +, *Epipactis helleborine* +, *Euphorbia cyparissias* +, *Festuca stricta* +, *Gentianella austriaca* +, *Globularia cordifolia* +, *Helianthemum canum* +, *Helianthemum nummularium* subsp. *obscurum* +, *Hieracium pilosella* +, *Hippocrepis comosa* +, *Homalothecium lutescens* +, *Hypnum cupressiforme* +, *Linum flavum* +, *Linum tenuifolium* +, *Pimpinella saxifraga* +, *Plantago media* +, *Polygala chamaebuxus* +, *Potentilla incana* +, *Prunella grandiflora* +, *Pulsatilla grandis* +, *Sanguisorba minor* +, *Scabiosa ochroleuca* +, *Scorzonera austriaca* +, *Scorzonera purpurea* +, *Senecio jacobaea* +, *Seseli annuum* +, *Seseli hippomarathrum* +, *Teucrium montanum* +, *Thymus praecox* +, *Tortella tortuosa* +, *Vincetoxicum hirundinaria* +.



Fig. 3. Stand of the *Scorzonero austriacae-Caricetum humilis* near Perchtoldsdorf (Photo: N. Sauberer, 28 May 2012).

Abb. 3. Bestand des *Scorzonero austriacae-Caricetum humilis* auf der Perchtoldsdorfer Heide (Foto: N. Sauberer, 28.05.2012).

These grasslands occur on less steep slopes, where several species of the *Fumano-Stipetum eriocaulis* are absent or very rare (e.g., *Festuca stricta*, *Stipa eriocaulis*, *Fumana procumbens*, *Allium sphaerocephalon*) while species preferring deeper soils, such as *Adonis vernalis*, *Stipa joannis*, *Festuca rupicola* and *Prunella grandiflora*, are common. The stands are mostly dominated by *Carex humilis* (total cover: 20%) but *Bromus erectus* can also reach higher cover values (total cover: 15%). WENDELBERGER (1953) and SIX (1986) classified such stands as *Polygalo majoris-Brachypodietum*, which is an association of semi-dry grasslands (see below), but both the TWINSPAN result (TPA clusters 9–11) and the summarised cover of diagnostic species indicated that unit 1.3 is more closely related to rocky grasslands and belongs to the *Seslerio-Festucion pallentis*. A comparison with the *Carex humilis* grasslands of Slovakia (JANIŠOVÁ & DÚBRAVKOVÁ 2010) shows that this community is most similar to the *Orphantho luteae-Caricetum humilis* Kliment & Bernátová 2000 (Table 11). However, these two units are also distinguished from each other by numerous differential species. Therefore, we describe the *Carex humilis* grasslands of the eastern margin of the Alps as a new association. Its most typical stands occur in the limestone part of the Vienna Woods, e.g. at the *locus classicus* Perchtoldsdorfer Heide, where it is the dominant grassland type. The relevés 13 and 47 in WILLNER et al. (2004), originally classified as *Fumano-Stipetum eriocaulis*, belong here, too.

On some north-facing slopes, *Sesleria caerulea* becomes dominant, and *Phyteuma orbicularis* has a higher frequency. This type was described as “*Polygalo-Brachypodietum phyteumetosum orbicularis*” by SIX (1986) but the existing data are not sufficient to decide about the status of this subassociation. A more deviating type can be found on marl on the steep southern slopes of Leopoldsberg and Bisamberg (PFUSTERSCHMID 1998, ZUKRIGL 2005).

(2.1) *Stipo capillatae-Festucetum valesiacae* Sillinger 1930 nom. invers. prop.
(Table 2: 5, Table 3)

(Incl. *Ranunculo illyrici-Festucetum valesiacae* Klika 1931; nom. corresp.: *Medicagini-Festucetum valesiacae iridetosum pumilae* Wagner 1941)

This association includes the *Festuca valesiaca* grasslands on limestone in the north-western part of the Pannonic region (DÚBRAVKOVÁ et al. 2010). The best developed examples in Austria can be found in the Leiser Berge (Weinviertel) and on the eastern slope of Leithagebirge (Northern Burgenland). In the Vienna Woods, the association occurs only in the surrounding of the village Gießhübl, where it grows on Jurassic limestone. The presence of *Trifolium arvense* indicates that the soil is slightly acidic. This is also underlined by the fact that two of the three relevés from this locality were included in TPA cluster 19, which corresponds to the more acidic *Avenulo pratensis-Festucetum valesiacae* (see WILLNER et al. 2013). The precise delimitation between these two *Festuca valesiaca* dominated associations has still to be elaborated. However, we think that for the Gießhübl grasslands the inclusion into the basiphilous *Stipo capillatae-Festucetum valesiacae* is more reasonable.

(2.2) *Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1959
(Table 2: 6, Fig. 4)

On the hill Eichkogel near Mödling, there are loess grasslands which can be classified as *Salvio nemorosae-Festucetum rupicolae*. The hill is composed of Tertiary sediments of the Vienna Basin but geographically belongs to the Vienna Woods. The *Salvio-Festucetum rupicolae* is very similar to the *Astragalo exscapi-Crambetum* Klika 1939 and was treated as

Table 11. Synoptic table of the *Carex humilis* grasslands of the Vienna Woods and the Western Carpathians. 1: *Scorzonero austriacae-Caricetum humilis* (Sa-C; Table 2, col. 4 in this paper); 2: *Orphantho luteae-Caricetum humilis* (Ol-C; JANIŠOVÁ & DÚBRAVKOVÁ 2010: Table 3, col. 3); 3: *Festuco pallentis-Caricetum humilis* (Fp-C; JANIŠOVÁ & DÚBRAVKOVÁ 2010: Table 3, col. 2); 4: *Poo badensis-Caricetum humilis* (Pb-C; JANIŠOVÁ & DÚBRAVKOVÁ 2010: Table 3, col. 5). Countries: AT: Austria, SK: Slovakia. Values are percentage constancies. Diagnostic species are shaded. Other species are only shown if they reach 60% constancy in at least one column. Within groups, the species are sorted by decreasing frequency.

Tabelle 11. Synoptische Tabelle der *Carex humilis*-Rasen des Wienerwalds und der Westkarpaten. Legende der Spaltennummern siehe oben. AT: Österreich, SK: Slowakei. Die Werte geben die Stetigkeit in Prozent wieder. Diagnostische Arten sind grau hinterlegt. Weitere Arten sind nur dargestellt, wenn sie zumindest in einer Spalte 60 % Stetigkeit erreichen. Innerhalb der Gruppen sind die Arten nach abfallender Häufigkeit sortiert.

Column number	1	2	3	4
Country	AT	SK	SK	SK
Number of relevés	76	20	57	41
Association	Sa-C	Ol-C	Fp-C	Pb-C
Scorzonero austriacae-Caricetum humilis				
Dorycnium pentaphyllum agg.	96	25	35	20
Inula ensifolia	96	35	42	39
Bupleurum falcatum	88	10	19	20
Bromus erectus	84	20	4	2
Pulsatilla grandis	76	5	12	12
Aster linosyris	75	.	.	.
Chamaecytisus ratisbonensis	72	.	.	.
Seseli annuum	66	20	.	2
Scabiosa canescens	63	.	.	.
Sesleria albicans	61	15	16	7
Globularia cordifolia	54	.	.	.
Adonis vernalis	53	.	.	.
Odontites luteus	53	15	.	.
Prunella grandiflora	53	25	.	.
Inula hirta	46	.	16	2
Seseli hippomarathrum	42	.	.	.
Scorzonera purpurea	38	.	.	.
Leontodon hispidus	32	10	.	2
Senecio jacobaea	30	.	.	.
Aster amellus	22	.	.	.
Peucedanum cervaria	22	5	2	.
Polygala chamaebuxus	22	.	.	.
Orphantho luteae-Caricetum humilis				
Potentilla heptaphylla	.	95	40	.
Hippocrepis comosa	4	90	19	10
Dianthus carthusianorum agg.	7	55	2	17
Carex caryophyllea	4	50	7	10
Bromus monocladus	.	45	2	.
Knautia kitaibelii	.	40	.	.
Viola hirta	14	40	5	17
Salvia verticillata	5	35	4	2
Trifolium montanum	5	35	.	.
Polygala major	8	30	.	2
Galium pumilum agg.	4	25	4	.
Ranunculus bulbosus	.	20	4	7

Column number	1	2	3	4
Scorzonero austriacae-Caricetum humilis & Orthantho luteae-Caricetum humilis				
Plantago media	71	85	5	.
Festuca rupicola	68	80	5	10
Genista pilosa	76	70	33	7
Pimpinella saxifraga agg.	70	70	18	12
Centaurea scabiosa	74	60	18	7
Thesium linophyllum	83	45	7	12
Lotus corniculatus agg.	51	65	4	10
Brachypodium pinnatum	42	65	2	7
Linum catharticum	50	45	5	2
Briza media	50	35	.	.
Carlina acaulis	42	40	7	.
Festuco pallentis-Caricetum humilis				
Alyssum montanum	.	10	65	29
Fumana procumbens	16	.	63	.
Silene otites s.lat.	3	.	42	5
Stipa joannis	16	.	35	12
Arenaria serpyllifolia agg.	1	5	30	15
Sedum album	.	.	30	2
Campanula rotundifolia agg.	3	10	26	5
Poo badensis-Caricetum humilis				
Stachys recta	12	5	16	51
Allium flavum	11	.	23	51
Eryngium campestre	18	.	9	44
Festuca valesiaca	4	5	14	41
Acinos arvensis	.	5	18	39
Verbascum lychnitis	.	.	.	39
Echium vulgare	1	10	12	37
Artemisia campestris	.	.	5	37
Lactuca perennis	.	.	.	37
Asplenium ruta-muraria	.	.	5	34
Sedum acre	.	5	7	32
Veronica spicata	.	10	9	29
Veronica austriaca	.	.	4	20
Festuco pallentis-Caricetum humilis & Poo badensis-Caricetum humilis				
Festuca pallens	.	10	81	59
Seseli osseum	.	15	65	71
Campanula sibirica	1	.	37	78
Jovibarba globifera s.lat.	1	15	44	66
Melica ciliata	4	5	42	61
Poa badensis	.	.	23	54
Stipa pulcherrima	8	5	25	32
Other differential species				
Linum tenuifolium	76	35	81	20
Scorzonera austriaca	57	.	53	7
Allium senescens ssp. montanum	33	5	23	10
Thymus pannonicus agg.	56	.	2	49
Leontodon incanus	43	50	72	.
Salvia pratensis	34	60	9	44
Helianthemum canum	61	10	37	29
Globularia punctata	7	80	68	5
Hieracium pilosella	11	30	42	5
Thymus praecox	13	55	95	32
Hieracium bauhinii	1	40	51	32
Koeleria macrantha	8	50	23	46

Column number	1	2	3	4
Constant non-differential species				
<i>Carex humilis</i>	97	100	100	100
<i>Teucrium chamaedrys</i>	71	80	54	95
<i>Euphorbia cyparissias</i>	68	80	75	68
<i>Sanguisorba minor</i>	87	80	95	27
<i>Asperula cynanchica</i>	78	65	68	73
<i>Helianthemum nummularium</i> s.lat.	84	70	68	59
<i>Anthericum ramosum</i>	80	75	63	56
<i>Teucrium montanum</i>	79	30	88	73
<i>Potentilla incana</i>	67	20	54	100
<i>Anthyllis vulneraria</i>	78	65	51	37
<i>Scabiosa ochroleuca</i>	67	25	39	44

a synonym of the latter by MUCINA & KOLBEK (1993). However, they do not mention the locality Eichkogel in their description of *Astragalo exscapi-Crambetum*. The numerical classification of a large supra-national data set suggested that these two communities should be treated as separate associations (DÚBRAVKOVÁ et al. 2010). Although we were not able to reproduce this result in our own TWINSpan classification (both types were mixed together in TPA clusters 23f–g, see WILLNER et al. 2013), we accept the *Salvio nemorosae-Festucetum rupicolae* as a separate unit because *Astragalus exscapus* and *Crambe tatarica* are both indicators of disturbed sites (CHYTRÝ 2007: 425) and are absent from the majority of Pannonian loess grasslands. However, a definite solution to this question remains a task for



Fig. 4. Stand of the *Salvio nemorosae-Festucetum rupicolae* on the hill Eichkogel near Mödling (Photo: N. Sauberer, 21 May 2012).

Abb. 4. Bestand des *Salvio nemorosae-Festucetum rupicolae* am Eichkogel bei Mödling (Foto: N. Sauberer, 21.05.2012).

future studies. The best examples of loess grasslands in Austria can be found in Weinviertel. Supra-regional differential species against the *Stipo capillatae-Festucetum valesiaca* are *Salvia nemorosa*, *Astragalus austriacus*, *Taraxacum serotinum*, *Bromus inermis*, *Viola ambigua*, *Seseli pallasii*, *Oxytropis pilosa*, *Chamaecytisus austriacus* and others. Most of these species also occur on Eichkogel.

(2.3) *Medicagini-Festucetum valesiaca* Wagner 1941

(Table 2: 7)

Typus: WAGNER (1941, Assoziationstabelle 2, rel. 5) (lectotypus MUCINA & KOLBEK 1993).

In his classical paper on the dry grasslands along the Eastern margin of the Alps, WAGNER (1941) included all *Festuca valesiaca* grasslands in a new association *Medicagini-Festucetum valesiaca*. He distinguished three subassociations: *M.-F. helianthemetosum cani* (which includes the nomenclatural type of the association), *M.-F. iridetosum pumilae*, and *M.-F. agropyretosum repentis*. We include the *M.-F. iridetosum pumilae* in the *Stipo capillatae-Festucetum valesiaca* (see above) as already suggested by MUCINA & KOLBEK (1993). However, the syntaxonomic position of the two other subassociations is less obvious. The *M.-F. helianthemetosum cani* contains a lot of *Seslerio-Festucion pallentis* species. Unlike the *Stipo capillatae-Festucetum valesiaca*, it occurs on dolomite soils, which probably have a higher content of clay than those of the *Seslerio-Festucion pallentis*. The relevés of this subassociation were divided between the TPA clusters 8 (corresponding to *Fumano-Stipetum eriocaulis*) and 23e (corresponding to *Stipo capillatae-Festucetum valesiaca*), indicating its transitional position. Also the summarised cover of diagnostic species gives ambiguous results, probably depending on the delimitation of the relevé plots. The *M.-F. agropyretosum repentis*, which was considered as another association *Poo angustifoliae-Festucetum valesiaca* by MUCINA & KOLBEK (1993), is only weakly differentiated. At least the two relevés from the Vienna Woods can easily be included in the *Medicagini-Festucetum valesiaca*.

However, these considerations are rather academic because the whole community has almost completely disappeared. Only small patches of a few square meters can be found which still resemble Wagner's original description, usually along tourist paths where the vegetation is frequently trampled. Most of its former localities have been overgrown by woodland. The only author who documented the *Medicagini-Festucetum valesiaca* after WAGNER (1941) was REICHENBERGER (1990). This stand has become a *Polygalo-Brachypodietum* in the meanwhile. Trampling by humans or grazing animals was probably the most important factor for the maintenance of this community as *Festuca valesiaca* is very resistant to trampling while it is readily outcompeted when higher grass and herb species become dominant.

(3.1) *Polygalo-Brachypodietum pinnati* Wagner 1941

(Table 2: 8, Table 4, Fig. 5)

(Incl. *Globulario punctatae-Caricetum michelii* Karrer 1985)

Typus: WAGNER (1941, Assoziationstabelle 3, rel. 3) (lectotypus hoc loco).

This community includes the semi-dry grasslands on base-rich soils (TPA clusters 25–28). It is rich in xero-thermophilous species such as *Dorycnium germanicum*, *Eryngium campestre*, *Bupleurum falcatum*, *Scabiosa ochroleuca*, *Asperula cynanchica*, *Peucedanum cervaria*, *Seseli annuum*, *Inula ensifolia*, *Stachys recta*, *Thymus odoratissimus*, *Potentilla incana*, *Chamaecytisus ratisbonensis*, *Aster linosyris*, *Aster amellus*, *Carex humilis*, *Pulsatilla grandis* and others, which differentiate against the two following associations. The dominant species is usually *Bromus erectus* (total cover: 27%). Higher cover of *Brachypodium pinna-*

tum usually indicates abandonment but might also be a result of past overgrazing. According to WAGNER (1941), mowing was the prevailing management practice at this time. Without management, these grasslands develop rather fast into fringe communities and subsequently into woodland. The *Polygalo-Brachypodium* is widespread in the Pannonian region, but its precise delimitation is not yet clear (ILLYÉS et al. 2007). In the Vienna Woods, it is mostly confined to the calcareous south-eastern part. A few localities are known from the northern margin of the Flysch zone, where it occurs on calcareous sandstone. The *Globulario punctatae-Caricetum michelii*, described by KARRER (1985b) from the southern Vienna Woods, has to be included in this association (and not in the *Euphorbio verrucosae-Caricetum montanae* as was suggested by MUCINA & KOLBEK 1993). The type relevé of the *Globulario punctatae-Caricetum michelii* has the highest alpha diversity among the grasslands in the Vienna Woods: 99 vascular plant species on 30 m² were recorded in this plot (KARRER 1985b: Table 10, rel. 9).

(3.2) *Filipendulo vulgaris-Brometum erecti* Hundt & Hübl ex Willner ass. nov. hoc loco (Table 2: 9, Table 4, Fig. 6)

(Syn.: *Filipendulo-Mesobrometum* Hundt & Hübl 1983 nom. inval. [Art. 3h of the ICPN (3rd ed.; WEBER et al. 2000)], *Onobrychido viciifoliae-Brometum* auct. non Müller 1966, *Cirsio pannonici-Brometum* Steinbuch 1995 nom. inval. [Art. 5])

Typus: HUNDT & HÜBL (1983, Table 4) (holotypus).

Semi-dry grasslands with a more mesic species composition are found on loamy, less base-rich soils (TPA cluster 30 p.p.). The stands are usually strongly dominated by *Bromus erectus* (total cover: 37%). This is the prevailing type of semi-dry grasslands in the Flysch zone, but it also occurs in the limestone part of the Vienna Woods, especially over clay-rich substrates such as the Gosau Formation. Despite its wide distribution in the region, this community type has not been given much attention in the literature. WAGNER (1941) mentioned it as “*Lathyrus pannonicus-Bromus erectus*-Ass. prov.”, and HUNDT & HÜBL (1983) published a single relevé under the invalid name *Filipendulo-Mesobrometum*. MUCINA & KOLBEK (1993) included the latter in the *Onobrychido viciifoliae-Brometum* Müller 1966 (alliance *Bromion erecti*). However, since we consider these grasslands as belonging to the *Cirsio-Brachypodium* (see WILLNER et al. 2013), this solution is no option. Similar grasslands occur in the Western Carpathians, where they are currently also classified as *Onobrychido viciifoliae-Brometum* (JANIŠOVÁ 2007, ŠKODOVÁ et al. 2011). The *Cirsio pannonici-Brometum*, which was (invalidly) described by STEINBUCH (1995) from south-eastern Styria, most probably belongs here, too. As no valid name seems to be available for this unit, we validate here the name of HUNDT & HÜBL (1983). Against the following association, the *Filipendulo vulgaris-Brometum* is only negatively differentiated. A comparison of these two units with the original diagnosis of the name *Onobrychido viciifoliae-Brometum* (MÜLLER 1966) and typical *Bromion erecti* grasslands of western Austria (MACHOLD 1996) is given in Table 12.

(3.3) *Euphorbio verrucosae-Caricetum montanae* Karrer 1985

(Table 2: 10, Table 4, Fig. 7)

Typus: KARRER (1985b, Tables 9 and 10, rel. 2) (holotypus).

In the same TPA cluster as the previous association, another type of semi-dry grasslands was included which is differentiated by the presence of species indicating nutrient-poor and moderately acidic soils (*Carex montana*, *Euphorbia verrucosa*, *Galium boreale* etc.). This



Fig. 5. Stand of the *Polygalo-Brachypodietum* on the hill Eichkogel near Mödling (Photo: N. Sauberer, 7 June 2012).

Abb. 5. Bestand des *Polygalo-Brachypodietum* am Eichkogel bei Mödling (Foto: N. Sauberer, 07.06.2012).



Fig. 6. Stand of the *Filipendulo vulgaris-Brometum* in Maria Enzersdorf (Photo: N. Sauberer, 8 June 2012).

Abb. 6. Bestand des *Filipendulo vulgaris-Brometum* in Maria Enzersdorf (Foto: N. Sauberer, 08.06.2012).



Fig. 7. Stand of the *Euphorbio verrucosae-Caricetum montanae* in Altenmarkt an der Triesting (Photo: N. Sauberer, 18 May 2012).

Abb. 7. Bestand des *Euphorbio verrucosae-Caricetum montanae* in Altenmarkt an der Triesting (Foto: N. Sauberer, 18.05.2012).

association was described from Terra fusca soils on limestone, but the majority of the documented localities belong to the Flysch part of the Vienna Woods. The soil moisture is rather variable across seasons, with short wet and longer dry phases (intermittently dry, German “*wechseltrocken*”). It is one of the most species-rich grassland types of the region, with an average of 53 species per plot. The plots with the second and third highest recorded vascular plant species richness (92 species on 64 m², and 83 species on 35 m², respectively) belong to this association. At the same time, it is also one of the most endangered grassland types in the study area. Several of the documented stands were fertilised during the last decades and thus have become less species-rich grasslands belonging to *Filipendulo-Brometum* or even *Filipendulo-Arrhenatheretum*.

The *Euphorbio verrucosae-Caricetum montanae* is very similar to the *Brachypodio-Molinietum* Klika 1939 of the White Carpathians (CHYTRÝ 2007, ŠKODOVÁ et al. 2011), but the latter contains a few species which are absent or extremely rare in the Vienna Woods (*Astragalus danicus*, *Cruciata glabra*, *Pulmonaria angustifolia*, *Veronica orchidea*), so we refrain from uniting these two associations for now.

(4.1) *Anthoxantho-Agrostietum tenuis* Sillinger 1933

(Table 2: 11–12, Table 5)

(Incl. *Campanulo rotundifoliae-Dianthetum deltoidis* Balátová-Tuláčková 1980)

On acidic, nutrient-poor soils in the Flysch zone of the Vienna Woods, grasslands with a peculiar combination of *Festuco-Brometea*, *Molinio-Arrhenatheretea* and *Calluno-Ulicetea* species can be found. Higher cover reach *Festuca rubra* agg. (total cover: 6.8%), *Anthoxan-*

Table 12. Comparison of the *Filipendulo vulgaris-Brometum* and *Euphorbio verrucosae-Caricetum montanae* of the Vienna Woods and *Bromion erecti* communities of SW Germany and W Austria. 1: *Onobrychido viciifoliae-Brometum* (original diagnosis – MÜLLER 1966: Table 20); 2: *Mesobrometum erecti* (MACHOLD 1996: Table 5); 3: *Filipendulo vulgaris-Brometum* (this paper: Table 2, col. 9); 4: *Euphorbio verrucosae-Caricetum montanae* (this paper: Table 2, col. 10). Countries: DE: Germany, AT: Austria. Values are percentage constancies. Diagnostic species are shaded. Other species are only shown if they reach 60% constancy in at least one column. Within groups, the species are sorted by decreasing frequency. Diagnostic species of *Bromion erecti* and *Cirsio-Brachypodion* according to DENGLER (2003: Table 29) are marked with (b) and (c), respectively.

Tabelle 12. Vergleich zwischen *Filipendulo vulgaris-Brometum* und *Euphorbio verrucosae-Caricetum montanae* des Wienerwalds und *Bromion erecti*-Gesellschaften in Südwest-Deutschland und West-Österreich. Legende der Spaltennummern siehe oben. DE: Deutschland, AT: Österreich. Die Werte geben die Stetigkeit in Prozent wieder. Diagnostische Arten sind grau hinterlegt. Weitere Arten sind nur dargestellt, wenn sie zumindest in einer Spalte 60 % Stetigkeit erreichen. Innerhalb der Gruppen sind die Arten nach abfallender Häufigkeit sortiert. Diagnostische Arten von *Bromion erecti* und *Cirsio-Brachypodion* nach DENGLER (2003: Table 29) sind mit (b) bzw. (c) gekennzeichnet.

Column number	1	2	3	4
Country	DE	AT	AT	AT
Number of relevés	22	32	145	53
Bromion erecti				
Sanguisorba minor	82	91	19	23
Anthyllis vulneraria	59	59	19	25
Koeleria pyramidata (b)	23	59	15	26
Thymus pulegioides	91	47	8	15
Campanula rotundifolia	95	59	3	9
Scabiosa columbaria (b)	77	91	.	2
Festuca guestfalica (b)	100	69	.	.
Prunella grandiflora	41	81	3	9
Hippocrepis comosa (b)	.	72	.	.
Gymnadenia conopsea (b)	9	38	1	2
Gentianopsis ciliata (b)	36	.	.	4
Gentianella germanica (b)	18	.	.	.
Cirsio-Brachypodion				
Festuca rupicola (c)	.	3	65	62
Filipendula vulgaris	.	.	54	77
Vicia cracca agg.	.	6	54	62
Veronica chamaedrys agg.	.	6	46	57
Rhinanthus minor	.	.	49	49
Ononis spinosa	5	3	36	60
Fragaria viridis	.	.	37	45
Cirsium pannonicum	.	.	30	62
Colchicum autumnale	18	.	28	40
Medicago falcata (c)	5	6	31	26
Ranunculus acris	9	.	28	38
Thesium linophyllum (c)	.	.	23	51
Stellaria graminea	.	.	18	34
Salvia verticillata (c)	.	3	15	6
Potentilla alba	.	.	7	30
Polygala major	.	.	8	15
Lathyrus pannonicus	.	.	6	19
Hypochaeris maculata (c)	.	.	6	6
Potentilla incana (c)	.	.	6	2
Hieracium bauginii (c)	.	.	1	4

Column number	1	2	3	4
Euphorbio verrucosae-Caricetum montanae				
Betonica officinalis	.	91	19	64
Carex montana	9	91	1	55
Galium boreale	.	3	7	53
Euphorbia verrucosa	.	.	13	43
Trifolium ochroleucon	.	.	1	15
Other species				
Bromus erectus (b)	100	100	100	100
Plantago lanceolata	82	94	91	94
Dactylis glomerata	77	63	89	91
Lotus corniculatus	100	91	78	79
Achillea millefolium agg.	86	47	86	85
Salvia pratensis	82	81	76	81
Knautia arvensis	100	63	74	66
Leontodon hispidus	55	81	70	81
Briza media	95	100	57	87
Centaurea jacea	91	84	65	64
Trifolium pratense	50	66	71	66
Trifolium montanum (c)	50	66	63	77
Leucanthemum vulgare agg.	82	56	60	72
Plantago media	91	50	60	64
Avenula pubescens	68	3	65	70
Pimpinella saxifraga	68	91	52	51
Centaurea scabiosa	77	88	51	49
Trisetum flavescens	32	13	62	64
Galium verum	14	72	46	70
Poa pratensis	77	.	57	53
Primula veris	50	59	39	77
Anthoxanthum odoratum	50	84	37	64
Viola hirta	18	44	42	70
Linum catharticum	73	91	29	49
Ranunculus bulbosus (b)	95	13	42	49
Daucus carota	86	53	36	43
Galium mollugo agg.	77	19	43	47
Medicago lupulina	86	9	43	38
Helianthemum nummularium	.	78	32	28
Onobrychis viciifolia	77	25	37	15
Buphthalmum salicifolium	.	75	20	43
Ranunculus polyanthemus agg.	.	72	20	38
Polygala comosa	68	16	17	21
Galium pumilum	.	63	12	23
Potentilla erecta	.	78	5	21
Allium carinatum	.	88	2	13
Polygala vulgaris	.	66	5	15
Column number	1	2	3	4
Vicia sepium	82	.	6	8
Abietinella abietina	32	69	?	?
Brachypodium rupestre	.	72	.	.
Avenula pratensis	.	66	1	.
Thuidium delicatulum	.	72	?	?
Rhinanthus glacialis	.	63	.	.

thum odoratum (6.2%), *Agrostis capillaris* (5.2%), *Holcus lanatus* (4.8%), *Bromus erectus* (4.8%), and *Nardus stricta* (3.9%). There are two subtypes which differ in soil moisture: The drier one (4.1a) (TPA cluster 29) is floristically related to the *Euphorbio verrucosae-Caricetum montanae*, while the wetter subtype (4.1b) (TPA cluster 35 p.p.; cluster F–G) is more closely related to the *Succiso-Molinietum* (association 7.1). However, we consider both subtypes as belonging to the same association, the *Anthoxantho-Agrostietum tenuis* sensu lato, which is reported for Austria here for the first time. We do not formally describe two subassociations since the association is probably in need of a supra-national revision. In particular, its delimitation towards the *Campanulo rotundifoliae-Dianthetum deltoidis* is unclear, although these two associations are usually placed in different alliances and even in different classes (see Appendix S4 and section 4.4).

(5.1) *Ranunculo bulbosi-Arrhenatheretum* Ellmauer 1993

(Table 2: 13, Table 6)

(Syn.: *Filipendulo vulgaris-Arrhenatheretum* Hundt & Hübl 1983 nom. inval. p.p. [“Subass. von *Centaurea scabiosa*”])

Typus: ELLMAUER & MUCINA 1993, p. 346 (holotypus).

The *Arrhenatherum* meadows of the Vienna Woods can be divided into three units. Two of them represent less nutrient-rich types used with intermediate intensity, which correspond to the TWINSPAN clusters H–I (association 5.2) and J–M (association 5.1). They are differentiated from the more nutrient-rich type (cluster D, association 5.3) by a group of *Festuco-Brometea* species (*Bromus erectus*, *Brachypodium pinnatum*, *Primula veris*, *Ranunculus bulbosus*, *Salvia pratensis*, *Trifolium montanum*, *Campanula glomerata* etc.). Many of these meadows are only rarely fertilised or not at all. Within this less nutrient-rich group, the *Ranunculo bulbosi-Arrhenatheretum* represents the type on base-rich, usually calcareous, and drier soils. It is mainly distributed in the limestone part of the Vienna Woods but also occurs on base-rich substrates in the Flysch zone.

The *Ranunculo bulbosi-Arrhenatheretum* is a widespread community in Central Europe (CHYTRÝ 2007, JANIŠOVÁ 2007). DIERSCHKE (1997) included it as “Subass.-Gr. von *Briza media*” in a broadly defined *Arrhenatheretum elatioris*, but according to our association concept, the less nutrient-rich *Arrhenatherum* meadows have to be treated as separate units. The diagnostic species given by ELLMAUER & MUCINA (1993) could only partly be confirmed, and probably the delimitation of this association is in need of a revision (see also next association).

(5.2) *Filipendulo vulgaris-Arrhenatheretum* Hundt & Hübl ex Ellmauer 1995

(Table 2: 14, Table 6, Fig. 8)

(Syn.: *Filipendulo vulgaris-Arrhenatheretum* Hundt & Hübl 1983 nom. inval. [Art. 5] p.p. [“typische Subass.”])

Typus: HUNDT & HÜBL (1983, Table 1, rel. 3) (lectotypus ELLMAUER 1995).

This association includes the less nutrient-rich *Arrhenatherum* meadows on non-calcareous Flysch substrates. The soils are intermittently dry (with short wet and longer dry phases) but the moisture supply is usually better than in the corresponding semi-dry grasslands. *Bromus erectus* can reach high cover (total cover: 13%) which occasionally even exceeds that of *Arrhenatherum elatius* (total cover: 16%). Floristically there is a continuous transition be-



Fig. 8. Stand of the *Filipendulo vulgaris-Arrhenatheretum* in the Gutenbach valley, Vienna (Photo: W. Willner, 12 June 2010).

Abb. 8. Bestand des *Filipendulo vulgaris-Arrhenatheretum* im Gutenbachtal, Wien (Foto: W. Willner, 12.06.2010).

tween the *Filipendulo-Brometum* and the *Filipendulo-Arrhenatheretum*. Quite often the latter occurs in the lower part of slopes, which have a better moisture supply, and the *Filipendulo-Brometum* in the upper part of the same slopes.

The *Filipendulo-Arrhenatheretum* is the most widespread *Arrhenatherion* community in the Vienna Woods. Unlike the *Ranunculo bulbosi-Arrhenatheretum*, however, this association has rarely been reported from other regions, although similar grasslands exist, e.g., in the White Carpathians. The *Pastinaco-Arrhenatheretum* sensu ŠKODOVÁ et al. (2011) mostly corresponds to the *Filipendulo-Arrhenatheretum*. In the TWINSPAN classification of the mesic meadows of the Vienna Woods, this unit formed a common group with the *Ranunculo bulbosi-Arrhenatheretum* (see above) while in the TPA, it was in the same cluster as the *Pastinaco-Arrhenatheretum* and *Ranunculo repentis-Alopecuretum* (WILLNER et al. 2013). We think that the *Filipendulo-Arrhenatheretum* is more closely related to the *Ranunculo bulbosi-Arrhenatheretum* and might even be treated as a subassociation of the latter, but this question can only be answered by a supra-regional comparison.

(5.3) *Pastinaco-Arrhenatheretum* Passarge 1964
(Table 2: 15, Table 7)

In *Arrhenatherum* meadows on very nutrient-rich soils, the *Festuco-Brometea* species are absent or have only negligible cover (< 1%). This grassland type, the *Pastinaco-Arrhenatheretum*, is probably the central association of the *Arrhenatherion*. It corresponds to the TWINSPAN cluster D. The community is widespread in Central Europe, but in the study region it is less common than the previous two associations. Most sites have been strongly fertilised in the past, and some are former arable land that has been transformed into mead-

ows. The stands are mown twice or thrice a year. If the first mowing takes place too early, *Arrhenatherum* declines in cover and can even completely disappear. Such meadows are usually dominated by *Trisetum flavescens*, and their species composition is similar to the *Poo-Trisetum* Knapp ex Oberdorfer 1957. However, the status of this association is doubtful and its diagnostic species are not clear (see, e.g., Table 5 in CHYTRÝ 2007), so we included all these relevés in the *Pastinaco-Arrhenatheretum*.

CHYTRÝ (2007) identifies this association with the *Arrhenatheretum* Braun 1915, which was described from the Cévennes in southern France (see also KLESCZEWSKI 2000), but rejects the latter name as *nomen ambiguum propositum*. In our opinion, it is premature to decide whether the *Arrhenatheretum* Braun 1915 belongs to the same association as Central European *Arrhenatherum* meadows. Therefore, we keep the name *Pastinaco-Arrhenatheretum*, which is well established in all countries of eastern Central Europe.

(5.4) *Ranunculo repentis-Alopecuretum pratensis* Ellmauer 1993

(Table 2: 16, Table 7, Fig. 9)

(Syn.: *Filipendulo vulgaris-Arrhenatheretum* Hundt & Hübl 1983 nom. inval. p.p. [“Subass. von *Cirsium oleraceum*”])

Typus: ELLMAUER & MUCINA 1993, p. 348 (holotypus)

In meadows on intermittently wet soils (i.e., with longer wet and short dry phases), *Arrhenatherum elatius* is usually absent, and *Alopecurus pratensis* is the dominant grass species (total cover: 20%). Occasionally, *Poa trivialis* (total cover: 8%) or *Holcus lanatus* (total



Fig. 9. Stand of the *Ranunculo repentis-Alopecuretum pratensis* near Mauerbach (Photo: M. Staudinger, 22 May 2010).

Abb. 9. Bestand des *Ranunculo repentis-Alopecuretum pratensis* bei Mauerbach (Foto: M. Staudinger, 22.05.2010).

cover: 6%) are dominant. Differential species against the *Pastinaco-Arrhenatheretum* are species of wet meadows, such as *Ranunculus repens*, *Ajuga reptans*, *Lysimachia nummularia*, *Lychnis flos-cuculi*, *Carex hirta*, *Cirsium canum*, *Cirsium oleraceum* and others. The majority of stands probably developed from *Molinion* meadows after fertilisation. Some of them are rather intensively used.

This association corresponds to the TWINSPAN cluster E. Its assignment to the *Arrhenatherion* is not fully convincing as *Alopecurus pratensis* is usually considered a diagnostic species of the *Cnidion* or *Deschampsion cespitosae* s. lat. (e.g., BERG et al. 2004, JANIŠOVÁ 2007). However, as this question can only be answered in a large-scale comparison, we follow the original assignment of ELLMAUER & MUCINA (1993) here.

(6.1) *Plantagini-Lolietum* Beger 1932 nom. invers. propos.

(Table 2: 17)

(Syn.: *Lolietum perennis* Gams 1927 nom. inval. [Art. 3d])

This association is only poorly documented from them Vienna Woods, and the few relevés included here were rather sampled by chance. It occurs along paths, on playgrounds, and other sites which are nutrient-rich and frequently trampled. Intensively used, frequently mown meadows also belong here.

In the TWINSPAN classification of mesic grasslands, the *Plantagini-Lolietum* formed a group with *Arrhenatherum* meadows which are differentiated by the presence of ruderal species such as *Elymus repens* (sometimes co-dominant), *Artemisia vulgaris*, *Cirsium arvense*, *Convolvulus arvensis* and others (clusters A–C). These ruderal grasslands correspond to the association *Tanaceto-Arrhenatheretum* Fischer 1985. However, the syntaxonomic position of this unit is not clear, as it has strong floristic relations to the *Artemisietea vulgaris*. More material would be necessary to evaluate both community types.

(6.2) *Cynosuro-Lolietum* Br.-Bl. & De Leeuw 1936

Mesic pastures are very rare in the study area, and there was only one plot that could be identified with this community (see below). It was included in cluster D (TPA cluster 34). However, more occurrences of the *Cynosuro-Lolietum* in the region are very likely, at least in the westernmost part of the Vienna Woods.

H. Rötzer, 2010/06/11, Gerichtsberg, 48.03897° N, 15.85661° E, 722 m, E, 5°; plot size: 25 m²; cover of herb layer: 80%. Bryophytes not recorded. TURBOVEG number 335090.

Trifolium repens 3, *Trisetum flavescens* 2a, *Dactylis glomerata* 2a, *Poa trivialis* 2a, *Cynosurus cristatus* 1, *Carum carvi* 1, *Plantago lanceolata* 1, *Trifolium pratense* 1, *Taraxacum officinale* agg. 1, *Ranunculus acris* 1, *Lolium perenne* +, *Achillea millefolium* agg. +, *Ajuga reptans* +, *Alchemilla monticola* +, *Arenaria serpyllifolia* +, *Cruciata laevipes* +, *Lathyrus pratensis* +, *Rumex acetosa* +, *Rumex obtusifolius* +, *Veronica chamaedrys* agg. +, *Vicia cracca* +, *Urtica dioica* +, *Vicia sepium* r.

(7.1) *Succiso-Molinietum caeruleae* (Kovács 1962) Soó 1969

(Table 2: 18, Table 8)

On nutrient-poor, intermittently wet soils, *Molinia* meadows with both *M. caerulea* and *M. arundinacea* are developed (TPA clusters 35 p.p., 45–48). This grassland type was probably more common in the past, but only few remnants can be found anymore in the Vienna Woods. These remnants are very similar to the *Molinia* meadows of the Vienna Basin, which is the *locus classicus* of the *Succiso-Molinietum caeruleae* (WAGNER 1950, ELLMAUER &

MUCINA 1993). The unit is only known from the Flysch part of the Vienna Woods, and 50% of the stands are located within the political borders of Vienna. Most of them are found in the “Lainzer Tiergarten” (a large protected area in the south-west of Vienna), including the most species-rich plot of a wet meadow in the Vienna Woods, with 77 vascular plant species on 30 m² (LEPUTSCH 1997, rel. 69).

(8.1) *Cirsietum rivularis* Nowiński 1928

(Table 2: 19, Table 8, Fig. 10)

(Incl. *Valeriano-Cirsietum oleracei* Kuhn 1937, *Cirsio-Brometum racemosi* Hundt & Hübl 1983)

In contrast to the previous association, nutrient-rich wet meadows of the *Calthion* are still relatively widespread in the Vienna Woods. The most characteristic species of these meadows is *Cirsium rivulare* (total cover 13%). The soil has a good water supply throughout the year, without pronounced phases of drought. Other conspicuous plants of this grassland type are *Trollius europaeus* and *Dactylorhiza majalis*, which make the stands very attractive during flowering time. The *Cirsietum rivularis* corresponds to the TPA clusters 35 p.p. and 54.



Fig. 10. Meadow with a strong moisture gradient and three different associations: *Caricetum davallianae* (in the foreground, with the hairy inflorescences of *Eriophorum angustifolium*), *Cirsietum rivularis* (the narrow strip with the yellow flowers of *Ranunculus acris*) and *Filipendulo vulgaris-Brometum* (on the slope behind) (near Wolfsgraben, Photo: W. Willner, 6 June 2010).

Abb. 10. Wiese mit einem starken Feuchtgradienten: Im Vordergrund ein *Caricetum davallianae* (mit den wolligen Köpfen von *Eriophorum angustifolium*), daran anschließend ein schmaler Streifen von *Cirsietum rivularis* (kennlich an den zahlreichen gelben Blüten von *Ranunculus acris*), und am Hang dahinter ein *Filipendulo vulgaris-Brometum* (bei Wolfsgraben, Foto: W. Willner, 06.06.2010).

Cirsium oleraceum is only a minor element in the *Calthion* meadows of the Vienna Woods (total cover: 6%). ELLMAUER & MUCINA (1993) mention the *Valeriano-Cirsietum oleracei* for this region but state at the same time that this association is very similar to the *Cirsietum rivularis* and probably has to be included in the latter. According to our results, the diagnostic species indicated by ELLMAUER & MUCINA (1993) for these two associations do not work at all, so we treat the *Valeriano-Cirsietum oleracei* as a synonym of the *Cirsietum rivularis* (see also BURKART et al. 2004).

(8.2) *Scirpetum sylvatici* Rałski 1931

This grassland type was documented by a single relevé which was included in TPA cluster 41. The plot was situated within a larger wet meadow, which mainly belonged to the *Cirsietum rivularis*. The patch dominated by *Scirpus sylvaticus* was located on a slope toe adjacent to a stream. The status of this association is disputed by BURKART et al. (2004).

W. Willner, 2010/06/09, Irenental, 48.21167° N, 16.10171° E, 340 m, S, 5°; plot size: 25 m²; cover of herb layer: 95%. Bryophytes not recorded. TURBOVEG number 335286.

Scirpus sylvaticus 4, *Poa trivialis* 2b, *Ranunculus repens* 2b, *Carex hirta* 2a, *Alopecurus pratensis* 1, *Festuca pratensis* 1, *Bromus racemosus* +, *Caltha palustris* +, *Galium palustre* +, *Holcus lanatus* +, *Lysimachia nummularia* +, *Ranunculus acris* +, *Rumex obtusifolius* +, *Taraxacum officinale* agg. +, *Trifolium dubium* +, *Trifolium pratense* +, *Trifolium repens* +, *Veronica beccabunga* +, *Cardamine pratensis* agg. r, *Cerastium holosteoides* r, *Lythrum salicaria* r, *Mentha aquatica* r.

(9.1) *Mentho-Juncetum inflexi* Lohmeyer ex Oberdorfer 1957 nom. invers. propos.

(Table 2: 20, Table 8)

This association occurs on frequently disturbed sites with very nutrient-rich, clayey soils and longer wet phases. It usually forms rather small patches within larger grasslands. Most stands are frequently trampled by animals. However, heavy tractors probably have a similar effect. The majority of the relevés originate from the “Lainzer Tiergarten”, which harbours an extremely dense population of wild boar. Besides *Juncus inflexus* (total cover: 15%), *Carex distans* can also become dominant (total cover: 11%). The unit corresponds to the TPA cluster 59.

The *Mentho-Juncetum inflexi* is probably not the only association of the *Potentillion anserinae* in the study area but no relevés or observations of other community types are available.

(10.1) *Caricetum davallianae* Dutoit 1924

(Table 2: 21, Table 9, Fig. 10)

Fens on nutrient-poor sites are rare and scattered in the Vienna Woods, and some sites are not much bigger than one relevé plot. They have many species in common with the *Succiso-Molinietum* and the *Cirsietum rivularis*, to which they are sometimes in direct contact (Fig. 10). Among the most abundant species are *Carex davalliana* (total cover: 13%), *C. panicea* (total cover: 7%), *Eriophorum angustifolium* (total cover: 7%) and *Valeriana dioica* (total cover: 5%). The unit corresponds to the TPA clusters 57, 58 and 60.

(10.2) *Juncus subnodulosi-Schoenetum nigricantis* Allorge 1921 nom. mut. et invers. prop.
(Table 2: 22, Table 9)
(Incl. *Juncetum subnodulosi* Koch 1926)

This community is documented from only three localities in the Vienna Woods. Two stands are dominated by *Juncus subnodulosus*, and one stand by *Schoenus nigricans*. All three relevés were included in different TPA clusters (46, 47 and 57, respectively). STEINER (1993) regards the *Juncetum subnodulosi* as a separate association, but the delimitation between these two units remains unclear.

4.4 Syntaxonomy of the *Anthoxantho-Agrostietum tenuis* and related communities

Association 4.1 has close floristic relations to both the *Anthoxantho-Agrostietum tenuis* Sillinger 1933 and the *Campanulo rotundifoliae-Dianthetum deltoïdis* Balátová-Tuláčková 1980. However, the delimitation between these two units is not clear despite the fact that they are usually placed in different alliances and even in different classes (Appendix S4). In a DCA of the relevés of our study area and pre-classified data of both associations from the Czech Republic and Slovakia (Fig. 11), the dry variant of the Vienna Woods (unit 4.1a) was largely congruent with the *Anthoxantho-Agrostietum tenuis* in the sense of CHYTRÝ (2007). Both groups were situated the lower left part of the diagram, while the moist variant of the Vienna Woods (unit 4.1b) occupied the lower right part. The *Anthoxantho-Agrostietum tenuis* and *Campanulo rotundifoliae-Dianthetum deltoïdis* of the White Carpathians (ŠKODOVÁ et al. 2011) showed a strong overlap both with each other and with the original diagnosis of the *Anthoxantho-Agrostietum tenuis* (Low Tatra mountains, SILLINGER 1933). All Slovak data were situated in the centre of the diagram, while the *Campanulo rotundifoliae-Dianthetum deltoïdis* of the Czech data set occupied its upper part.

In the light of these findings, we preliminarily classified unit 4.1 within a broadly defined *Anthoxantho-Agrostietum tenuis*, but the syntaxonomy of this and related associations is clearly in need of a revision. This concerns not only the internal classification of the group but also its assignment to higher taxonomic units. While the *Campanulo rotundifoliae-Dianthetum deltoïdis* is unanimously placed in the *Violion caninae* (CHYTRÝ 2007, JANIŠOVÁ 2007), the taxonomic position of the *Anthoxantho-Agrostietum tenuis* is less clear. CHYTRÝ (2007) placed it into the *Cynosurion*, JANIŠOVÁ (2007) and ROZBROJOVÁ et al. (2010) into the *Arrhenatherion*. LICHTENECKER et al. (2003) described a similar grassland type from the Austrian part of the Bohemian Massif (Waldviertel) as *Diantho deltoïdis-Festucetum rubrae* and classified it within the alliance *Phyteumo-Trisetion*. DIERSCHKE (1997) united analogous grasslands as “*Festuca rubra-Agrostis tenuis*-Gesellschaft” and considered them as “fragmentary” *Arrhenatheretalia* community, but he did not assign this community to any alliance.

Here we propose to classify the *Anthoxantho-Agrostietum tenuis* s. lat. into the *Violion caninae*. This solution is, of course, provisional, not least because the delimitation of the class which the *Violion caninae* is assigned to varies considerably between authors (with or without dwarf shrub communities, with or without the subalpine *Nardion strictae*; see, e.g., MUCINA et al. 1993, THEURILLAT et al. 1995, PEPLER-LISBACH & PETERSEN 2001). Depending on the adopted class concept, the diagnostic species of the *Calluno-Ulicetea/Nardetea strictae* will be different and thus have a higher or lower portion compared to the *Molinio-Arrhenatheretea* species. Moreover, several species usually considered as character species of the *Molinio-Arrhenatheretea*, such as *Plantago lanceolata*, *Rumex acetosa*, *Leucanthe-*

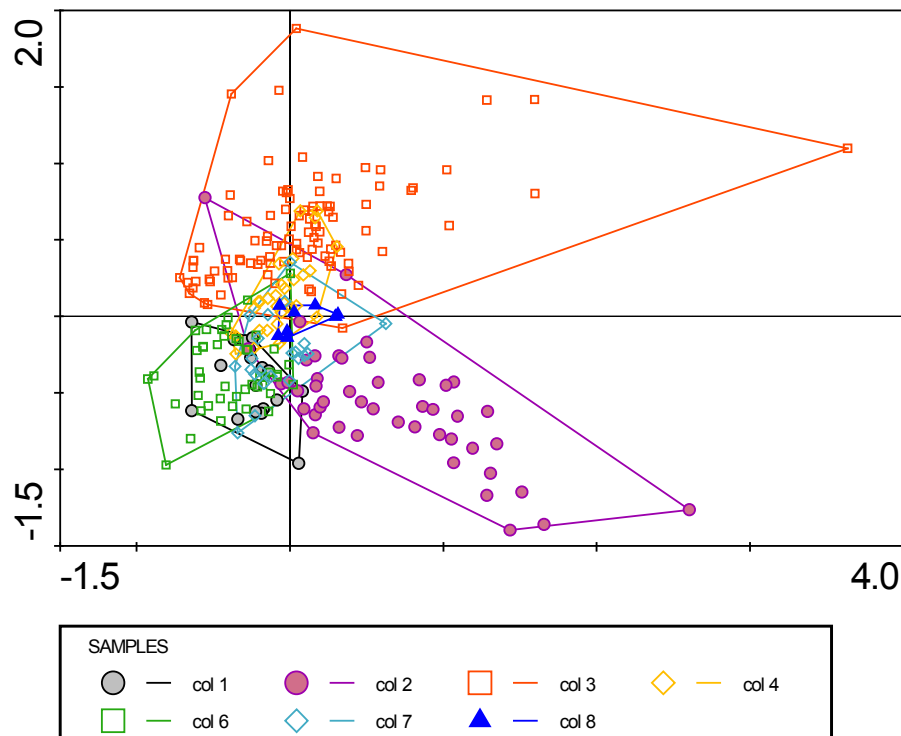


Fig. 11. DCA of the *Anthoxantho-Agrostietum s. lat.* in the study area and neighbouring countries (CZ: Czech Republic, SK: Slovakia). The columns in Appendix S4 are given as different symbols (see there for data sources); col. 1: dry variant (Vienna Woods); col. 2: moist variant (Vienna Woods); col. 3: *Campanulo rotundifoliae-Dianthetum deltoidis* (CZ); col. 4: *Campanulo rotundifoliae-Dianthetum deltoidis* (SK, White Carpathians); col. 6: *Anthoxantho-Agrostietum* (CZ); col. 7: *Anthoxantho-Agrostietum* (SK, White Carpathians); col. 8: *Anthoxantho-Agrostietum* (original diagnosis; SK, Low Tatra).

Abb. 11. DCA des *Anthoxantho-Agrostietum s. lat.* im Untersuchungsgebiet und Nachbarländern. Die Spalten in Anhang S4 sind durch unterschiedliche Symbole dargestellt (für Datenquellen siehe dort); col. 1: trockene Variante (Wienerwald); col. 2: feuchte Variante (Wienerwald); col. 3: *Campanulo rotundifoliae-Dianthetum deltoidis* (CZ); col. 4: *Campanulo rotundifoliae-Dianthetum deltoidis* (SK, Weiße Karpaten); col. 6: *Anthoxantho-Agrostietum* (CZ); col. 7: *Anthoxantho-Agrostietum* (SK, Weiße Karpaten); col. 8: *Anthoxantho-Agrostietum* (Originaldiagnose; SK, Niedere Tatra).

mum vulgare agg., *Holcus lanatus*, *Trifolium pratense*, *Ranunculus acris* or *Molinia caerulea* agg., regularly reach constancy values of >40% even in “classical” *Violion caninae* communities (see PEPLER-LISBACH & PETERSEN 2001, CHYTRÝ 2007). If the *Anthoxantho-Agrostietum tenuis* and related associations is included in the *Calluno-Ulicetea/Nardetea strictae*, most of the aforementioned species would probably become shared differential species of this class and the *Molinio-Arrhenatheretea*. Obviously, a large-scale revision of the two classes is needed before a definite assignment of the *Anthoxantho-Agrostietum tenuis* can be achieved.

5. Conclusions

5.1 General thoughts on the process of vegetation classification

The Braun-Blanquet system aims at providing a universal classification of plant communities which is applicable on the local as well as on the global scale. This ambitious goal can only be reached by a stepwise process where results from both large-scale comparisons (e.g. ILLYÉS et al. 2007, DÚBRAVKOVÁ et al. 2010) and more detailed regional studies are integrated. While classifications of large data sets reveal the broad patterns of vegetation, which are reflected in the higher syntaxonomic units (classes, orders, alliances), regional studies are equally important for the delimitation of the basic units (the associations and subassociations). This does not mean that regionally described units should be treated as unchangeable components in supra-regional surveys. On the contrary, the association status of a regional unit can only be assessed by comparison on a broader geographical scale (see DENGLER 2003, WILLNER 2006). Moreover, local units which were originally considered as mere variants of an association, might be revealed to belong to different alliances or even classes, when examined from a global point of view. However, only the detailed classification of the plant communities within a relatively small area such as the Vienna Woods, where the syntaxonomic position of each single plot can be pondered, gives the Braun-Blanquet system the level of confidence and sharpness that is required for its application, e.g. in nature conservation and habitat mapping. The different levels of the syntaxonomic work can be compared to the construction of a house, where large-scale studies provide the general plan, but regional and local studies assure that the walls are smooth and have no holes. The first part of this series (WILLNER et al. 2013) surveyed a medium-sized wing of the building, while the present study, to stay with this picture, focused on a rather tiny room of the latter. However, even from this regional perspective major inconsistencies in the system of European grasslands could be detected (see section 4.4).

The development of a consistent syntaxonomic system of European grasslands (see DENGLER et al. 2013) will only be successful if unequivocal assignment criteria are provided for all vegetation units (DE CÁCERES & WISER 2012). These criteria should be designed in such way that the number of plots matching the definition of more than one unit or of none at all is minimized (DENGLER 2003, WILLNER 2011). In the present study, the summarised cover of diagnostic species proved to be an effective tool for this aim, although uncertainties in the diagnostic value of species for the higher syntaxa suggested using a more pragmatic hierarchy in the field determination key of the regional vegetation units (Appendix 1). Diagnostic species used for the assignment of relevés should not be uncritically derived from a single fidelity calculation (e.g., all species exceeding a certain phi coefficient) as the latter is inevitably affected by idiosyncrasies of the data set. We propose instead a supervised development of diagnostic species lists involving various data sources and approaches to calculate fidelity as well as expert knowledge about the ecological properties of the species (see also BECKER et al. 2012).

In addition to unambiguous floristic definitions, also the differences in site conditions and/or distribution areas among vegetation units should be provided as explicitly as possible (WILLNER 2006). Only a syntaxon that is defined by a certain species composition on the one hand and certain non-floristic characters on the other hand is a falsifiable hypothesis, thus making syntaxonomy a “real” science.

5.2 Nature conservation

The major part of the Vienna Woods was declared as landscape protection area in 1979, as Special Protection Area (Natura 2000 network of the European Union) in 2004, and as UNESCO Biosphere Reserve in 2005. Most grasslands are part of the so-called conservation zone of the Biosphere Reserve. In comparison to other regions of Austria, the meadows of the Vienna Woods are much less intensively used. The *Arrhenatherum* meadows are generally less fertilised and still rich in species. One explanation for this is that cattle are not very common in the Vienna Woods, and the hay is mostly fed to horses. Nevertheless, the most species rich semi-dry grasslands, the *Polygalo-Brachypodietum* and the *Euphorbio verrucosae-Caricetum montanae*, have strongly declined during the last decades, mainly due to abandonment and subsequent succession. There are several initiatives and projects which stem against this overall trend of abandonment on the one hand and intensification on the other hand. Numerous farmers have been involved in agri-environment schemes since 1995, and they have been paid for mowing and extensification of their meadows (e.g., reduction or cessation of fertilising). These measures decelerated the speed of the negative developments mentioned above. Since 2006, farmers are awarded for the best management of species-rich grasslands in a yearly, regional championship (*Wiesenmeisterschaft*). This competition raises the awareness for grasslands as habitats and old cultural heritage. Funding of the European Union could be used especially for the endangered dry and semi-dry grasslands. Between 2004 and 2008, the LIFE-Nature project “Pannonic Steppes and Dry Grasslands” successfully enlarged areas of dry grasslands through the means of acquisition of land, clearing of trees and shrubs, and initiating extensive pasturing with sheeps in some areas (<http://www.steppe.at/en/index.html>). In 2010, a project on dry grasslands was launched within the Rural Development Policy of the European Union. In the course of this project various measures were taken to improve the situation of dry and semi-dry grasslands in three municipalities at the easternmost border of the Vienna Woods.

Currently, a biotope mapping of all non-forest areas of the Biosphere Reserve Vienna Woods is conducted using the determination key presented in Appendix 1. This will provide detailed distribution maps of the grassland types within the Biosphere Reserve and a sound basis for their conservation as well as for the monitoring of future changes.

Erweiterte deutsche Zusammenfassung

Einleitung – Nachdem im ersten Teil dieser Serie ein allgemeiner Überblick über die pannonischen Rasengesellschaften Österreichs gegeben wurde (WILLNER et al. 2013), legen wir hier nun eine detaillierte Klassifikation für das Gebiet des Wienerwalds vor. Obwohl geographisch zu den Alpen gehörig, weist der Wienerwald enge floristische Beziehungen zum Pannonischen Becken auf. Die Wiesen und Trockenrasen dieser Region zählen zu den best erhaltenen in Österreich und dank der in den letzten zwanzig Jahren durchgeführten zahlreichen Freilandhebungen auch zu den best dokumentierten. Allerdings lag bislang keine befriedigende Klassifikation dieser Pflanzengesellschaften vor. Die 2005 erfolgte Einrichtung des Biosphärenparks Wienerwald, und nachfolgende Pläne für eine flächendeckende Kartierung des Gebiets machten die Erarbeitung einer solchen Gliederung dringend notwendig. Dies gab – neben Unklarheiten in der Zuweisung der pannonischen Rasengesellschaften zu Natura 2000-Lebensraumtypen – den Anstoß zu der vorliegenden Untersuchung.

Untersuchungsgebiet – Als Wienerwald bezeichnet man den nordöstlichsten Ausläufer des Alpenbogens, nördlich der Talfurche der Flüsse Triesting und Gölsen (Abb. 1). Die Seehöhe beträgt zwischen 200 und 893 m ü. Adria. Geologisch hat der Wienerwald Anteil an der Flyschzone und den Nördlichen Kalkalpen sowie in geringem Ausmaß auch an der Molassezone. Klimatisch und biogeographisch

handelt es sich um eine Übergangszone zwischen der mitteleuropäischen und der pannonischen Region. Die mittlere Jahrestemperatur beträgt je nach Höhenlage zwischen 6 und 10 °C, der mittlere Jahresniederschlag zwischen 600 mm am Ostabfall zum Wiener Becken und 900 mm auf den höchsten Erhebungen.

Material und Methoden – Von 2005 bis 2010 wurden im Gebiet des Biosphärenparks Wienerwald mehr als 250 neue Vegetationsaufnahmen durchgeführt. Diese wurden mit allen verfügbaren Aufnahmen pannonischer Rasengesellschaften aus Ost-Österreich und Süd-Mähren zu einem Datensatz von 3384 Aufnahmen kombiniert (davon 1055 aus dem Wienerwald) und mit TWINSPAN klassifiziert (s. WILLNER et al. 2013 für Details). Aufnahme-Cluster, welche keine erkennbaren standörtlichen oder geographischen Unterschiede aufwiesen, wurden zusammengefasst. Aufnahmen, bei welchen die Deckungssumme der Verbands-, Ordnungs- und Klassencharakterarten eine andere Zuordnung nahelegte, wurden per Hand umsortiert. Für die weitere Bearbeitung wurde ein Auszug aus der Gesamttabelle erstellt, welcher nur die Aufnahmen aus dem Wienerwald enthielt. Die im ersten Schritt dem Verband *Arrhenatherion* zugeordneten Aufnahmen wurden zur besseren Auflösung der Variabilität nochmals mit TWINSPAN klassifiziert. Die finale Abgrenzung der Assoziationen und Subassoziationen erfolgte mit dem Ziel, Einheiten herauszuarbeiten, welche optimal durch diagnostische Arten gekennzeichnet und standörtlich möglichst informativ sind. Die Zuordnung der Einzelaufnahmen erfolgte nach der in WILLNER (2011) beschriebenen Deckungssummenmethode.

Ergebnisse und syntaxonomische Diskussion – Die TWINSPAN-Klassifikation der zunächst als *Arrhenatherion* eingestuften Aufnahmen ergab 13 Cluster, welche – um Verwechslungen mit den in WILLNER et al. (2013) beschriebenen Clustern des Gesamtdatensatzes zu vermeiden – mit Buchstaben bezeichnet sind (Tab. 1).

Die Rasengesellschaften des Wienerwalds wurden in 22 Assoziationen (plus zwei Subassoziationen) gegliedert, welche wir zu zehn Verbänden und vier Klassen stellen (s. syntaxonomisches Schema in Kap. 4.2.; für Anmerkungen zur Nomenklatur s. Anhang S1). Die regionalen diagnostischen sowie weitere häufige Arten sind in einer synoptischen Tabelle dargestellt (Tab. 2 in der Beilage, Herkunft der Aufnahmen: Anhang S2). Tabelle 3–9 in der Beilage enthalten neu erhobene Aufnahmen der Gesellschaften (man beachte, dass diese nicht unbedingt besonders typische Bestände repräsentieren, sondern bislang noch nicht untersuchte Flächen dokumentieren sollen; für weitere Kopfdaten s. Anhang S3). Ein Feld-Bestimmungsschlüssel für die Gesellschaften findet sich in Anhang 1. Die Übereinstimmung zwischen TWINSPAN-Gruppen und finaler Klassifikation ist in Tabelle 10 in der Beilage dargestellt.

Kurzbeschreibung der Gesellschaften:

(1.1) *Drabo aizoidis-Seslerietum albicantis*: Blaugrasrasen auf nordexponierten Felshängen.

(1.2) *Fumano-Stipetum eriocaulis* (Abb. 2): lückige, von *Stipa eriocaulis* und *Festuca stricta* dominierte Felstrockenrasen auf steilen Südhängen, meist auf Dolomit.

(1.3) *Scorzonero austriacae-Caricetum humilis* (Abb. 3): Trockenrasen auf weniger stark geneigten Dolomitböden, etwas tiefgründiger als in der vorigen Assoziation. Obwohl diese floristisch deutlich eigenständige Gesellschaft am Ostrand des Wienerwalds relativ großflächig auftritt (insbesondere auf der Perchtoldsdorfer Heide südlich von Wien), wurde sie bisher verkannt und mit den Halbtrockenrasen des *Polygalo-Brachypodietum* vereint (WENDELBERGER 1953). Ein Vergleich mit den *Carex humilis*-Rasen der Slowakei (Tab. 11) zeigte, dass diese Gesellschaft dem *Orphantho luteae-Caricetum humilis* Kliment & Bernátová 2000 nahe steht, aber doch durch zahlreiche Differentialarten von diesem getrennt ist.

(2.1) *Stipo capillatae-Festucetum valesiaca*: von *Festuca valesiaca* dominierte Trockenrasen auf tonreichen Böden über Jurakalk.

(2.2) *Salvio nemorosae-Festucetum rupicola* (Abb. 4): meist von *Festuca rupicola* beherrschte Löss-Trockenrasen; im Gebiet nur auf dem Eichkogel bei Mödling vorhanden.

(2.3) *Medicagini-Festucetum valesiaca*: Walliserschwingelrasen auf stark trittbeeinflussten Dolomitböden. Diese von WAGNER (1941) beschriebene Gesellschaft vermittelt floristisch zwischen den Verbänden *Seslerio-Festucion pallentis* und *Festucion valesiaca*. Sie ist heute bis auf winzige Fragmente verschwunden.

(3.1) *Polygalo-Brachypodietum* (Abb. 5): sehr artenreiche Halbtrockenrasen auf tiefgründigen, aber relativ trockenen, karbonatreichen Böden.

(3.2) *Filipendulo vulgaris-Brometum* (Abb. 6): weniger artenreiche, meist stark von *Bromus erectus* dominierte Halbtrockenrasen auf besser wasserversorgten, relativ nährstoffreichen Böden. Diese Gesellschaft wurde von MUCINA & KOLBEK (1993) zum *Onobrychido-Brometum* (Verband *Bromion erecti*) gestellt. Ein Vergleich mit Halbtrockenrasen aus West-Österreich und Süd-Deutschland (Tab. 12) macht jedoch deutlich, dass sie nicht mit dem *Onobrychido-Brometum* identifiziert werden kann.

(3.3) *Euphorbio verrucosae-Caricetum montanae* (Abb. 7): sehr artenreiche Halbtrockenrasen auf tonreichen, wechsellöschenden, nährstoffarmen und etwas sauren Böden. Ähnliche Halbtrockenrasen sind aus den Weißen Karpaten als *Brachypodio-Molinietum* bekannt.

(4.1) *Anthoxantho-Agrostietum tenuis*: mäßig saure Magerrasen, welche floristisch zwischen *Arrhenatherion* und *Violion caninae* vermitteln. Diese von SILLINGER (1933) aus der Niederen Tatra beschriebene Assoziation wird hier zum ersten Mal für Österreich angegeben. Ihre syntaxonomische Stellung und Umgrenzung bedarf allerdings einer gründlichen Revision, wie ein Vergleich mit ähnlichen Rasentypen aus Tschechien und der Slowakei zeigt (Anhang S4, Abb. 11). So ist die Grenzziehung gegenüber dem aus Böhmen beschriebenen *Campanulo rotundifoliae-Dianthetum deltoidis* unklar, weshalb wir letzteres hier in ein sehr weit gefasstes *Anthoxantho-Agrostietum* einbeziehen. Diese Lösung, wie auch die von uns zur Diskussion gestellte Zuordnung der Gesellschaft zum *Violion caninae*, ist allerdings nur als vorläufig zu betrachten.

(5.1) *Ranunculo bulbosi-Arrhenatheretum*: magere Glatthaferwiesen auf karbonatreichen, trockenen Böden.

(5.2) *Filipendulo vulgaris-Arrhenatheretum* (Abb. 8): magere Glatthaferwiesen auf tonreichen, wechsellöschenden Böden.

(5.3) *Pastinaco-Arrhenatheretum*: nährstoffreiche, eher artenarme Glatthaferwiesen; meist auf frischeren Böden, oft auf ehemaligen Ackerstandorten.

(5.4) *Ranunculo repentis-Alopecuretum pratensis* (Abb. 9): nährstoffreiche, wechselfeuchte Fuchschwanzwiesen, in vielen Fällen wahrscheinlich durch Düngung aus ehemaligen *Molinion*-Wiesen entstanden.

(6.1) *Plantagini-Lolietum*: Trittrassen und häufig gemähte Scherrasen. Die Gesellschaft ist im Gebiet nicht selten, aber kaum dokumentiert.

(6.2) *Cynosuro-Lolietum*: nährstoffreiche Weiden auf frischen Böden; bislang nur durch eine Aufnahme aus dem Gebiet belegt, aber zumindest im westlichen Wienerwald sicher weiter verbreitet.

(7.1) *Succiso-Molinietum*: nährstoffarme, wechselfeuchte Pfeifengraswiesen. Etwa die Hälfte der Bestände dieser ehemals wohl weiter verbreiteten Gesellschaft befinden sich innerhalb der politischen Grenzen Wiens, insbesondere im Naturschutzgebiet „Lainzer Tiergarten“, einem ehemaligen kaiserlichen Jagdgebiet, wo die Wiesen weniger intensiv genutzt werden als anderswo.

(8.1) *Cirsietum rivularis* (Abb. 10): nährstoffreiche Feuchtwiesen. Im Vergleich zu den Pfeifengraswiesen ist dieser Wiesentyp noch relativ häufig im Wienerwald anzutreffen.

(8.2) *Scirpetum sylvatici*: von *Scirpus sylvaticus* dominierter Bereich innerhalb einer größeren Feuchtwiese; nur durch eine Aufnahme belegt.

(9.1) *Mentho-Juncetum inflexi*: sehr nährstoffreiche, durch Wildbetritt stark gestörte Wiesenbestände auf regelmäßig vernässten, tonreichen Böden.

(10.1) *Caricetum davalliana* (Abb. 10): basenreiche Niedermoore mit *Carex davalliana*; im Gebiet meist nur sehr kleinflächig ausgebildet.

(10.2) *Junco subnodulosi-Schoenetum nigricantis*: Niedermoorgesellschaft mit *Juncus subnodulosus* und *Schoenus nigricans*; nur von drei Lokalitäten dokumentiert.

Schlussfolgerungen. Syntaxonomische Gebietsmonographien wie die vorliegende sind als Ergänzung zu großräumigen Bearbeitungen nach wie vor wichtig, da nur auf diesem Weg hinreichend scharfe, ökologisch aussagekräftige Gesellschaftseinheiten erarbeitet werden können, wie sie für naturschutzfachliche Kartierungen notwendig sind. Der Wienerwald ist seit 2005 als UNESCO Biosphärenreservat anerkannt und in seiner Gesamtheit Teil des Natura 2000-Netzwerks. Im Jahr 2011 wurde mit der flächendeckenden Kartierung des Offenlands im Biosphärenpark Wienerwald begonnen, bei welcher auch der hier präsentierte Bestimmungsschlüssel zum Einsatz kommt. Neben diesen mehr grundlagenorientierten Aktivitäten gibt es auch spezifische Naturschutz-Initiativen, wie eine „Wiesenmeisterschaft“, bei welcher Bauern für besonders nachhaltige Bewirtschaftung wertvoller Wiesen ausgezeichnet werden. Im Rahmen von EU-kofinanzierten Projekten wurden zahlreiche Maßnahmen für die Trockenrasen am Ostrand des Wienerwaldes initiiert (Entbuschung, Wiedervernetzung, Beweidung).

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Supplements and Appendices

Supplement 1. Table 2. Synoptic table of the grassland communities of the Vienna Woods.

Beilage 1. Tabelle 2. Stetigkeitstabelle der Graslandgesellschaften im Wienerwald.

Supplement 2–8. Table 3–9. New relevés of the alliances *Seslerio-Festucion pallentis*, *Festucion valesiacae*, *Cirsio-Brachypodion*, *Molinion*, *Calthion*, *Potentillion anserinae* and *Caricion davallianae*, and the associations *Anthoxantho-Agrostietum tenuis*, *Ranunculo bulbosi-Arrhenatheretum*, *Filipendulo vulgaris-Arrhenatheretum*, *Pastinaco-Arrhenatheretum* and *Ranunculo repentis-Alopecuretum* from the Vienna Woods.

Beilage 2–8. Tabelle 3–9. Neue Vegetationsaufnahmen der Verbände *Seslerio-Festucion pallentis*, *Festucion valesiacae*, *Cirsio-Brachypodion*, *Molinion*, *Calthion*, *Potentillion anserinae* und *Caricion davallianae* und der Assoziationen *Anthoxantho-Agrostietum tenuis*, *Ranunculo bulbosi-Arrhenatheretum*, *Filipendulo vulgaris-Arrhenatheretum*, *Pastinaco-Arrhenatheretum* und *Ranunculo repentis-Alopecuretum* aus dem Wienerwald.

Supplement 9. Table 10. Correspondence between TWINSPAN clusters and the final classification.

Beilage 9. Tabelle 10. Vergleich zwischen TWINSPAN- und finaler Klassifikation der Aufnahmen.

Appendix 1. Field determination key for the grassland types of the Vienna Woods.

Anhang 1. Feld-Bestimmungsschlüssel für die Rasengesellschaften des Wienerwalds.

Important notes:

(i) Diagnostic species lists (D): If both alternatives contain a list of diagnostic species, follow the alternative where the summarised cover of the listed species is higher. If only one alternative contains a list of diagnostic species, follow this alternative if the species have a summarised cover > 1%, otherwise follow the other alternative (“species group absent”).

(ii) The following units are not included in the key because their floristic composition could not be evaluated with certainty due to insufficient documentation in the data set:

(2.3) *Medicagini-Festucetum valesiaca*: grasslands dominated by *Festuca valesiaca* on dolomite.

(6.1) *Plantagini-Lolietum*: nutrient-rich, frequently trampled grasslands, usually dominated by *Lolium perenne*.

(6.2) *Cynosuro-Lolietum*: mesic pastures.

(8.2) *Scirpetum sylvatici*: wet meadows dominated by *Scirpus sylvaticus*.

(10.2) *Junco subnodulosi-Schoenetum nigricantis*: mires dominated by *Juncus subnodulosus* and/or *Schoenus nigricans*.

- 1 Dry grassland, usually dominated by *Festuca stricta*, *Stipa eriocalis*, *Carex humilis*, *Sesleria caerulea*, *Festuca valesiaca* or *F. rupicola* 2
- Semi-dry grassland, mesic to wet meadow or mire; not dominated by one of these species 6
- 2 Rocky steppe; D: *Sesleria caerulea*, *Carex humilis*, *Globularia cordifolia*, *Leontodon incanus*, *Helianthemum canum*, *Scabiosa canescens*, *Scorzonera austriaca*, *Teucrium montanum*, *Seseli hippomarathrum*, *Allium montanum*, *Anthericum ramosum*, *Genista pilosa*, *Pulsatilla grandis*, *Linum tenuifolium* (*Seslerio-Festucion pallentis*) 3
- Dry grassland on deeper soil and/or rich in fine earth; D: *Festuca valesiaca*, *Artemisia campestris*, *Astragalus onobrychis*, *Inula oculus-christi*, *Salvia nemorosa*, *Elymus hispidus*, *Poa bulbosa* (*Festucion valesiaca*) 5
- 3 *Sesleria caerulea* grassland on north-facing cliffs; D: *Draba aizoides*, *Saxifraga paniculata*, *Asplenium trichomanes*, *Primula auricula*, *Achillea clavennae*, *Dianthus plumarius* subsp. *neilreichii*, *Acinos alpinus*, *Carex brachystachys*. **(1.1) *Drabo aizoidis-Seslerietum***
- Community different; species group absent 4
- 4 Rocky grassland on shallow soil, usually on south-facing slopes; D: *Festuca stricta*, *Stipa eriocalis*, *Fumana procumbens*, *Jurinea mollis*, *Campanula sibirica*, *Melica ciliata*, *Jovibarba globifera* subsp. *hirta*, *Poa badensis*, *Allium sphaerocephalon*, *Ononis pusilla*, *Alyssum montanum*, *Onosma visianii*. **(1.2) *Fumano-Stipetum eriocalis***
- Grassland on less shallow soil, dominated by *Carex humilis*, more rarely by *Festuca rupicola* or *Bromus erectus*; D: *Prunella grandiflora*, *Seseli annuum*, *Adonis vernalis*, *Linum catharticum*, *Carex caryophylla*, *Scorzonera purpurea*, *Brachypodium pinnatum*, *Briza media*, *Plantago lanceolata*, *Leontodon hispidus*, *Salvia pratensis*, *Carlina acaulis*, *Hypochaeris maculata*, *Stipa joannis*, *Aster amellus*, *Linum flavum*. **(1.3) *Scorzonero austriacae-Caricetum humilis***
- 5 (2) Grassland on hard rock, usually dominated by *Festuca valesiaca*; D: *Medicago minima*, *Poa bulbosa*, *Sedum sexangulare*, *Petrorhagia saxifraga*, *Cruciata pedemontana*. **(2.1) *Stipo capillatae-Festucetum valesiaca***
- Grassland on loess, usually dominated by *Festuca rupicola*; D: *Salvia nemorosa*, *Elymus hispidus*, *Bromus inermis*, *Viola ambigua*, *Oxytropis pilosa*, *Astragalus austriacus*, *Seseli pallasii*. **(2.2) *Salvio nemorosae-Festucetum rupicolae***
- 6 (1) Wet meadow or mire; D: *Ranunculus repens*, *Lychnis flos-cuculi*, *Lysimachia nummularia*, *Carex hirta*, *Carex panicea*, *Cirsium canum*, *Cirsium oleraceum*, *Cirsium rivulare*, *Silaum silaus*, *Succisa pratensis*, *Sesleria uliginosa*, *Molinia caerulea* agg., *Carex davalliana*, *Juncus effusus*, *Juncus articulatus*, *Deschampsia cespitosa*, *Dactylorhiza majalis*, *Scorzonera humilis* 15
- Semi-dry or mesic grassland; species group absent 7
- 7 Moderately acidic grassland; never dominated by *Bromus erectus* or *Arrhenatherum elatius*; D: *Carex pallescens*, *Agrostis capillaris*, *Danthonia decumbens*, *Nardus stricta*, *Polygala vulgaris*, *Galium pumilum*, *Viola canina*, *Thymus pulegioides*, *Potentilla erecta*, *Molinia caerulea* agg., *Calluna vulgaris*, *Veronica officinalis*, *Carex pilulifera*, *Dianthus armeria*, *Antennaria dioica* (*Violion caninae*) 14
- Base-rich grassland; usually dominated by *Bromus erectus* or *Arrhenatherum elatius*; species group absent 8

- 8 Nutrient-poor or moderately nutrient-rich grassland; D: *Bromus erectus*, *Brachypodium pinnatum*, *Primula veris*, *Ranunculus bulbosus*, *Salvia pratensis*, *Plantago media*, *Pimpinella saxifraga*, *Trifolium montanum*, *Ononis spinosa*, *Hypericum perforatum*, *Campanula glomerata*, *Festuca rupicola*, *Cirsium pannonicum*, *Ranunculus polyanthemos* 9
 – Nutrient-rich mesic meadow; species group absent (*Arrhenatherion* p.p.) 13
- 9 Semi-dry grassland; usually dominated by *Bromus erectus*; D: *Helianthemum nummularium*, *Euphorbia cyperissias*, *Thesium linophyllum*, *Teucrium chamaedrys*, *Sanguisorba minor*, *Anthyllis vulneraria*, *Linum catharticum*, *Carlina acaulis*, *Carex caryophylla*, *Trifolium alpestre*, *Koeleria pyramidata*, *Polygala major*, *Polygala comosa* (Cirsio-Brachypodion) 10
 – Mesic meadow; usually dominated by *Arrhenatherum elatius*; D: *Vicia sepium*, *Pimpinella major*, *Alopecurus pratensis* 12
- 10 Grassland on very base-rich soil; D: *Dorycnium germanicum*, *Eryngium campestre*, *Bupleurum falcatum*, *Scabiosa ochroleuca*, *Asperula cynanchica*, *Peucedanum cervaria*, *Seseli annuum*, *Inula ensifolia*, *Stachys recta*, *Thymus odoratissimus*, *Potentilla incana*, *Chamaecytisus ratisbonensis*, *Aster linosyris*, *Aster amellus*, *Carex humilis*, *Pulsatilla grandis*, *Globularia punctata*, *Inula hirta*, *Geranium sanguineum*, *Adonis vernalis*, *Muscari neglectum*, *Cuscuta epithymum*, *Phleum phleoides*, *Prunella grandiflora*, *Scorzonera hispanica*, *Carex michelii*, *Hypochaeris maculata*.
 (3.1) **Polygala majoris-Brachypodietum**
 – Grassland on less base-rich, loamy soil; D: *Filipendula vulgaris*, *Betonica officinalis*, *Trisetum flavescens*, *Festuca pratensis*, *Lathyrus pratensis*, *Rumex acetosa*, *Campanula patula*, *Colchicum autumnale*, *Ranunculus acris*, *Crepis biennis*, *Festuca rubra* agg., *Holcus lanatus* 11
- 11 Grassland on rather nutrient-poor, intermittently dry soil; D: *Carex montana*, *Galium boreale*, *Euphorbia verrucosa*, *Chamaecytisus supinus*, *Galium pumilum*, *Trifolium ochroleucon*.
 (3.3) **Euphorbia verrucosae-Caricetum montanae**
 – Grassland on less nutrient-poor soil; species group absent. (3.2) **Filipendulo vulgaris-Brometum**
- 12 (9) Meadow on base-rich soil without moist-wet phases; D: *Centaurea scabiosa*, *Festuca rupicola*, *Plantago media*, *Securigera varia*, *Onobrychis viciifolia*, *Bupthalmum salicifolium*, *Dianthus carthusianorum* agg., *Medicago falcata*. (5.1) **Ranunculo bulbosi-Arrhenatheretum**
 – Meadow on less base-rich soil with short moist-wet phases; D: *Holcus lanatus*, *Cynosurus cristatus*, *Alopecurus pratensis*, *Betonica officinalis*, *Galium boreale*, *Euphorbia verrucosa*, *Potentilla alba*, *Alchemilla* sp., *Knautia drymeia*. (5.2) **Filipendulo vulgaris-Arrhenatheretum**
- 13 (8) Meadow without longer wet phases; usually dominated by *Arrhenatherum elatius*; D: *Avenula pubescens*, *Campanula patula*, *Knautia arvensis*. (5.3) **Pastinaco-Arrhenatheretum**
 – Meadow with longer wet phases; usually dominated by *Alopecurus pratensis*; D: *Ranunculus repens*, *Ajuga reptans*, *Lysimachia nummularia*, *Lychnis flos-cuculi*, *Carex hirta*, *Cirsium canum*, *Cirsium oleraceum*, *Carex panicea*, *Carex pallescens*, *Sanguisorba officinalis*.
 (5.4) **Ranunculo repentis-Alopecuretum**
- 14 (7) Grassland on rather dry soil; D: *Chamaecytisus supinus*, *Hieracium pilosella*, *Helianthemum nummularium*, *Hypericum perforatum*, *Thesium linophyllum*, *Carex montana*, *Carex caryophylla*.
 (4.1a) **Anthoxantho-Agrostietum tenuis** (dry)
 – Grassland on moist soil; D: species group absent. (4.1b) **Anthoxantho-Agrostietum tenuis** (moist)
- 15 (6) Mire community; D: *Carex davalliana*, *Carex hostiana*, *Carex pulicaris*, *Valeriana dioica*, *Epipactis palustris*, *Eriophorum angustifolium*, *Eriophorum latifolium*, *Parnassia palustris*.
 (10.1) **Caricetum davallianae**
 – Community not a mire; species group absent 16
- 16 Grassland frequently disturbed by trampling animals; D: *Juncus inflexus*, *Carex distans*, *Pulicaria dysenterica*, *Eleocharis uniglumis*, *Potentilla reptans*, *Potentilla anserina*, *Agrostis stolonifera* agg., *Festuca arundinacea*, *Mentha aquatica*, *Mentha longifolia*.
 (9.1) **Mentho-Juncetum inflexi**
 – Grassland not frequently disturbed by trampling animals; species group absent 17
- 17 Meadow on constantly wet soil; D: *Cirsium rivulare*, *Scirpus sylvaticus*, *Caltha palustris*, *Filipendula ulmaria*, *Carex nigra*, *Carex flava* agg., *Bromus racemosus*. (8.1) **Cirsietum rivularis**
 – Meadow on intermittently wet soil (with longer dry phase); species group absent 18

18 Nutrient-rich meadow; usually dominated by *Alopecurus pratensis*; D: *Poa trivialis*, *Ranunculus repens*, *Cirsium oleraceum*, *Crepis biennis*, *Heracleum sphondylium*, *Ajuga reptans*.

(5.4) *Ranunculo repentis-Alopecuretum*

– Nutrient-poor meadow; usually dominated by *Molinia caerulea* agg.; D: *Briza media*, *Galium boreale*, *Betonica officinalis*, *Potentilla alba*, *Allium carinatum*, *Potentilla erecta*, *Bromus erectus*, *Trifolium montanum*, *Sesleria uliginosa*, *Carex tomentosa*, *Selinum carvifolia*, *Inula salicina*, *Succisa pratensis*.

(7.1) *Succiso-Molinietum*

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Appendix S1. Nomenclatural remarks.

Anhang S1. Nomenklatorische Anmerkungen.

Appendix S2. Data sources for Table 2.

Anhang S2. Herkunft der Aufnahmen in Tabelle 2.

Appendix S3. Additional header data for Tables 3–9.

Anhang S3. Weitere Kopfdaten zu den Tabellen 3–9.

Appendix S4. Synoptic table of the *Anthoxantho-Agrostietum* s. lat. in the study area and neighbouring countries.

Anhang S4. Synoptische Tabelle des *Anthoxantho-Agrostietum* s. lat. im Untersuchungsgebiet und Nachbarländern.

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