UNIVERSITY OF LJUBLJANA
BIOTECHNICAL FACULTY

Vladimir STUPAR

PHYTOSOCIOLOGICAL CHARACTERISTICS OF THERMOPHILOUS DECIDUOUS FORESTS OF THE CLASS *QUERCETEA PUBESCENTIS* IN BOSNIA AND HERZEGOVINA WITHIN THE FRAMEWORK OF THE FOREST VEGETATION OF THE WESTERN BALKANS

Doctoral dissertation

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DOCTORAL DISSERTATION

FITOCENOLOŠKE ZNAČILNOSTI TERMOFILNIH LISTOPADNIH GOZDOV RAZREDA *QUERCETEA PUBESCENTIS* V BOSNI IN HERCEGOVINI V OKVIRU GOZDNE VEGETACIJE ZAHODNEGA BALKANA

DOKTORSKA DISERTACIJA

Ljubljana, 2016

This doctoral dissertation represents final part of Interdisciplinary doctoral study program in Biosciences at the Biotechnical Faculty, University of Ljubljana. The research was carried out at the Jovan Hadži Institute of Biology, Research Centre of the Slovenian Academy of Sciences and Arts. On the basis of the Statute of the University of Ljubljana and the decision of the Senate of the Biotechnical Faculty on 19 September 2012, it was confirmed that the candidate fulfils the conditions for carrying out Doctoral study in Biosciences, scientific field: Biology, dissertation topic was approved and doc. dr. Andraž Čarni was appointed as the supervisor.

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AB We studied phytosociological characteristics of thermophilous deciduous forests (TDF) in Bosnia and Herzegovina (B&H) in the framework of the forest vegetation of the Western Balkans. The research was divided into several parts. First, we explored the relation of zonal TDF to other zonal forest communities (ZFPCs) in B&H. Than we conducted phytosociological analysis of the complex feature of oak forests of the Pre-Pannonian region of the Western Balkans in order to separate TDF from meso-acidophilous oak forests, after which we classified the main vegetation types of TDF (*Quercetea pubescentis*) in the Western Balkans, and characterized them by their species composition, ecology and distribution. Finally, we performed the formalized classification of TDF in B&H at the level of association. Several methods of numerical analysis were used on the dataset of around 3500 phytosociological relevés made by the standard Braun-Blanquet's method (399 were made in the field during preparation of the thesis, while the rest was collected from literature). We confirmed that seven ZFPCs (two types belonging to TDF) can be floristically, ecologically, and functionally distinguished for the area of B&H. We also provided criteria for the separation of TDF (class *Quercetea pubescentis*) from meso-acidophilous oak forests (class *Quercetea robori-petraeae*) in the Western Balkans, where it was found that the transitional acido-thermophilous communities should be classified within TDF of *Quercetea pubescentis*. Numerical analysis classified TDF of the Western Balkans into six floristically and ecologically well-defined types, that more or less relate to the syntaxonomical level of already established alliances, while formalized classification of TDF in B&H provided syntaxonomical scheme with 18 associations.

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IN FITOCENOLOŠKE ZNAČILNOSTI TERMOFILNIH LISTOPADNIH GOZDOV RAZREDA *QUERCETEA PUBESCENTIS* V BOSNI IN HERCEGOVINI V OKVIRU GOZDNE VEGETACIJE ZAHODNEGA BALKANA

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AI Obdelali smo fitocenološke značilnosti termofilnih listopadnih gozdov v Bosni in Hercegovini v okviru gozdne vegetacije zahodnega dela Balkanskega polotoka. Raziskava je bila razdeljena na več delov. Najprej smo raziskali razlike med zonalnimi termofilnimi listopadnimi in ostalimi zonalnimi gozdnimi združbami v Bosni in Hercegovini. Potem smo izvedli fitocenološko analizo kompleksne strukture hrastovih gozdov v predpanonski regiji na zahodnem delu Balkanskega polotoka, da smo lahko ločili termofilne listopadne gozdove od mezo-acidofilnih hrastovih gozdov. Nato smo izvedli klasifikacijo glavnih tipov termofilnih listopadnih gozdov (*Quercetea pubescentis*) na zahodnem delu Balkanskega polotoka in jih označili na podlagi vrstne sestave, ekoloških razmer in razširjenosti. Na koncu smo izvedli še formalizirano klasifikacijo termofilnih listopadnih gozdov v Bosni in Hercegovini do ravni asociacij. Podatkovno bazo okoli 3500 fitocenoloških popisov, ki so bili narejeni v skladu s standardno Braun-Blanquetovo metodo (399 popisov smo naredili med pripravo doktorske disertacije, ostale pa smo zbrali iz literaturnih virov), smo analizirali z različnimi numeričnimi analizami. Potrdili smo sedem zonalnih gozdnih združb, od katerih dve uvrščamo med termofilne listopadne gozdove. Te gozdove lahko floristično, ekološko in funkcionalno razlikujemo na ozemlju Bosne in Hercegovine. Ugotovili smo kriterije za delitev termofilnih listopadnih gozdov (razreda *Quercetea pubescentis*) in mezo-acidofilnih hrastovih gozdov (razreda *Quercetea robori-petraeae*) na zahodnem delu Balkanskega polotoka. Tu pa smo našli tudi prehodne acido-termofilne gozdove, ki jih uvrščamo med termofilne listopadne gozdove razreda *Quercetea pubescentis*. Na podlagi numeričnih analize termofilnih listopadnih gozdov zahodnega delu Balkanskega polotoka smo termofilne listopadne gozdove uvrstili v šest skupin, ki so floristično in ekološko dobro opredeljene in bolj ali manj ustrezajo zvezam, ki so že bile opisane, medtem ko smo s formalizirano klasifikacijo pripravili sintaksonomski pregled, ki obsega 18 asociacij.

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II. Stupar V., Brujić J., Škvorc Ž., Čarni A. 2016. Vegetation types of thermophilous deciduous forests (*Quercetea pubescentis*) in the Western Balkans. Phytocoenologia, 46(1): 49–68. doi:10.1127/phyto/2016/0052.

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ABBREVIATIONS

B&H:	Bosnia and Herzegovina
DCA:	detrended correspondence analysis
EIV:	ecological indicator value
GIVD:	Global Index of Vegetation-Plot Databases
ICPN:	International Code of Phytosociological Nomenclature
TDF:	thermophilous deciduous forests
ZFPC:	zonal forest plant community

1 INTRODUCTION AND HYPOTHESES

This work extensively and comprehensively explores the phytosociological characteristics of thermophilous deciduous forests (TDF) of the class *Quercetea pubescentis* in Bosnia and Herzegovina (B&H) within the framework of the forest vegetation of the Western Balkans. The research of TDF in B&H has not been done thoroughly in the whole area of interest until present. In the last 50 years there were only several sporadic and casual observations and descriptions of those forests (Fabijanić et al., 1963, 1967; Stefanović and Manuševa, 1966, 1971; Fukarek, 1975; Stefanović, 1989), but they were never comprehensively elaborated. This motivated us to carry out the research which would contribute to better understanding of the complex structure and distribution of the TDF in the B&H and Western Balkans.

During the preparation of dissertation we dealt with the four aspects of this problem: 1) relation of the TDF to other types of B&H forest (on the example of the zonal forest plant communities (ZFPCs); 2) separation of the TDF from meso-acidophilous oak forests; 3) ecology, floristic composition and distribution of the main types of TDF in the Western Balkans; and 4) classification and nomenclatural revision of the TDF communities of B&H at the level of association.

1.1 RESEARCH AREA

The study was conducted in two overlapping areas: Western Balkans and B&H. In the sense of this study the Western Balkans refers to countries that are completely or in part within the area of the western part of the Balkan Peninsula, i.e., B&H, Croatia, Montenegro, Serbia and Slovenia. This area includes the entire range of the Dinaric Alps, southeastern fringes of the Alps in Slovenia, southwestern fringes of the Carpathian Mountains and the western fringes of the Balkan Mountains in Serbia and the hills and low mountains of the southern margin of the Pannonian Plain in Slovenia, Croatia, B&H and Serbia (Figure 1). We added also relevés from three associations from southern and western Hungary (Mecsek Hills and Transdanubian Range), which were collected from the literature. All in all, 399 relevés was sampled in the field (all of them in TDF in B&H), while all other relevés were collected from the literature (274 relevés from TDF in B&H, around 550 from other zonal forests in B&H, and around 2300 from TDF from other countries). Biogeographically, the study area belongs to (a) the Euro-Siberian biogeographical region, particularly the Illyrian sector of the Apennine-Balkan province, the Pannonian sector of the Pannonian-Carpathian province and the Eastern Alpine sector of the Alpine province, and (b) the Mediterranean biogeographical region, particularly the Epiro-Dalmatian sector of the Adriatic province (Rivas-Martínez et al., 2004). In addition to its diverse topography, it comprises a great variety of bedrock and soils. Carbonate bedrock prevails in the southern and western parts of the study area (southwestern Dinaric

Alps), while bedrock is mostly siliceous in the northern and eastern parts (northeastern Dinaric Alps, Carpathian and Balkan Mountains, and the hills and low mountains of the southern margin of the Pannonian Plain) (Velić and Velić, 1983). The climate is also diverse, since two major climatic zones overlap in the Western Balkans: central European one from the north and Mediterranean one from the south. The borderline between these two climate types is not distinct and lies in the transitional zone of the Dinaric Alps, being highly influenced by mountain massifs (Delijanić et al., 1964). River valleys and canyons also have a significant role in climate modification, since the Mediterranean climate penetrates through them deep into the continent. This part of Europe has been under intensive anthropogenic influence since the early Neolithic, especially the sub-Mediterranean and Pannonian regions. Large portions of this land were altered, mainly deforested, quite early because of the early spread of agriculture (Horvat et al., 1974).

Figure 1: The area of the Western Balkans in the sense of this study (in saturated tints).

B&H is located in the central part of the Western Balkans. Biogeographically, it is divided into four regions (Stefanović et al., 1983) (Figure 2): Pre-Pannonian (continental, northern B&H), Dinaric (mountainous, central B&H), Mediterranean (southern and south-western

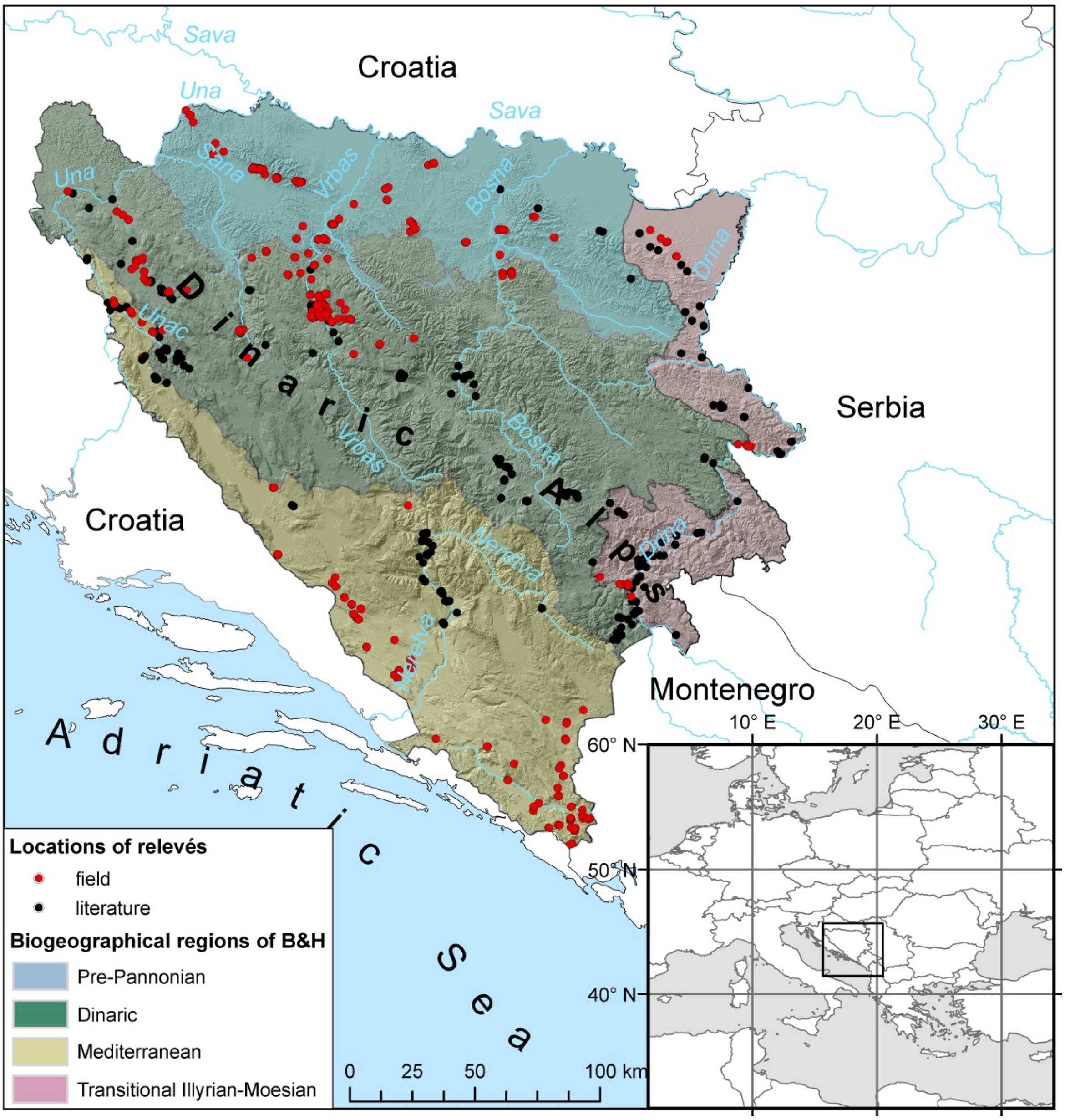

Figure 2: Biogeographical division of B&H. Dots represent localities of 673 relevés from TDF used in this study (black – 274 relevés from literature, red – 399 relevés from author's field research).

B&H), and Transitional Illyrian-Moesian (eastern B&H). Pre-pannonian B&H embraces the southern outcrops of the Pannonian Plain and the northern foothills of the Dinaric Alps and is an area of predominantly low mountains, hills and the alluvial plains of the Sava River and lower reaches of the rivers Una, Vrbas, Bosna and Drina. Dominant forest vegetation is represented by meso-neutrophilous forests of beech, common hornbeam and sessile oak. The major part of the central (Dinaric) region is mountainous, with the high

Dinaric Alps spreading in a NW-SE direction. Forest vegetation is for the most part represented by mesic forests of beech, fir and spruce. Deep limestone river canyons and valleys, which generally have a north-south direction, are a prominent feature of this mountainous region. The southern, Mediterranean part of the country is highly influenced by the Mediterranean climate and mainly belongs to the sub-Mediterranean zone, while the Eu-Mediterranean zone occupies only a narrow belt around the short Adriatic coastline. This part of the country consists of limestone mountains and hills intersected by numerous karstic fields (Livanjsko polje, Duvanjsko polje, Posuško polje, Mostarsko blato, Popovo polje, Nevesinjsko polje, Gatačko polje, Dabarsko polje etc.) with the large alluvial plane of the Mediterranean River Neretva in the south. Zonal vegetation of this region is represented by downy oak/oriental hornbeam forests. The eastern, Transitional Illyrian-Moesian biogeographical region comprises a relatively narrow belt along the River Drina at the border with Serbia. It is a biogeographical and climatic transition between the western more humid Illyrian zone and the eastern, dryer Central Balkans. The zonal community is Central Balkans hungarian oak/turkey oak forest. Carbonate bedrock (limestone and dolomite) predominates in the southern and western parts of the country, while the northern and eastern parts are composed of carbonate, siliceous and ultramafic rocks (Velić and Velić, 1983). The climate is similar to that of the Western Balkans with central European influence from the north, Mediterranean from the south, and transitional mountain zone intersected with river valleys and canyons, with their south-north direction, bringing the Mediterranean climate deeper into the central and northern parts of the country. Bearing in mind this great diversity of abiotic features in B&H, it is not surprising that it harbors great diversity of vascular plants, with a large number of endemics (Lubarda et al., 2014) and, consequently, great diversity of vegetation types (Lakušić et al., 1978; Jovanović et al., 1986; Redžić, 2007). Forests cover around 54% of the country's area and thermophilous deciduous forests occupy ca. 5800 km^2, which is around 11% of the country's territory (Stefanović et al., 1983).

1.2 PROBLEM OF CLASSIFICATION OF THERMOPHILOUS DECIDUOUS FORESTS IN WESTERN BALKANS AND IN BOSNIA AND HERZEGOVINA

TDF of the class *Quercetea pubescentis* are broadly distributed in the southern parts of Europe, with the highest diversity in the Balkan and Apennine peninsulas (Horvat et al., 1974; Bohn and Neuhäusl, 2004; Ellenberg, 2009). They form a climax vegetation on zonal sites here, while further to the north, in Central Europe, they are extrazonal and occur on the warmest and driest sites of southern slopes or rocky outcrops (Ellenberg, 2009) or they result from former forest management practices (Hédl et al., 2010). They are dominated by deciduous oaks, mostly *Quercus pubescens, Q. frainetto* and *Q. cerris* much less by *Q. petraea* and *Q. robur*. Other tree species may be admixed or even dominate, particularly *Carpinus orientalis, Fraxinus ornus* and *Ostrya carpinifolia*.

Steep biogeographical and ecological gradients and a variety of human impact over time generated a great diversity of TDF (Blasi et al., 2004; Bergmeier and Dimopoulos, 2008; Ketenoğlu et al., 2010; Redžić, 2011; Borhidi et al., 2012; Uğurlu et al., 2012; Tomić and Rakonjac, 2013), which in some parts of Europe have been well described using numerical classification methods (Blasi et al., 2004; Roleček, 2005; Bergmeier and Dimopoulos, 2008; Kevey, 2008; Chytrý, 2013). Although the study of TDF has a long tradition in the Western Balkans (Horvat, 1938; Tomažič, 1939; Rudski, 1949; Fabijanić et al., 1963; Blečić and Lakušić, 1967), numerous ecological and syntaxonomical issues remained unresolved (Čarni et al., 2009; Vukelić, 2012; Tomić and Rakonjac, 2013). Čarni et al. (2009) showed a general lack of available phytosociological data for the central part of the Western Balkans. For example, *Quercus pubescens* and *Carpinus orientalis* climax communities in the area of southern B&H, Croatia and Montenegro, remained to date uninvestigated in terms of phytosociology.

The situation is similar at the level of B&H where TDF of the class *Quercetea pubescentis* occupy about one fifth of the forest area (Stefanović et al., 1983). In southern B&H, TDF are represented by zonal communities dominated by *Quercus pubescens* and *Carpinus orientalis* (Stefanović et al., 1977b). Similar communities are developed extrazonally in other parts of the country, mainly along river canyons (Fukarek, 1975; Stefanović, 1979a, 1989). *Ostrya carpinifolia* takes a dominant role at higher altitudes in southern B&H, in moister and cooler limestone canyons in central B&H and on steep southern exposure limestone and dolomite outcrops of central and northern B&H (Fabijanić et al., 1967; Stefanović, 1979a; Lakušić et al., 1982b). Azonal *Quercus cerris* forests are the main type of forest vegetation in dry karst fields of western and southern parts of the country (Stefanović, 1968), while *Quercus frainetto* is the main species in zonal forest vegetation in eastern B&H in the zone of biogeographical and climatic transition towards the dryer Central Balkans (Fukarek et al., 1974; Horvat et al., 1974; Stefanović, 1988). Acido-thermophilous *Quercus petraea* dominated forests are a particular type of thermophilous deciduous forests in B&H, which are found on warmer habitats over acidic bedrock throughout eastern, central and northern B&H. This large diversity of TDF over relatively small area of B&H resulted in many problems related to the classification and nomenclature of these communities (Lakušić et al., 1982b; Redžić, 2007, 2011). Redžić (2007, 2011) compiled two versions of syntaxa checklists for B&H, but he affirms that the status of vegetation of TDF in this region remains unclear. Besides to the large diversity of this vegetation type, these problems can mainly be related to poor coverage by phytosociological relevés (only 274 have been published for the whole country). Research in the past was mainly restricted to canyon systems and *Carpinus orientalis* scrub (Lakušić et al., 1987; Lakušić and Redžić, 1989, 1991; Stefanović, 1989; Muratspahić et al., 1991) (Figure 2). Studies of other types were conducted at a limited number of localities, resulting with only a modest number of relevés (Fabijanić et al., 1963; Stefanović, 1964b, 1968; Fukarek et al., 1974; Bucalo, 1999; Redžić and Barudanović, 2010; Brujić, 2013), while some types were not recorded at all. Furthermore, as relevés were sampled by many authors, they were burdened by methodological inconsistencies, while relatively long period of time in which relevés were sampled (over 60 years) could have meant that some older relevés did not correspond to the current state in the field (because of possible structural and compositional shift over time due to various ecological factors), all of which made the information contained in them less reliable. Additionally, the nomenclature is far from being settled. Original literature is overcrowded with pseudonyms, invalidly published names, new names for already validly published syntaxa and a plethora of *nomina nuda*. Some syntaxa from neighbouring regions have been uncritically included in B&H syntaxonomical overviews. This can be illustrated by the fact that in the first overview of this type of vegetation in B&H, the number of different associations was 14 (Lakušić et al., 1978), while in the last, in which the author listed all names that occurred in published or unpublished sources, the number of associations was 44 (Redžić, 2011).

Finally, there is an issue of the syntaxonomical position of the acido-thermophilous *Quercus petraea* forests, which are transitional between thermophilous *Quercetea pubescentis* and mesic acidophilous *Quercetea robori-petraeae* forests (Horvat, 1963; Cross and Pallas, 2004; Härdtle, 2004; Baričević et al., 2006a, 2006b; Vukelić, 2012). Oak forests of *Quercetea robori-petraeae* (acidophilous species-poor oak, oak-birch and beech-dominated deciduous woods on mesic nutrient-poor soils) extend within the temperate zone of Europe from the Atlantic coast to western Russia, and reach their south-easternmost limit in the Western Balkans. They are characterized by acidophytes of central European and temperate Eurasian distribution in the undestorey. The soils are characteristically permeable or intermittently moist, oligotrophic, acidic, often sandy and sometimes shallow or rocky. Their characteristic species combination gradually changes towards the south, where thermophilous oak forests become dominant (Bohn and Neuhäusl, 2004; Härdtle, 2004). Syntaxonomical position of the transitional acido-thermophilous forests, mainly dominated by *Quercus petraea*, is often considered ambiguous (Chytrý, 1997; Kasprowicz, 2010; Indreica, 2012). In the study area, these communities are found particularly on acidic soils on southern slopes of hills and low mountains on the southern margins of the Pannonian Plain and northern Dinaric Alps, which are rich in thermophilous species of southeast European, as well as wider distribution. Although these forests are easily distinguished from acido-mesophilous *Quercetea robori-petraeae* by the number of thermophilous and xerophilous species and the absence of strong acidophytes, in this region authors differ in their syntaxonomical treatment: in B&H, they are classified to *Quercetea robori-petraeae* (Stefanović et al., 1977a; Stefanović, 1984), in Serbia to *Quercetea pubescentis* (Jovanović et al., 1986; Tomić et al., 2006; Tomić and Rakonjac, 2013), while in Croatia and Hungary different associations are classified to different classes (Kevey and Borhidi, 2005; Baričević et al., 2006a, 2006b; Trinajstić, 2008; Borhidi et al., 2012; Vukelić, 2012). The complexity of this problem and necessity of further study have been highlighted by many local and regional studies (Fabijanić et al., 1963; Gajić, 1971; Janković, 1974; Stefanović, 1984; Kevey and Borhidi, 2005). Syntaxonomical issues are linked also to taxonomical ambiguities, since there exist morphologically intermediate individuals between *Quercus petraea, Q. pubescens* and *Q. robur,* which are nearly impossible to distinguish during field research (Dupouey and Badeau, 1993; Kleinschmit et al., 1995). At the same time, different authors use different concepts of taxa (Škvorc et al., 2005; Di Pietro et al., 2012). These issues contribute to difficulties regarding the classification of TDF in the Western Balkans.

1.3 CONCEPT OF ZONAL FOREST VEGETATION

Every plant community is a result of a complex interaction of various ecological factors in a given place and time. In terms of natural vegetation, there are three types of vegetation that generally develop in accordance with the biotic, climatic and soil conditions: zonal, extrazonal and azonal (Dierschke, 1994; Ellenberg, 2009; Surina, 2014). Zonal vegetation is a large-scale expression of climate dominating a particular area, while it is not confined to specific soil conditions, i.e., it most precisely reflects the macroclimatic conditions of particular regions (Kovar-Eder and Kvaček, 2007). Furthermore, zonal vegetation often does not represent a single homogenous plant association but rather a number of similar communities, which can differ to some extent and, consequently, it is possible to talk of a 'zonal vegetation group' (Ellenberg, 2009). For example, when different bedrocks and soil series occur within the same climatic zone or there is a species turnover due to minor biogeographical differences, several different, yet similar associations make up the zonal vegetation group. Furthermore, a mountainous relief of a particular climatic zone leads to vertical differentiation of the climatic factors and, accordingly, vertical differentiation of zonal vegetation communities, which are then often called 'altitudinal belts'.

Although in the last several thousand years man has deforested great parts of Europe (Gunia et al., 2012), the potential natural vegetation and, consequently, the zonal vegetation of most of temperate Europe is forest (Bohn and Neuhäusl, 2004; Ellenberg, 2009). The same is valid for B&H (Horvat et al., 1974; Stefanović et al., 1983). Authors who investigated the problem of the zonal forest vegetation of the Western Balkans and B&H generally agree that, following the macro-climatic diversity, seven ZFPCs can be distinguished for the territory of B&H (Figure 3) (Horvat et al., 1974; Stefanović et al., 1983; Beus, 1984). Four communities are represented by various oak forests, which occupy the lowlands and hilly region of B&H, while the other three are altitudinal belts (montane, altimontane and subalpine) above the oak forests, mainly built by various types of beech forests (pure and mixed). Two of them belong to TDF of the class *Quercetea pubescentis*: 1) sub-Mediterranean *Quercus pubescens-Carpinus orientalis* forests (major part of lowland and hilly region in southern B&H); and 2) Central Balkans *Quercus frainetto* forests (relatively narrow lowland and hilly belt of eastern B&H). These communities cover nearly 4% of the country's territory (or around 8% of all forests) (Stefanović et al., 1983), while their potential area is much bigger (about 15% of country) (Horvat et al., 1974).

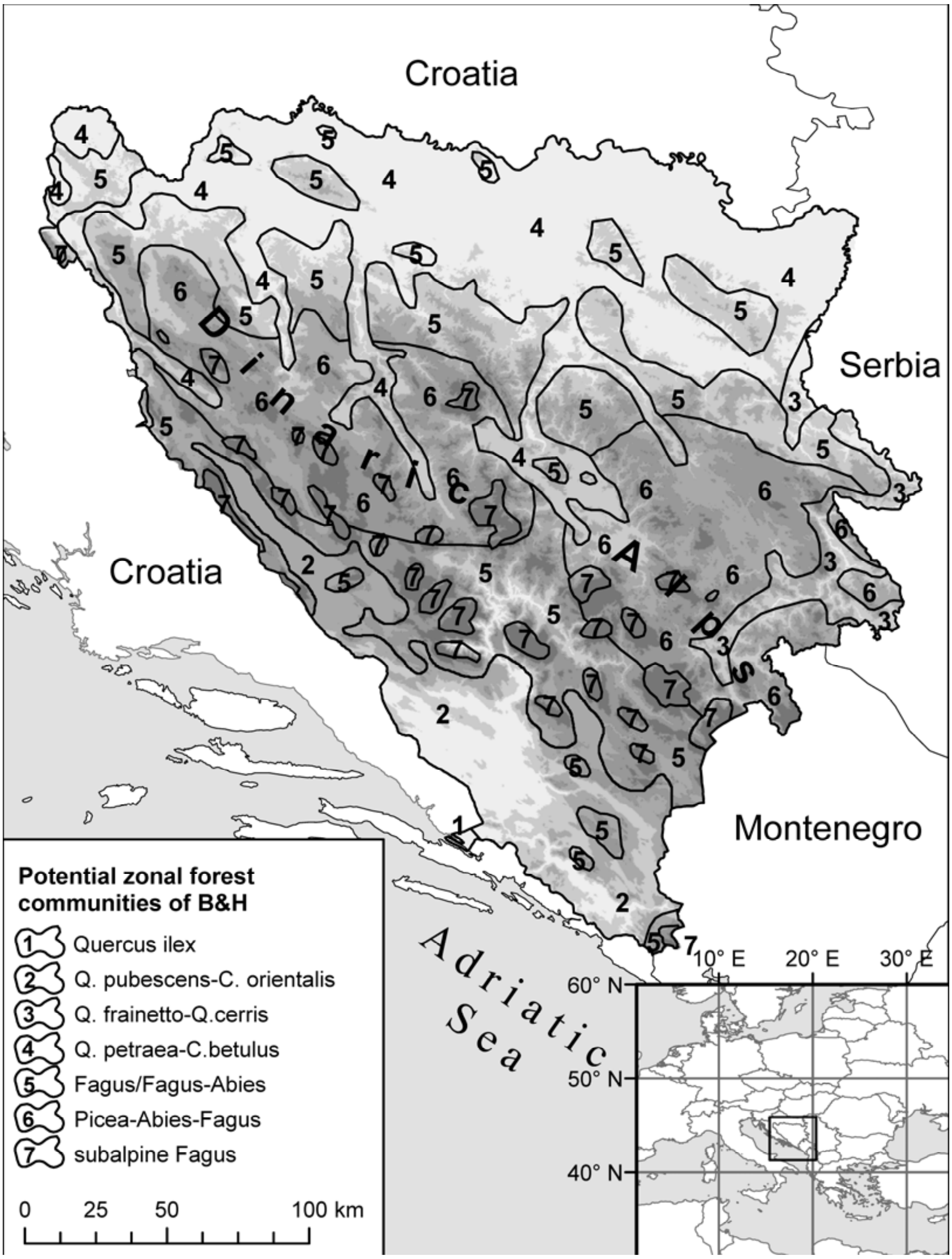

Figure 3: Potential areas of ZFPCs in B&H (Horvat et al. 1974, modified after Stefanović et al. 1983).

1.4 FUNCTIONAL APPROACH TO CLASSIFICATION OF PLANT COMMUNITIES

There are two different conceptual frameworks for the classification of plant communities. The traditional approach to classification (Braun-Blanquet, 1964) is performed at the species level, while a more recent 'functional' approach is based on plant functional types (Duckworth et al., 2000; Shipley, 2010; Škornik et al., 2010).

While traditional floristic approach to classification of plant communities is widely accepted in Europe and in use for over a century (Flahault and Schröter, 1910), some vegetation studies gained from a functional approach which can compare samples of different floristic composition. Functional approach to vegetation classification is based on 'plant functional types', which are non-phylogenetic groupings of species that show close similarities in their response to environmental and biotic factors. They are derived from plant traits based on species morphology, physiology and/or life history (Pérez-Harguindeguy et al., 2013). Plant functional types can aid in the understanding of ecological processes, such as the assembly and stability of communities and succession, and facilitate the detection and prediction of response to environmental change on a range of scales (Duckworth et al., 2000). With plant functional types, comparisons between communities of widely differing floristic composition can be facilitated (Diaz et al., 2004). There are two main approaches to classify functional types (Shipley, 2010). The first is used especially by plant geographers, concentrating on the morphological properties of plants, e.g., Raunkiaer's life-forms (Raunkiaer, 1934) and how, on average, such morphologies change as a function of major climatic variables. A second approach is based on the notion of ecological 'strategies', for which Grime's model of CSR triangle (Grime, 1974, 1977, 2001) is often used (Pugnaire and Valladares, 2007). This model is a classification based on how plants deal with two groups of external factors, i.e., stress and disturbance, which results in three primary plant strategies: competitors (C), stress-tolerators (S), and ruderals (R) and four secondary, intermediate ones. The position of each species, as well as relevé, can be determined in a CSR triangle. The whole community is thus given a functional signature, which can be very useful in comparative studies involving widely differing samples (Hunt et al., 2004). While the use of ecological strategies is quite common in studies of herbaceous vegetation (Hunt et al., 2004; Zelnik and Čarni, 2008; Škornik et al., 2010; Pipenbaher et al., 2013), it is lately also gaining ground in the study of forest and woodland communities (Kilinç et al., 2010; Paušič and Čarni, 2012; Juvan et al., 2013; Košir et al., 2013; Rozman et al., 2013). Its use is most often related to studies of changes in communities' composition as a response to disturbance, succession, environmental changes or in gradient analysis.

1.5 NOMENCLATURE OF SYNTAXA

Nomenclature of TDF syntaxa in B&H is very perplexed. This, undoubtedly, for the main part can be attributed to the absence of modern statistical software without which the use of powerful numerical methods in vegetation classification was not possible. This led (not only in B&H) to the proliferation of syntaxonomical synonyms and pseudonyms. Another problem that was also not exclusive to B&H was that vegetation scientists were inconsistent in following the rules of ICPN (Weber et al., 2000), which led to a great number of invalidly published names.

While trying to clean up the syntaxonomical nomenclature of the TDF associations in B&H we strictly followed the rules of ICPN. The correct name was determined for every association in their orthographically correct form according to ICPN Art. 41. The accepted names of associations that contained only the genus name(s) in the original diagnosis were supplemented with species epithets in accordance with Recommendation 10c of the Code. All synonyms older than the respective accepted name include a reference to the article and paragraph of the Code according to which the name must be rejected. This was not done in case of synonyms that were younger than the accepted names because such names were not candidates for the correct name due to the priority principle. Lists of synonyms also included frequently used pseudonyms, i.e., names of syntaxa used with the original author citation, but misinterpreted by later authors. Pseudonyms were cited with the name of the misinterpreting author, preceded by the word *sensu*, and followed by the name of the author of the original description after the word *non.* For every accepted correct name, the original name as given in the original diagnosis was provided. The dates of effective publication of syntaxa were taken from the papers in which they were validly published, regardless of possible different indications reported by the authors in the papers. Doctoral or master theses that were not available in libraries were not considered to be effective publications. Lectotypes and neotypes were chosen for syntaxa not yet typified. For invalidly published syntaxa according to Article 5, holotypes were indicated. When the name of a syntaxon was published by an author without a sufficient original diagnosis, that syntaxon was considered to be *nomen nudum*. A modified form of the name, i.e., *nomen mutatum,* was used as a replacement for a syntaxon name that was originally formed from the names of taxa not used in recent taxonomic and floristic literature, with syntaxon names that include the names of taxa that are in accordance with contemporary taxonomic literature. Diagnoses of new associations were accompanied by a description of the association and a phytosociological table with holotype indicated.

1.6 RESEARCH OBJECTIVES AND HYPOTHESES

In our study, we aimed to address the following questions: 1) Can zonal TDF in B&H be differentiated from the other ZFPCs in terms of ecological factors and plant traits? 2) Can we syntaxonomicaly separate different types of oak forests in the complex feature of these forests in the hills of Pre-Pannonian region of the Western Balkans, i.e., northern B&H and northern Croatia (Slavonia)? 3) Can we identify the main types of TDF in the Western Balkans and the main underlying gradients driving the variation in their species composition? 4) Can TDF of B&H be formally classified at the level of association so that we can give the comprehensive syntaxonomical scheme with the valid nomenclature?

The main objectives of our research were:

- to evaluate ecological factors that drive the separation of ZFPCs in B&H and to test how different plant traits reflect the differences in floristic composition of the ZFPCs of which the TDF of *Quercetea pubescentis* are important constituent part,
- to distinguish communities of *Quercetea pubescentis* from those of *Quercetea robori-petraeae,*
- to classify the main vegetation types of TDF (*Quercetea pubescentis*) in the Western Balkans based on numerical analysis, and to characterize them by their species composition, ecology and distribution,
- to identify the main underlying gradients driving the variation in species composition of *Quercetea pubescentis* in the Western Balkans,
- to formally classify TDF of *Quercetea pubescentis* in B&H (at the level of association),
- to check the validity and legitimacy of the existing nomenclature in B&H and to correct and typify syntaxa according to the ICPN.

We hypothesized that:

H1) Ecological, structural and chorological differences expressed through site ecology, plant functional types and plant chorotypes reflect the differences in floristic composition of the forests plant communities of *Aremonio-Fagion*, *Erythronio-Carpinion* and *Quercetea pubescentis* that form zonal forest vegetation of the region.

H2) Due to the complex ecological gradients, oak forests of northern B&H represent a mixture of thermophilous, mesophilous and acidophilous communities; within this complex feature the main pattern can be defined.

H3) Floristic composition within TDF enables to build a logical system and to integrate it in a wider framework of the forest vegetation of the Western Balkans.

2 SCIENTIFIC PAPERS

2.1 EKOLOŠKA, FLORISTIČNA IN FUNKCIONALNA ANALIZA ZONALNE GOZDNE VEGETACIJE V BOSNI IN HERCEGOVINI

Stupar V., Čarni A. 2016. Ecological, floristic and functional analysis of zonal forest vegetation in Bosnia and Herzegovina. Acta Botanica Croatica, accepted for publishing

I declare that the version in this thesis is identical to the version accepted for publication.

Izvleček

Zonalna vegetacija odraža v makroklimatske razmere. Ker je država klimatsko precej raznolika, je bilo ugotovljeno, da lahko v BiH ločimo sedem zonalnih gozdnih združb. Na podlagi podatkov iz BiH smo hoteli ugotoviti, ali je makroklima (podnebje) res najbolj pomemben dejavnik, ki omogoča razvoj določenih conalnih gozdnih rastlinskih združb. Korespondenčna analiza z odstranjenim trendom (DCA) vseh 398 popisov sedmih zonalnih gozdnih združb je pokazala, da je sprememba vrstne sestave vzdolž prve osi, ki predstavlja najdaljši gradient, v veliki meri odvisna od makroklimatskega gradienta (povprečna letna temperatura, povprečna temperatura najhladnejšega četrtletja in padavin v najtoplejšem četrtletju). Med spremembami vrstne sestave vzdolž prve osi in topografskimi dejavniki (nagib in ekspozicija) in reakcijo tal nismo našli statistično značilnih korelacij. Floristična analiza na podlagi diagnostičnih vrst pa je jasno pokazala ločitev sedmih zonalnih gozdnih združb. Funkcionalna analiza vseh vegetacijskih plasti je pokazala, da ima konkurenčno ekološko strategijo največji delež rastlinskih vrst, medtem ko smo pri analizi samo zeliščne plasti opazili premik ekoloških strategij (CSR) prosti sredini osi, ki prestavlja os kompetitorji-stres toleratorji. Ruderalnost je na splošno slabo v teh gozdovih slabo izražena. Ugotovili smo, da se obstajajo statistično pomembne razlike med življenjskimi oblika v deležih fanerofitov, geofitov in hemikriptofitov. Naša raziskava potrjuje, da je makroklimatski gradient najpomembnejši dejavnik pri formiranju conalnih gozdnih združb. Podpisi ekoloških strategij (CSR) kažejo, da je obravnavana conalna gozdna vegetacija v produktivni fazi in v zadnji sukcesijski fazi. To pa ne velja za degradirane sestoje črničevja (*Quercus ilex*) (makija), ki so v srednji stopnji sekundarne sukcesije.

Ecological, floristic and functional analysis of zonal forest vegetation in Bosnia and Herzegovina

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Running title: Zonal forest vegetation of Bosnia and Herzegovina

Abstract - Zonal vegetation is a large-scale expression of macro-climate and, due to the climatic diversity of the country, there are seven traditionally recognized zonal forest plant communities in Bosnia and Herzegovina (B&H). Using data from Bosnia and Herzegovina, this study aimed to reveal whether macro-climate is indeed the most important factor determining the existence of zonal forest plant communities (ZFPC). Detrended correspondence analysis of 398 relevés of seven ZFPCs revealed that the species turnover along the first axis is strongly related to the macro-climatic gradient (annual mean temperature, mean temperature of the coldest quarter and precipitation of the warmest quarter). No correlation was detected between this gradient and topographic factors (slope and aspect) and soil reaction. Floristic analysis revealed clear separation of ZFPCs in terms of diagnostic species. Functional analysis of all layers showed that competitive ecological strategy has the highest proportion, while analysis of the herb layer alone expressed a shift of CSR signatures towards the middle of the C–S axis. Ruderality was overall poorly expressed. Statistically significant differences between communities were discovered along the C–S axis. In terms of life forms, statistically significant differences between communities were discovered in proportions of Phanerophytes, Geophytes and Hemicryptophytes. Our study confirms that macro-climatic gradient is the most important determinant of the species turnover along ZFPCs. CSR signatures show that zonal forest vegetation is represented by productive communities in a terminal stage of succession. This does not refer to degraded *Quercus ilex* stands (maquis), which are in the middle stage of secondary succession.

Key words: Balkans, climatic gradient, chorotypes, ecological strategies, life forms, ordination, plant functional types, zonal communities

Abbreviations: B&H - Bosnia and Herzegovina, ZFPC - zonal forest plant community

Introduction

Every plant community is a result of a complex interaction of various ecological factors in a given place and time. In terms of natural vegetation, there are three types of vegetation that generally develop in accordance with the biotic, climatic and soil conditions: zonal, extrazonal and azonal (Dierschke 1994, Ellenberg 2009, Surina 2014). Zonal vegetation is a large-scale expression of climate dominating a particular area, while it is not confined to specific soil conditions, i.e., it most precisely reflects the macroclimatic conditions of particular regions (Kovar-Eder and Kvaček 2007). Zonal vegetation often does not represent a single homogenous plant association but rather a number of similar communities, which can differ to some extent and, consequently, it is possible to talk of a 'zonal vegetation group' (Ellenberg 2009). For example, when different bedrocks and soil series occur within the same climatic zone or there is a species turnover due to minor biogeographical differences, several different, yet similar associations make up the zonal vegetation group. Furthermore, a mountainous relief of a particular climatic zone leads to vertical differentiation of the climatic factors and, accordingly, vertical differentiation of zonal vegetation communities, which are then often called 'altitudinal belts'.

Although in the last several thousand years man has deforested great parts of Europe (Gunia et al. 2012), the potential natural vegetation and, consequently, the zonal vegetation of most of temperate Europe is forest (Bohn and Neuhäusl 2004, Ellenberg 2009). The same is valid for Bosnia and Herzegovina (B&H) (Horvat et al. 1974, Stefanović et al. 1983). B&H is situated in the western part of the Balkan Peninsula in SE Europe (Fig. 1). Its climate is very diverse, since two major climatic zones overlap here: central European from the north and Mediterranean from the south. The climate of the transitional zone is highly modified by the influence of mountain massifs (Dinaric Alps), while in the eastern part of country the influence of the dryer continental climate can be felt (Milosavljević 1976). While vegetation studies of forests in the neighboring regions have produced synthetic overviews (Borhidi et al. 2012, Vukelić 2012, Chytrý 2013, Tomić and Rakonjac 2013), despite the fairly long tradition of phytosociological studies in B&H (Horvat 1933, 1941, Horvat and Pawlowski 1939, Tregubov 1941) and considerable number of relevés, the ecology, nomenclature and syntaxonomical position of the majority of B&H forests still remains unsettled (Redžić 2007). With the exception of thermophilous deciduous forest communities (Stupar et al. 2015), this also applies to zonal vegetation, which has only been the subject of a few studies in the past (Horvat et al. 1974, Stefanović et al. 1983, Beus 1984). However, following the macro-climatic diversity, these authors generally agree that seven ZFPCs can be distinguished for the territory of B&H (Tab. 1, Fig. 1). Four communities are represented by various oak forests, which occupy the lowlands and hilly region of B&H, while the other three are altitudinal belts (montane, altimontane and subalpine) above the oak forests, mainly built by various types of beech forests (pure and mixed).

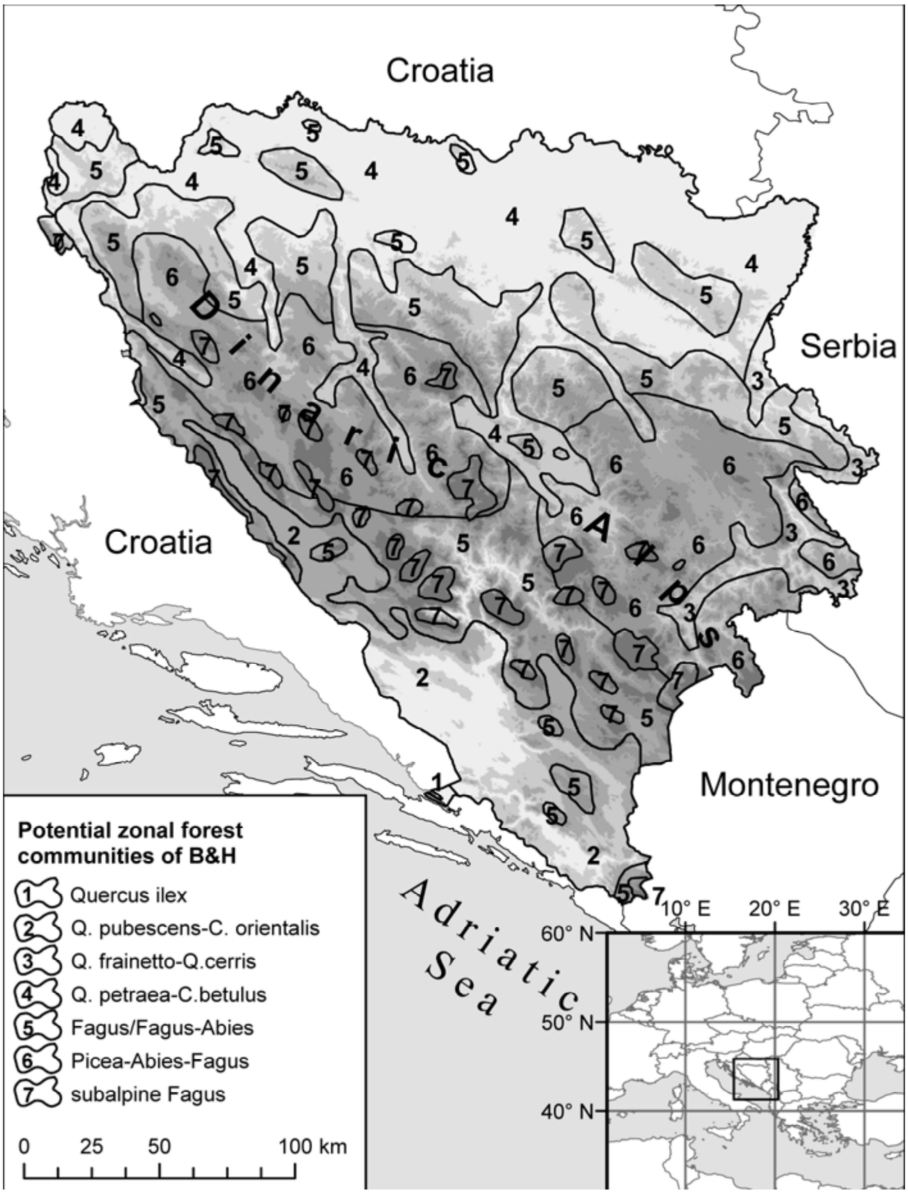

Fig. 1. Location of the study area. The potential ZFPCs are indicated (Horvat et al. 1974, modified after Stefanović et al. 1983). Numbers on the map correspond to community numbers in Tab. 1.

There are two different conceptual frameworks for the study of plant communities. The traditional approach to classification is performed at the species level, while a more recent 'functional' approach is based on plant functional types (Duckworth et al. 2000, Shipley 2010, Škornik et al. 2010). Plant functional types are non-phylogenetic groupings of species that show close similarities in their response to environmental and biotic factors. They are derived from plant traits based on species morphology, physiology and/or life history (Pérez-Harguindeguy et al. 2013). Plant functional types can aid in the understanding of ecological processes, such as the assembly and stability of communities and succession, and facilitate the detection and prediction of response to environmental change on a range of scales (Duckworth et al. 2000). With plant functional types, comparisons between communities of widely differing composition can be facilitated (Diaz et al. 2004). There are two main approaches to classify functional types (Shipley 2010). The first is used especially by plant geographers, concentrating on the morphological properties of plants, e.g., Raunkiaer's life-forms (Raunkiaer 1934) and how, on average, such morphologies change as a function of major climatic variables. A second approach is based on the notion of ecological 'strategies', for which Grime's model of CSR triangle (Grime 1974, 1977, 2001) is often used (Pugnaire and Valladares 2007). This model is a classification based on how plants deal with two groups of external factors, i.e., stress and disturbance, which results in three primary plant strategies: competitors (C), stress-tolerators (S), and ruderals (R) and four secondary, intermediate ones. The position of each species, as well as relevé, can be determined in a CSR triangle. The whole community is thus given a functional signature, which can be very useful in comparative studies involving widely differing samples (Hunt et al. 2004).

While the use of ecological strategies is quite common in studies of herbaceous vegetation (Hunt et al. 2004, Zelnik and Čarni 2008, Škornik et al. 2010, Pipenbaher et al. 2013), it is lately also gaining ground in the study of forest and woodland communities (Kilinç et al. 2010, Paušič and Čarni 2012, Juvan et al. 2013, Košir et al. 2013b, Rozman et al. 2013). Its use is most often related to studies of changes in communities' composition as a response to disturbance, succession, environmental changes or in gradient analysis.

Tab. 1. Zonal forest plant communities in Bosnia and Herzegovina. Community numbers correspond to those used in Tabs. 3–4, and Figs. 1–4. Asterisk (*) denotes provisional invalid names still in use in Bosnia and Herzegovina.

Community no.	Forest type	Related syntaxa	No of relevés	No of resampled relevés
1	*Quercus ilex*	*Quercion ilicis* Br.-Bl. 1931 (1936)	5	5
2	*Quercus pubescens-Carpinus orientalis*	*Querco pubescenti-Carpinetum orientalis* Horvatić 1939 (*Carpinion orientalis* Horvat 1958)	30	16
3	*Quercus frainetto*	*Quercetum frainetto-cerridis* (Rudski 1949) Trinajstić et al. 1996 (*Quercion frainetto* Horvat 1954)	38	24
4	*Quercus petraea-Carpinus betulus*	*Querco-Carpinetum illyricum* Horvat et al. 1974* (*Erythronio-Carpinion betuli* (Horvat 1938) Marinček in Wallnöfer et al. 1993)	43	26
5	pure *Fagus* / mixed *Fagus-Abies*	*Fagetum montanum illyricum* Fukarek et Stefanović 1958*, *Abieti-Fagetum dinaricum* Tregubov 1957* (*Aremonio-Fagion* Török et al. ex Marinček et al. 1993)	231	162
6	mixed *Picea-Abies-Fagus*	*Piceo-Abieti-Fagetum* Stefanović et al. 1983* (*Abieti-Piceenion* Br.-Bl. in Br.-Bl. et al. 1939)	191	123
7	Subalpine *Fagus sylvatica*	*Fagetum subalpinum* s. lato* (*Saxifrago rotundifoliae-Fagenion* Marinček et al. 1993)	74	42

The aim of this study was to test whether zonal vegetation is an expression of macro-climatic conditions or there are also other environmental factors involved. The underlying assumptions were (1) that the macro-climatic gradient is the most important for the species and structure turnover along the gradient of ZFPCs in B&H; and (2) that ZFPCs would demonstrate similarities in Grime's ecological strategies, due to the fact that the communities are in terminal stages of succession, with a low level of degradation and occupying habitats on moderately fertile soils.

Materials and methods

Data collection and preparation

Seven ZFPCs were identified for B&H (Tab. 1, Fig. 1, Stefanović et al. 1983, Beus 1984): (1) eu-Mediterranean evergreen *Quercus ilex* forests (very small area of the warmest, southernmost part of B&H; represented by maquis); (2) sub-Mediterranean thermophilous deciduous *Quercus pubescens-Carpinus orientalis* forests (major part of lowland and hilly region in southern B&H); (3) Central Balkans thermophilous *Quercus frainetto* forests (relatively narrow lowland and hilly belt of eastern B&H); (4) Illyrian mesophilous *Quercus petraea-Carpinus betulus* forests (major part of northern B&H and marginally in central B&H); (5) montane mesoneutrophilous pure *Fagus* or mixed *Fagus-Abies* forests (altitudinal belt above oak forests in all B&H but mainly in mountainous region of central B&H (Dinaric Alps); (6) alti-montane, colder and more acidophilous mixed *Picea-Abies-Fagus* forests (altitudinal belt above Community 5, mainly in the Dinaric mountainous region); and (7) subalpine *Fagus sylvatica* forests (uppermost forest altitudinal belt).

Relevés were extracted from the Forest Vegetation Database of Bosnia and Herzegovina stored in the Global Index of Vegetation-Plot Databases (Dengler et al. 2011) with the ID EU-BA-001. This database consists of 2810 published and available unpublished forest vegetation relevés in B&H. We compiled all relevés that were assigned to one of the seven ZFPCs by their authors (Tab. 1), with the exception of two zonal communities of thermophilous deciduous forests (Communities 2 and 3), for which we used the results of formalized classification (Stupar et al. 2015). We did not consider relevés of stands with less than 70% of canopy cover, nor those with edifier tree species cover value less than 3 (25%) on the Braun-Blanquet scale, considering them structurally degraded. Only stands of high, productive forests were thus taken into account, except in the case of Community 1 (*Quercus ilex* stands) because well-established stands do not exist in B&H, and all relevés were made in structurally degraded maquis. All relevés were made using the standard Central European phytosociological method (Braun-Blanquet 1964). Only relevés that could be georeferenced relatively precisely and those that contained complete species records were taken into consideration. A total of 612 relevés was compiled in the Turboveg database (Hennekens and Schaminée 2001) and exported to JUICE 7 software (Tichý 2002) for further analysis.

Mosses, as well as taxa determined only to the genus level, were removed from the data set prior to numerical analysis. All vegetation layers were merged into one layer. Taxonomy and nomenclature followed Flora Europaea (Tutin et al. 1968–1993) unless a more modern taxon concept or circumscription suggested otherwise. These taxa, as well as those from taxonomically critical groups that were combined into aggregates (agg.) or species that included several subspecies that were not always recorded or recognized by authors and were combined under the abbreviation 's.l.' (*sensu lato*), were listed in On-line Suppl. Tab. 1. The dubious taxon *Quercus dalechampii* was treated as part of *Quercus petraea* agg., following Di Pietro et al. (2012). Records of *Fagus moesiaca* were treated as *F. sylvatica* (Marinšek et al. 2013).

To avoid geographic overrepresentation of some vegetation types due to oversampling of certain regions, we performed geographical stratification and resampling of the initial data set (Knollová et al. 2005), which is often applied in recent national and regional level vegetation studies (Chytrý 2013, Košir et al. 2013a, Rodríguez-Rojo et al. 2014). Stratification was performed in a geographical grid with 1 km^2 size. If two or more relevés assigned to the same community fell in the same grid cell, only one of them was selected. Stratification was not performed on Community 1 since it consisted of only five relevés. The resulting stratified data set contained 398 relevés and 669 species.

Data analysis

The data set was then subjected to detrended correspondence analysis (DCA) in R software, version 2.10.1 (R Development Core Team 2009) using the *vegan* package (http://cc.oulu.fi/~jarioksa/softhelp/vegan.html) on presence-absence data. To extract the main gradients in species composition, 398 relevés, together with the selected ecological variables were projected onto the two-dimensional ordination space of DCA. Unweighted average species ecological indicator values (EIVs) for soil reaction (Pignatti et al. 2005) and selected climatic variables available from the WorldClim database (Hijmans et al. 2005) were used as explanatory ecological variables. The significance of EIVs correlation with the DCA relevé scores was tested using the modified permutation test proposed by Zelený and Schaffers (2012). Climate variables best explaining variation in species composition were selected through forward selection in canonical correspondence analysis (CCA) in CANOCO 4.5 software (Microcomputer Power, Ithaca, NY, US). Other explanatory variables (altitude, inclination of slope, aspect, chorotypes, latitude and longitude, life forms and ecological strategies) were selected and projected based on the strength of correlation with the first and second DCA axis. The significances of correlations between these explanatory variables and DCA relevé scores were calculated using the Kendall tau coefficient in Statistica software (StatSoft, Inc.; v 7.0, http://www.statsoft.com). Chorological spectra of the zonal forest communities (Gajić 1980, Pignatti et al. 2005) were calculated for each relevé using presence-absence data. Endemic Illyrian species were separated from southeast European species in a broader sense.

In order to reveal the floristic differences among the seven ZFPCs, we calculated their diagnostic species in the resampled data set using phi coefficient in the JUICE 7 program (Chytrý et al. 2002), after standardization to a relevé group size equal to 1/7 of the total data set size (Tichý and Chytrý 2006). Fisher’s exact test was calculated giving a zero fidelity value to species whose phi values were not statistically significant ($P > 0.001$). The threshold phi value for a species to be considered diagnostic was set at 0.25.

The functional study of zonal forest communities was performed using data of plant functional traits, i.e., life forms (Raunkiaer 1934) and ecological strategies (Grime 1977). Plants were classified based on Grime's primary and secondary strategies to seven functional types using data from the BIOLFLOR database (Klotz et al. 2002). We thus obtained data for about 80% of species. Ecological strategies for the remaining species were calculated using the dichotomous key suggested by Véla (2002). Averages of each strategy type weighted by cover-percentage were calculated and standardized for each relevé as suggested by Hunt et al. (2004). Ecological strategy scores for each group of relevés were then calculated with the CSR Signature Calculator 1.2 program (Hunt et al. 2004) and represented on a CSR ternary plot. We did a separate analysis for all layers and for the herb layer alone because herb functional signatures respond more quickly to environmental changes in the course of late succession (Paušič and Čarni 2012). Plant life forms obtained from Pignatti et al. (2005) and supplemented by our expert knowledge were used for the calculation of life forms spectra for each relevé using presence-absence data, and mean proportions were compared between ZFPCs. The occurrence of an individual functional trait in each of the ZFPCs was compared using the Scheffé post hoc test for normal distributions and Kruskal-Wallis test by ranks and median for non-normal distributions using Statistica software. A normality check was performed using Lilliefors test.

Results

Gradient analysis within ZFPCs in Bosnia and Herzegovina

Forward selection suggested that the climatic variables with the highest explanatory value of the variation in species composition are annual mean temperature (BIO1), mean temperature of the coldest quarter (BIO11) and precipitation of the warmest quarter (BIO18). The first DCA axis represents the main gradient in the data set, and all three climatic variables are significantly related to the first DCA axis at $P < 0.001$ (Tab. 2, Fig. 2). It runs from the coldest and most mesophilous subalpine beech forests (Community 7) on the left side of the diagram to the most xerothermophilous *Quercus ilex* maquis (Community 1) on the far right side of diagram. It is positively correlated with annual mean temperature and mean temperature of the coldest quarter, and negatively with the precipitation of the warmest quarter (Fig. 2, Tab. 2). These are strong indicators that the first DCA axis represents a macro-climatic gradient that runs from wet summers, cold winters and lower annual temperatures to dry summers but warmer winters and higher overall annual temperatures. There is also a high negative correlation with altitude, which is again related to macro-climatic factors. The positive correlation with longitude and negative with latitude expresses the fact that south and east parts of B&H are warmer and dryer than the north and west. Correlations between the first axis and slope and aspect are not statistically significant (Tab. 2). A modified permutation test also showed that the correlation between DCA 1 and EIVs for soil reaction was not statistically significant (R^2 = 0.125, P = 0.195). In terms of chorotypes, DCA axis 1 shows a positive correlation with the proportions of south- and southeast European, Eurimediterranean and Stenomediterranean chorotypes, and a negative correlation with Boreal and south European orophytic chorotypes, while the correlation with the most abundant European and Eurasian is not statistically significant. Correlations between the first axis and life forms are significant only for the proportions of phanerophytes (positive) and geophytes (negative). There is no significant correlation between ecological strategies and DCA axes (Tab. 2).

Tab. 2. Correlations (Kendall-Tau coefficient) between detrended correspondence analysis relevé scores and explanatory variables. BIO1 - annual mean temperature; BIO11 - mean temperature of the coldest quarter; BIO18 - precipitation of the warmest quarter; Eur - European and Eurasian; SEur - south and southeast European; EuriMed - Eurimediterranean; StMed - Stenomediterranean; Illyr - Endemic Illyrian; Bor - Boreal; SEOro - South European orophytes; Cosm -Widespread species; P - Phanerophytes; NP - Nanophanerophytes; Ch - Chamaephytes; H - Hemicryptophytes; G - Geophytes; T - Terophytes; C - Competitors; S - Stress-tolerators; R - Ruderals.
Asterisk (*) denotes significant correlation at 0.001

	Ecological factors						Geogr. factor	
	Altitude	Aspect	Slope	BIO1	BIO11	BIO18	Latit.	Longit.
DCA 1	-0.521*	0.046	0.050	0.569*	0.566*	-0.451*	-0.200*	0.367*
DCA 2	-0.151*	-0.034	-0.103	0.118*	0.103	-0.011	0.028	-0.041
	Chorotypes							
	Eur	SEur	EuriMed	StMed	Illyr	Bor	SEOro	Cosm
DCA 1	0.088	0.203*	0.445*	0.309*	-0.172*	-0.313*	-0.510*	-0.155*
DCA 2	0.077	-0.034	0.035	-0.004	-0.066	-0.009	-0.138*	0.077

	Life forms						Ecological strategies		
	P	NP	Ch	H	G	T	C	S	R
DCA 1	0.182*	0.020	0.045	0.080	-0.317*	0.109	0.045	-0.048	0.014
DCA 2	0.010	-0.059	0.110	0.057	-0.121*	0.126*	-0.049	-0.067	0.109

Floristic differentiation

Analysis revealed differences in the floristic composition between seven ZFPCs. Tab. 3 shows a simplified frequency-fidelity synoptic table of the ZFPCs of B&H based on a data set of 398 resampled relevés (full version is given in On-line Suppl. Tab. 2).

Analysis of functional traits

In the standard CSR triangle plot, communities are positioned in the upper right part of the diagram (Fig. 3a). This means that zonal forest plant communities are dominated by species with considerable competitive capacity. However, there is apparent divergence of Communities 1, 2 and 4 from the main cluster along the C–S axis, whereby statistically

Tab. 3. Frequency-fidelity table of zonal forest plant communities (ZFPCs) in Bosnia and Herzegovina. Frequencies of species are presented as percentages with phi values multiplied by 100 shown in superscript. Diagnostic species (phi values higher than 0.25) for each community are shaded (only ten species with the highest phi value for every community are presented). Proportions of chorotypes and altitudinal ranges of each community are also shown. Community numbers correspond to those used in Tab. 1 and Fig. 1.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
No. of relevés	5	16	24	26	162	123	42
Altitudinal range (m)	0–150	100–650	150–700	200–900	700–1400	800–1600	1400–1800
Chorotype (% of all species in a community)							
Widespread species	3	1	3	5	7	7	4
European and Eurasian	13	29	56	67	59	55	49
south and southeast European	21	30	21	16	13	10	12
Eurimediterranean	29	29	13	5	1	1	0
Stenomediterranean	33	7	0	0	0	0	0
Endemic Illyrian	1	3	1	0	1	2	3
Boreal	0	1	6	6	10	13	13
South European orophytes	0	0	0	1	9	12	19
ZFPC 1							
Quercus ilex	$100^{96.5}$	6^{-}	.	.	.	.	.
Arbutus unedo	80^{88}	.	.	.	.	.	.
Teucrium polium ssp. *capitatum*	$80^{84.1}$	6^{-}	.	.	.	.	.
Centaurium erythraea	$80^{83.2}$	.	.	8^{-}	.	.	.
Pistacia terebinthus	$100^{82.6}$	$38^{18.3}$	.	.	.	.	.
Juniperus phoenicea	60^{75}	.	.	.	.	.	.
Pistacia lentiscus	60^{75}	.	.	.	.	.	.
Juniperus oxycedrus ssp. *macrocarpa*	$40^{60.3}$	.	.	.	.	.	.
Crepis sancta	$40^{60.3}$	.	.	.	.	.	.
Cistus salvifolius	$40^{60.3}$	.	.	.	.	.	.
ZFPC 2							
Quercus pubescens	20^{-}	$100^{84.5}$	12^{-}	.	.	.	.
Cornus mas	.	$88^{83.6}$	8^{-}	8^{-}	.	.	.
Acer monspessulanum	.	$62^{76.7}$	.	.	.	.	.
Sesleria autumnalis	20^{-}	$81^{76.5}$	.	.	1^{-}	1^{-}	.
Frangula rupestris	.	$56^{72.4}$	.	.	.	.	.
Viola hirta	.	$75^{69.4}$	17^{-}	12^{-}	.	.	.
Rubus ulmifolius	.	$50^{67.9}$	.	.	.	.	.
Carex halleriana	20^{-}	$62^{64.2}$	.	.	.	.	.
Brachypodium sylvaticum	.	$75^{61.1}$	12^{-}	19^{-}	5^{-}	6^{-}	7^{-}
Juniperus oxycedrus	40^{-}	69^{60}	.	.	.	.	.
ZFPC 3							
Quercus frainetto	.	19^{-}	$100^{90.3}$	.	.	.	.
Chamaecytisus hirsutus agg.	.	.	$58^{70.4}$	4^{-}	.	1^{-}	.
Quercus cerris	.	50^{23}	$100^{69.8}$	27^{-}	1^{-}	1^{-}	.
Thymus pulegioides	.	.	$54^{65.7}$	.	4^{-}	1^{-}	2^{-}
Lychnis coronaria	.	.	$46^{64.8}$	.	.	.	.
Lathyrus niger	.	12^{-}	58^{63}	4^{-}	.	.	.
Euphorbia cyparissias	.	19^{-}	$58^{61.7}$	.	.	.	.
Dianthus armeria	.	.	$42^{61.6}$	.	.	.	.
Carex caryophyllea	.	19^{-}	$58^{57.8}$	8^{-}	.	.	.
Silene viridiflora	.	12^{-}	$46^{55.4}$	.	.	.	.
ZFPC 4							
Carpinus betulus	.	.	$42^{19.6}$	$100^{77.3}$	11^{-}	.	.
Cruciata glabra	.	.	4^{-}	$69^{67.5}$	11^{-}	8^{-}	.

Prunus avium	.	.	25^{-}	65$^{60.7}$	6^{-}	1^{-}	.
Luzula luzuloides	.	.	.	58$^{59.9}$	1^{-}	8^{-}	12^{-}
Pteridium aquilinum	.	.	38^{-}	77$^{57.7}$	12^{-}	15^{-}	.
Stellaria holostea	.	.	8^{-}	50$^{56.6}$	1^{-}	.	7^{-}
Melampyrum pratense	.	.	17^{-}	50$^{54.5}$	.	1^{-}	2^{-}
Erythronium dens-canis	.	.	.	27^{49}	.	.	.
Crataegus monogyna	.	44^{-}	29^{-}	69$^{45.3}$	15^{-}	2^{-}	.
Hieracium racemosum	.	.	.	23$^{45.2}$	.	.	.
ZFPC 5							
Galium odoratum	.	.	.	12^{-}	76$^{46.5}$	59^{-}	36^{-}
Acer pseudoplatanus	.	.	.	12^{-}	81$^{44.6}$	69^{-}	52^{-}
Cardamine bulbifera	.	.	.	12^{-}	67$^{42.3}$	30^{-}	55^{-}
Lonicera xylosteum	.	.	.	.	31$^{38.9}$	15^{-}	2^{-}
Cardamine enneaphyllos	.	.	.	.	62$^{38.1}$	35^{-}	62^{-}
Daphne mezereum	.	.	.	.	51$^{35.1}$	37^{-}	38^{-}
Salvia glutinosa	.	.	4^{-}	4^{-}	31$^{34.9}$	14^{-}	2^{-}
Glechoma hirsuta	.	.	17^{-}	19^{-}	50$^{34.6}$	26^{-}	12^{-}
Rubus hirtus	.	.	12^{-}	42^{-}	57$^{33.1}$	36^{-}	14^{-}
Cardamine trifolia	.	.	.	.	28$^{32.9}$	20^{-}	2^{-}
ZFPC 6							
Picea abies	.	.	.	.	51^{-}	100$^{59.7}$	69^{-}
Abies alba	.	.	.	8^{-}	73^{-}	98$^{52.5}$	76^{-}
Athyrium filix-femina	.	.	.	8^{-}	38^{-}	63^{49}	14^{-}
Galium rotundifolium	.	.	.	.	9^{-}	41$^{46.5}$	12^{-}
Oxalis acetosella	.	.	.	.	64^{-}	83$^{46.1}$	69^{-}
Lonicera nigra	.	.	.	.	19^{-}	46$^{43.9}$	17^{-}
Sorbus aucuparia	.	.	.	.	33^{-}	63$^{42.1}$	50^{-}
Senecio nemorensis s.l.	.	.	.	.	38^{-}	59$^{40.8}$	38^{-}
Prenanthes purpurea	.	.	.	4^{-}	46^{-}	68$^{38.9}$	67^{-}
Lamiastrum galeobdolon	.	.	.	27^{-}	56^{-}	73$^{38.8}$	52^{-}
ZFPC 7							
Saxifraga rotundifolia	.	.	.	.	12^{-}	24^{-}	76$^{66.7}$
Luzula sylvatica	.	.	.	.	3^{-}	20^{-}	67$^{65.6}$
Adenostyles alliariae	.	.	.	.	5^{-}	23^{-}	64$^{61.8}$
Valeriana montana	.	.	.	.	4^{-}	8^{-}	45$^{55.3}$
Cicerbita alpina	.	.	.	.	1^{-}	10^{-}	43$^{53.9}$
Veronica urticifolia	.	.	.	.	4^{-}	23^{-}	52$^{52.8}$
Ranunculus platanifolius	.	.	.	.	2^{-}	5^{-}	38$^{52.4}$
Astrantia major	.	.	.	.	.	1^{-}	31$^{51.8}$
Homogyne alpina	.	.	.	.	.	.	29$^{50.5}$
Veratrum lobelianum	.	.	.	.	.	.	24^{46}
Species diagnostic for more than one community							
Phillyrea latifolia	100$^{78.2}$	50$^{28.4}$	.	.	.	.	.
Clematis flammula	80$^{64.5}$	50^{33}	.	.	.	.	.
Asparagus acutifolius	60$^{40.5}$	81$^{62.1}$	.	.	.	.	.
Carpinus orientalis	.	88$^{68.3}$	54$^{34.5}$	.	.	.	.
Fraxinus ornus	60^{-}	100$^{50.4}$	83$^{36.5}$	31^{-}	2^{-}	1^{-}	.
Genista tinctoria	.	.	54$^{50.6}$	35$^{26.7}$	1^{-}	.	.
Quercus petraea	.	.	71$^{43.7}$	100$^{71.3}$	1^{-}	1^{-}	.
Acer campestre	.	12^{-}	42$^{27.5}$	58$^{45.1}$	4^{-}	.	.
Fagus sylvatica	.	.	12^{-}	46^{-}	100$^{39.8}$	100$^{39.8}$	100^{-}
Vaccinium myrtillus	.	.	.	4^{-}	12^{-}	57$^{40.3}$	57$^{40.6}$

significant differences were discovered (Tab. 4). The highest ratio of stress tolerant-species occurs in Community 1, much less in Community 2, while the most competitive ability is expressed by Community 4. CSR signatures of the herb layer are shifted to the middle of the C–S axis (Fig. 3b).

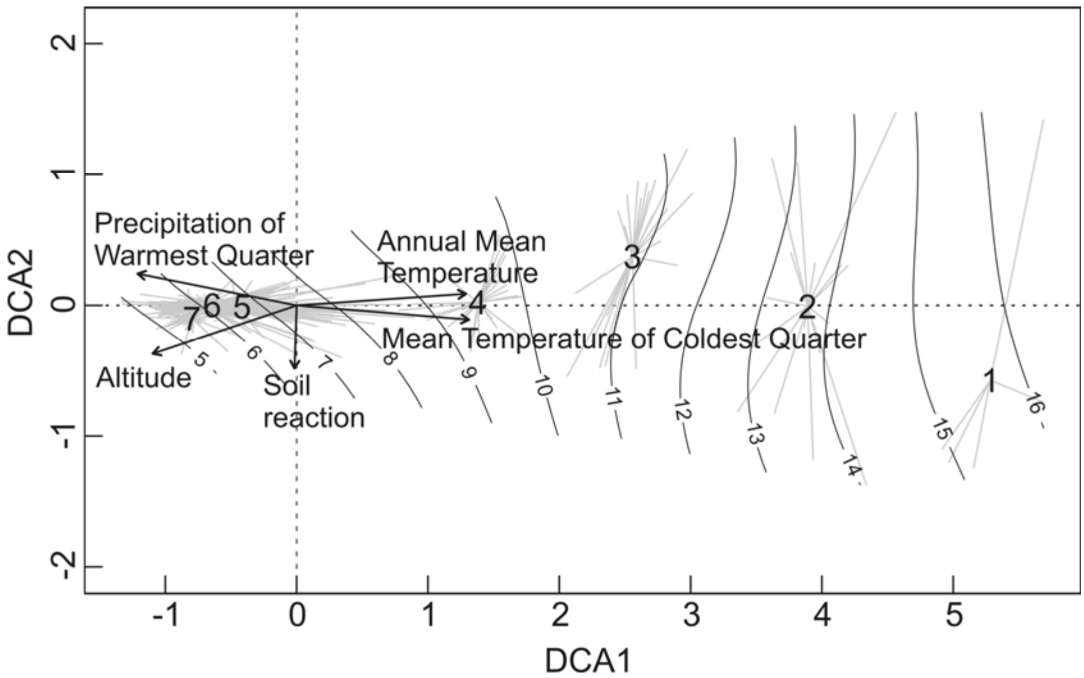

Fig. 2. DCA spider plot of 398 relevés of ZFPCs with climatic variables, EIVs for soil reaction and altitude passively projected. The surface variable is annual mean temperature. The length of the first DCA axis is 7.02 SD units, the length of the second axis is 2.85 SD units. Centroids of clusters are indicated by numbers that refer to Tab. 1 and Fig. 1.

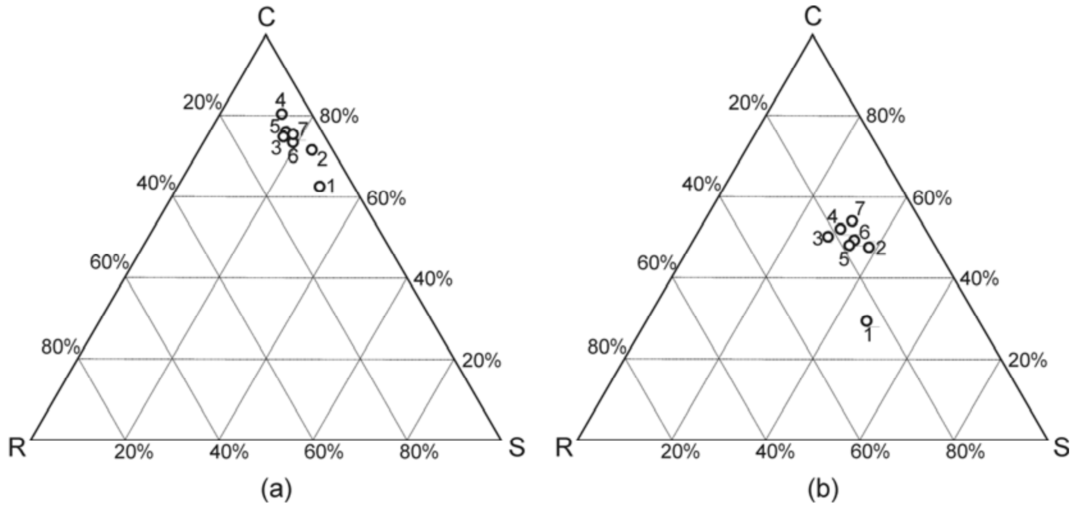

Fig. 3. CSR triangle of the ordination of ZFPCs in B&H according to ecological strategy scores (proportion of C, S and R components in each community). Community numbers correspond to those used in Tab. 1 and Fig. 1. (a) All layers together; (b) Herb layer.

The most significant differences in functional traits of a life form were detected for Phanerophytes and Geophytes between Communities 1–4 and Communities 5–7, and for Hemicryptophytes between Communities 1 and 5 and the rest of the data set (Tab. 4). The highest ratios of Phanerophytes and Nanophanerophytes are found in the first two communities, with a decline in Phanerophytes towards Community 7 (Fig. 4). Beech dominated forests (Communities 5–7) have twice the ratio of Geophytes compared to oak dominated forests (Communities 1–4). The highest proportion of Chamaephytes is in Community 1, while the biggest share of Therophytes is in Communities 1 and 3.

Tab. 4. Comparison of differences in functional traits occurrences between each pair of ZFPCs. Statistical significance established using Kruskal-Wallis test by ranks and median, except for R, H and G, for which the Scheffé post hoc test for a normal distribution was used. Community numbers correspond to those used in Tab. 1 and Fig. 1. FT - Functional type; C - Competitors; S - Stress tolerators; R - Ruderals; P - Phanerophytes; NP - Nanophanerophytes; Ch - Chamaephytes; H - Hemicryptophytes; G - Geophytes; T - Therophytes.
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

FT	Compared pairs of ZFPCs																				
	1-2	1-3	1-4	1-5	1-6	1-7	2-3	2-4	2-5	2-6	2-7	3-4	3-5	3-6	3-7	4-5	4-6	4-7	5-6	5-7	6-7
C			***	*				**				*				**	***	*			
S		**	***	**		*	**	***	***							*	***	**	***		
R							**		***	**											
P					*	***			*	**	***				***	**	***	***		***	***
NP							***	***	***	*	***										
Ch	**			*		**	***	*					*		**						
H	***	***	**		**	***			**				***			*		***	***	***	***
G				***	**	***			***	***	***		***	***	***	***	***	***	***	*	
T						*	**						***	**	***						

Discussion

Our study strongly suggests macro-climatically based differentiation of ZFPCs in B&H. While gradient analysis revealed a major influence of climatic factors on the species turnover, there is little or no impact of topographic (slope and aspect) or edaphic conditions (Fig. 2, Tab. 2), which is congruent with the traditional understanding of zonal vegetation (Dierschke 1994, Ellenberg 2009, Surina 2014). Macro-climatic gradient is supported by the significant correlation with the geographic factors (altitude, longitude and latitude), which are all determinants of climate on a larger scale (Ellenberg 2009, Adams 2010). Similarly, the recent study of zonal forests of Korean Peninsula showed that the main factor discriminating between individual forest types was temperature (annual mean temperature, as well as temperature extremes) followed by precipitation, altitude and aridity (Černý et al. 2015). While chorotypes indicate units that describe distribution patterns shared by several species, explaining origins and history of development of particular floras (Pignatti and Pignatti 2014, Passalacqua 2015), some studies suggest that there is a correlation between chorotypes and climatic conditions (Ferrer-Castán and Vetaas 2003, Abbate et al. 2012). In the case of our study, proportion of 'warmer'

(Eurimediterranean and Stenomediterranean) chorotypes increases in a direction of the main gradient, while the proportion of ‘colder’ (Boreal and Orophytic) decreases (Tab. 3), which again suggests the macro-climatic gradient.

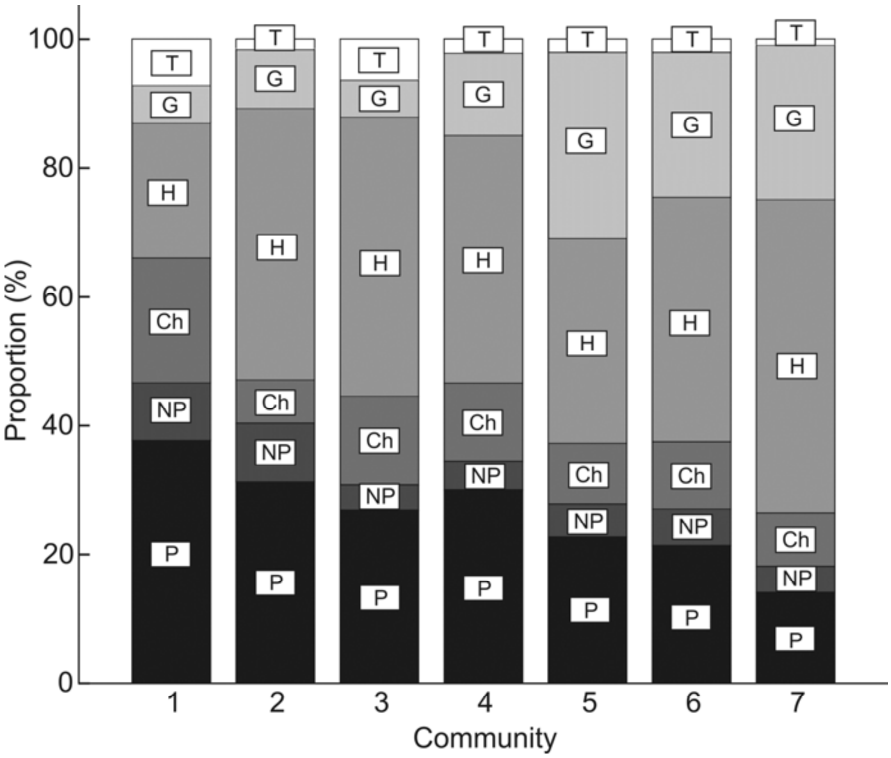

Fig. 4. Proportions of life forms in ZFPCs in B&H. Community numbers correspond to those used in Tab. 1 and Fig. 1. P - Phanerophytes; NP - Nanophaneorphytes; Ch - Chamaephytes; H - Hemicryptophytes; G - Geophytes; T - Therophytes.

Floristic analysis showed a clear separation of seven ZFPCs in B&H. **Community 1** (*Quercus ilex* maquis, Tab. 3, col. 1) occupies only a small area (about 20 km^2) in the extreme south of B&H. It is represented by the secondary succession stage of the eastern Adriatic eu-Mediterranean zonal association *Fraxino orni-Quercetum ilicis* (Kutleša and Lakušić 1964). Mean annual temperatures are above 15 °C (Fig. 2) and elevations 0–150 m. Diagnostic species are mainly of Stenomediterranean, Eurimediterranean and south and southeast European chorotypes. Diagnostic herb species are mainly indicators of rocky habitats due to structural degradation. Although in the last 50 years this community has expanded its distribution area in B&H, due to the abandonment of coppicing, burning and goat breeding, there are still no high stands (Drešković et al. 2011). The situation is similar, though a little better, in neighboring Croatia (Vukelić 2012). **Community 2** (*Quercus pubescens-Carpinus orientalis* forests, Tab. 3, col. 2) is represented by high, not degraded stands of zonal thermophilous deciduous forest of the association *Querco pubescenti-Carpinetum orientalis* (Stupar et al. 2015) found in the lowlands and hilly area of sub-Mediterranean B&H. However, due to the negative human impact, they are mainly replaced by the secondary scrub community *Rusco aculeati-Carpinetum orientalis*

(Muratspahić et al. 1991), while their present distribution area is restricted to small patches of mainly private old groves (Stupar et al. 2015). Mean annual temperatures are between 12 and 15 °C (Fig. 2), occupying elevations between 100 and 650 m. Diagnostic species are thermophilous and xerophilous plants of mainly S/SE European or Eurimediterranean distribution, although some widespread nemoral forest herbs and shrubs appear with high frequency, e.g.: *Brachypodium sylvaticum, Dactylis glomerata, Veronica chamaedrys, Crataegus monogyna, Hedera helix* etc., which indicate more mesophilous microclimatic conditions under the closed canopy. **Community 3** (*Quercus frainetto* forests, Tab. 3, col. 3) is found in the eastern parts of B&H, where the influence of the continental dryer climate increases. It is a zonal community of Central Balkans lowlands and hilly areas (Horvat et al. 1974) and it is represented by the fairly heterogeneous association *Quercetum frainetto-cerridis* (Tomić and Rakonjac 2013, Stupar et al. 2015). Although we included in the analysis only stands with 70% and more canopy cover, these forests are mainly found in the proximity of human settlements, so they are frequently degraded by grazing and browsing, as well as occasional fires. Mean annual temperatures are between 10 and 12 °C (Fig. 2), and elevations are between 150 and 700 m. They are dominated by a mixture of thermophilous, acid tolerant and widespread nemoral forest species, as well as some more light-demanding herbs, indicating wood-pasture and cutting. **Community 4** is represented by sessile oak-common hornbeam forests, which are considered a zonal forest vegetation community for the area of NW Balkans (*Quercus petraea-Carpinus betulus* forests, Tab. 3, col. 4). In B&H they are found mainly in the hilly area of northern parts of the country but can also penetrate deeper into south (e.g., Central Bosnian basin, Fig. 1). Habitats of these forests have been under intensive anthropogenic influence since the Neolithic (Horvat et al. 1974), so it is hard to find stands of high, productive forests with *Quercus petraea* cover value in the tree layer more than 3 on the Braun-Blanquet scale (25-50% of cover) and more than 70% of overall canopy cover. They are often, due to bad management, structurally degraded to *Carpinus betulus* coppice. Mean annual temperatures are between 9 and 10 °C (Fig. 2) and they occupy elevations between 200 and 900 m. Several types of these forests occur in B&H but neither the syntaxonomy nor nomenclature has been settled (Lakušić et al. 1978, Redžić 2007). In addition, there is disagreement about syntaxonomical position of these forests on the regional level. While Croatian and Slovenian authors assign these forest to the Illyrian alliance *Erythronio-Carpinion betuli* (Vukelić 2012, Košir et al. 2013a), some other authors question this view, arguing that this group is weakly characterized by diagnostic species (Willner and Grabherr 2007, Borhidi et al. 2012). This is sustained by our results, in the sense that this ZFPC is the only one in B&H that completely lacks endemic Illyrian species (Tab. 3). Diagnostic species are mainly represented by mesophilous European and Eurasian elements. **Community 5** (pure *Fagus /* mixed *Fagus-Abies* forests, Tab. 3, col. 5) represents the first altitudinal belt above oak forests and is made up of mesoneutrophilous montane pure beech, as well as mixed fir-beech forests. The syntaxonomy and nomenclature of these forests have not yet been the subject of thorough analysis but two main types, or widely understood associations, are included: *Fagetum montanum illyricum* and *Abieti-Fagetum dinaricum* (Beus 1984). They belong to the alliance *Aremonio-Fagion* (Marinšek et al. 2013). Mean annual temperatures are between 6 and 8 °C (Fig. 2) and they are mainly found on elevations between 700 and 1400 m. Floristically and ecologically similar to this type is **Community 6** (mixed *Picea-Abies-Fagus* forests Tab. 3, col. 6), which also has a considerable amount of Boreal and south European orophytic elements, while annual mean temperatures are between 5 and 7 °C (Fig. 2). In the view of Beus (1984), which is supported by our results, the main difference between Community 6 and the previous community is that Community 6 has a higher proportion of spruce (100% frequency) and acidophilous *Vaccinio-Piceetea* species, while the proportion of mesoneutrophilous *Aremonio-Fagion* species is remarkably lower. In addition, it comes as an altitudinal belt above Community 5 (elevations between 800 and 1600 m) and can be found exclusively in the central range of Dinaric Alps, while Community 5 extends more to the north and south (Fig. 1). This is explained by the fact that the hot dry summers of the northern and southern chains of Dinaric Alps do not favor spruce (Beus 1984). The syntaxonomy and nomenclature of Community 6 have also not been settled, so in B&H this complex type is identified under the invalid provisional name *Piceo-Abieti-Fagetum*. **Community 7** is the highest altitudinal belt, represented by subalpine *Fagus sylvatica* forests (Tab. 3, col. 7). This is yet another group that the syntaxonomy and nomenclature of which has not been analyzed in B&H and it is known by the generic name of *Fagetum subalpinum* s. lato. These forests belong to the suballiance *Saxifrago rotundifoliae-Fagenion* of the alliance *Aremonio-Fagion* (Marinšek et al. 2013). These are mainly mesoneutrophilous pure beech forests found mainly on the mountains of the central and southern chains of Dinaric Alps (Fig.1). Mean annual temperatures are between 5 and 6 °C (Fig. 2), with elevations between 1400 and 1800 m. This community harbors the highest proportion (32%) of Boreal and south European orophytic elements.

Functional analysis of ecological strategies showed small overall differences between ZFPCs. Based on the communities' location on the CSR triangle, competitive strategy (C) is dominant in all seven communities, followed by CSR and SC strategies (Fig. 3). Considering the course of succession (Fig. 3a), site production is high (Grime 1974), while the importance of ruderality is insignificant, which indicates late stages of succession, as pointed out by Prévosto et al. (2011). The terminal stage of zonal communities is supported by the position of the communities on the CSR plot when only the herb layer was analyzed (Fig. 3b). In this plot, stress tolerance becomes more important since shading and lack of nutrients in the herb layer coincide with the development of large long-lived forest trees (Grime 1977, 1988). Only Community 1 (*Quercus ilex* maquis), which has the largest share of ruderals, expresses conditions of moderate productivity and middle to late stage of secondary succession (maquis). The increased proportion of stress-tolerators in Community 1 and much less but also in Community 2 is related to drought stress during the summer season in the Mediterranean limestone region of B&H. On the other hand, Community 4 (*Quercus petraea-Carpinus betulus* forests) has an increased proportion of competitors, which indicates the higher productive capacities. Also, this community lies in the middle of the macro-climatic gradient (Fig. 2), which altogether suggests the most favorable conditions for forest vegetation development in B&H.

Changes in the life form proportions of different communities are expressed in the greater share of woody species in the more thermophilous vegetation types, which corresponds with the statement that 'the Phanerophyte is the plant type that belongs to warm regions' (Raunkiaer 1934). Similar results were obtained in the study of the gradient from warm to mesic temperate forests on the Galičica mountain range in Macedonia (Čarni et al. 2015). The proportion of Geophytes is higher in Communities 5–7 (beech dominated forests), which besides spring ephemerals (mainly bulbous Geophytes), abundant also in the oak communities (Popović et al. 2015), harbor a considerable number of non-ephemeral rhizomatous ferns and species from the family Liliaceae. This is congruent with the notion that rhizomatous Geophytes are adapted to life in regions with a severe unfavorable period (e.g., hard winters), but have at the same time a long period of vegetation (Raunkiaer 1934). The proportion of Therophytes is insignificant except in Communities 1 and 3, which can be explained by water shortage in the conditions of harsher Mediterranean and continental climates (Kavgaci et al. 2012, Raju et al. 2014). The same can be said for the proportion of Chamaephytes in Community 1. On the other hand, according to Bloch-Petersen et al. (2006) plant life forms differentiate not only due to climatic variations, but seem also to relate to humane disturbance and management. Prasad (1995) studied the effects of grazing on the plant species and life form composition and found that the percentage of Therophytes was higher on grazed areas than on protected areas, which reflects the disturbance through grazing in the Comunities 1 and 3.

To conclude, the results of our analysis support the hypothesis that zonal forest vegetation in B&H is an expression of macro-climatic conditions and that there are no remarkable differences in CSR plant strategies between ZFPCs in B&H (excluding Community 1). However, having in mind that currently protected forest area in B&H is very small and covers only a few types of ZFPCs (Stupar 2011), in order to facilitate further research of ecological, floristic and functional characteristics of ZFPCs there is a need for establishment of a national network of protected areas which would cover all ZFPC types, thus preserving the representative stands with as natural conditions as possible (Milanović et al. 2015). Particular emphasis should be given to thermophilous forests, especially to Community 1 (stands of *Quercus ilex*) which should be converted from maquis to high forests.

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2.2 VEGETACIJSKI TIPI TERMOFILNIH LISTOPADNIH GOZDOV (*QUERCETEA PUBESCENTIS*) NA ZAHODNEM DELU BALKANSKEGA POLOTOKA

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Izvleček

Sintaksonomija, ekologija in vzorci razširjenosti termofilnih listopadnih gozdov razreda *Quercetea pubescentis* doslej še niso bili dovolj raziskani na zahodnem delu Balkanskega polotoka. Nekateri tipi hrastovih gozdov pa sploh še niso bili raziskali, prav tako pa klasifikacija številnih tradicionalno uporabljanih tipov še ni bila kritično obdelana s pomočjo numeričnih metod. To še posebej velja za združbe acido-termofilnih gradnovih (*Quercus petraea* agg.), ki so prehodni med termofilnimi in mezo-acidofilnimi hrastovimi gozdovi in jih običajno uvrščamo v razred *Quercetea robori-petraeae*. Problematike smo se lotili z numeričnimi analizami skoraj 3000 vegetacijskih popisov. Na osnovi teh analiz smo termofilne listopadne gozdove na zahodnem delu Balkanskega polotoka uvrstili v šest skupin, ki odražajo glavne (makro)ekološke in fitogeografske vzorce na obravnavanem območju: tip 1 - submediteranski gozdovi, v katerih prevladujeta puhasti hrast (*Quercus pubescens*) in/ali kraški gaber (*Carpinus orientalis*); tip 2 - submediteranski in celinski gozdovi s puhastim hrastom (*Quercus pubescens*) brez kraškega gabra (*Carpinus orientalis*); tip 3 - mezo-termofilni supramediteranski in/ali relikti gozdovi, v katerih prevladuje črni gaber (*Ostrya carpinifolia*); tip 4 - termofilni celinski gozdovi na globokih, nevtralnih do rahlo kislih tleh, v katerih prevladujta sladun (*Quercus frainetto*) in/ali cer (*Q. cerris*); tip 5 - acido-termofilni celinski gozdovi, v katerih prevladujeta graden (*Quercus petraea* agg.) in/ali cer (*Q. cerris*); tip 6 - acido-termofilni severnodinarsko-južnopanonski gozdovi, kjer prevladuje graden (*Quercus petraea* agg.). Korespondenčna analiza z odstranjenim trendom je pokazala, da spremembe vrstne sestave v glavnem sledijo geografskemu jugozahodno-severovzhodno gradientu, v katerem se odražajo makro-ekološki (makroklimatski in geološki) in fitogeografski dejavniki (vrsni obrat prevladujočih drevesnih vrst). Statistično pomembna je tudi vloga svetlobnega režima, ki v glavnem odraža lokalen način gospodarjenja, raven motenj in hemerobije na posameznih območjih. V nasprotju z večino tradicionalnih klasifikacij, smo uvrstili acido-termofilne gozdove na zahodnem delu Balkanskega polotoka (tip 6) v razred *Quercetea pubescentis*.

Vegetation types of thermophilous deciduous forests (*Quercetea pubescentis*) in the Western Balkans

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Running head: Thermophilous deciduous forests in the Western Balkans

Abstract

Syntaxonomy, ecology and distribution patterns of thermophilous deciduous forests of the class *Quercetea pubescentis* remain understudied in the Western Balkans. Some oak forest types have not been investigated to date in large parts of the region and classification of many traditionally distinguished types has not been critically revised based on numerical data analysis. This is particularly true for the acido-thermophilous communities dominated by *Quercus petraea*, that are transitional between thermophilous and meso-acidophilous oak forests and were traditionally classified mostly to the class *Quercetea robori-petraeae*. Numerical analysis of nearly 3000 relevés allowed us to approach these issues. We classified thermophilous deciduous forests of the Western Balkans into six types reflecting the main broad-scale ecological and phytogeographical patterns in species composition within the study area: type 1 – sub-Mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis*; type 2 – sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis*; type 3 – meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*; type 4 – thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris*; type 5 – acido-thermophilous continental forests dominated by *Quercus petraea* and/or *Quercus cerris*; type 6 – acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests. Detrended correspondence analysis revealed that the variation in species composition mainly follows the geographical southwest-northeast gradient, reflecting the broad-scale ecological (macroclimatic and geological) and phytogeographical (turnover of dominant tree species) gradients. There is also a significant role of light regime, which mainly reflects local management practice, level of disturbance and the hemeroby of particular sites. Contrary to most traditional classifications, we place the acido-thermophilous forests of the Western Balkans (type 6) to the class *Quercetea pubescentis*.

Keywords: *Carpinion orientalis*; *Fraxino orni-Ostryion*; gradient analysis; oak forest; ordination; phytosociology; *Quercetalia pubescenti-petraeae*; *Quercetea robori-petraeae*; *Quercion frainetto*; *Quercion petraeo-cerridis*; *Quercion roboris*; vegetation classification.

Nomenclature: Tutin et al. (1968–1993).

Abbreviations: B&H = Bosnia and Herzegovina; DCA = detrended correspondence analysis; EIV = species ecological indicator value; HCR = heterogeneity-constrained random resampling; TDF = thermophilous deciduous forests.

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Introduction

Thermophilous deciduous forests (TDF) of the class *Quercetea pubescentis* are broadly distributed in the southern parts of Europe, with the highest diversity in the Balkan and Apennine peninsulas (Horvat et al. 1974; Bohn & Neuhäusl 2004; Ellenberg 2009). They form a climax vegetation on zonal sites here, while further to the north, in Central Europe, they are extrazonal and occur on the warmest and driest sites of southern slopes or rocky outcrops (Ellenberg 2009) or they result from former forest management practices (Hédl et al. 2010). They are dominated by deciduous oaks, mostly *Quercus pubescens, Q. frainetto* and *Q. cerris* much less by *Q. petraea* and *Q. robur*. Other tree species may be admixed or even dominate, particularly *Carpinus orientalis, Fraxinus ornus* and *Ostrya carpinifolia*.

Steep biogeographical and ecological gradients and a variety of human impact over time generated a great diversity of TDF (Blasi et al. 2004; Bergmeier & Dimopoulos 2008; Ketenoglu et al. 2010; Redžić 2011; Borhidi et al. 2012; Uğurlu et al. 2012; Tomić & Rakonjac 2013), which in some parts of Europe have been well described using numerical classification methods (Blasi et al. 2004; Roleček 2005; Kevey 2008; Bergmeier & Dimopoulos 2008; Chytrý 2013). Although the study of TDF has a long tradition in the Western Balkans (Horvat 1938; Tomažič 1939; Rudski 1949; Fabijanić et al. 1963; Blečić & Lakušić 1967), numerous ecological and syntaxonomical issues remain (Čarni et al. 2009; Vukelić 2012; Tomić & Rakonjac 2013). Redžić (2007, 2011) compiled two versions of syntaxa checklists for B&H, but he affirms that the status of vegetation of TDF in this region remains unclear. Čarni et al. (2009) show a general lack of available phytosociological data for the central part of the Western Balkans. In this area, including southern B&H, Croatia and Montenegro, *Quercus pubescens* and *Carpinus orientalis* build climax communities, which remained to date uninvestigated in terms of phytosociology. The situation is similar in central and northern B&H with relatively small but numerous areas of extrazonal occurrence of TDF. One of the main reasons could be that this type of vegetation often does not possess significant economic value and is frequently found in rough or even inaccessible terrain. Most studies dealing with this type of vegetation in B&H have been carried out at the small number of localities in the canyon systems of the Dinaric Alps, along the major roads, focusing, above all, on successional stages dominated by *Carpinus orientalis* (Lakušić & Redžić 1989; Stefanović 1989; Lakušić & Redžić 1991; Muratspahić et al. 1991). The problems related to the level of knowledge of the distribution, ecology and syntaxonomy of TDF in B&H were discussed in detail by Stupar et al. (2015).

Another issue is the classification of vegetation transitional between thermophilous *Quercetea pubescentis* and mesic acidophilous *Quercetea robori-petraeae* forests (Horvat 1963; Cross & Pallas 2004; Härdtle 2004; Baričević et al. 2006a, 2006b; Vukelić 2012). Oak forests of *Quercetea robori-petraeae* (acidophilous species-poor oak, oak-birch and beech-dominated deciduous woods on mesic nutrient-poor soils) extend within the temperate zone of Europe from the Atlantic coast to western Russia, and reach their south-easternmost limit in the Western Balkans. They are characterized by acidophytes of central European and temperate Eurasian distribution in the undestorey. The soils are characteristically permeable or intermittently moist, oligotrophic, acidic, often sandy and sometimes shallow or rocky. Their characteristic species combination gradually changes towards the south, where thermophilous oak forests become dominant (Härdtle 2004; Bohn & Neuhäusl 2004). Syntaxonomical position of the transitional communities, mainly dominated by *Quercus petraea*, is often considered ambiguous (Chytrý 1997; Kasprowicz 2010; Indreica 2012). In the study area, these communities are found particularly on acidic soils on southern slopes of hills and low mountains on the southern margins of the Pannonian Plain and northern Dinaric Alps, which are rich in thermophilous species of southeast European, as well as wider distribution. Also in this region authors differ in their syntaxonomical treatment: in B&H, they are classified to *Quercetea robori-petraeae* (Stefanović 1984), in Serbia to *Quercetea pubescentis* (Jovanović et al. 1986), while in Croatia and Hungary different associations are classified to different classes (Kevey & Borhidi 2005; Baričević et al. 2006a, 2006b; Trinajstić 2008; Borhidi et al. 2012; Vukelić 2012). The complexity of this problem and necessity of further study have been highlighted by many local and regional studies (Fabijanić et al. 1963; Gajić 1971; Janković 1974; Stefanović 1984; Kevey & Borhidi 2005). Syntaxonomical issues are linked also to taxonomical ambiguities, since there exist morphologically intermediate individuals between *Quercus petraea, Q. pubescens* and *Q. robur,* which are nearly impossible to distinguish during field research (Dupouey & Badeau 1993; Kleinschmit et al. 1995). At the same time, different authors use different concepts of taxa (Škvorc et al. 2005; Di Pietro et al. 2012). These issues contribute to difficulties regarding the classification of TDF in the Western Balkans.

Therefore, the objectives of this study were (1) to distinguish communities of *Quercetea pubescentis* from those of *Quercetea robori-petraeae* and to describe the diversity of main vegetation types of TDF (*Quercetea pubescentis*) in the Western Balkans based on numerical analysis; (2) to characterize the identified vegetation types by their species composition, ecology and distribution; and (3) to identify the main underlying gradients driving the variation in species composition of *Quercetea pubescentis* in the Western Balkans.

Methods

Study area

The study area was the Western Balkans, i.e., Slovenia, Croatia, B&H, Serbia and Montenegro. This includes the entire range of the Dinaric Alps, southeastern fringes of the Alps in Slovenia, southwestern fringes of the Carpathian Mountains and the western fringes of the Balkan Mountains in Serbia and the hills and low mountains of the southern margin of the Pannonian Plain in Slovenia, Croatia, B&H and Serbia (Fig. 1). This area was supplemented with localities in southern and western Hungary (Mecsek Hills and Transdanubian Range), from where we collected relevés from three associations. Biogeographically, the study area belongs to (a) the Euro-Siberian biogeographical region, particularly the Illyrian sector of the Apennine-Balkan province, the Pannonian sector of the Pannonian-Carpathian province and the Eastern Alpine sector of the Alpine province, and (b) the Mediterranean biogeographical region, particularly the Epiro-Dalmatian sector of the Adriatic province (Rivas-Martínez et al. 2004). In addition to its diverse topography, it comprises a great variety of bedrock and soils. Carbonate bedrock prevails in the southern and western parts of the study area (southwestern Dinaric Alps), while it is mostly siliceous in the northern and eastern parts (northeastern Dinaric Alps, Carpathian and

Balkan Mountains, and the hills and low mountains of the southern margin of the Pannonian Plain) (Velić & Velić 1983). The climate is also diverse, since two major climatic zones overlap in the Western Balkans: central European one from the north and Mediterranean one from the south. The borderline between these two climate types is not distinct and lies in the transitional zone of the Dinaric Alps, being highly influenced by mountain massifs (Delijanić et al. 1964). River valleys and canyons also have a significant role in climate modification, since the Mediterranean climate penetrates through them deep into the continent. In this paper, for practical reasons, we refer to communities under the influence of the central European climate as *continental*, though on a European scale they are rather sub-continental-sub-Mediterranean. This part of Europe has been under intensive anthropogenic influence since the early Neolithic, especially the sub-Mediterranean and Pannonian regions. Large portions of this land were altered, mainly deforested, quite early because of the early spread of agriculture (Horvat et al. 1974).

Fig. 1. Location of the study area (in saturated tints).

Data preparation and stratified resampling

The study focused on the vegetation of TDF of the class *Quercetea pubescentis*, but we also compiled relevés assigned by their authors to the mesic-acidophilous alliance *Quercion roboris* from the class *Quercetea robori-petraeae*. In agreement with previous regional studies, we considered *Quercion roboris* to include also pure birch, mixed birch-aspen, as well as sweet chestnut communities, in addition to those of pure oak and mixed oak-birch communities. For Croatia and B&H, relevés were collected from GIVD (EU-BA-001, EU-HR-002), while for Slovenia, Serbia and Montenegro from the literature. For Hungary, we compiled relevés from Kevey (2008) for three associations: *Luzulo forsteri-*

Quercetum petraeae and *Viscario vulgaris-Quercetum polycarpae* (Kevey & Borhidi 2005) for comparison with Balkan acido-thermophilous forests and *Fraxino orni-Quercetum cerridis* Kevey et Sonnevend in Kevey 2008 for comparison with *Fraxino orni-Quercetum cerridis* Stefanović 1968, a widespread community in western B&H. In addition, 399 relevés were recently recorded in B&H in TDF, mainly in areas that were overall very poorly sampled. A total of 3159 relevés was compiled in a Turboveg database (Hennekens & Schaminée 2001). Relevés from the alliances *Syringo-Carpinion orientalis* and *Buxo-Syringion* (synonym *Pruno tenellae-Syringion*) were then excluded because they were represented by heterogeneous data coming from eastern periphery of the study area (Diklić & Vukićević 1997; Mišić 1997; Čarni et al. 2009). Fourteen relevés originally asigned to *Aceri tatarici-Quercion* were omitted because of the absence of oaks (Stjepanović-Veseličić 1979). The remaining eight relevés assigned to *Aceri tatarici-Quercion* were also omitted as they were collected on the north-eastern periphery of the study area (Jovanović 1978). The resulting data set thus consisted of 2946 relevés (Supplement S1).

Because many authors did not record mosses, we excluded them from the data set before numerical analysis. Taxa recorded for more than one layer were merged into one layer because of inconsistent sampling. Records of species determined to the genus level were deleted. Plant nomenclature follows Flora Europaea (Tutin et al. 1968–1993). Species not included in this reference but mentioned in this paper have been listed in Supplement S2. Species from taxonomically critical groups that were not always identified by the relevé authors were combined into aggregates (agg.) and species that included several subspecies that were not always recorded or recognized by authors were combined and marked with the abbreviation "s.l." (*sensu lato*) and are also listed in Supplement S2. *Aristolochia pallida* is considered to be *A. lutea* (Nardi 1984) and *Teucrium polium* to be *T. polium* subsp. *capitatum* (Hadžiablahović 2010). The dubious taxon *Quercus dalechampii* was treated as part of *Quercus petraea* agg., following Di Pietro et al. (2012). Taxa occurring in three or fewer relevés were omitted from the analysis in order to reduce noise (Tsiripidis et al. 2007; Juvan et al. 2013).

The data set of 2946 relevés was then stratified in the JUICE 7 program (Tichý 2002) by means of numerical classification (Knollová et al. 2005) using TWINSPAN (Hill 1979). TWINSPAN pseudospecies cut levels were set to 0-5-25 % scale units. Four levels of division were chosen because we expected more than eight and fewer than 16 ecologically and floristically interpretable groups of relevés. Within these 16 groups, a total of 968 relevés were resampled using heterogeneity-constrained random (HCR) resampling, using beta-diversity within strata as a criterion for the number of relevés to be selected (measured as mean Bray-Curtis dissimilarity between all relevé pairs), and the number of relevés to be resampled was set within the range of 1–100 per stratum (Lengyel et al. 2011).

Data analysis

Separation of Quercetea pubescentis from Quercetea robori-petraeae

The resampled data set of 968 relevés was subjected to hierarchical classification by the PC-ORD program (McCune & Mefford 1999). Logarithmic transformation of data, Euclidean distances and Ward's linkage method were used. We accepted nine clusters of relevés, because they were ecologically and floristically best interpretable. We intentionally selected this coarser level of resolution of classification because we wanted to provide a synthetic classification reflecting main patterns (ecological and phytogeographical) in species composition over a larger area and not local small-scale heterogeneities. For the interpretation of relevé grouping, we used DCA in R software, version 2.10.1 (R Development Core Team 2009) using the *vegan* package (http://cc.oulu.fi/~jarioksa/softhelp/vegan.html). All 968 relevés were projected onto the two-dimensional ordination space of DCA, with centroids calculated for each of the nine clusters.

In order to better understand the relationship between *Quercetea pubescentis* and *Quercetea robori-petraeae* and to determine the position of the transitional acido-thermophilous communities, we made two separate analyses of the clusters: (1) we calculated diagnostic species for all nine clusters, in order to see the floristic differences and indicate ecological characteristics of the respective types (Supplement S3); (2) then we combined three clusters of meso-acidophilous and mesophilous communities in one group and compared it to the cluster of transitional acido-thermophilous oak forests to identify the differential species (Table 1).

Differentiation of TDF types

After we excluded 233 relevés of three meso-acidophilous and mesophilous forest types, we were able to analyze 735 relevés of TDF in the Western Balkans and calculate diagnostic species for the six distinguished clusters (Table 2, Supplement S4). Diagnostic species obtained in this way are only relevant within the class *Quercetea pubescentis* in the Western Balkans. All 735 relevés, together with the selected ecological variables, were projected onto a DCA plot. Species ecological indicator values (EIVs) for temperature, light, moisture, continentality, soil reaction and nutrients (Pignatti et al. 2005) and selected bioclimatic variables available from the WorldClim database (Hijmans et al. 2005) were used as explanatory ecological variables. Unweighted average EIVs were calculated in JUICE and passively projected onto a DCA plot. The significance of their correlation with the DCA relevé scores was tested using the modified permutation test proposed by Zelený & Schaffers (2012). All bioclimatic variables available in the WorldClim database were extracted for each relevé. The possible effect of climatic variables on vegetation composition was tested using canonical correspondence analysis (CCA) in CANOCO 4.5 software (Microcomputer Power, Ithaca, NY, US). Forward selection of explanatory variables was used to provide a ranking of the importance of individual variables and to avoid co-linearity, following Zelnik & Čarni (2013). Three climatic variables with the highest explanatory value were selected for further analysis and projected onto a DCA plot.

Diagnostic species

Diagnostic species were determined using the phi coefficient (Chytrý et al. 2002) in the JUICE 7 program (Tichý 2002). For each combination of clusters, each of the nine, two and six groups was virtually adjusted to $1/9^{th}$, 1/2 and $1/6^{th}$ of the size of the entire data set, while holding the percentage occurrences of species within and outside the target group the same as in the original data set (Tichý & Chytrý 2006). We also calculated Fisher's exact test and gave a zero fidelity value to species whose phi values were not statistically significant ($P > 0.001$). The threshold phi value for a species to be considered diagnostic was set at 0.25. Species that appear in 50% of relevés of a cluster or more were treated as constant.

Chorotypes and distribution mapping

We also determined chorological spectra of groups following Pignatti et al. (2005) and Gajić (1980). Endemic Balkan and Illyrian species were distinguished from southeast European species in a broader sense. Representation of different chorological types in the nine groups of relevés was analyzed for every chorotype and presented using box-and-whiskers plots.

For the purpose of distribution mapping of the distinguished vegetation types, we assigned plots that were excluded during resampling into the resulting vegetation types (as proposed by Lengyel et al. 2011) using semi-supervised classification (Tichý et al. 2014). We used K-means with nine *a priori* defined groups and ten output groups. We thus excluded relevés that do not fit well into any of the nine previously accepted groups.

Results and discussion

Separation of Quercetea pubescentis and Quercetea robori-petraeae communities in the Western Balkans

Numerical classification yielded nine ecologically sound clusters of relevés (vegetation types), which are presented in the dendrogram (Fig. 2) and in the synoptic table (Supplement S3). They formed three major ecological groups: (i) basophilous thermophilous communities dominated by *Quercus pubescens, Carpinus orientalis* and *Ostrya carpinifolia* (clusters 1–3); (ii) slightly to moderately acidophilous thermophilous communities of *Quercus frainetto, Q. petraea* agg. and *Q. cerris* (clusters 4–6, with cluster 6 being a group of transitional acido-thermophilous relevés); (iii) mesophilous and meso-acidophilous communities on acidic bedrock from the western part of the region with higher precipitation, dominated by *Quercus petraea* agg., *Castanea sativa* and *Betula pendula* (clusters 7–9). This division, as well as the first DCA axis, reflect the pH gradient from basophilous to acidophilous forests.

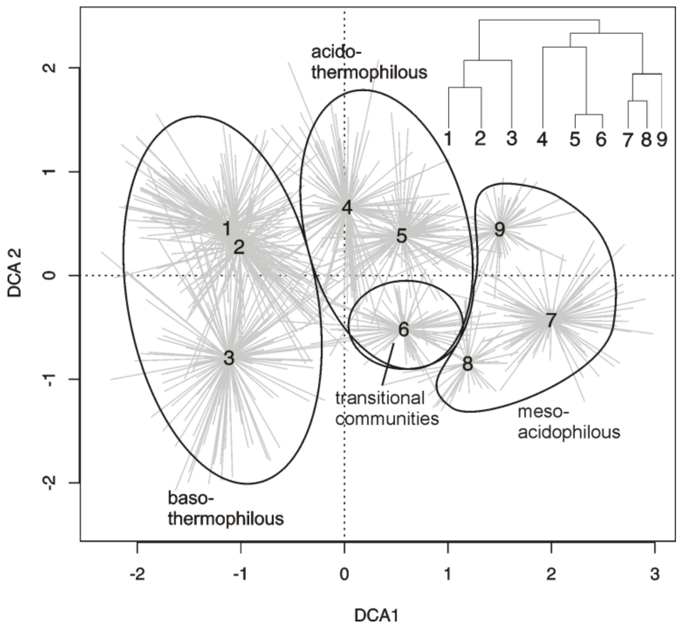

Fig. 2. DCA spider plot of the resampled dataset (968 relevés). The lenght of the first DCA axis is 5.19 SD units, the lenght of the second axis is 3.94 SD units. Centroids of clusters are indicated by numbers. Grey lines connect individual relevés with centroids of the clusters to which the relevés were classified. The classification dendrogram is shown in the upper right corner. The numbers of clusters refer to Tables 1–2, Supplements S1, S3–S4 and Figs. 3–5. Numbers also correspond to type numbers used in the Results and discussion section.

The comparison of chorotype frequency distribution between the vegetation types (Fig. 3) shows that cosmopolitan and Eurasian chorotype percentages rise from cluster 1 to cluster 9. South and southeast European, steno-Mediterranean and eury-Mediterranean elements show the opposite trend. The Mediterranean-montane element is highest in cluster 3. The endemic Illyrian element is present in clusters 1–3 only, while the endemic Balkan element is most abundant in clusters 4 and 5, less in clusters 1–3 and is absent in clusters 6–9. The Pontic element prevails in clusters 1 and 4, while it is absent in clusters 3, 7 and 9.

To show the separation between thermophilous and meso-acidophilous and mesophilous types clearly, we provide diagnostic species for the level of nine cluster (clusters 7–9 being meso-acidophilous and mesophilous) in Supplement S3. Species indicating very acidic soil and a somewhat cooler climate and mostly of wider European or Eurasian distribution (Fig. 3b) are diagnostic for clusters 7–9. Short description of the analyzed meso-acidophilous and mesophilous communities is given below.

Meso-acidophilous forests dominated by *Quercus petraea* agg. (cluster 7) represent species poor, acidic oak-dominated forests of the class *Quercetea robori-petraeae*. Diagnostic species (e.g. *Vaccinium myrtillus, Calluna vulgaris, Luzula luzulina, Hieracium murorum, Melampyrum pratense*) indicate acidic conditions. Mesophilous forests dominated by *Castanea sativa* (cluster 8) have diagnostic species that indicate mesic conditions (e.g. *Aposeris foetida, Scrophularia nodosa, Sanicula europaea, Corylus avellana*). All relevés from this group were traditionally classified within *Quercion roboris*, but they harbor a considerable number of beech forest elements, which suggests that this type probably belongs to the alliance *Aremonio-Fagion,* which is congruent with the recent work of

Medak (2011). Diagnostic species for acidophilous pioneer *Betula pendula* or *B. pendula/Populus tremula* communities (cluster 9) indicate acidic and open sites (e.g. *Betula pendula, Pteridium aquilinum, Populus tremula, Potentilla erecta, Agrostis capillaris*). Although traditionally classified to *Quercion roboris,* these communities show clear ecological and floristic distinctions from the rest, so it would be reasonable to classify them into a separate order, i.e., *Betulo pendulae-Populetalia tremulae*, as already suggested by several authors (Rivas-Martínez et al. 2001; Rodwell et al. 2002; Biondi et al. 2014).

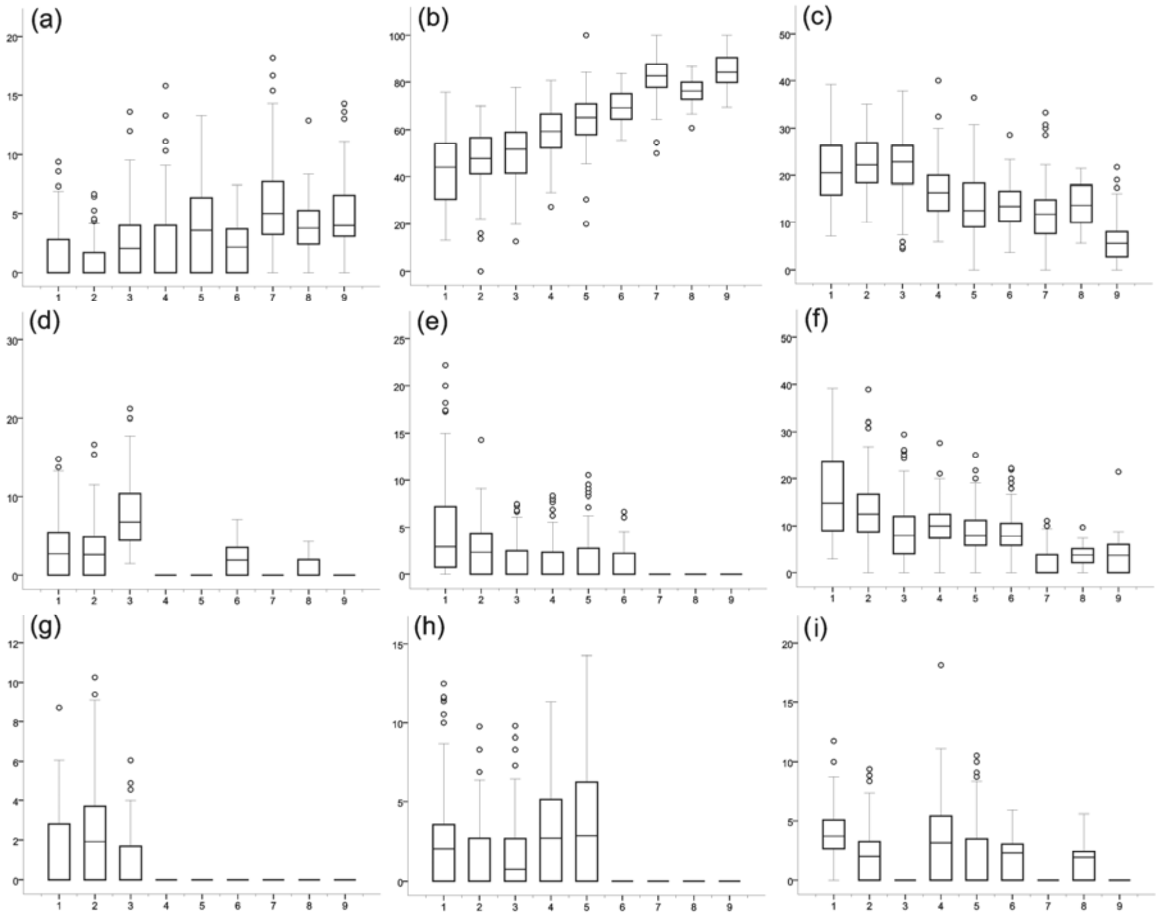

Fig. 3. Box-and-whisker plots showing the representation of different chorological types in the distinguished vegetation types. (**a**) Cosmopolitan, (**b**) European and Eurasian, (**c**) South and southeast European, (**d**) Mediterranean-montane, (**e**) Stenomediterranean, (**f**) Eurimediterranean, (**g**) Endemic Illyrian, (**h**) Endemic Balkan, (**i**) Pontic. Horizontal axis represents the clusters of relevés, numbers of which refer to Fig. 2 and to type numbers used in the Results and discussion section, while vertical axis is a percentage scale.

Comparison of diagnostic species of transitional acido-thermophilous communities (cluster 6) and meso-acidophilous and mesophilous communities (clusters 7–9 grouped together) showed that the former are characterized by species that are mostly thermophilous and/or have a southeast European distribution (e.g. *Fraxinus ornus, Dactylis glomerata* s.l., *Lathyrus niger, Festuca drymeja, Sorbus torminalis, Melittis melissophyllum* s.l., *Campanula persicifolia, Vincetoxicum hirundinaria, Tanacetum corymbosum*), while the latter are characterized by species indicating strongly acidic soil and somewhat lower air temperature, generally with a wider European or Eurasian distribution pattern (e.g. *Calluna vulgaris, Vaccinium myrtillus, Betula pendula, Potentilla erecta, Pteridium aquilinum*; Table 1). This supports our hypothesis that transitional acido-termophilous communities (cluster 6) should be, together with clusters 1–5, classified within TDF of the class *Quercetea pubescentis.*

Table 1. Diagnostic species of meso-acidophilous TDF (cluster 6) versus mesophilous forests (clusters 7–9 grouped together) in Western Balkans. Species phi values multiplied by 100 are shown. Only species with phi values higher than 0.3 are included.

Cluster	**6**	**7–9**
No. of relevés	**90**	**233**
Fraxinus ornus	69	.
Dactylis glomerata s.l.	54	.
Lathyrus niger	49	.
Festuca drymeja	45	.
Prunus avium	43	.
Sorbus torminalis	43	.
Melittis melissophyllum s.l.	42	.
Galium schultesii	41	.
Campanula persicifolia	40	.
Vincetoxicum hirundinaria	38	.
Tanacetum corymbosum	37	.
Carex digitata	35	.
Symphytum tuberosum s.l.	35	.
Acer campestre	34	.
Hieracium racemosum	34	.
Melica uniflora	34	.
Robinia pseudacacia	34	.
Tilia tomentosa	34	.
Cornus mas	33	.
Hedera helix	33	.
Festuca heterophylla	32	.
Ruscus aculeatus	32	.
Carex flacca s.l.	31	.
Poa nemoralis	30	.
Sesleria autumnalis	30	.
Calluna vulgaris	.	65
Vaccinium myrtillus	.	56
Betula pendula	.	52
Potentilla erecta	.	40
Pteridium aquilinum	.	38
Agrostis capillaris	.	35
Frangula alnus	.	34
Gentiana asclepiadea	.	34

Pinus sylvestris	.	33
Populus tremula	.	33
Picea abies	.	32

It should be mentioned that after semi-supervised classification of relevés from the initial dataset, one fairly homogenous group of relevés remained unclassified. These relevés come from the northwestern margin of the range of *Quercus frainetto* and were traditionally classified to *Quercion frainetto,* mainly as *Quercetum frainetto-cerris* subass. *carpinetosum betuli* (Rudski 1949; Stefanović 1988; Trinajstić et al. 1996) (Fig. 4h). This group has a distinct mesophilous character, as its species composition is similar to oak-hornbeam forests (alliance *Carpinion betuli*), where they probably should be classified.

Vegetation types of TDF in the Western Balkans

Synoptic table of the six distinguished types of TDF (class *Quercetea pubescentis*) in the Western Balkans is given in Table 2 (full version in Supplement S4). Geographical distribution of the types is shown in Fig. 4. Photo plates with photographs of the types are given in Supplement S5.

Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis* (Table 2, column 1)

This type includes mainly structurally degraded coppices of *Quercus pubescens* and *Carpinus orientalis,* which are often further degraded to pure *Carpinus orientalis* scrub. Very rarely can they be found as high forests. Two variants can be distinguished within this cluster, based on the floristic composition and spatial distribution: 1) climax sub-Mediterranean communities with several species characteristic of the warmer belt closer to the Adriatic coast (e.g. *Asparagus acutifolius, Clematis flammula, Cyclamen hederifolium, Juniperus oxycedrus, Smilax aspera, Phillyrea latifolia, Pistacia terebinthus*); and 2) extrazonal, continental communities, which are also found in warmer sites (typically river canyons and gorges) but lack the aforementioned species (Fukarek 1975; Stefanović 1989). This type is widespread on calcareous bedrock in the sub-Mediterranean regions of the Balkan and Apennine peninsulas (Horvat et al. 1974; Lakušić et al. 1982; Stefanović 1983; Poldini 1988; Blasi et al. 2004; Čarni et al. 2009). Due to its geographical distribution (Fig. 4a), it has a high number of south and southeast European floral elements, particularly Mediterranean, but also endemic Illyrian and Balkan ones (Figs. 3c-h). All published relevés classified to this type were originally assigned to the alliance *Carpinion orientalis*.

Type 2: Sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis* (Table 2, column 2)

This type comprises relevés similar to the extrazonal variant of *type 1* but generally without *Carpinus orientalis*. They are represented by structurally degraded high forests or coppices and characterized by species of more open habitats, such as *Helleborus multifidus* s.l., *Brachypodium pinnatum* s.l., *Geranium sanguineum, Inula hirta, Carex humilis, Teucrium chamaedrys*. Other diagnostic species are *Sesleria autumnalis* and *Carex flacca* s.l., while constant species are *Quercus pubescens*, *Fraxinus ornus* and *Crataegus monogyna*. It appears on southerly exposed sites on carbonate bedrock in continental regions, while in the sub-Mediterranean regions it appears as zonal at lower altitudes in the north (especially in Slovenia) but can reach up to 1100 m a.s.l. on south facing slopes in B&H (Fig. 4b). Published relevés classified to this type were originally assigned mostly to *Carpinion orientalis*, but also to *Quercion pubescenti-petraeae* (particularly those from more continental regions).

Type 3: Meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia* (Table 2, column 3)

Although these forests are mainly coppices, they tend to maintain closed canopy and similar floristic composition as natural non-coppiced stands, if not heavily disturbed. As they usually occupy steep rocky limestone and dolomite slopes with thin soil layer, where *Ostrya* is competitively stronger than *Quercus pubescens*, they are regarded as edaphic climax communities. In canyon systems along the Dinaric arc, where they are accompanied by various local endemic relict species (Tomić 1980, 2000) they are also considered natural relict communities. In sub-Mediterranean region they can be found as an altitudinal belt above *Quercus pubescens-Carpinus orientalis* communities, or even as secondary successional stages of those forests (Trinajstić & Cerovečki 1978; Puncer & Zupančič 1982; Trinajstić 1982). On carbonate outcrops in continental regions (northern parts of Slovenia, Croatia and B&H), they are found as a more mesophilous edaphic climax (association *Querco-Ostryetum*; Horvat 1963). Some communities have developed on steep slopes of dolomite massifs; they show similarities to the vegetation of the class *Erico-Pinetea* (Horvat 1959). There are many diagnostic species for this type, some of them indicating limestone outcrops, some are relicts and local endemics and others are related to dolomite bedrock and the class *Erico-Pinetea* (Table 2, Supplement S4). *Ostrya carpinifolia, Fraxinus ornus* and *Cornus mas* are constant species of the tree and shrub layer. This vegetation type can be found over a large area of the Dinaric Mountains (Trinajstić & Cerovečki 1978; Stefanović 1979; Lakušić et al. 1982; Puncer & Zupančič 1982; Tomić 2006) (Fig. 4c), typically in places with higher air moisture, such as river canyons and gorges in the continental regions, and higher altitudes in the sub-Mediterranean regions, which explains the considerable number of Mediterranean-montane elements in this group (Fig. 3g). Published relevés were originally assigned to the alliances *Fraxino orni-Ostryion* or *Carpinion orientalis,* depending on the adopted syntaxonomical concept: while some authors consider *Fraxino orni-Ostryion* to be an independent alliance (Tomić 1980; Lakušić et al. 1982; Čarni et al. 2009; Tomić & Rakonjac 2013), others consider it to be a part of or synonymous with *Carpinion orientalis* sensu lato (Stefanović 1979; Trinajstić 2008; Šilc & Čarni 2012; Vukelić 2012).

Type 4: Thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris* (Table 2, column 4)

Forests of this type are usually structurally degraded high forests and coppices. *Physospermum cornubiense, Acer tataricum* and *Paeonia mascula* are diagnostic species, while *Quercus frainetto*, *Quercus cerris, Fraxinus ornus, Crataegus monogyna* and *Fragaria vesca* are constant. This type is found at lower altitudes (200–500 m), mainly on bedrock with a slightly acidic to neutral soil reaction. The stands are warm and open, with the center of distribution in the central Balkans (Serbia, Bulgaria, Macedonia; Fig. 4d), where they form climax vegetation (Horvat et al. 1974; Jovanović 1997). Typical communities dominated by *Quercus frainetto* can be found in the eastern and northeastern parts of B&H and in eastern Slavonia in Croatia, as the last outposts of the dominant species in the northwestern direction (Glišić 1956; Fukarek et al. 1974; Stefanović 1988; Trinajstić et al. 1996). They also occur extrazonally on deeper soils in the sub-Mediterranean Herzegovina (B&H; Fukarek 1966), while they reach their westernmost limit probably in northern Dalmatia (Croatia; Trinajstić 2008). Most relevés of this type are traditionally classified within the *Quercion frainetto* alliance. Although traditionally assigned mostly to *Quercion petraeo-cerridis*, relevés of *Fraxino orni-Quercetum cerridis* were also classified within this type. The latter community is lacking *Quercus frainetto* and is found mostly on carbonate bedrock in western Bosnia (Stefanović 1968) and western Hungary (Kevey 2008). In B&H these forests mainly thrive on flat terrain, where deeper slightly acidic soils are formed over limestone, which leads to the appearance of some acidophilous plant species. The open canopy allows a greater abundance of heliophilous plants from the surrounding dry grasslands.

Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* agg. and/or *Quercus cerris* (Table 2, column 5)

This type comprises relevés of structurally degraded high forests or coppices dominated by *Quercus petraea* agg. and *Quercus cerris*, mainly over siliceous bedrock. Species characteristic for this type (e.g. *Veronica officinalis, Chamaespartium sagittale, Genista pilosa, Hieracium praealtum* subsp. *bauhinii*) indicate dry soils with low pH and low nutrient content. *Quercus petraea* agg., *Quercus cerris, Fraxinus ornus* and *Fragaria vesca* are constant. Similarly to *type 4,* this type contains a significant percentage of endemic Balkan chorotypes (Fig. 3h). While in the northern and northwestern parts of the distribution area this type occupies warmer sites at lower altitudes (500–800 m), in the central and southern parts of its range it forms the altitudinal belt above forests of *Quercion frainetto* (*type 4*; Em 1964; Tomić et al. 2006). It can reach up to 1400 m and is characterized by a cooler and damper microclimate and more acidic soil reaction compared to *type 4*. This type is of central Balkan distribution (Serbia, Macedonia, eastern B&H), with exclaves in nortwestern B&H, eastern Croatia and southern Hungary (Fig. 4e). Relevés of this type mainly correspond to the alliance *Quercion petraeo-cerridis* (Čarni et al. 2009). Bulgarian communities similar to this type, which are also rich in Balkan elements, were previously classified into the central European alliance *Quercion petraeae* with the remark that they show a great resemblance to *Quercion petraeo-cerridis* (Lyubenova et al. 2011).

Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests (Table 1, column 1; Table 2, column 6)

This type is represented by highly productive forests of *Quercus petraea* agg. with relatively closed canopy (mostly over 80%). The shrub layer is poorly developed, with the exception of *Fraxinus ornus* and sometimes *Sorbus torminalis*. Since this type floristically combines attributes of thermophilous, acidophilous and mesophilous *Quercus petraea* forests, diagnostic species are mainly mesophilous and acidophilous (e.g. *Hieracium racemosum, Festuca drymeja, Castanea sativa, Carpinus betulus, Robinia pseudacacia, Melampyrum pratense, Carex pilosa* and *Luzula luzuloides*). Besides *Quercus petraea* agg. and *Fraxinus ornus, Dactylis glomerata* s.l., *Lathyrus niger* and *Festuca heterophylla* are constant. However, our results suggest that relevés of this transitional type should be classified to TDF (class *Quercetea pubescentis*). Species that distinguish them from meso-acidophilous forests (class *Quercetea robori-petraeae*) are thermophilous plants such as *Fraxinus ornus, Lathyrus niger, Sorbus torminalis, Melittis melissophyllum* s.l., *Campanula persicifolia, Vincetoxicum hirundinaria, Tanacetum corymbosum, Festuca heterophylla* and, *Carex flacca* s.l. At the same time, there is a lack of indicators of highly acidic soils (Table 1). These communities are transitional to mesophilous beech or oak-hornbeam forests and often occur nearby. Usually they occupy warmer exposures and the upper parts of moderate to steep slopes above beech or oak-hornbeam forests, which suggests that they represents an edaphic climax. The fact that mesophilous trees *Carpinus betulus, Fagus sylvatica* and *Prunus avium* are frequent in this type, but always in the sapling or lower shrub layer with poor vitality and very low coverage, supports the assumption that the edaphic conditions are not favorable for mesophilous communities to develop even though the canopy is usually relatively closed. Similar transitional communities are known from Central Europe (e.g. the associations *Sorbo torminalis-Quercetum* and *Melico pictae-Quercetum roboris*), where they are also classified into the class *Quercetea pubescentis* (alliance *Quercion petraeae*; Roleček 2013). Some authors (e.g. Roleček 2005, 2007; Hédl et al. 2010) argue that these central European open-canopy communities are often artifacts of the former traditional forest management, consisting of coppicing, woodland grazing and deliberate planting of oak as an economic species, and that the recent cessation of those practices is causing the retreat of those forests in favor of mesophilous *Carpinion* communities. Forests of *type 6* have a closed canopy, they were not coppiced or grazed, nor were they subjected to deliberate planting of oaks, which supports the hypothesis about their natural origin, in spite of their transitional character. These forests are found on moderately deep soils over acidic bedrock, with a pH between 4.5 and 5.5. They thrive on the hills and low mountains of the southern fringes of the Pannonian Plain, with the highest abundance in northern Bosnia and Slavonia (northern Croatia) (Fig. 4f). They are differentiated from the central European alliance *Quercion petraeae* by some characteristic species with a southeast European distribution pattern, e.g., *Fraxinus ornus, Hieracium racemosum* and *Festuca drymeja.* They are also related to forests of *type 5* (central Balkans *Quercion petraeo-cerridis*), with the main difference being that the latter typically occur in dryer microecological conditions on more shallow and dryer soil, thus with lower share of mesophilous species and with a significant share of endemic Balkan species (Fig. 3h). The Balkan element does not occur in *type 6* and typical stands appear at altitudes of 200–700 m, which is an elevational shift of 300 m downwards compared to *type 5*. Relevés of this group have traditionally been mainly assigned to the meso-acidophilous *Quercion roboris* (Stefanović et al. 1977a; Stefanović 1984; Vukelić 1991; Kevey & Borhidi 2005; Baričević et al. 2006a; Vukelić et al. 2010) and relevés of more thermophilous stands to *Quercion pubescenti-petraeae* (Baričević et al. 2006b) (Supplement S1). The similar distribution pattern of sub-Pannonian beech forests of *Tilio tomentosae-Fagenion sylvaticae,* which are also syntaxonomically complex (Marinšek et al. 2013), indicates the peculiar ecological and phytogeographical character of this transitional region.

Table 2. Synoptic table of TDF (class *Quercetea pubescentis*) types in the Western Balkans. The frequency values are shown, diagnostic species (phi values higher than 0.25) are shaded. Only ten species with the highest phi value are presented. Vegetation type numbers correspond to Figs. 2–5 and to those used in text.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
No. of relevés	**140**	**121**	**124**	**129**	**131**	**90**
Type 1						
Carpinus orientalis	96	22	5	19	12	.
Acer monspessulanum	46	21	23	2	1	.
Pistacia terebinthus	23	3	2	.	.	.
Paliurus spina-christi	25	8	1	.	.	.
Clematis flammula	25	9	1	.	.	.
Cyclamen hederifolium	14	.	.	1	.	.
Asparagus acutifolius	34	21	14	.	.	.
Ruscus aculeatus	44	10	23	8	6	19
Juniperus oxycedrus	25	12	6	1	4	.
Smilax aspera	8	.	.	.	.	.
Type 2						
Helleborus multifidus s.l.	11	37	5	2	2	.
Brachypodium pinnatum s.l.	20	55	34	18	5	8
Geranium sanguineum	10	37	19	2	1	6
Inula hirta	1	19	2	5	.	.
Carex flacca s.l.	8	37	8	2	.	28
Sesleria autumnalis	57	65	56	.	8	17
Filipendula vulgaris	10	31	4	16	2	2
Peucedanum cervaria	1	24	7	4	1	7
Carex humilis	8	30	19	.	1	3
Teucrium chamaedrys	41	55	35	17	11	7
Type 3						
Ostrya carpinifolia	32	45	100	2	1	13
Asplenium ruta-muraria	4	2	44	.	.	.
Asplenium trichomanes	13	6	57	2	8	1
Sorbus aria	8	13	56	.	1	9
Cyclamen purpurascens	13	9	52	.	.	10
Galium laevigatum	.	2	30	.	.	2
Campanula pyramidalis	1	1	25	.	.	.
Moehringia muscosa	1	2	27	2	.	.
Campanula rapunculoides	2	2	31	2	5	1
Anemone trifolia	.	1	23	.	.	3
Type 4						
Quercus frainetto	4	6	1	71	9	.
Quercus cerris	31	55	27	92	51	33
Physospermum cornubiense	6	.	6	33	5	.
Acer tataricum	9	2	.	27	8	4
Paeonia mascula	.	.	.	10	.	.
Type 5						
Veronica officinalis	1	2	.	32	47	12
Chamaespartium sagittale	.	4	1	5	26	1
Genista pilosa	.	.	.	2	21	4
Poa nemoralis	8	3	8	25	50	23
Hieracium praealtum subsp. *bauhinii*	6	3	.	26	34	6
Omalotheca sylvatica	.	.	.	.	9	.
Pteridium aquilinum	14	13	4	21	50	38
Hieracium sabaudum	7	6	3	14	35	20
Sedum cepaea	2	.	2	6	17	1
Hieracium pilosella	9	2	1	20	27	2
Type 6						
Hieracium racemosum	1	10	.	3	3	59

Festuca drymeja	1	.	.	2	5	36
Castanea sativa	1	4	3	3	4	40
Carpinus betulus	11	6	9	29	23	70
Robinia pseudacacia	1	3	.	1	.	30
Melampyrum pratense	3	2	2	5	15	43
Prunus avium	11	12	6	26	11	61
Carex pilosa	1	.	1	1	4	27
Luzula luzuloides	1	.	.	2	23	39
Galium sylvaticum	2	2	2	6	3	31
Species diagnostic for more than one type						
Quercus pubescens	71	93	44	14	1	3
Quercus petraea agg.	22	8	31	46	100	100
Other species with high frequency						
Fraxinus ornus	96	94	92	62	69	96
Crataegus monogyna	64	68	35	68	48	36
Cornus mas	64	45	50	33	9	20
Melittis melissophyllum s.l.	20	41	49	14	7	33
Fragaria vesca	33	19	30	52	51	27
Acer campestre	34	35	18	49	24	37
Festuca pseudovina agg.	16	19	10	36	18	.
Dactylis glomerata s.l.	39	47	15	46	36	59
Lathyrus niger	17	40	6	36	22	54
Festuca heterophylla	16	26	10	48	27	50
Genista tinctoria	6	13	10	31	42	43
Hedera helix	41	29	37	5	5	42
Campanula persicifolia	19	17	11	19	15	38
Pyrus pyraster	25	26	17	44	25	37
Tanacetum corymbosum	24	28	22	27	12	37
Rosa arvensis	23	31	18	27	26	36
Veronica chamaedrys	32	23	15	46	41	34
Cruciata glabra	21	24	6	24	20	33
Symphytum tuberosum s.l.	24	23	17	16	6	32
Potentilla micrantha	25	12	14	24	35	31
Viola reichenbachiana	24	10	10	23	24	30

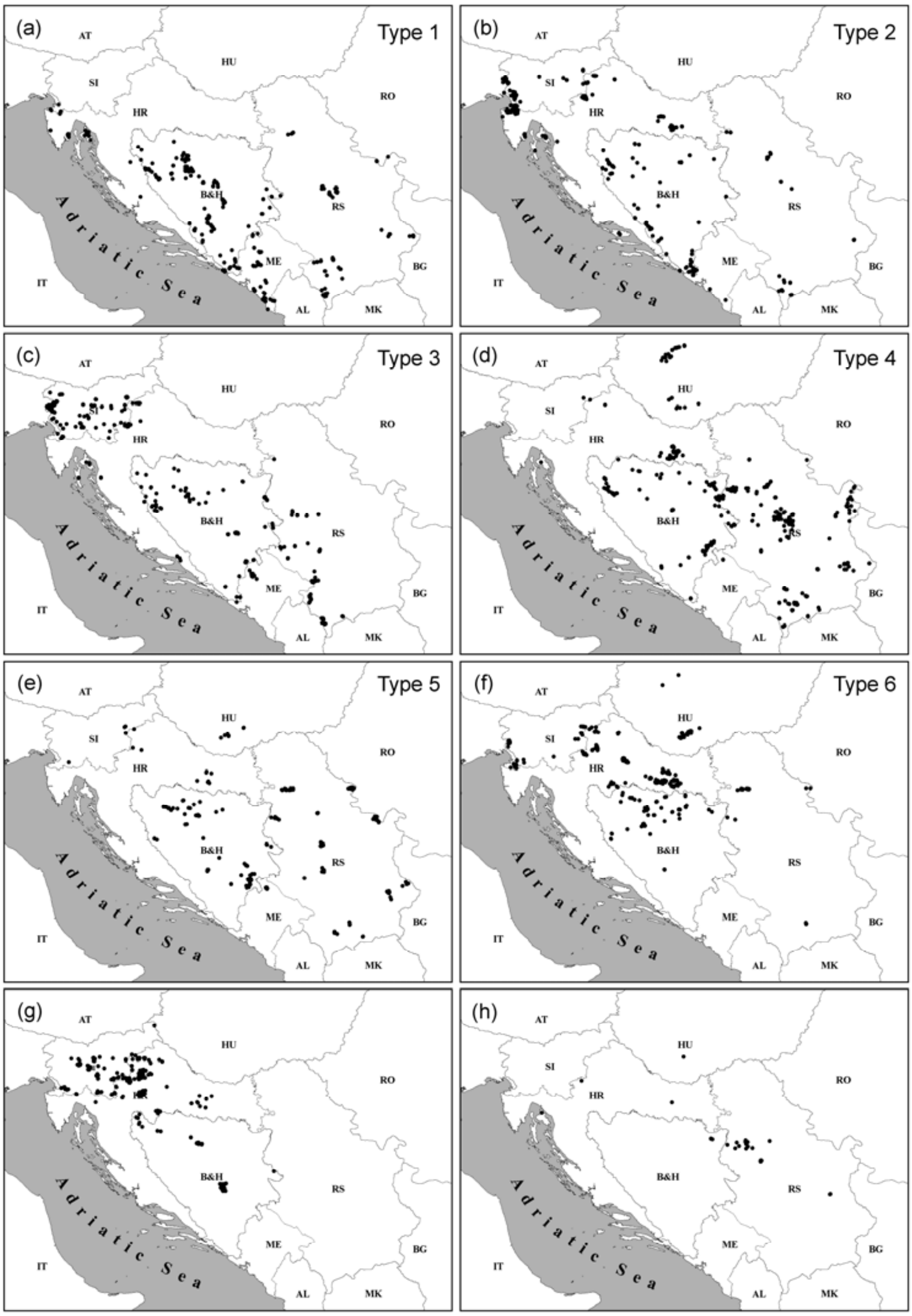

Fig. 4. (a–f) Sites of TDF (*Quercetea pubescentis*) types in the Western Balkans distinguished in this study. (g) Sites of meso-acidophilous and mesophilous forest originally assigned by their authors to *Quercetea robori-petraeae*. (h) Sites of mesophilous *Quercus frainetto* stands unassigned to any of the previous types by semi-supervised classification. Type numbers correspond to TDF type numbers used in this paper.

Gradients within TDF in the Western Balkans

All six EIVs are significantly related to the first two DCA axes ($P \leq 0.05$; Table 3). Climatic variables with the highest explanatory value are annual precipitation, precipitation of warmest quarter and annual temperature range, all three being significantly related to the first two DCA axes at $P < 0.001$.

Table 3. Relationship between the first two DCA axes and mean EIVs calculated using modified permutation test. *P* values are based on 999 permutations. DCA1 and DCA2 are normalized regression coefficients for the first and second DCA axis, respectively. R^2 is a coefficient of determination.

	DCA1	DCA2	R^2	*P*
Light	-0.093	0.996	0.527	0.001
Temperature	-0.105	0.994	0.624	0.001
Continentality	-0.265	0.964	0.425	0.002
Moisture	0.355	-0.935	0.624	0.001
Soil reaction	-0.998	0.063	0.637	0.001
Nutrients	0.245	-0.970	0.254	0.031

The first DCA axis (Fig. 5) can be interpreted as a complex geographical southwest-northeast gradient, expressed by the turnover of the dominant tree species, climate and geological substrates (which is reflected through the calculated EIVs for soil reaction). It runs from basophilous forests dominated by *Quercus pubescens, Carpinus orientalis* and *Ostrya carpinifolia*, occuring in the southern and western parts of the investigated area on carbonate bedrock (*types 1–3* in Figs. 4 and 5) to slightly to moderately acidophilous forests dominated by *Quercus frainetto, Q. petraea* and *Q. cerris*, occuring in the northern and eastern parts of the investigated area with acidic siliceous bedrock (*types 4–6* in Figs. 4 and 5). This gradient is also positively correlated with annual precipitation and negatively with the temperature annual range. However, since the majority of rainfall in southwestern part falls during the winter, we suggest this variable is not connected with the variation in the floristic composition and it merely corresponds to the southwest-northeast geographical gradient. Another variable that probably derives from southwest-northeast geographical pattern is temperature annual range (i.e., the difference between the maximum temperature of the warmest month and the minimum temperature of the coldest month). This is basically a measure of climatic continentality and runs from smaller differences in southern and western parts of the area to larger differences (i.e., pronounced continentality) in eastern and northern parts of the investigated area.

The second DCA axis mainly shows a gradient from meso-thermophilous closed canopy forests (lower part of the diagram) to xero-thermophilous open canopy forests (upper part of the diagram), so it can be interpreted as a microclimatic humidity/temperature gradient. This gradient is positively correlated with EIVs for temperature and light, and negatively with precipitation of the warmest quarter. *Ostrya carpinifolia* communities (*type 3*; lower part of the diagram) thus occupy more humid and cooler habitats at higher altitudes or in river canyons (Stefanović 1979; Lakušić et al. 1982; Puncer & Zupančič 1982; Tomić 2006), while communities of *Quercus pubescens* and *Carpinus orientalis* (*types 1* and *2*; upper part of the diagram) are found at warmer, lower altitudes with more pronounced summer drought (Stefanović et al. 1977b; Lakušić et al. 1982; Vukelić 2012). A similar pattern can be observed in the continental part of the investigated area, where dry acidophilous continental forests (*type 5*; lower part of the diagram) occupy cooler higher altitudes (Tomić et al. 2006) while *Quercus frainetto* forests (*type 4*; upper part of the diagram) occurs at warmer, lower altitudes. The gradient of precipitation of the warmest quarter runs in northwest-southeast direction, along the northern part of the Dinaric Alps and southern parts of the Pannonian Plain, from higher to lower precipitation in the summer. Thus, acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests (*type 6*; lower part of the diagram) are found in the northwestern, more humid part of this gradient, while *Quercus frainetto* forests (*type 4*; upper part of the diagram) are found mainly in the southeastern, dryer part of this area. Also this gradient runs from dryer, lower altitude communities (*types 1, 2* and *4*) to more humid, higher altitude communities (*types 3* and *5*). It should be noted that temperature is often correlated with light regime, in terms that more closed stands are less thermophilous and vice versa, so it can be assumed that a great part of the variation explained by temperature is actually driven by light conditions.

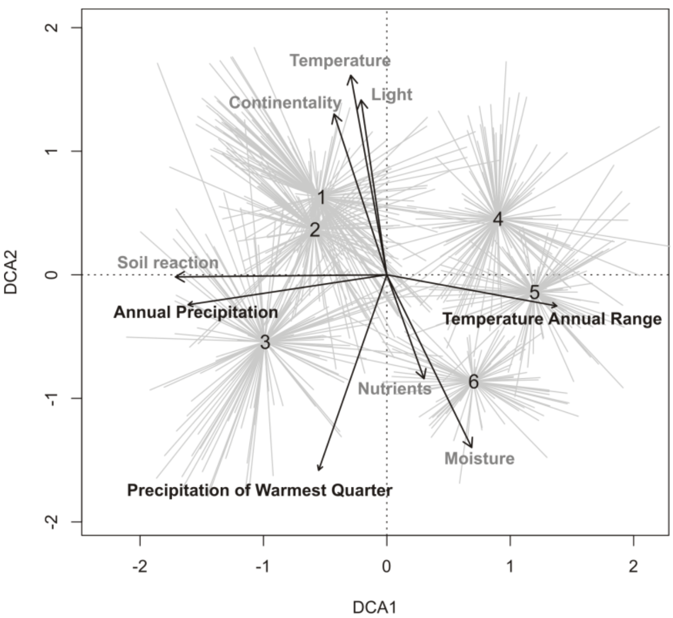

Fig. 5. DCA spider plot of 735 classified relevés of TDF with EIVs and climatic variables passively projected. The lenght of the first DCA axis is 4.19 SD units, the lenght of the second axis is 3.61 SD units. Centroids of clusters are indicated by numbers corresponding to Figs. 2–4, Tables 1–2 and to TDF type numbers used in this paper.

The light regime is often related to management practices in some oak forest communities (Roleček 2007; Bergmeier et al. 2010; Bauer & Bergmeier 2011; Uğurlu et al. 2012). *Types 1, 2* and *4*, which are often overexploited, coppiced, grazed and browsed, susceptible to fires etc., thus have more open canopies (Horvat et al. 1974; Stefanović et al. 1977b; Jovanović 1997; Vukelić 2012). Due to the macroclimatic conditions of these communities (mostly summer drought), these forests are more easily degraded and maintained in open-canopy state than forests in more humid macroclimatic conditions. An important question thus arises: if those forests were found in their natural, undegraded state, what would be their light regime? As we were able to see in the field in several undisturbed stands of *type 1*, the floristic composition shifts strongly towards that of mesic forest: less light demanding, less thermophilous, less xerophilous and even less basophilous. Since these preserved forests are very rare (there were only a dozen such relevés in our database), they have not influenced our classification. However, it would be very interesting to pay more attention to the ecological characteristics and development trends of natural and undisturbed stands of those communities (Surina 2014). Acido-thermophilous *Quercus petraea* dominated communities (*type 6*), on the other hand, which are mostly well managed, with a closed canopy (mostly over 80%), are at the darker end of the light gradient, so they can be perceived as the result of naturally induced factors, as opposed to sub-continental oak forests of Central Europe (*Quercion petraeae*), which, with their relatively open canopies, can be seen as artifacts of former forest management practices (Roleček 2007; Hédl et al. 2010). Forests of *Ostrya carpinifolia* (*type 3*) are also less light demanding (Tomić 2006). They either thrive on north facing slopes or are found in inaccessible places, such as canyons, and thus are not subjected to exploitation of any kind. As a result they have preserved canopies, which contributes to their pronounced mesophilous character.

To summarize, we consider the first DCA axis to be the geographical southwest-northeast gradient, which reflects large-scale ecological (geological and macroclimatic) as well as phytogeographical patterns, while the second axis for the most part reflects small-scale ecological patterns, such as topographic conditions, management practice and the level of disturbance (mainly structural degradation).

Conclusions

This study provides criteria for the separation of acidophilous forest (class *Quercetea robori-petraeae*) from TDF (class *Quercetea pubescentis*) in the Western Balkans. It was established that acidophilous forests appear mainly in the western, more humid part of the study area, whereas TDF are more frequent in the warmer and dryer eastern and southern parts. At the same time, it was found that the communities transitional between the two groups should be rather classified within *Quercetea pubescentis*. We classified TDF of the Western Balkans into six floristically and ecologically well defined types using numerical methods. Some types relate well to the established syntaxonomical schemes, while the status of others, especially meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*, sub-Mediterranean and continental *Quercus pubescens* woodland without *Carpinus orientalis*, as well as acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests, is not very clear and requires further investigation. The variation in floristic composition was best explained by soil reaction, annual precipitation and precipitation of the warmest quarter, as well as temperature, which all more or less reflect geographical southwest-northeast gradient in the Western Balkans. There was also a significant role of light regime, which mainly reflects local management practices, level of disturbance and the hemeroby of particular sites.

Author contribution

V.S. and A.Č. planned the research, V.S., J.B. and Ž.Š. conducted the field sampling, V.S. performed the statistical analyses and led the writing, while all authors critically revised the manuscript.

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Appendix 1
Names of the syntaxa above the association rank that are cited in the text.

Aceri tatarici-Quercion Zólyomi 1957
Aremonio-Fagion (Horvat 1950) Borhidi in Török et al. 1989
Betulo pendulae-Populetalia tremulae Rivas-Martínez et Costa in Rivas-Martínez et al. 2002
Carpinion betuli Issler 1931
Carpinion orientalis Horvat 1958
Carpino-Fagetea Jakucs ex Passarge 1968
Erico-Pinetea Horvat 1959
Fraxino orni-Ostryion carpinifoliae Tomažič 1940
Buxo-Syringion P. Fukarek ex Diklić 1965
Quercion frainetto Horvat 1954
Quercion petraeae Issler 1931

Quercion petraeo-cerridis Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015
Quercetea pubescentis Doing-Kraft ex Scamoni et Passarge 1959
Quercion pubescenti-petraeae Br.-Bl. 1932 nom. mut.
Quercion roboris Malcuit 1929
Quercetea robori-petraeae Br.-Bl. et Tüxen ex Oberdorfer 1957
Syringo-Carpinion orientalis Jakucs (1959)1960
Tilio tomentosae-Fagenion sylvaticae Marinšek et al. 2013

Electronic supplements

Supplementary material associated with this article is embedded in the pdf of this article. The online version of *Phytocoenologia* is hosted at www.ingentaconnect.com/content/schweiz/phyt and the journal's website www.schweizerbart.com/journals/phyto. The publisher does not bear any liability for the lack of usability or correctness of supplementary material.

Supplement S1. Sources of data used for the analysis.

Supplement S2. List of species merged to aggregates (agg.), broadly defined taxa (s.l.) or taxa deviating from Tutin et al. (1968–1993) or not included therein.

Supplement S3. Synoptic table of *Quercetea pubescentis* supplemented by *Querceta robori-petraeae* relevés (as assigned by their authors) in the W Balkans in PDF and CSV formats.

Supplement S4. Full synoptic table of *Quercetea pubescentis* forest vegetation types in the W Balkans in PDF and CSV formats.

Supplement S5. Photo plates of TDF types described in this paper.

2.3 FORMALIZIRANA KLASIFIKACIJA IN NOMENKLATURNA REVIZIJA TERMOFILNIH LISTOPADNIH GOZDOV (*QUERCETALIA PUBESCENTIS*) V BOSNI IN HERCEGOVINI

Stupar V., Milanović Đ., Brujić J., Čarni A. 2015. Formalized classification and nomenclatural revision of thermophilous deciduous forests (*Quercetalia pubescentis*) of Bosnia and Herzegovina. Tuexenia, 35, 85–130

Izvleček

Termofilni listopadni gozdovi reda *Quercetalia pubescentis* so široko razširjeni v Bosni in Hercegovini (BiH), kjer pokrivajo približno 11 % celotnega ozemlja in predstavljajo približno 20 % celotne gozdne površine. Prispevek se ukvarja z formalizirano klasifikacijo in nomenklaturno revizijo termofilnih listopadnih gozdov v BiH in temelji na 274 popisov iz literature in 399 popisov, ki smo jih zbrali v času raziskave na terenu. Nadzorovano klasifikacijo smo izvedli s Cocktail metodo, na podlagi katere je bilo za ozemljen BiH ugotovljenih 17 asociacij. Poleg tega pa je bila ugotovljena še ena nova asociacija na podlagi delno-nadzorovane klasifikacije popisov, ki niso bili razvrščeni po Cocktail metodi. Ugotovljene so bile naslednje asociacije, ki so značene s floristično sestavo, ekološkimi razmerami in razširjenostjo: 1. *Querco pubescenti-Carpinetum orientalis*; 2. *Rusco aculeati-Carpinetum orientalis*; 3. *Carici hallerianae-Quercetum pubescentis*; 4. *Cruciato glabrae-Carpinetum orientalis*; 5. *Seslerio autumnalis-Quercetum pubescentis*; 6. *Aristolochio luteae-Quercetum pubescentis*; 7. *Asparago tenuifolii-Quercetum pubescentis*; 8. *Seslerio autumnalis-Ostryetum carpinifoliae*; 9. *Rusco aculeati-Ostryetum carpinifoliae*; 10. *Querco pubescenti-Ostryetum carpinifoliae*; 11. *Quercetum frainetto-cerridis*; 12. *Fraxino orni-Quercetum cerridis*; 13. *Lathyro nigri-Quercetum petraeae*; 14. *Aceri obtusati-Quercetum petraeae*; 15. *Cytiso hirsuti-Quercetum petraeae*; 16. *Festuco drymejae-Quercetum petraeae*; 17. *Potentillo micranthae-Quercetum petraeae*; 18. *Seslerio autumnalis-Quercetum petraeae*. Veljavnost in legitimnost poimenovanja asociacij smo preverili, pri čemer smo opravili validacijo in popravili imena, kjer je bilo to potrebno. Pri tem smo se natančno držali pravil Mednarodnega kodeksa fitocenološke nomenklature. Celoten seznam sinonimov smo pripravili za vsako asociacijo, z navedbo členov Mednarodnega kodeksa, po katerem je ime zavrnjeno. Asociacije so bile razdeljene v štiri skupine, glede na dominantno vrsto v drevesni plasti. Tako smo ugotovili razlike in podobnosti v floristični zgradbi med asociacijami istega tipa, se pravi, v asociacijah z istimi dominantnimi drevesnimi vrstami. Pripravili smo tudi ekogram, ki prikazuje relativno ekološko nišo posameznih združb v odvisnosti od pH tal in vlažnosti. Največje število asociacij (13) se pojavlja v sredozemski regiji, v dinarski in predpanonski po deset asociacij, medtem ko najdemo v prehodni ilirsko-mezijski regiji je le pet asociacij. Pri naši analizi nismo mogli potrditi sedem asociacij, ki jih navajajo med termofilnimi listopadnimi gozdovi v BiH. Poleg tega dodajamo seznam asociacij brez zadostnega opisa (*nomina nuda*), ki jih nismo mogli opredeliti in uvrstiti kot sinonime veljavno opisanih asociacij.

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Formalized classification and nomenclatural revision of thermophilous deciduous forests (*Quercetalia pubescentis*) of Bosnia and Herzegovina

Formalisierte Klassifikation und nomenklatorische Revision thermophiler Laubwälder (*Quercetalia pubescentis*) in Bosnien und Herzegowina

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Abstract

Thermophilous deciduous forests of *Quercetalia pubescentis* are widespread in Bosnia and Herzegovina (B&H), where they occupy about 11% of the national territory and account for about 20% of the total forest area. This paper provides their formalized classification and nomenclatural revision, based on 274 relevés from the literature and 399 relevés collected during intensive field research. The Cocktail method was used for supervised classification, which resulted in 17 associations recognized for B&H. Additionally, one new association emerged after semi-supervised classification of relevés not classified by Cocktail. The following associations were recognized, and characterized by species composition, ecology and distribution: 1. *Querco pubescenti-Carpinetum orientalis*; 2. *Rusco aculeati-Carpinetum orientalis*; 3. *Carici hallerianae-Quercetum pubescentis*; 4. *Cruciato glabrae-Carpinetum orientalis*; 5. *Seslerio autumnalis-Quercetum pubescentis*; 6. *Aristolochio luteae-Quercetum pubescentis*; 7. *Asparago tenuifolii-Quercetum pubescentis*; 8. *Seslerio autumnalis-Ostryetum carpinifoliae*; 9. *Rusco aculeati-Ostryetum carpinifoliae*; 10. *Querco pubescenti-Ostryetum carpinifoliae*; 11. *Quercetum frainetto-cerridis*; 12. *Fraxino orni-Quercetum cerridis*; 13. *Lathyro nigri-Quercetum petraeae*; 14. *Aceri obtusati-Quercetum petraeae*; 15. *Cytiso hirsuti-Quercetum petraeae*; 16. *Festuco drymejae-Quercetum petraeae*; 17. *Potentillo micranthae-Quercetum petraeae*; 18. *Seslerio autumnalis-Quercetum petraeae*. The validity and legitimacy of associations were checked and they were validated and corrected as needed, strictly following the rules of the International Code of Phytosociological Nomenclature. A complete list of synonyms has been given for every association, with an indication of the article of the Code according to which the name must be rejected. The associations were assembled into four groups, following the criterion of dominant species in a tree layer, in order to present differences and similarities in floristic composition between associations of the same type, i.e., dominated by the same tree species. An ecogram was drawn displaying the relative ecological range of each association along soil pH and moisture gradients. The largest number of associations (13) occurs in the Mediterranean region; the Dinaric and Pre-Pannonian regions each harbour ten associations, while there are only five associations in the Transitional Illyrian-Moesian region. Seven syntaxa previously reported for thermophilous deciduous forests of B&H were not recognized during the analysis. A list is given of all *nomina nuda* that could not be resolved and ascribed to synonymy with accepted associations.

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Erweiterte deutsche Zusammenfassung am Ende des Artikels

1. Introduction

Thermophilous deciduous forests of the order *Quercetalia pubescentis* (*Querco-Fagetea*) occupy about one fifth of the forest area of Bosnia and Herzegovina (B&H) (STEFANOVIĆ et al. 1983). In southern B&H, they are represented by zonal communities dominated by *Quercus pubescens* and *Carpinus orientalis* (STEFANOVIĆ et al. 1977b). Similar communities are developed extrazonally in other parts of the country, mainly along river canyons (FUKAREK 1975, STEFANOVIĆ 1979a, 1989). *Ostrya carpinifolia* takes a dominant role at higher altitudes in southern B&H, in moister and cooler limestone canyons in central B&H and on steep southern exposure limestone and dolomite outcrops of central and northern B&H (FABIJANIĆ et al. 1967, STEFANOVIĆ 1979a, LAKUŠIĆ et al. 1982b). Azonal *Quercus cerris* forests are the main type of forest vegetation in dry karst fields of western and southern parts of the country (STEFANOVIĆ 1968), while *Quercus frainetto* is the main species in zonal forest vegetation in eastern B&H in the zone of biogeographical and climatic transition towards the dryer Central Balkans (FUKAREK et al. 1974, HORVAT et al. 1974, STEFANOVIĆ 1988). Acido-thermophilous *Quercus petraea* forests are a particular type of thermophilous deciduous forests in B&H, which are found on warmer habitats over acidic bedrock throughout eastern, central and northern B&H.

Although phytosociological studies of the vegetation have a relatively long tradition in B&H (HORVAT 1933, 1941, HORVAT & PAWLOWSKI 1939, TREGUBOV 1941), there are clearly many problems related to the classification and nomenclature of thermophilous deciduous forests (LAKUŠIĆ et al. 1982b, REDŽIĆ 2007, 2011). These problems can mainly be related to the large diversity of this vegetation type and poor coverage by phytosociological relevés (only 274 have been published for the whole country). Research in the past was mainly restricted to canyon systems and *Carpinus orientalis* scrub (LAKUŠIĆ et al. 1987, LAKUŠIĆ & REDŽIĆ 1989, 1991, STEFANOVIĆ 1989, MURATSPAHIĆ et al. 1991) (Fig. 1). Studies of other types were conducted at a limited number of localities, resulting with only a modest number of relevés (FABIJANIĆ et al. 1963, STEFANOVIĆ 1964b, 1968, FUKAREK et al. 1974, BUCALO 1999, REDŽIĆ & BARUDANOVIĆ 2010, BRUJIĆ 2013), while some types were not recorded at all. Additionally, the nomenclature is far from being settled. Original literature is overcrowded with pseudonyms, invalidly published names, new names for already validly published syntaxa and a plethora of *nomina nuda*. Some syntaxa from neigbouring regions have been uncritically included in B&H syntaxonomical overviews. This can be illustrated by the fact that in the first overview of this type of vegetation in B&H, the number of different associations was 14 (LAKUŠIĆ et al. 1978), while in the last, in which the author listed all names that occurred in published or unpublished sources, the number of associations was 44 (REDŽIĆ 2011). Finally, there is a problem with the syntaxonomical position of acido-thermophilous *Quercus petraea* forests. These forests are easily distinguished from acido-mesophilous *Quercion roboris* by the number of thermophilous and xerophilous species and the absence of strong acidophytes. While such forests in Serbia were classified into *Quercetalia pubescentis* (JOVANOVIĆ et al. 1986, TOMIĆ et al. 2006, TOMIĆ & RAKONJAC 2013), in B&H and Croatia they have mainly been treated as part of *Quercion roboris* (STEFANOVIĆ et al. 1977a, STEFANOVIĆ 1984, VUKELIĆ 2012). However, bearing in mind their ecological and floristical features and knowing that such misclassifications have also been reported for Central Europe (CHYTRÝ 1997, KASPROWICZ 2010, INDREICA 2012), we included them in thermophilous deciduous forests.

There are several national classifications of thermophilous deciduous forests in neighbouring regions made using the traditional expert method (SARIĆ 1997, ŠKORIĆ 2006, BERGMEIER & DIMOPOULOS 2008, KEVEY 2008, VUKELIĆ 2012). A formalized classification method (i.e., the Cocktail method) was used for classification of thermophilous deciduous forests in the Czech Republic (ROLEČEK 2007, CHYTRÝ 2013), and is used increasingly for classification of other vegetation types on the national level (KOČÍ et al. 2003, ŠILC & ČARNI 2007, CHYTRÝ 2013, RODRÍGUEZ-ROJO et al. 2014). This method appears to be the most suitable for producing a stable and formally defined classification system for the vegetation of large areas (CHYTRÝ 2007). Although it has been tested and applied mainly on large national data sets that, beside relevés of analyzed vegetation types, consist of relevés of all other vegetation types of the research area (typically a national territory), some works have been published that demonstrate its usability on data sets consisting of only one vegetation type, e.g., mesic grasslands (RODRÍGUEZ-ROJO et al. 2014).

The aim of this work was to fill the gap in available data about thermophilous deciduous forests in the B&H by intensive field research, to formally classify thermophilous deciduous forests in B&H, to check the validity and legitimacy of the existing nomenclature and to correct and typify syntaxa according to the ICPN (International Code of Phytosociological Nomenclature).

2. Study area

Bosnia and Herzegovina is located in south-eastern Europe, in the western Balkan Peninsula. Biogeographically, it is divided into four regions (STEFANOVIĆ et al. 1983) (Fig. 1): Pre-Pannonian (continental, northern B&H), Dinaric (mountainous, central B&H), Mediterranean (southern and south-western B&H), and Transitional Illyrian-Moesian (eastern B&H). Northern B&H embraces the southern outcrops of the Pannonian Plain and the northern foothills of the Dinaric Alps and is an area of predominantly low mountains, hills and the alluvial plains of the Sava River and lower reaches of the rivers Una, Vrbas, Bosna and Drina. Dominant forest vegetation is represented by meso-neutrophilous forests of beech (*Fagus sylvatica*), common hornbeam (*Carpinus betulus*) and sessile oak (*Quercus petraea*). The major part of the central (Dinaric) region is mountainous, with the high Dinaric Alps spreading in a NW-SE direction. Forest vegetation is for the most part represented by mesic forests of beech, fir (*Abies alba*) and spruce (*Picea abies*). Deep limestone river canyons and valleys, which generally have a north-south direction, are a prominent feature of this mountainous region. The southern, Mediterranean part of the country is highly influenced by the Mediterranean climate and mainly belongs to the sub-Mediterranean zone, while the Eu-Mediterranean zone occupies only a narrow belt around the short Adriatic coastline. This part of the country consists of limestone mountains and hills intersected by numerous karstic fields (Livanjsko polje, Duvanjsko polje, Posuško polje, Mostarsko blato, Popovo polje, Nevesinjsko polje, Gatačko polje, Dabarsko polje etc.) with the large alluvial plain of the Mediterranean River Neretva in the south. Zonal vegetation of this region is represented by downy oak/oriental hornbeam (*Quercus pubescens*, *Carpinus orientalis*) forests. The eastern, Transitional Illyrian-Moesian biogeographical region comprises a relatively narrow belt along the River Drina at the border with Serbia. It is a biogeographical and climatic transi-

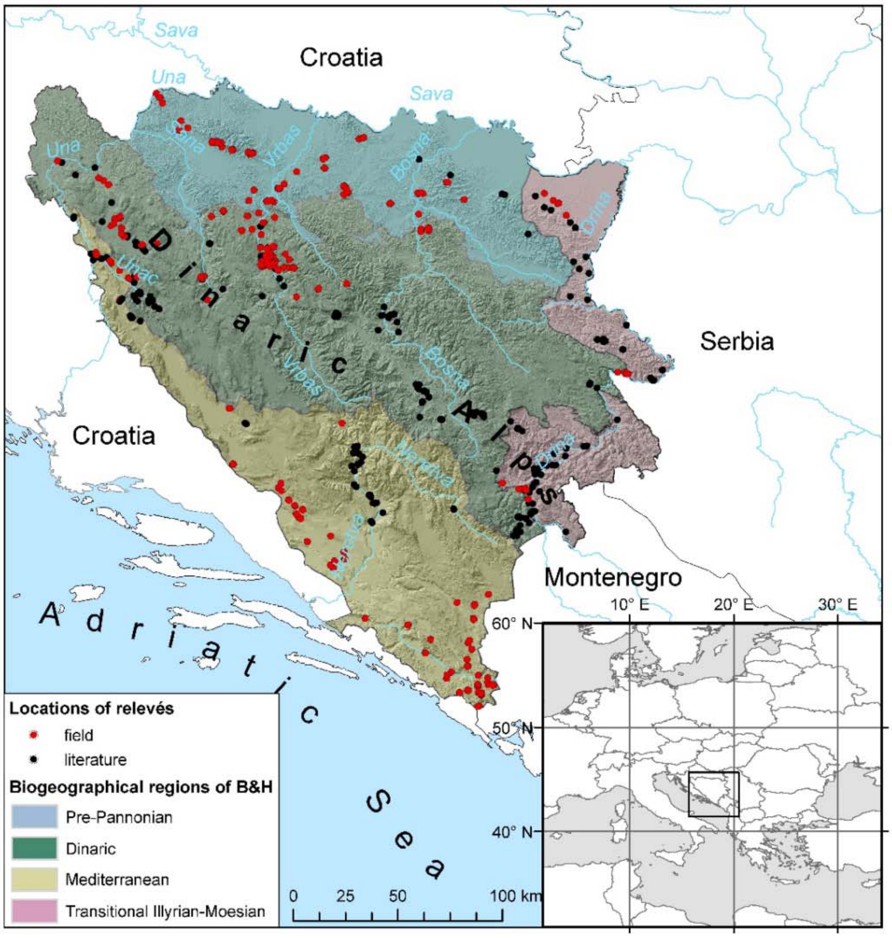

Fig. 1. Location of the study area. The biogeographical division of B&H is indicated. Dots represent localities of 673 relevés used in this study (black - literature, red - field research).

Abb. 1. Lage des Untersuchungsgebiets mit der biogeographischen Gliederung von B&H. Punkte geben die Orte der 673 Vegetationsaufnahmen dieser Studie an (schwarz – Literatur, rot: eigene Feldarbeit).

tion between the western more humid Illyrian zone and the eastern, dryer Central Balkans. The zonal community is Central Balkans hungarian oak/turkey oak (*Quercus frainetto*, *Q. cerris*) forest. Carbonate bedrock (limestone and dolomite) predominates in the southern and western parts of the country, while the northern and eastern parts are composed of carbonate, siliceous and ultramafic rocks (VELIĆ & VELIĆ 1983). The climate is also very diverse, since two major climatic zones overlap here: central European from the north and Mediterranean from the south. The transitional zone is highly modified by the influence of mountain massifs (DELIJANIĆ et al. 1964). River valleys and canyons, with their south-north direction, play a significant role in this climate modification, since, through them, the Mediterranean climate penetrates deep into the central and northern parts of the country. This part of Europe has been under intensive anthropogenic influence since the Early Neolithic, especially the Submediterranean and Pannonian regions. Large portions of this land were altered, mainly deforested, quite early because of the spread of agriculture (HORVAT et al. 1974). Bearing in mind this great diversity of abiotic features in B&H, it is not surprising that it harbors great diversity of vascular plants, with a large number of endemics (LUBARDA et al. 2014) and, consequently, great diversity of vegetation types (LAKUŠIĆ et al. 1978, JOVANOVIĆ et al. 1986, REDŽIĆ 2007). Forests cover around 54% of the country's area and thermophilous deciduous forests occupy ca. 5800 km^2, which is around 11% of the country's territory (STEFANOVIĆ et al. 1983).

3. Methods

3.1 Collection and sampling of data

All relevés used in this study are stored in, and available from, the Oak Forests Vegetation Database of Bosnia and Herzegovina, with the ID EU-BA-001 in the Global Index of Vegetation-Plot Databases (DENGLER et al. 2011). This database consists of all 1,195 published and available unpublished relevés of oak-dominated forests in B&H. All relevés assigned by their authors to *Quercetalia pubescentis*, as well as those of acido-thermophilous *Quercus petraea* forests, were selected for the analysis. Four relevés of pure *Castanea sativa* woods from the sub-Mediterranean region of B&H, designated *Castanetum sativae hercegovinum* (WRABER 1958), were omitted. Although this association has been classified by some authors within *Quercetalia pubescentis* (LAKUŠIĆ et al. 1978, REDŽIĆ 2011), after inspection of those relevés, it was determined that they are floristically very close to continental acidophilous *Castanea sativa* forests. In addition to the relevés collected from the literature, 399 relevés were collected in the field by the authors, in different types of thermophilous deciduous forests, mainly in areas that had previously been overall very poorly sampled. All relevés were made using the standard Central European phytosociological method (BRAUN-BLANQUET 1964) with Braun-Blanquet scale cover-abundance estimates of each species. The size of most relevé plots was 225–400 m^2. The minimum distance between relevé plots was 100 m. The minimum canopy cover was 50%, although for the majority it was 70% and higher. Only relevés of stands with more than 5 m in height were considered. Relevés from the literature were taken into consideration only when they could be georeferenced relatively precisely, and when they contained complete species records. A total of 673 relevés was collected and entered into the Turboveg database (HENNEKENS & SCHAMINÉE 2001). The relevés covered most of the territory of B&H in wich thermophilous deciduous forests occur (see Fig. 1 for their geographical distribution). Some larger gaps occur in areas that are mine contaminated (mainly the central parts of the Dinaric and Mediterranean regions). Relevés from the literature, due to the mainly local character of older vegetation studies, were clustered over a few localities: river canyons (mid-stream Neretva River (MURATSPAHIĆ et al. 1991), upper-stream Drina River (STEFANOVIĆ 1964a, STEFANOVIĆ & MANUŠEVA 1966) mid-stream Bosna River (around Zenica) (FUKAREK et al. 1974, FUKAREK 1975), mid-stream Vrbas River) (STEFANOVIĆ 1989), Osječenica and Jadovnik Mts area in western B&H (STEFANOVIĆ 1968, BUCALO 1999), Lepenica area (FABIJANIĆ et al. 1963) and Trebević Mt in central B&H (STEFANOVIĆ 1964b) and NP "Sutjeska" in eastern B&H (FUKAREK 1970b). These nine localities account for over 90% of relevés from the literature. With field research conducted over the last several years, we tried to fill the gaps in the available data, sampling mostly in the northern and southern regions of B&H since they were totally uncovered by relevés. In northern B&H this included the areas of the mountains Crni Vrh, Kozara, Ljubić, Majevica, Motajica, Ozren, Pastirevo, Planinica and Trebava. Most relevés from southern B&H were made in the area of Popovo Polje, Orjen Mt and the large limestone plateau between Trebinje and Gacko. On the west side of the Neretva River we recorded over a large area between Ljubuški, Grude and Posušje. A considarable number of relevés was made on western B&H carbonate mountains (Čemernica, Grmeč, Manjača, Osmača, Starčevica, Šiša) that are under certain influence of the Mediterranean climate. Central parts of B&H were not sampled due to the already mentioned mine contamination, but also because apart from river canyons, this is a region of predominantly mesic forests of beech, fir and spruce. In the overall very well covered, but also mine contaminated, region of eastern B&H we made only a few relevés in order to test some established concepts and revise some doubtful taxonomic identifications. We also tried to collect at least 10 relevés from every type, over as large area as possible.

Since many authors did not record mosses, we excluded them from the data set before numerical analysis. Taxa recorded for more than one layer were merged into a single layer to take account of inconsistent sampling. Records of species determined to the genus level were deleted. Plant nomenclature followed Flora Europaea (TUTIN et al. 1968–1993). Species not included in this reference but mentioned in this paper have been listed in the Supplement E1. Species from taxonomically critical groups that were not always recognized by the relevé authors were combined into aggregates (agg.) and species that included several subspecies that were not always recorded or recognized by authors were combined under the abbreviation 's.l.' (*sensu lato*) and also listed in the Supplement E1. *Aristolochia pallida* has been considered to be *A. lutea* (NARDI 1984) and *Teucrium polium* to be *T. polium* subsp. *capitatum* (HADŽIABLAHOVIĆ 2010). The dubious taxon *Quercus dalechampii* was treated as part of *Quercus petraea* agg. following DI PIETRO et al. (2012). Woody species recorded for more than one layer were merged into one layer. Taxa occurring in three or fewer relevés were omitted from the analysis in order to reduce noise (TSIRIPIDIS et al. 2007).

3.2 Classification

Formalized classification of thermophilous deciduous forests in B&H was performed using the Cocktail method (BRUELHEIDE 2000). This supervised classification method using sociological species groups for the construction of formal definitions was applied in JUICE software (TICHÝ 2002) to the original set of all 673 relevés, because we were unable to perform stratified resampling of the original data.

We tried to perform geographical stratification but, since the majority of relevés from the literature were clustered over nine localities, the stratification resulted in a fairly small number of relevés resampled. In addition, since the majority of relevés were not assigned to a specific association, geographical stratification often completely discarded some types, especially those with a smaller number of relevés. Finally, we decided that stratification based on unsupervised classification methods applied prior to the supervised classification would not be appropriate. The methods we used to create sociological groups and formal definitions followed KOČÍ et al. (2003). Sociological groups are groups of species that tend to occur together in relevés of a large database. If a database covers a broad spectrum of different habitats and a large geographical area, the species groups obtained are of more general validity. In our case, since the database only covers one vegetation type, i.e., thermophilous deciduous forests, the validity of species groups is restricted to thermophilous deciduous forests of B&H. We started the extraction of each group by preselecting one species. After selecting a starting species, we calculated the phi coefficient (CHYTRÝ et al. 2002) of the association between each species in the data set and the group of relevés that contained the starting species. Of the species not belonging to the species group, we usually chose one with the highest phi value and included it in the group as its next member. In some cases, a species with second or third highest phi value was included as the next member, particularly if the species with the highest phi value was already included in another species group or had several times more or fewer occurrences in the data set than the species already included in the species group. After including the new species in the species group, the group of relevés was redefined, and the phi coefficient for all species in the data set and the new group of relevés was recalculated. If the species group disintegrated after this step, i.e. some of the species not included in the species group had a higher phi value than some of the species included, the group was rejected. If the species belonging to the group had the highest phi values, the group was either accepted or further optimized by including additional species. The optimization process was stopped if any of the candidate species for addition in the next step either caused group disintegration or substantially changed the ecological coherence of the group, or if the number of species in the group reached its maximum (we set it at four). Following ROLEČEK (2007), this rather low number of species was used to receive groups that are ecologically homogenous. We thus made 22 species groups, which, together with expert knowledge and the traditional circumscriptions of target associations, were used for the creation of the formal definitions. Formal definitions are a set of rules that a particular relevé should fulfil to enter the scope of a particular association defined by that formal definition. They are basically combinations of occurrences of sociological species groups and single species dominance values connected by the logical operators AND, OR and NOT. If the relevé contained at least half of the species from the group, the group was considered to be contained in a relevé. After several trials and errors, we finally managed to produce 17 formal definitions of traditionally accepted target associations using only 18 out of the initial 22 sociological species groups (Table 1). After formulating all the definitions, we attempted classification of all 673 relevés from the original dataset. Relevés that remained unclassified after Cocktail classification, or were assigned to two associations due to marginal overlapping of some Cocktail definitions, were subjected to semi-supervised classification (TICHÝ et al. 2014). We used a K-means algorithm with 17 *a priori* defined groups (all groups produced by the Cocktail method) and 18 output groups in case there was another possible unrecognized association within the group of unclassified relevés. All the relevés that were classified by the semi-supervised classification were taken into account for the random selection of the initial centroids of each *a priori* defined vegetation type (five relevés to define the starting centroids and 20 algorithm starts for each type). The Cocktail definition for the new association that emerged after semi-supervised classification was made *a posteriori*.

Our decision to accept 18 associations is mainly based on our expert judgement and could undoubtedly be argued. The concept of an association in the Central European phytosociological school has changed over time, from relatively large and broadly defined associations to more narrow units that were able to provide a more suitable description of the many variations in habitat and geographic locations (MUELLER-DOMBOIS & ELLENBERG 1974). One possible way of classifying our relevés could have been lumping into eight to ten broader groups, which would be interpretable using large-scale ecological (macroclimatic) parameters. However, in that way we would lose a lot of information that differentiates communities on a more local scale (topographical and geological patterns, management type etc.), which are very useful on a national scale, e.g., in forest management or nature conservation. On the other hand, we could have continued splitting some of the vegetation units, using their local peculiarities (often of a methodological origin) but, at this level of knowledge and available data, it would probably have led us to associations (or sub-associations) that are poorly defined and hard to interpret, making them useless in a broader scope. Following BERGMEIER & DIMOPOULOS (2001), we made what we believe to be a well-founded compromise that provides manageable units for national and supra-national surveys. Additionally, we tried not to create more confusion in an already tangled situation in the syntaxonomy of thermophilous deciduous forests in the region, so we made definitions of associations to be as close to the traditionally accepted vegetation concepts as possible (in B&H and neighbouring countries) (HORVAT 1938, LAKUŠIĆ et al. 1978, 1982b, LAKUŠIĆ & REDŽIĆ 1991, MURATSPAHIĆ et al. 1991, SARIĆ 1997, ŠKORIĆ 2006, TRINAJSTIĆ 2008, REDŽIĆ 2011, VUKELIĆ 2012, TOMIĆ & RAKONJAC 2013), and we disregarded only associations that could not be defined by means of their own diagnostic species or where no sociological species group or dominant species could be found to create a formal definition.

For assessment of the quality of the definition of individual associations, we used diagnostic species determined by calculating the species' fidelity measure (CHYTRÝ et al. 2002), for which we used the phi coefficient in the JUICE 7 program (TICHÝ 2002). For this purpose we classified associations into four groups. For each group, relevés that belong to the same association were compared with the remaining relevés in the group, which were taken as a single undivided group. Each association was virtually adjusted to 1/(number of associations in the group) of the size of the entire group, while holding the percentage occurrences of a species within and outside a target association the same as in the original data set (TICHÝ & CHYTRÝ 2006). We also calculated Fischer's exact test and gave a zero fidelity value to a species with $p > 0.001$. The threshold phi value for the species to be considered as diagnostic was set at 0.25.

Table 1. Sociological groups of species used for the Cocktail definitions of B&H thermophilous deciduous forests.

Tabelle 1. Für die Cocktail-Definitionen verwendete soziologische Artengruppen der thermophilen Laubwälder in B&H.

Group	Species
Group Aremonia agrimonoides	*Aremonia agrimonioides*, *Primula vulgaris*, *Sanicula europaea*
Group Asparagus acutifolius	*Asparagus acutifolius*, *Juniperus oxycedrus*, *Paliurus spina-christi*, *Ruscus aculeatus*
Group Carex pilosa	*Acer tataricum*, *Carex pilosa*, *Epimedium alpinum*, *Tilia tomentosa*
Group Chamaecytisus austriacus	*Chamaecytisus austriacus*, *Chamaespartium sagittale*, *Hieracium praealtum* subsp. *bauhinii*, *Poa nemoralis*
Group Clematis flammula	*Clematis flammula*, *Phillyrea latifolia*, *Pistacia terebinthus*, *Rubus ulmifolius*
Group Cnidium silaifolium	*Bunium alpinum* subsp. *montanum*, *Carex humilis*, *Cnidium silaifolium*, *Thymus longicaulis*
Group Cornus mas	*Buglossoides purpurocaerulea*, *Cornus mas*, *Euonymus verrucosus*, *Viburnum lantana*
Group Festuca drymeja	*Festuca drymeja*, *Galium schultesii*, *Lathyrus vernus*, *Symphytum tuberosum*
Group Galium pseudaristatum	*Physospermum cornubiense*, *Galium pseudaristatum*, *Agrimonia eupatoria*
Group Geranium robertianum	*Arabis turrita*, *Asarum europaeum*, *Asplenium trichomanes*, *Geranium robertianum*
Group Geranium sanguineum	*Betonica officinalis*, *Filipendula vulgaris*, *Geranium sanguineum*, *Trifolium alpestre*
Group Hieracium racemosum	*Cephalanthera longifolia*, *Chamaecytisus hirsutus* agg., *Hieracium racemosum*, *Silene nutans*
Group Luzula luzuloides	*Genista tinctoria*, *Hieracium murorum*, *Luzula luzuloides*, *Pteridium aquilinum*
Group Lychnis coronaria	*Aira elegantissima*, *Genista pilosa*, *Lychnis coronaria*, *Vulpia myuros*
Group Melittis melissophyllum	*Lathyrus niger*, *Melittis melissophyllum*, *Sorbus torminalis*, *Tanacetum corymbosum*
Group Prunus spinosa	*Acer campestre*, *Crataegus monogyna*, *Ligustrum vulgare*, *Prunus spinosa*
Group Teucrium chamaedrys	*Bromus erectus* agg., *Dorycnium pentaphyllum* subsp. *germanicum*, *Teucrium chamaedrys*
Group Veronica officinalis	*Avenella flexuosa*, *Hieracium pilosella*, *Hieracium sabaudum*, *Veronica officinalis*

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3.3 Nomenclature of syntaxa

Syntaxonomical nomenclature, as well as descriptions of new syntaxa, strictly followed the rules of ICPN (WEBER et al. 2000). The correct name was determined for every association in their orthographically correct form according to ICPN Art. 41. The accepted names of associations that contained only the genus name(s) in the original diagnosis were supplemented with species epithets in accordance with Recommendation 10c of the Code. All synonyms older than the respective accepted name include a reference to the article and paragraph of the Code according to which the name must be rejected. This was not done in case of synonyms that were younger than the accepted names because such names were not candidates for the correct name due to the priority principle. Lists of synonyms also included frequently used pseudonyms, i.e., names of syntaxa used with the original author citation, but misinterpreted by later authors. Pseudonyms were cited with the name of the misinterpreting author, preceded by the word *sensu*, and followed by the name of the author of the original description after the word *non*. For every accepted correct name, the original name as given in the original diagnosis was provided. The dates of effective publication of syntaxa were taken from the papers in which they were validly published, regardless of possible different indications reported by the authors in the papers. Doctoral or master theses that were not available in libraries were not considered to be effective publications. Lectotypes and neotypes were chosen for syntaxa not yet typified. For invalidly published syntaxa according to Article 5, holotypes were indicated. When the name of a syntaxon was published by an author without a sufficient original diagnosis, that syntaxon was considered to be *nomen nudum*. A modified form of the name, i.e., *nomen mutatum*, was used as a replacement for a syntaxon name that was originally formed from the names of taxa not used in recent taxonomic and floristic literature, with syntaxon names that include the names of taxa that are in accordance with contemporary taxonomic literature. Diagnoses of new associations were accompanied by a description of the association and a phytosociological table with holotype indicated. Assignment of the species to syntaxonomic groups in phytosociological tables was done according to POLDINI (1989) and VUKELIĆ (2012).

Abbreviations: Art. = article of ICPN; ass. nov. = associatio nova; Bas. = basionym; nom. illeg. = nomen illegitimum; nom. ined. = nomen ineditum; nom. inval. = nomen invalidum; nom. nud. = nomen nudum; nom. superf. = nomen superfluum; nom. mut. = nomen mutatum; Orig. = original form of the valid syntaxon name; rel. = relevé; Syn. = synonym; Tab. = phytocoenological table in the publication.

4. Results

Thermophilous deciduous forests of B&H were formally classified by Cocktail definitions into 17 target associations, to which 483 relevés of the original data set were classified. Semi-supervised classification classified the remaining 190 unclassified relevés into 17 target associations, and additionally yielded one more ecologically and floristically well defined group, which was recognized as a new association, and described as *Aceri obtusati-Quercetum petraeae*. Because the primary aim of this paper was formally to classify thermophilous deciduous forests in B&H at the association level, we did not consider their assignment to alliances, which would require a broader regional survey that exceeds the scope of this study. The associations were rather grouped following the criterion of dominant species in a tree layer, in order to present differences in floristic composition between associations of the same type, i.e., dominated by the same tree species. All associations were separated into four groups: (*i*) group of associations dominated by *Quercus pubescens* and/or *Carpinus orientalis*, (*ii*) group of associations dominated by *Ostrya carpinifolia*, (*iii*) group of associations dominated by *Quercus frainetto* and/or *Quercus cerris* and (*iv*) group of associations dominated by *Quercus petraea* agg. Apart from the brief description of each association given below, synoptic tables (Tables 2–5) show floristic differences and similarities between associations within different groups. The distribution of the relevés of the different associations is given in a map (Fig. 2). Altitudinal zonation and distribution of associations across the biogeographical regions in B&H is given in Figure 3. The largest number of associations (13) occurs in the Mediterranean region; the Dinaric and Pre-Pannonian regions harbour ten associations each, while there are only five associations in the Transitional Illyrian-Moesian region. The biggest altitudinal range, with the highest altitudes of relevés, occurs in the Mediterranean region (130–1030 m), followed by the Dinaric (310-1000 m), Transitional Illyrian-Moesian (190–880 m) and Pre-Pannonian (250–780 m). An ecogram displaying the relative ecological range of each association along soil pH and moisture gradients is shown in Figure 4.

4.1 Group of associations dominated by *Quercus pubescens* and/or *Carpinus orientalis* (Table 2)

4.1.1 *Querco pubescenti-Carpinetum orientalis* Horvatić 1939 (Table 2, column 1)

Orig. (HORVATIĆ 1939): Asocijacija *Quercus lanuginosa-Carpinus orientalis*

Syn.: *Carpinetum orientalis croaticum* Horvatić 1939 nom. illeg. [Art. 34a], *Carpinetum orientalis adriaticum* Horvat et al. 1974 nom. illeg. [Art. 34a]

Neotypus hoc loco: tree layer: *Quercus pubescens* 4; upper shrub layer: *Carpinus orientalis* 5, *Fraxinus ornus* 1, *Cornus mas* 1, *Pistacia terebinthus* +; lower shrub layer: *Ruscus aculeatus* 2, *Asparagus acutifolius* 1, *Carpinus orientalis* 1, *Hedera helix* 1, *Cornus mas* 1, *Fraxinus ornus* 1, *Quercus pubescens* 1, *Sorbus torminalis* 1, *Frangula rupestris* +, *Clematis flammula* r, *Crataegus monogyna* r, *Juniperus oxycedrus* r, *Celtis australis* r, *Paliurus spina-christi* r; herb layer: *Brachypodium sylvaticum* +, *Carex halleriana* +, *Dictamnus albus* +, *Viola hirta* +, *Sesleria autumnalis* +, *Oenanthe pimpinelloides* +, *Acanthus spinosus* r, *Salvia pratensis* r.

Relevé details: B&H, southern Herzegovina, between Ljubuški and Čitluk, date 2014/07/23, author Vladimir Stupar, relevé area 400 m^2, altitude 180 m, slope 0°, limestone, deeper calcocambisol, 5% bare rock, cover tree layer 70%, cover upper shrub layer 90%, cover lower shrub layer 30%, cover herb layer 5%, lat. 43.199475, lon. 17.603471, GIVD EU-BA-001 (Global Index of Vegetation-Plot Databases) relevé number 323.

Note: This association was published with a synoptic table (HORVATIĆ 1939). Since there were no representative relevés of this association in published sources to which to refer, we selected a representative unpublished relevé.

Cocktail definition: *Quercus pubescens* >25% AND (Group Asparagus acutifolius OR Group Clematis flammula)

This is a zonal association of the submediterranean region of B&H, Montenegro and Croatia (Fig. 2a). In B&H it occurs in southernmost parts of the Mediterranean region (Bileća, Čitluk, Hamzići, Klobuk, Kravice, Ljubinje, Ljubuški, Međugorje, Popovo Polje, Prapratnica, Trebinje etc.). Typical stands are of closed canopy, dominated by *Quercus pubescens* in the tree layer, often with an admixture of *Carpinus orientalis*, sometimes with *Quercus cerris* and rarely *Quercus frainetto*, while in the understory, *Carpinus orientalis* and *Fraxinus ornus* dominate over *Acer monspessulanum*, *Cornus mas*, *Paliurus spina-christi*, *Frangula rupestris* and *Pistacia terebinthus*. The lower shrub layer is abundant with Mediterranean evergreen elements, such as: *Asparagus acutifolius*, *Juniperus oxycedrus*, *Phillyrea latifolia*, *Ruscus aculeatus* and deciduous *Clematis flammula* and *Rubus ulmifolius*. *Hedera helix* is very frequent in these stands, which indicates increased humidity. The herb layer is typically of low coverage (5–20%) due to the poor light conditions. The most abundant are thermophilous nemoral species: *Carex halleriana*, *Carex flacca* s.l., *Potentilla micrantha*, *Ptilostemon strictus*, *Sesleria autumnalis*, *Tamus communis* and *Viola hirta* agg., but there are also some mesophilous species with a high frequency, e.g.,: *Brachypodium sylvaticum*, *Dactylis glomerata* s.l. and *Veronica chamaedrys*. It occupies all aspects at altitudes between 100 and 600 m, on flat to moderate slopes, over limestone and dolomite with typically deeper but always rocky soils. In B&H, this type of forest has only been studied once from the aspect of forest typology (STEFANOVIĆ et al. 1977b) and no phytosociological relevés were provided. They are frequently degraded high forests, much less coppices, sometimes used as wood pasture.

4.1.2 *Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967 (Table 2, column 2)

Orig. (BLEČIĆ & LAKUŠIĆ 1967): *Rusco-Carpinetum orientalis*

non: *Rusco aculeati-Carpinetum orientalis* Quézel, Barbéro and Akman 1980 nom. illeg. [Art 31]

Typus: BLEČIĆ & LAKUŠIĆ 1967, Table on page 95, rel. 32 – lectotypus hoc loco

Cocktail definition: *Carpinus orientalis* >10% NOT (*Quercus pubescens* >10% OR *Quercus cerris* >10% OR *Quercus frainetto* >10% OR *Ostrya carpinifolia* >10%) AND (Group Asparagus acutifolius OR Group Clematis flammula)

This association consists of closed to semi-open scrub that is the secondary succession stage of *Querco-Carpinetum orientalis*. It is widely distributed in southern B&H (Fig. 2b; the Neretva River canyon, Grude, Hamzići, Kravice, Popovo Polje, Posušje etc.). It occurs on limestone or dolomite, in an altitudinal range from 100–400 m, regardless of aspect, on flat to moderate slopes. It completely lacks a tree layer and *Quercus pubescens* is found only occasionally in the shrub layer as the remnant of the original forest. The upper shrub layer is absolutely dominated by *Carpinus orientalis* accompanied by *Fraxinus ornus*. The high abundance of *Paliurus spina-christi* and *Petteria ramentacea* indicates its syngenetical connection to submediterranean *šibljak* vegetation. Another difference with *Querco-Carpinetum orientalis* is that it completely lacks mesophilous forest species. It is formed by the initial cutting of *Quercus pubescens* from the tree layer and later coppicing of *Carpinus orientalis* scrub which, because of the great sprouting capacity of this species, hampers progressive succession towards *Querco-Carpinetum orientalis*. Another path of establishment of this association is progressive succession of vegetation after fires or clear cuts. This community therefore harbours a number of species of open rocky habitats, such as: *Aethionema saxatile*, *Asperula purpurea*, *Bupleurum baldense* subsp. *gussonei*, *Melica ciliata*, *Satureja montana* s.l. It is degraded coppice, with intensive use as wood pasture.

4.1.3 *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco (Table 2, column 3)

Syn.: *Orno-Quercetum pubescentis* Lakušić et al. 1991 nom. nud. [Art. 2b]

Typus: Supplement S1, rel. 4 – holotypus hoc loco

Cocktail definition: ((*Quercus pubescens* >25% AND *Carpinus orientalis* >5%) NOT *Ostrya carpinifolia* >5%) NOT (Group Asparagus acutifolius OR Group Clematis flammula OR Group Cnidium silaifolium)

This is an extrazonal, continental type of *Quercus pubescens* and *Carpinus orientalis* forests. It develops in central B&H, in the zone in which Continental and Mediterranean climates overlap, in the southern foothills of the Dinaric Alps or in the proximity of river canyons (Fig. 2c; River Ribnik valley, River Unac valley, River Vrbas mid-stream valley, Grmeč Mt, Manjača Mt, Mesihovina, Posušje etc.). It develops at altitudes of 300–900 m, on moderate slopes (15–20°) and mainly southern and western aspects. The bedrock is limestone or dolomite and soils are of moderate depth. The tree layer is dominated by *Quercus pubescens*, sometimes accompanied by *Quercus cerris* or *Quercus petraea*. *Carpinus orientalis* dominates the shrub layer, always accompanied by *Fraxinus ornus*. Other important shrub species are mainly of thermophilous character: *Acer monspessulanum, Coronilla emerus* s.l, *Cornus mas, Crataegus monogyna, Euonymus verrucosus, Ligustrum vulgare, Lonicera etrusca, Rosa arvensis* and *Sorbus torminalis*. Average coverage of the herb layer is more than 50%, and *Sesleria autumnalis* is most abundant. Other important species of the herb layer are thermophilous: *Asperula cynanchica, Brachypodium pinnatum* s.l., *Bromus erectus* agg., *Campanula persicifolia, Carex halleriana, Festuca pseudovina* agg., *Teucrium chamaedrys, Viola hirta* agg. etc. Mesophilous species are rare and with low cover: *Brachypodium sylvaticum, Cruciata glabra, Dactylis glomerata* s.l. and *Veronica chamaedrys*. Although this association is relatively common, it had only previously been mentioned once, as "continental *Orno-Quercetum pubescentis*" (MURATSPAHIĆ et al. 1991). The reason for the neglect of this type of forest in the past may be its low economic value and relatively modest area of recent distribution (owing to the high degree of anthropogenic degradation). They are mainly degraded high forests and coppices, frequently used as wood pasture. The floristic composition of this association is shown in Supplement S1.

4.1.4 *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. ass. nov. hoc loco (Table 2, column 4)

Syn.: *Carpinetum orientalis illyricum* Fabijanić 1960 nom. ined. [Art. 1], *Carpinetum orientalis illyricum* Stefanović 1961 nom. ined. [Art. 1], *Orno-Carpinetum orientalis* Fabijanić et al. 1963 nom. inval. [Art. 3b], *Carpinetum orientalis illyricum* Stefanović 1977 nom. illeg. [Art. 34a], *Carpinetum betuli-orientalis* Lakušić, Pavlović, Abadžić, et al. 1982 nom. inval. [Art. 5], *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić 1982 nom. nud. [Art. 2b], *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić 1988 nom. inval. [Art. 5], *Fraxino orni-Carpinetum orientalis* (Fabijanić et al. 1963) Stefanović 1988 [recte 1989] nom. inval [Art. 5], *Rusco aculeati-Carpinetum orientalis continentale* Lakušić et Redžić 1991 nom. nud.

Typus: ŠUGAR & TRINAJSTIĆ 1988, Tab. 1, rel. 6 - holotypus hoc loco

Cocktail definition: *Carpinus orientalis* >25% NOT (*Quercus cerris* >10% OR *Quercus petraea* agg. >10% OR *Quercus pubescens* >10% OR *Quercus frainetto* >10% OR *Ostrya carpinifolia* >10% OR Group Asparagus acutifolius OR Group Clematis flammula)

This association is widespread in the central belt of B&H (Dinaric and Transitional Illyrian-Moesian regions) under similar conditions as *Carici hallerianae-Quercetum pubescentis* (Fig. 2d). It is largely a secondary succession stage of the former association, but can also appear on sites of *Quercetum frainetto-cerris carpinetosum orientalis, Fraxino orni-Quercetum cerridis carpinetosum orientalis, Lathyro nigri-Quercetum petraeae* or *Aceri obtusati-Quercetum petraeae*. It is also known from Croatia (Lika) (ŠUGAR & TRINAJSTIĆ 1988). The altitudinal range is from 300–900 m, on primarily south and west facing mild to steep slopes. The bedrock is mainly limestone and dolomite, with the exception of several stands from E. B&H, which are found on siliceous sandstone. Oaks are found only in the juvenile form in the understory. The herb layer consists of thermophilous species such as: *Buglossoides purpurocaerulea, Campanula persicifolia, Carex halleriana, Festuca heterophylla, Lathyrus niger, Lathyrus venetus, Melittis melissophyllum, Potentilla micrantha, Sesleria autumnalis, Tamus communis, Tanacetum corymbosum* and *Viola hirta* agg., but also mesophilous: *Aremonia agrimonoides, Brachypodium sylvaticum, Cruciata glabra, Dactylis glomerata* s.l., *Helleborus odorus, Primula vulgaris* and *Veronica chamaedrys*.

However, cover of the herb layer is fairly low; in some stands it does not exceed 5%. This is largely due to the closed canopy formed by *Carpinus orientalis*, which does not allow much light to get to the ground. Stands are in the form of degraded coppice, frequently used as wood pastures.

4.1.5 *Seslerio autumnalis-Quercetum pubescentis* Zupančič 1999 (Table 2, column 5)

Orig. (ZUPANČIĆ 1999): *Seslerio autumnalis-Quercetum pubescentis* ass. nova

Syn.: *Quercetum montanum submediterraneum* Fukarek 1970 p.p. nom. nud. [Art. 2b]

non: *Seslerio autumnalis-Quercetum pubescentis* Trinajstić 2008 nom. illeg. [Art. 31]

Cocktail definition: (*Quercus pubescens* >25% NOT (*Carpinus orientalis* >5% OR *Quercus cerris* >50%)) AND *Sesleria autumnalis* >1%) AND (Group Cnidium silaifolium OR Group Geranium sanguineum)

This submediterranean association is known from SW Slovenia (Kras) (ZUPANČIČ 1999), where it is found on flysch. While there it is found at lower altitudes (50–300 m) and is considered to be a secondary succession stage, in Herzegovina (the mountains Bijela Gora, Cincar, and Orjen; around Bileća, Gacko, Grude, Posušje, Široki Brijeg etc.) it occurs at much higher elevations (700–1000 m), where it forms an altitudinal belt between *Querco-Carpinetum orientalis* and beech forests (Fig. 2e). It can be found on moderate slopes of all aspects, where it is bound to deeper soil on limestone or dolomite. This *Quercus pubescens* forest is often accompanied by *Quercus cerris*. The main feature in the shrub layer is the absence of *Carpinus orientalis*, which appears only sporadically in the lower shrub layer, with low cover. The shrub layer is dominated by *Fraxinus ornus* and *Acer obtusatum* and much less by *Acer monspessulanum*. The herb layer is very abundant (over 75% of cover), with a dominance of *Sesleria autumnalis*, accompanied by submediterranean species: *Bunium alpinum* subsp. *montanum*, *Cnidium silaifolium*, *Thymus longicaulis* and some endemics, such as *Genista sylvestris* subsp. *dalmatica* and *Helleborus multifidus*. Other important species include those of forest fringes and more open habitats, such as: *Betonica officinalis*, *Brachypodium pinnatum* s.l., *Carex humilis*, *Filipendula vulgaris*, *Geranium sanguineum*, *Trifolium alpestre* etc. and also thermophilous nemoral species: *Clinopodium vulgare*, *Lathyrus niger*, *Tanacetum corymbosum*, *Teucrium chamaedrys*, *Viola hirta* agg. etc. Sometimes degraded high forests or coppice, very often used as wood pasture.

4.1.6 *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini 2008 (Table 2, column 6)

Orig. (POLDINI 2008): *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini, nom. nov. hoc loco

Bas.: *Seslerio autumnalis-Ostryetum carpinifoliae quercetosum pubescentis* Horvat et Horvatić in Horvat 1950 ex Horvat 1959

Syn.: *Ostryo-Quercetum pubescentis* (Horvat 1959) Trinajstić 1977 nom. illeg. [Art. 32d], *Seslerio autumnalis-Quercetum pubescentis* Trinajstić 2008 non Zupančič 1999 nom. illeg. [Art. 31], *Fraxino orni-Ostryetum carpinifoliae* Braun-Blanquet 1961 nom. illeg. [Art. 31]

Cocktail definition: *Ostrya carpinifolia* >5% AND *Quercus pubescens* >5% AND Group Cnidium silaifolium

This association was described from Croatia under the name of *Ostryo-Quercetum pubescentis* (TRINAJSTIĆ 1977), and considered to be transitional association between *Querco pubescenti-Carpinetum orientalis* and *Seslerio-Ostryetum*. We encountered only six relevés

Table 2. Synoptic table for the group of associations dominated by *Quercus pubescens* and/or *Carpinus orientalis*: QpC, *Querco pubescenti-Carpinetum orientalis*; RuC, *Rusco aculeati-Carpinetum orientalis*; CaQ, *Carici hallerianae-Quercetum pubescentis*; CrC, *Cruciato glabrae-Carpinetum orientalis*; SeQ, *Seslerio autumnalis-Quercetum pubescentis*; ArQ, *Aristolochio luteae-Quercetum pubescentis*; AsQ, *Asparago tenuifolii-Quercetum pubescentis*. Frequency values of species are shown; species diagnostic for the association (phi values > 0.25) are shaded. Only ten diagnostic species with the highest fidelity and more than 20% frequency are shown for each association. Woody species that occurred in more than one layer were merged into one line.

Tabelle 2. Übersichtstabelle für die Gruppe der von *Quercus pubescens* und/oder *Carpinus orientalis* dominierten Assoziationen. Abkürzungen der Assoziationen s. o. Angegeben sind die Stetgkeiten der Arten (in %); diagnostische Arten für die jeweilige Assoziation (phi-Werte > 0,25) sind durch einen grauen Hintergrund markiert. Nur die zehn diagnostischen Arten mit der höchsten Treue und mehr als 20 % Stetigkeit sind für jede Assoziation aufgeführt. Gehölze, die in mehr als einer Schicht vorkamen, wurden in einer Zeile zusammengefasst.

Association	QpC	RuC	CaQ	CrC	SeQ	ArQ	AsQ
Number of relevés	28	21	25	118	35	6	23
Cornus mas	82	38	56	59	31	33	48
Juniperus oxycedrus	68	14	.	2	9	.	.
Carex halleriana	64	.	36	8	23	.	.
Frangula rupestris	50	24	20	6	23	17	.
Acer monspessulanum	54	81	32	27	40	33	4
Petteria ramentacea	29	62	4	2	20	.	.
Viola reichenbachiana	4	38	4	14	3	.	.
Melica ciliata	14	33	4	7	3	.	4
Bupleurum baldense subsp. *gussonei*	.	24	.	5	.	.	.
Cyclamen repandum	7	24	.	2	.	.	.
Acer campestre	14	10	60	40	6	.	52
Festuca heterophylla	14	10	52	25	20	.	43
Euonymus verrucosus	11	5	48	42	9	17	9
Lonicera etrusca	11	10	40	1	20	33	.
Campanula persicifolia	.	.	40	13	17	.	17
Veratrum nigrum	.	.	28	8	.	17	4
Asperula cynanchica	11	.	24	2	3	.	.
Serratula tinctoria	.	.	24	3	9	.	4
Ligustrum vulgare	7	24	44	67	.	33	39
Thymus pulegioides	.	19	16	52	6	17	22
Glechoma hirsuta	.	5	24	47	.	.	17
Viburnum lantana	.	.	24	37	.	.	13
Cyclamen purpurascens	.	.	4	36	.	.	4
Trifolium alpestre	7	.	28	10	77	33	22
Quercus cerris	46	.	44	26	74	33	30
Betonica officinalis	32	24	24	17	71	33	26
Filipendula vulgaris	18	19	16	19	63	33	39
Helleborus multifidus	25	5	24	6	49	.	17
Luzula multiflora	.	.	.	.	31	17	4
Inula salicina	7	.	.	3	26	.	4
Ostrya carpinifolia	4	19	24	41	17	100	17
Acer obtusatum	4	5	52	47	54	83	17
Hieracium tommasinianum	25	10	20	.	43	83	.

Association	QpC	RuC	CaQ	CrC	SeQ	ArQ	AsQ
Number of relevés	28	21	25	118	35	6	23
Bunium alpinum subsp. *montanum*	18	.	4	.	43	67	4
Asperula scutellaris	7	.	.	.	17	67	.
Cotoneaster nebrodensis	.	.	4	1	3	50	.
Serratula cetinjensis	.	.	.	.	14	50	.
Scilla lakusicii	.	.	.	.	9	33	.
Rosa tomentosa	4	.	.	.	3	33	4
Centaurea triumfettii	.	.	.	3	11	33	.
Brachypodium sylvaticum	57	19	52	30	20	.	91
Prunus spinosa	7	19	16	29	6	.	65
Carex flacca s.l.	39	10	16	3	11	.	61
Fragaria moschata	7	.	12	2	6	.	48
Rubus canescens	4	.	4	5	3	.	43
Pteridium aquilinum	.	5	8	15	.	.	39
Carpinus betulus	.	.	20	15	.	.	35
Tilia tomentosa	.	.	8	.	.	.	30
Carex montana	.	.	.	1	6	.	22
Astragalus glycyphyllos	.	.	8	4	.	.	22
Asparagus acutifolius	79	67	.	2	3	.	.
Ruscus aculeatus	64	71	12	17	.	.	.
Paliurus spina-christi	46	81	.	2	.	.	.
Rubus ulmifolius	46	76	.	2	6	.	.
Clematis flammula	39	38	8	.	6	17	.
Phillyrea latifolia	36	29	.	.	.	.	.
Pistacia terebinthus	32	43	.	2	3	.	.
Sesleria autumnalis	75	100	72	67	97	67	.
Cruciata glabra	4	5	72	42	14	.	61
Sorbus torminalis	14	5	72	32	20	.	57
Rosa arvensis	14	.	68	42	29	17	74
Prunus avium	.	.	32	9	3	.	35
Helleborus odorus	.	5	44	56	.	.	70
Geranium sanguineum	.	5	16	16	71	83	9
Cnidium silaifolium	7	.	4	.	69	83	4
Carex humilis	32	14	20	14	66	83	9
Thymus longicaulis	7	5	8	3	46	67	4
Carpinus orientalis	79	100	100	100	29	.	.
Quercus pubescens agg.	100	62	100	55	100	100	100
Fraxinus ornus	100	86	96	95	94	100	91
Viola hirta agg.	93	57	60	50	71	50	26
Brachypodium pinnatum s.l.	54	71	48	10	83	67	70
Dactylis glomerata s.l.	50	43	52	30	40	33	43
Hedera helix	50	52	24	36	3	.	35
Bromus erectus agg.	46	14	40	31	46	33	13
Tamus communis	46	52	60	27	20	17	61
Crataegus monogyna	43	71	88	73	51	50	83
Teucrium chamaedrys	39	67	48	61	63	83	70
Festuca pseudovina agg.	36	10	28	9	51	50	9
Asperula purpurea	36	38	16	26	29	17	13

Association	QpC	RuC	CaQ	CrC	SeQ	ArQ	AsQ
Number of relevés	28	21	25	118	35	6	23
Vincetoxicum hirundinaria	36	5	8	27	26	.	43
Veronica chamaedrys	32	14	32	25	11	33	22
Thalictrum minus	29	5	16	5	43	33	4
Lathyrus venetus	29	19	36	22	29	33	35
Potentilla micrantha	25	38	40	43	26	.	26
Coronilla emerus s.l.	21	29	24	23	9	17	4
Asplenium ceterach	21	33	4	26	6	.	.
Clematis vitalba	18	52	24	32	3	.	52
Melittis melissophyllum	14	.	40	33	23	33	30
Euphorbia cyparissias	14	.	28	34	29	17	35
Cotinus coggygria	14	.	16	32	14	.	17
Dorycnium pentaphyllum subsp. *germanicum*	11	.	24	19	26	33	48
Tanacetum corymbosum	11	5	48	23	34	33	35
Galium lucidum	11	.	24	40	17	17	22
Buglossoides purpurocaerulea	11	14	36	19	26	17	43
Lathyrus niger	7	.	36	11	43	17	35
Aremonia agrimonoides	4	.	48	27	20	33	30
Iris graminea	.	.	28	8	17	17	35
Quercus petraea agg.	.	.	32	36	3	17	30
Calamintha sylvatica	.	38	12	31	.	.	30

that fit the original diagnosis and all are from southern B&H (Orjen Mt), where this forest alternates with *Seslerio-Quercetum pubescentis,* between 900 and 1000 m on rockier and shallower soils of moderate slopes and predominantly eastern aspect (Fig. 2f). *Quercus pubescens* and *Ostrya carpinifolia* dominate the tree layer, with an admixture of *Fraxinus ornus* and *Acer obtusatum*. The herb layer is composed of *Bunium alpinum* subsp. *montanum, Carex humilis, Cnidium silaifolium, Geranium sanguineum, Hieracium tommasinianum, Sesleria autumnalis, Teucrium chamaedrys* etc. Degraded coppice, often used as wood pasture.

4.1.7 *Asparago tenuifolii-Quercetum pubescentis* Lakušić et Redžić 1991 (Table 2, column 7)

Orig. (LAKUŠIĆ & REDŽIĆ 1991): *Asparago-Quercetum pubescentis* ass. nova

Cocktail definition: (*Quercus pubescens* >25% AND (Group Cornus mas OR Group Prunus spinosa)) NOT (*Carpinus orientalis* >0% OR *Sesleria autumnalis* >0% OR *Ostrya carpinifolia* >5% OR *Quercus cerris* >50%)

This forest of *Quercus pubescens* also lacks *Carpinus orientalis*, but is differentiated from the submediterranean *Seslerio autumnalis-Quercetum pubescentis* by the absence of *Sesleria autumnalis* and all other submediterranean species. It is found in northern Bosnia, where it is bound to several localities with southerly exposed limestone outcrops on mild to moderate slopes and altitudes from 300–900 m (Grmeč, Kozara, Majevica, Manjača and Ozren Mts) (Fig. 2g). *Quercus cerris* and *Quercus petraea* agg. are sometimes admixed in the tree layer. The understory is dominated by *Fraxinus ornus, Sorbus torminalis, Acer campestre* and sometimes *Carpinus betulus, Tilia tomentosa* and *Acer obtusatum*. The shrub layer is composed of mainly mesophilous species: *Clematis vitalba, Crataegus monogyna,* *Ligustrum vulgare, Prunus spinosa, Pyrus pyraster, Rosa arvensis* and, in some relevés, thermophilous species, such as *Cornus mas* and *Rubus canescens*. The herb layer is a mixture of thermophilous and mesophilous species: *Brachypodium pinnatum* s.l., *Brachypodium sylvaticum, Buglossoides purpurocaerulea, Carex flacca* s.l., *Cruciata glabra, Dactylis glomerata* s.l., *Festuca heterophylla, Fragaria moschata, Helleborus odorus, Symphytum tuberosum, Tamus communis, Teucrium chamaedrys, Vincetoxicum hirundinaria* etc. There was only one relevé previously recorded in B&H that fits the definition (LAKUŠIĆ & REDŽIĆ 1991). It was at that time recognized as a new association and validly named *Asparago tenuifolii-Quercetum pubescentis*, and although it is located further to the south (near Ribnik on the Sana River) and *Asparagus tenuifolius* occurs in only two relevés of this group, it otherwise floristically matches the stands from northern B&H, so we kept this name for the association. They are degraded high forests or coppice, frequently used as wood pasture. The floristic composition of this association is shown in Supplement S2.

4.2 Group of associations dominated by *Ostrya carpinifolia* (Table 3)

4.2.1 *Seslerio autumnalis-Ostryetum carpinifoliae* Horvat et Horvatić ex Horvat 1959 (Table 3, column 1)

Orig. (HORVAT 1959): *Seslerieto-Ostryetum*

Syn.: *Ostryeto-Seslerietum autumnalis* Horvat et Horvatić in Horvat 1950 nom. inval. [Art. 2b; 3b]

Typus: BUCALO 1999, Tab. 2, rel.8 - neotypus hoc loco

Note: This association was validly published with a synoptic table (HORVAT 1959), so we selected a representative published relevé of this association as a neotype.

Cocktail definition: *Ostrya carpinifolia* >25% NOT (Group Geranium robertianum OR *Quercus petraea* agg. >5% OR *Quercus pubescens* >5% OR *Quercus cerris* >10%)

This association was described from the submediterranean Dinaric Alps as an altitudinal belt between *Querco pubescenti-Carpinetum orientalis* and thermophilous beech forests (HORVAT 1950). However, in addition to the Mediterranean region (the mountains Bijela Gora, Ilija, Orjen and Viduša) in B&H it also occurs further inland (Dinaric and Pre-Pannonian regions), where it is found on limestone and dolomite, on moderate to very steep slopes and primarily southern aspects beneath thermophilous beech forests (mountains Čemernica, Grmeč, Igman, Jadovnik, Kozara, Maglić, Ozren, Trebević etc.; Fig. 2h). The altitudinal range is between 600 and 1200 m. These are mainly low forests dominated by *Ostrya carpinifolia* in the tree layer, always accompanied by *Fraxinus ornus* and often by *Acer obtusatum* and *Sorbus aria*. Much rarer, but still frequent are *Quercus petraea* agg., *Q. pubescens* and *Q. cerris*. The main feature of the herb layer is *Sesleria autumnalis* accompanied by xerothermophilous species *Carex humilis, Galium lucidum, Origanum vulgare, Polygonatum odoratum, Stachys recta, Tanacetum corymbosum, Teucrium chamaedrys, Thymus pulegioides, Vincetoxicum hirundinaria* etc. Mesophilous species are rare and connected to two fairly mesophilous variants: subass. *coryletosum colurnae* and subass. *tilietosum* (FUKAREK 1970b), which are probably related to thermophilous beech forests of *Seslerio-Fagetum* and *Tilio-Acerion* ravine forests. Accessible stands are mainly used as irregular coppices with little importance to forestry.

Table 3. Synoptic table for the group of associations dominated by *Ostrya carpinifolia*: SeO, *Seslerio autumnalis-Ostryetum carpinifoliae*; RuO, *Rusco aculeati-Ostryetum carpinifoliae*; QuO, *Querco pubescenti- Ostryetum carpinifoliae*. Frequency values of species are shown; species diagnostic for the association (phi values > 0.25) are shaded. Only ten diagnostic species with the highest fidelity and more than 20% frequency are shown for each association. Woody species that occurred in more than one layer were merged into one line.

Tabelle 3. Übersichtstabelle für die Gruppe der von *Ostrya carpinifolia* dominierten Assoziationen. Abkürzungen der Assoziationen s.o. Angegeben sind die Stetgkeiten der Arten (in %); diagnostische Arten für die jeweilige Assoziation (phi-Werte > 0,25) sind durch einen grauen Hintergrund markiert. Nur die zehn diagnostischen Arten mit der höchsten Treue und mehr als 20 % Stetigkeit sind für jede Assoziation aufgeführt. Gehölze, die in mehr als einer Schicht vorkamen, wurden in einer Zeile zusammengefasst.

Association	SeO	RuO	QuO
Number of relevés	51	19	19
Sesleria autumnalis	94	68	16
Sorbus aria	76	63	21
Origanum vulgare	51	16	16
Quercus petraea agg.	49	21	21
Trifolium rubens	35	.	21
Thalictrum minus	31	.	5
Convallaria majalis	31	11	5
Scabiosa cinerea	29	5	5
Melica ciliata	22	5	.
Asplenium trichomanes	24	95	21
Fragaria vesca	35	79	16
Mycelis muralis	6	74	11
Cyclamen purpurascens	20	68	16
Carex digitata	18	68	11
Valeriana officinalis	8	68	5
Geranium robertianum	4	63	21
Asplenium ruta-muraria	8	53	.
Lamiastrum galeobdolon s.l.	8	47	5
Moehringia muscosa	8	42	.
Quercus pubescens agg.	24	16	100
Tamus communis	18	32	63
Glechoma hirsuta	4	21	58
Anthericum ramosum	12	.	53
Dorycnium pentaphyllum subsp. *germanicum*	16	11	42
Coronilla varia	8	11	37
Genista tinctoria	6	.	37
Silene nemoralis	2	5	37
Clematis recta	4	.	32
Campanula bononiensis	4	.	26
Ostrya carpinifolia	100	100	100
Fraxinus ornus	100	100	100
Galium lucidum	75	37	79
Teucrium chamaedrys	73	21	74
Acer obtusatum	57	74	37
Tanacetum corymbosum	51	37	74

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Association	SeO	RuO	QuO
Number of relevés	51	19	19
Vincetoxicum hirundinaria	49	37	63
Crataegus monogyna	45	47	74
Euphorbia cyparissias	45	11	58
Brachypodium pinnatum s.l.	41	21	63
Euonymus verrucosus	39	68	32
Melittis melissophyllum	39	37	58
Potentilla micrantha	37	63	32
Coronilla emerus s.l.	25	58	5
Asplenium ceterach	24	53	5
Bromus erectus agg.	24	11	37
Juniperus communis	20	5	37
Clematis vitalba	18	74	53
Carpinus orientalis	18	63	16
Carex flacca s.l.	16	5	32
Primula vulgaris	14	47	16
Campanula persicifolia	14	32	53
Lonicera xylosteum	10	42	.
Melica uniflora	8	42	26
Achnatherum calamagrostis	8	42	16
Saxifraga rotundifolia	8	37	.
Hepatica nobilis	8	32	5
Arabis turrita	6	58	21
Asarum europaeum	6	58	21
Brachypodium sylvaticum	4	47	42
Digitalis grandiflora	4	21	26
Stellaria holostea	2	32	37
Campanula trachelium	2	32	32
Polypodium vulgare	2	32	.

4.2.2 *Rusco aculeati-Ostryetum carpinifoliae* Lakušić et Redžić ex Stupar et al. ass. nov. hoc loco (Table 3, column 2)

Syn.: *Rusco aculeati-Ostryetum carpinifoliae* Lakušić et Redžić 1991 nom. inval. [Art. 5], *Fraxino orni-Ostryetum carpinifoliae* auct. non Aichinger 1933 nom. illeg. [Art. 31]

Typus: LAKUŠIĆ & REDŽIĆ 1991. Tab. 6, rel. 12 - holotypus hoc loco

Cocktail definition: *Ostrya carpinifolia* >25% AND Group Geranium robertianum NOT *Quercus pubescens* >10%

This community forms a permanent stage on shallow rocky soils over limestone in river canyons of W. B&H (Una, Unac, Sana and Vrbas) (LAKUŠIĆ & REDŽIĆ 1991) (Fig. 2i). It thrives on steep slopes (25–45°), various aspects and altitudes from 300–1000 m. The canopy layer is dominated by *Ostrya carpinifolia*, while the dominant species of the understory are *Fraxinus ornus* and *Acer obtusatum*. Although *Sesleria autumnalis* still plays an important role, this association is distinguished from *Seslerio autumnalis-Ostryetum* by a set of mesophilous species e.g.: *Aremonia agrimonoides, Asarum europaeum, Carex digitata, Clematis vitalba, Lamiastrum galeobdolon* s.l., *Stellaria holostea* etc. and species of mesic rocky habitats: *Arabis turrita, Asplenium ruta-muraria, Asplenium trichomanes, Geranium* *robertianum, Moehringia muscosa, Mycelis muralis, Saxifraga rotundifolia* etc. The stands are mainly difficult of access, so there is almost no current use, but signs of coppicing in previous times are evident.

4.2.3 *Querco pubescenti-Ostryetum carpinifoliae* Horvat 1938 (Table 3, column 3)

Orig. (HORVAT 1938): *Querceto-Ostryetum carpinifoliae*

Syn.: asocijacija *Quercus pubescens-Geranium sanguineum* Horvat 1937 nom. nud. [Art. 2b]

Typus: HORVAT 1938, Tab. 1, rel. 8 – lectotypus hoc loco

Cocktail definition: (*Ostrya carpinifolia* >5% AND *Quercus pubescens* >5%) NOT (*Quercus cerris* >50% OR *Quercus petraea* agg. >10% OR *Carpinus orientalis* >5% OR Group Cnidium silaifolium)

This association was described from continental Croatia (HORVAT 1938), on southerly exposed, steep limestone outcrops. HORVAT (1950, 1963) suggests that the same type must be distributed in similar places in the mountains of northern B&H. Indeed, they have been found on the mountains Trebević (STEFANOVIĆ 1964b), Majevica (FABIJANIĆ et al. 1967) and, more recently, Grmeč, Kozara, Manjača and Ozren, where they are often linked to forests of *Asparago tenuifolii-Quercetum pubescentis* (Fig. 2j). They thrive over limestone and dolomite, on shallow rocky soil and steep slopes. Altitudes are between 300 and 1000 m, always on southern aspect. The canopy is codominated by *Ostrya carpinifolia* and *Quercus pubescens*, while much less by *Acer obtusatum, Acer campestre* and *Quercus cerris*. The main species in the understory is *Fraxinus ornus*, sometimes accompanied by *Cotinus coggygria*. The shrub layer is represented by *Chamaecytisus hirsutus, Cornus mas, Cornus sanguinea, Corylus avellana, Crataegus monogyna, Euonymus verrucosus, Genista tictoria, Juniperus communis, Prunus spinosa, Rosa arvensis, Sorbus torminalis*, etc. The herb layer is composed of the xerothermophilous species *Euphorbia cyparissias, Galium lucidum, Teucrium chamadrys, Vincetoxicum hirundinaria*; thermophilous species: *Campanula persicifolia, Melittis melissophyllum, Tamus communis, Tanacetum corymbosum* and mesophilous ones *Brachypodium sylvaticum, Clematis vitalba, Dactylis glomerata* s.l., *Glechoma hirsuta, Helleborus odorus, Stelaria holostea, Symphytum tuberosum* etc. Since they are mainly found on rocky and difficult of access terrain, they have been used as irregular coppices, with little importance to forestry.

4.3 Group of associations dominated by *Quercus frainetto* and/or *Quercus cerris* (Table 4)

4.3.1 *Quercetum frainetto-cerridis* (Rudski 1949) Trinajstić et al. 1996 (Table 4, column 1)

Orig. (TRINAJSTIĆ et al. 1996): *Quercetum frainetto-cerris* Rudski 1949

Syn.: *Quercetum confertae-cerridis serbicum* Rudski 1949 nom. illeg. [Art. 34a], *Quercetum frainetto-cerridis moesiacum* Horvat et al. 1974 nom. illeg. [Art. 34a], *Quercetum frainetto hercegovinicum* Fukarek 1966 nom. illeg. [Art. 34a]

Typus: RUDSKI 1949, Tab. 4, rel. 5 – lectotypus hoc loco

Cocktail definition: (*Quercus frainetto* >25% NOT *Quercus petraea* agg. >10%) AND (Group Melittis melissophyllum OR Group Galium pseudaristatum OR Group Lychnis coronaria OR Group Hieracium racemosum OR Group Chamaecytisus austriacus OR Group Veronica officinalis OR Group Carex pilosa OR Group Teucrium chamaedrys)

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This rather heterogeneous association was first described by RUDSKI (1949) in central Serbia. It is zonal forest of the central Balkans (HORVAT et al. 1974), with several subassociations and ecological or geographical variants described (TOMIĆ & RAKONJAC 2013). In B&H it is found in the eastern part (Transitional Illyrian-Moesian region; narrow belt along the River Drina, from Foča to Bijeljina, Majevica Mt), with exclaves in southern (lower Herzegovina, Jablanica region), central (Zenica region) and northern B&H (Vučjak Mt) (Fig. 2k). It occurs over deep soil, mainly on acidic substrate, on mild to moderate slopes, predominantly southern and western aspects, with the altitudinal range of 200–500 m. The main species in the tree layer is *Quercus frainetto,* almost always accompanied by *Quercus cerris*, but much less *Quercus petraea.* The understory is built of *Fraxinus ornus* and, in some stands, of *Carpinus orientalis*, while in others of *Carpinus betulus, Acer tataricum* and *Acer campestre.* Other frequent species of the shrub layer are *Ligustrum vulgare, Prunus spinosa, Pyrus pyraster, Sorbus torminalis* etc. The herb layer is always made up of thermophilous species and some that are acid tolerant: *Chamaecytisus hirsutus* agg., *Clinopodium vulgare, Dianthus armeria, Euphorbia cyparissias, Festuca heterophylla, Galium pseudaristatum, Genista tinctoria, Hieracium pilosella, Hieracium sabaudum, Lathyrus niger, Lychnis coronaria, Physospermum cornubiense, Potentilla micrantha, Pteridium aquilinum, Silene viridiflora, Teucrium chamaedrys, Thymus pulegioides, Veronica officinalis* etc. The association *Quercetum frainetto hercegovinicum* that was described for southern B&H (FUKAREK 1966) could not be recognized because there were no original relevés (only a synoptic table was provided in the original diagnosis). However, our relevés from this region fitted the scope of the traditionally accepted association. The stands are mainly degraded high forests and coppices, often used as wood pasture.

4.3.2 *Fraxino orni-Quercetum cerridis* Stefanović 1968 nom. mut. propos. [Art. 45] (Table 4, column 2)

Orig. (STEFANOVIĆ 1968): *Orno-Quercetum cerris* ass. nov.

Syn.: *Quercetum cerridis hercegovinicum* Fukarek 1970 nom. nud. [Art. 2b], *Quercetum montanum submediterraneum* Fukarek 1970 p.p. nom. nud. [Art. 2b, 3a], *Carpino orientalis-Quercetum cerridis* Lakušić 1976 nom. nud. [Art. 2b], *Quercetum cerris mediterraneo-montanum* Lakušić et Kutleša 1976 nom. nud. [Art. 2b], *Lathyro nigri-Quercetum cerridis* Redžić et Barudanović 2010, *Lithospermo-Qeurcetum cerridis* Redžić 2011 nom. nud. [Art. 2b]

non: *Fraxino orni-Quercetum cerridis* Kevey & Sonnevend in Kevey 2008 nom. illeg. [Art. 31]

non: *Fraxino orni-Quercetum cerridis* Stefanović 1968 sensu Tomić 1997

Typus: STEFANOVIĆ 1968, Tab. 1, rel. 6 – lectotypus hoc loco

Cocktail definition: *Quercus cerris* >25% NOT (*Quercus frainetto* >5% OR *Quercus petraea* agg. >10% OR *Quercus pubescens* >25% OR *Ostrya carpinifolia* >25% OR Group Asparagus acutifolius OR Group Luzula luzuloides)

Quercus cerris is the main species in the canopy layer, which is accompanied to a much lesser extent by *Acer obtusatum, Quercus pubescens, Quercus petraea* agg. and *Ostrya carpinifolia.* It was originally described from western B&H (STEFANOVIĆ 1968), with three subassociations: *carpinetosum orientalis* from the southern part of the distribution area (Aržano, Posušje, Trebinje (Lastva, Tuli), Unac River valley); *quercetosum petraeae* from the northern part of the distribution area, or on deeper soil and northern aspects in the southern part (Grmeč Mt, Kozara Mt, Pastirevo Mt, Petrovačko Polje, Bileća (Meka Gruda), Posušje, Trebinje (Zupci, Ubli); *ostryetosum carpinifoliae,* which occurs throughout the

Table 4. Synoptic table for the group of associations dominated by *Quercus frainetto* and/or *Quercus cerris*: Qfc, *Quercetum frainetto-cerridis*; FrQ, *Fraxino orni-Quercetum cerridis*. Frequency values of species are shown; species diagnostic for the association (phi values > 0.25) are shaded. Only ten diagnostic species with the highest fidelity and more than 20% frequency are shown for each association. Woody species that occurred in more than one layer were merged into one line.

Tabelle 4. Übersichtstabelle für die Gruppe der von *Quercus frainetto* und/oder *Quercus cerris* dominierten Assoziationen. Abkürzungen der Assoziationen s.o. Angegeben sind die Stetgkeiten der Arten (in %); diagnostische Arten für die jeweilige Assoziation (phi-Werte > 0,25) sind durch einen grauen Hintergrund markiert. Nur die zehn diagnostischen Arten mit der höchsten Treue und mehr als 20 % Stetigkeit sind für jede Assoziation aufgeführt. Gehölze, die in mehr als einer Schicht vorkamen, wurden in einer Zeile zusammengefasst.

Association	Qfc	FrQ
Number of relevés	53	87
Quercus frainetto	100	.
Quercus petraea agg.	58	24
Acer tataricum	40	7
Juniperus communis	36	9
Helleborus odorus	36	8
Hieracium pilosella	30	3
Dianthus armeria	30	.
Lychnis coronaria	28	2
Physospermum cornubiense	28	.
Betula pendula	26	.
Crataegus monogyna	42	86
Festuca heterophylla	30	79
Rosa arvensis	32	70
Cruciata glabra	4	66
Betonica officinalis	11	56
Filipendula vulgaris	2	55
Helleborus multifidus	.	54
Buglossoides purpurocaerulea	17	52
Symphytum tuberosum	8	51
Sesleria autumnalis	9	48
Quercus cerris	91	100
Fraxinus ornus	81	84
Dactylis glomerata s.l.	58	64
Carpinus orientalis	55	29
Lathyrus niger	55	77
Potentilla micrantha	47	52
Silene viridiflora	45	21
Pyrus pyraster	45	53
Euphorbia cyparissias	43	18
Thymus pulegioides	43	20
Genista tinctoria	43	21
Clinopodium vulgare	42	67
Carex caryophyllea	42	29
Brachypodium pinnatum s.l.	40	59
Acer campestre	40	52

Association	Qfc	FrQ
Number of relevés	53	87
Carpinus betulus	40	28
Chamaecytisus hirsutus agg.	38	26
Veronica chamaedrys	36	46
Ligustrum vulgare	34	37
Fragaria vesca	34	22
Teucrium chamaedrys	32	49
Pteridium aquilinum	32	21
Veronica officinalis	32	17
Hypericum perforatum	30	9
Galium lucidum	30	32
Prunella vulgaris	30	14
Primula vulgaris	28	20
Sorbus torminalis	26	54
Prunus spinosa	26	48
Melittis melissophyllum	26	45
Tamus communis	26	40
Viola hirta agg.	25	34
Hieracium sabaudum	25	25
Cornus mas	21	47
Prunus avium	21	41
Vincetoxicum hirundinaria	17	39
Quercus pubescens agg.	17	38
Carex montana	17	32
Brachypodium sylvaticum	17	32
Corylus avellana	15	33
Dorycnium pentaphyllum subsp. *germanicum*	15	24
Tanacetum corymbosum	13	43
Malus sylvestris	13	39
Bromus erectus agg.	13	29
Serratula tinctoria	9	31
Verbascum nigrum s.l.	8	29
Geum urbanum	6	26
Carex flacca s.l.	6	25
Pimpinella saxifraga	6	24

association range in more humid and rocky habitats. This heliophilous association is typical of dry karst fields of western and southern B&H, where it occupies flat terrain or mild to moderate slopes on deep soil over carbonate bedrock (Fig. 21). The typical altitudinal range is 600–800 m. A faithful species of the shrub layer is *Fraxinus ornus* together with *Cornus mas, Corylus avellana, Malus sylvestris, Prunus avium, Prunus spinosa, Pyrus pyraster, Rosa arvensis* and *Sorbus torminalis*. *Carpinus orientalis* is characteristic of subass. *carpinetosum orientalis*, together with *Sesleria autumnalis* in the herb layer, while *Carpinus betulus* and *Quercus petraea* agg. occur in subass. *quercetosum petraeae*. The herb layer of all subassociations is composed of several sets of species (thermophilous, heliophilous, mesophilous and slightly acidophilous): *Betonica officinalis, Brachypodium pinnatum* s.l., *Buglossoides purpurocaerulea, Clinopodium vulgare, Cruciata glabra, Dactylis glomerata* s.l., *Festuca heterophylla, Filipendula vulgaris, Helleborus multifidus, Iris graminea, Lathyrus niger, Melittis melissophyllum, Potentilla micrantha, Serratula tinctoria, Symphytum tuberosum, Teucrium chamaedrys, Trifolium alpestre, Veronica chamaedrys* etc. Although these are mainly irregularly cut high forests, they are often degraded by spring forest fires and grazing, so they form a distinctive park-forest feature. This variant is similar throughout the distribution range of the association and is characterized by the absence of a shrub layer and high cover of light demanding species of the forest mantle and dry grasslands: *Brachypodium pinnatum* s.l., *Filipendula vulgaris, Geranium sanguineum, Trifolium montanum* etc.

4.4 Group of associations dominated by *Quercus petraea* agg. (Table 5)

4.4.1 *Lathyro nigri-Quercetum petraeae* Horvat (1938) 1959 (Table 5, column 1)

Orig. (HORVAT 1959): *Lathyreto-Quercetum petraeae*

Bas.: *Querco pubescenti-Ostryetum carpinifoliae quercetosum petraeae* Horvat 1938

Syn.: *Serratulo tinctoriae-Quercetum petraeae* Zupančič et Vreš in Zupančič et al. 2009 nom. superf. [Art. 29a]. *Quercetum petraeo-cerridis* Jovanović (1960) 1979 *seslerietosum autumnalis* Redžić et Barudanović 2010

non: *Lathyro nigri-Quercetum petraeae* Horvat (1938) 1959 sensu Vukelić 1990, Baričević 2006

Typus: HORVAT 1938, Tab. 1, rel. 12 – lectotypus hoc loco

Cocktail definition: *Quercus petraea* agg. >10% AND (*Ostrya carpinifolia* >0% OR Group Melittis melissophyllum) NOT (Group Luzula luzuloides OR Group Carex pilosa OR *Quercus pubescens* agg. >25% OR (*Carpinus betulus* >0% AND *Carpinus orientalis* >0%))

This association has been treated in an inconsistent manner (VUKELIĆ 1990, BARIČEVIĆ et al. 2006b). Here, we treat it as in the original diagnosis (HORVAT 1938), i.e., *Quercus petraea* dominated forests over deep carbonate soil, with a dominance of baso-neutrophilous species (HORVAT 1963, ŠUGAR 1972, REGULA-BEVILACQUA 1978, ZUPANČIČ et al. 2009). The understory is made up of *Fraxinus ornus, Acer obtusatum* and *Ostrya carpinifolia*. The shrub layer consists of *Carpinus orientalis, Corylus avellana, Crataegus monogyna, Euonymus verrucosus, Pyrus pyraster, Sorbus aria* etc. The herb layer is mainly thermophilous: *Clinopodium vulgare, Iris graminea, Lathyrus niger, Melittis melissophyllum, Potentilla micrantha, Sesleria autumnalis, Tanacetum corymbosum* etc. Mesophilous species have much lower frequency: *Aremonia agrimonoides, Cruciata glabra* and *Helleborus odorus* to mention the most frequent. *Pteridium aquilinum, Serratula tinctoria* and *Silene nutans* indicate slight acidity in the upper soil layer due to carbonates leaching. This forest occurs on carbonate bedrock across B&H (the mountains Crvanj, Čemernica, Jadovnik, Kozara, Majevica, Makljen, Manjača, Motajica, Starčevica, Trebava, Vlašić; Fig. 2m), at altitudes from 400 to 1200 m, mainly on moderate, south facing slopes. On some mountains (e.g., Čemernica) it forms an altitudinal belt below Dinaric thermophilous beech forests of *Aceri obtusati-Fagetum*. They are degraded high forests or coppices, which are under high negative human influence. They are often used as wood pasture.

4.4.2 *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco (Table 5, column 2)

Typus: Supplement S3, rel. 9 – holotypus hoc loco

Cocktail definition: *Quercus petraea* agg. >25% AND *Carpinus betulus* >1% AND *Carpinus orientalis* >1% AND Group Aremonia agrimonoides NOT (*Quercus frainetto* >0% OR *Quercus pubescens* >25%)

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This interesting meso-thermophilous association, although quite common in NW B&H, had not previously been recorded (Fig. 2n). While the tree layer is dominated almost exclusively by *Quercus petraea*, the understory is much more diverse and consists mostly of thermophilous species, amongst which the most abundant is *Carpinus* orientalis. Others include *Acer obtusatum, Cornus mas, Euonymus verrucosus, Fraxinus ornus, Quercus pubescens, Sorbus torminalis* and *Viburnum lantana,* but there are also some mesophilous species that are present in almost every relevé: *Acer campestre, Carpinus betulus, Crataegus monogyna* and *Prunus avium*. In contrast, the herb layer is mostly made up of mesophilous species: *Aremonia agrimonoides, Cruciata glabra, Glechoma hirsuta, Helleborus odorus, Primula vulgaris, Sanicula europaea, Stellaria holostea, Symphytum tuberosum, Veronica chamaedrys* etc., although there are also some thermophilous species with high frequency: *Buglossoides purpurocarulea, Cyclamen purpurascens, Festuca heterophylla, Lathyrus niger, Lathyrus venetus, Melittis melissophyllum, Potentilla micrantha, Tamus communis, Tanacetum corymbosum, Viola hirta* agg. etc. This association clearly represents the transition from thermophilous forests of *Carpinion orientalis* towards mesophilous forests of *Carpinion betuli*. They are found in the NW B&H (the mountains Čemernica, Grmeč, Kozara, Manjača, Starčevica) in the zone in which mediterranean and continental climates mix, and also *Carpinus betulus* and *Carpinus orientalis* meet and compete each other. They occur at 300–900 m, on flat to moderate slopes on mainly warm exposures on limestone and dolomite. This association is newly described and its floristic composition is presented in Supplement S3. They are mainly degraded high forests or coppices, often used as wood pasture.

4.4.3 *Cytiso hirsuti-Quercetum petraeae* (Stefanović 1964) Pallas in Bohn et Neuhäusl 2004 (Table 5, column 3)

Orig. (BOHN & NEUHÄUSL 2004): *Cytiso hirsuti-Quercetum petraeae* (Stefanovic 1964) Pallas 2003 nom. nov. hoc loco pro nom. illegit. (Art. 34) *Quercetum montanum illyricum* Stefanovic 1964

Syn.: *Quercetum montanum illyricum* Stefanović 1964 nom. illeg. [Art. 34a], *Luzulo nemorosae-Quercetum petraeae* Redžić 2007

Cocktail definition: (*Quercus petraea* agg. >10% NOT (*Quercus frainetto* >10% OR Group Cornus mas)) AND (Group Galium pseudaristatum OR Group Lychnis coronaria OR Group Hieracium racemosum OR Group Chamaecytisus austriacus OR Group Veronica officinalis) NOT (Group Festuca drymeja OR Group Melittis melissophyllum)

These species-poor forests are found on dry, shallow and acidic soil over siliceous bedrock (andesite, dacite, siliceous sandstone and schists), mainly in eastern B&H (Transitional Illyrian-Moesian region; Drina River basin (Foča, Goražde, Srebrenica, Ustikolina), but stands are also scattered over the northern part of the country (Pre-Pannonian region; the mountains Becanj, Kozara, Krnjin, Ljubić, Motajica and Trebava) when ecological conditions meet the demands of the community (Fig. 2o). The altitudinal range is (300)500-900 m, on mainly south and west facing moderate to steep slopes. This community is the westernmost type of dry acidophilous forests of *Quercion petraeo-cerridis,* which have the centre of their distribution in the central Balkans (ČARNI et al. 2009). The tree layer is dominated by *Quercus petraea* and/or *Quercus cerris* (sometimes accompanied by *Quercus frainetto*), while the herb layer is dominated by species tolerant of soil acidity and dryness: *Chamaecytisus hirsutus, Chamaespartium sagittale, Genista pilosa, Genista tinctoria, Hieracium murorum, Hieracium pilosella, Hieracium piloselloides, Hieracium praealtum* subsp. *bau-*

Table 5. Synoptic table for the group of associations dominated by *Quercus petraea*: LaQ, *Lathyro nigri-Quercetum petraeae*; AcQ, *Aceri obtusati-Quercetum petraeae*; CyQ, *Cytiso hirsuti-Quercetum petraeae*; FeQ, *Festuco drymejae-Quercetum petraeae*; PoQ, *Potentillo micranthae-Quercetum petraeae*; SaQ, *Seslerio autumnalis-Quercetum petraeae*. Frequency values of species are shown; species diagnostic for the association (phi values > 0.25) are shaded. Only ten diagnostic species with the highest fidelity and more than 20% frequency are shown for each association. Woody species that occurred in more than one layer were merged into one line.

Tabelle 5. Übersichtstabelle für die Gruppe der von *Quercus petraea* dominierten Assoziationen. Abkürzungen der Assoziationen s. o. Angegeben sind die Stetgkeiten der Arten (in %); diagnostische Arten für die jeweilige Assoziation (phi-Werte > 0,25) sind durch einen grauen Hintergrund markiert. Nur die zehn diagnostischen Arten mit der höchsten Treue und mehr als 20 % Stetigkeit sind für jede Assoziation aufgeführt. Gehölze, die in mehr als einer Schicht vorkamen, wurden in einer Zeile zusammengefasst.

Association	LaQ	AcQ	CyQ	FeQ	PoQ	SaQ
Number of relevés	30	30	57	24	38	9
Clinopodium vulgare	67	23	32	17	34	44
Iris graminea	47	10	.	.	5	.
Ostrya carpinifolia	43	3	.	.	3	11
Sorbus aria	37	.	.	.	.	11
Veratrum nigrum	33	20	.	.	.	.
Origanum vulgare	33	.	.	.	.	.
Vincetoxicum hirundinaria	30	10	.	13	8	.
Serratula tinctoria	30	10	5	13	13	.
Mercurialis perennis	30	10	.	.	.	.
Peucedanum austriacum	23	.	.	.	.	.
Acer campestre	33	100	16	58	18	.
Carpinus orientalis	50	97	14	8	5	22
Cornus mas	33	77	2	4	11	11
Tamus communis	30	77	11	38	24	.
Glechoma hirsuta	20	73	2	4	5	.
Ligustrum vulgare	27	70	7	25	.	.
Hedera helix	13	63	2	17	24	.
Viburnum lantana	20	53	2	.	.	.
Stellaria holostea	23	53	.	.	.	.
Sanicula europaea	7	50	.	.	3	11
Hieracium sabaudum	3	20	74	33	34	.
Quercus cerris	20	13	72	8	5	.
Hieracium pilosella	.	3	53	.	3	.
Chamaespartium sagittale	.	.	49	.	3	22
Melampyrum pratense	7	3	37	13	18	.
Rubus fruticosus agg.	.	3	28	4	.	.
Luzula pilosa	.	3	28	.	8	.
Avenella flexuosa	.	.	26	.	3	.
Prunus avium	40	70	25	83	47	.
Rubus hirtus	13	23	28	75	50	33
Carex pilosa	7	20	.	58	.	.
Epimedium alpinum	23	13	2	58	3	.
Acer tataricum	10	37	12	54	.	.
Ruscus hypoglossum	.	7	.	25	5	.

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Association	LaQ	AcQ	CyQ	FeQ	PoQ	SaQ
Number of relevés	30	30	57	24	38	9
Genista tinctoria	13	3	68	50	79	44
Galium mollugo agg.	10	13	5	21	50	44
Carex flacca s.l.	30	20	9	42	50	.
Silene viridiflora	3	13	2	4	34	.
Hieracium racemosum	3	3	11	13	34	.
Hypericum montanum	17	.	5	4	32	.
Asplenium adiantum-nigrum	17	20	4	.	24	100
Sesleria autumnalis	47	17	5	.	.	100
Cardamine glauca	3	.	2	.	.	89
Lychnis flos-cuculi	3	.	.	.	5	89
Hieracium tommasinianum	.	.	.	.	.	89
Cephalanthera rubra	10	.	.	.	.	78
Hieracium piloselloides	3	.	2	.	5	78
Trifolium rubens	17	.	5	.	3	78
Lychnis viscaria	3	.	4	.	5	67
Juniperus oxycedrus	.	.	.	.	.	56
Helleborus odorus	53	97	16	.	.	.
Euonymus verrucosus	33	33	.	.	.	.
Quercus pubescens agg.	23	23	.	.	.	.
Festuca heterophylla	40	67	25	29	71	.
Veronica officinalis	7	.	67	4	5	44
Festuca drymeja	10	3	7	71	47	.
Galium schultesii	27	30	28	67	66	.
Tilia tomentosa	10	10	2	63	50	.
Fagus sylvatica	7	30	25	50	79	89
Tanacetum corymbosum	47	33	4	17	71	78
Luzula luzuloides	.	.	28	17	63	67
Hieracium murorum	10	3	18	13	55	78
Quercus petraea agg.	100	97	100	100	100	100
Fraxinus ornus	87	87	93	100	95	78
Dactylis glomerata s.l.	63	50	30	38	74	89
Lathyrus niger	60	47	25	67	84	67
Crataegus monogyna	60	97	35	46	39	.
Acer obtusatum	60	73	2	13	39	89
Rosa arvensis	57	83	26	58	39	.
Sorbus torminalis	57	97	21	79	84	56
Melittis melissophyllum	57	33	4	50	53	67
Potentilla micrantha	50	70	67	46	68	67
Cruciata glabra	50	93	35	67	45	.
Aremonia agrimonoides	50	60	.	.	29	44
Fragaria vesca	50	40	56	4	42	67
Corylus avellana	50	30	14	8	24	44
Pyrus pyraster	40	73	25	46	42	.
Primula vulgaris	37	77	4	8	21	44
Veronica chamaedrys	37	53	47	21	84	100
Brachypodium sylvaticum	37	47	14	50	39	.
Pteridium aquilinum	33	30	81	67	68	100

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Association	LaQ	AcQ	CyQ	FeQ	PoQ	SaQ
Number of relevés	30	30	57	24	38	9
Chamaecytisus hirsutus agg.	30	3	60	46	45	89
Viola hirta agg.	30	40	19	8	13	44
Symphytum tuberosum	30	63	5	42	66	33
Silene nutans	30	3	25	4	34	.
Cyclamen purpurascens	27	37	.	.	5	11
Lathyrus vernus	27	50	2	50	37	44
Betonica officinalis	27	10	5	4	3	11
Teucrium chamaedrys	27	10	16	.	.	11
Buglossoides purpurocaerulea	23	40	2	.	.	.
Lathyrus venetus	23	40	7	8	26	.
Clematis vitalba	20	40	2	.	11	.
Brachypodium pinnatum s.l.	20	17	7	8	5	56
Juniperus communis	20	20	30	38	34	11
Carpinus betulus	17	83	23	58	42	.
Melica uniflora	17	43	5	21	8	.
Campanula persicifolia	13	23	7	29	39	78
Cephalanthera longifolia	13	27	9	42	39	.
Ajuga reptans	10	47	2	4	21	.
Galium lucidum	10	7	18	17	26	11
Pulmonaria officinalis	3	37	2	8	21	.
Luzula forsteri	3	27	35	33	45	.

hinii, *Luzula luzuloides*, *Veronica officinalis* etc. The only constant thermophilous species is *Potentilla micrantha*, while *Lathyrus niger* and *Festuca heterophylla* appear with much lower frequency. Apart from occasional dominance of *Fraxinus ornus*, the shrub layer is poor in species and coverage, which can be partly attributed to regular spring fires and browsing of domestic animals. They are frequently degraded high forests or coppices, often used as wood pastures.

Next page (nächste Seite):

Fig. 2. Distribution of relevés of the different associations of thermophilous deciduous forests in B&H (ordered as in the Results section): QpC, *Querco pubescenti-Carpinetum orientalis*; RuC, *Rusco aculeati-Carpinetum orientalis*; CaQ, *Carici hallerianae-Quercetum pubescentis*; CrC, *Cruciato glabrae-Carpinetum orientalis*; SeQ, *Seslerio autumnalis-Quercetum pubescentis*; ArQ, *Aristolochio luteae-Quercetum pubescentis*; AsQ, *Asparago tenuifolii-Quercetum pubescentis*; SeO, *Seslerio autumnalis-Ostryetum carpinifoliae*; RuO, *Rusco aculeati-Ostryetum carpinifoliae*; QuO, *Querco pubescenti-Ostryetum carpinifoliae*; Qfc, *Quercetum frainetto-cerridis*; FrQ, *Fraxino orni-Quercetum cerridis*; LaQ, *Lathyro nigri-Quercetum petraeae*; AcQ, *Aceri obtusati-Quercetum petraeae*; CyQ, *Cytiso hirsuti-Quercetum petraeae*; FeQ, *Festuco drymejae-Quercetum petraeae*; PoQ, *Potentillo micranthae-Quercetum petraeae*; SaQ, *Seslerio autumnalis-Quercetum petraeae*.

Abb. 2. Verteilung der Vegetationsaufnahmen der verschiedenen Assoziationen thermophiler Laubwälder in B&H (geordnet wie im Abschnitt Ergebnisse). Abkürzungen der Assoziationen s. o.

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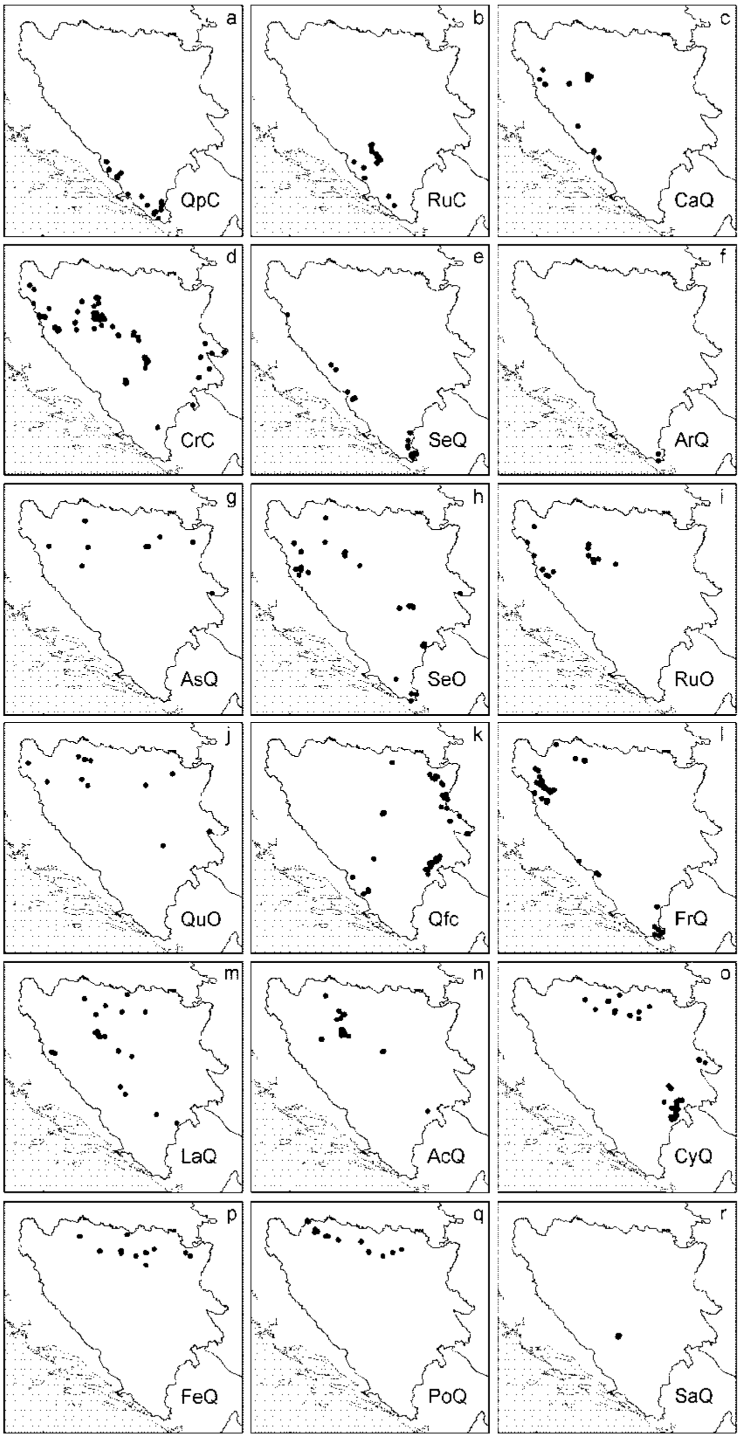
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4.4.4 *Festuco drymejae-Quercetum petraeae* (Janković et Mišić 1960) Janković 1968 nom. mut. propos. |Art. 45| (Table 5, column 4)

Orig. (JANKOVIĆ 1968): *Festuco-Quercetum petraeae*
Bas.: *Quercetum montanum festucetosum montanae* Janković et Mišić 1960 nom. illeg. |art. 29b|
Syn.: *Lathyro nigrae-Quercetum petraeae* Horvat 1959 sensu Vukelić 1990, Baričević 2006
non: *Festuco drymeiae-Quercetum petraeae* Morariu, Ularu, Danciu et Lungescu 1970 nom. illeg. [art. 32b]
Typus: JANKOVIĆ & MIŠIĆ 1960, Tab. 4, rel. 9 – lectotypus hoc loco
Cocktail definition: (*Quercus petraea* agg. >50% NOT (*Carpinus orientalis* >0% OR *Sesleria autumnalis* >0%)) AND Group Melittis melissophyllum AND Group Carex pilosa AND (Group Luzula luzuloides OR Group Hieracium racemosum OR Group Festuca drymeja)

Originally described from Fruška Gora Mt. in Serbia (JANKOVIĆ & MIŠIĆ 1960), this association combines attributes of thermophilous, acidophilous and mesophilous *Quercus petraea* forests (HRUŠKA-DELL'UOMO 1975). The stands are found on low mountains of northern B&H (Becanj, Crni Vrh, Kozara, Krnjin, Ljubić, Majevica, Motajica, Ozren, Trebava) on deep soil over acidic substrate (non-carbonate flysch, siliceous sandstone, diabase, chert etc.), on moderate slopes of primarily southerly aspects (Fig. 2p). The association occupies the upper parts of slopes above meso-neutrophilous oak-hornbeam or beech forests (300–500 m), which explains the high frequency of *Carpinus betulus* or *Fagus sylvatica*, but it should be pointed out that they are of poor vitality, found only in the lower shrub layer with very low coverage (r/+). The only species in the tree layer is *Quercus petraea*, accompanied in the shrub layer by *Fraxinus ornus* and *Sorbus torminalis*, which on some stands can have very high abundance. Other species in the shrub layer include *Acer campestre*, *Acer tataricum*, *Chamaecytisus hirsutus*, *Genista tinctoria*, *Prunus avium*, *Rosa arvensis*, *Rubus hirtus*, *Tilia tomentosa*, etc. Thermophilous species are represented by: *Carex flacca* s.l., *Lathyrus niger*, *Melittis melissophyllum*, *Potentilla micrantha*, and *Tamus communis*, and acidophilous by: *Genista tinctoria*, *Hieracium sabaudum*, *Luzula forsteri*, *Pteridium aquilinum* etc. However, several mesophilous species give this association a peculiar transitional character: *Carex pilosa*, *Epimedium alpinum*, *Festuca drymeja* and *Galium schultesii*. These are mainly high, productive forests.

4.4.5 *Potentillo micranthae-Quercetum petraeae* Vukelić et al. ex Vukelić, Baričević et Šapić ass. nov. hoc. loco (Table 5, column 5)

Syn.: *Potentillo micranthae-Quercetum petraeae* Vukelić, Baričević et Šapić 2010 nom. inval. [Art 5], *Hieracio racemosi-Quercetum petraeae* Vukelić 1991 nom. illeg. [Art. 31] p.p.
Typus: VUKELIĆ et al. 2010, Tab. 1, rel. 15 – holotypus hoc loco
Cocktail definition: (*Quercus petraea* agg. >50% NOT (*Carpinus orientalis* >0% OR *Sesleria autumnalis* >0% OR Group Carex pilosa)) AND Group Melittis melissophyllum AND (Group Luzula luzuloides OR Group Hieracium racemosum OR Group Festuca drymeja)

Originally described from Zrinska gora (Croatia) (VUKELIĆ et al. 2010), this *Quercus petraea* association is a more acidophilous and less mesophilous community than *Festuco drymejae-Quercetum petraeae*. It appears on the upper parts of moderate to steep slopes and ridges, on deep soil over siliceous bedrock (diabase, chert, siliceous sandstone etc.), primarily on southern aspects. It is mainly found in the low mountains of north and northwestern B&H (Kozara, Krnjin, Ljubić, Motajica, Pastirevo, Planinica, Trebava) between 300 and 600 m (Fig. 2q). There is a larger number of acidophilous species, led by: *Genista tinctoria*,

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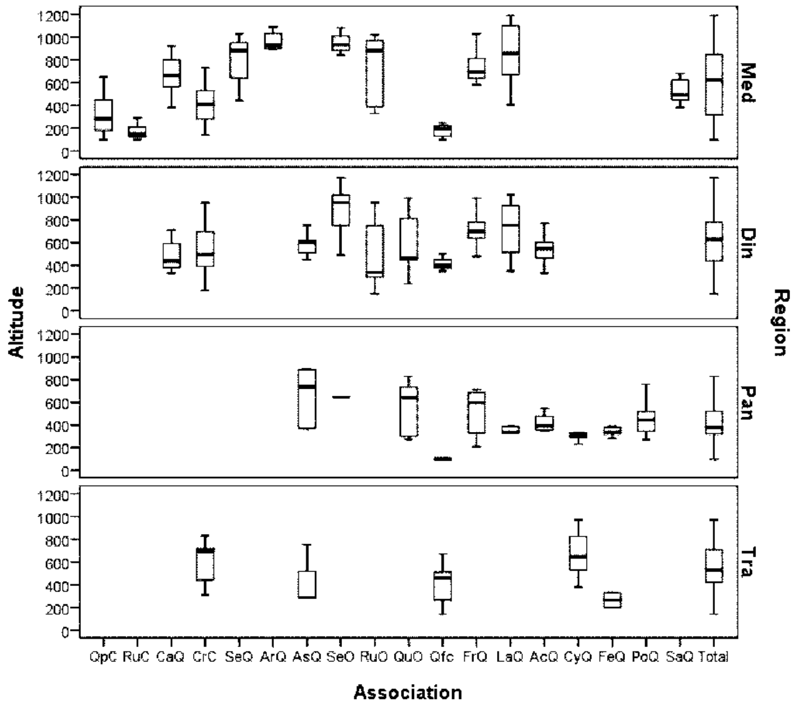

Fig. 3. Boxplot showing the altitudinal zonation and distribution of associations of thermophilous deciduous forests accross the biogeographical regions in B&H. Association names abbreviated as in Figure 2 and ordered as in the Results section; last column (total) presents altitudinal distribution of all relevés in biogeographical region. Biogeographical regions: **Med**, Mediterranean; **Din**, Dinaric; **Pan**, Pre-Pannonian; **Tra**, Transitional Illyrian-Moesian.

Abb. 3. Boxplotdiagramme mit der Höhenzonierung und Verbreitung von Assoziationen thermophiler Laubwälder in den biogeographischen Regionen in B&H. Die Assoziationen sind abgekürzt wie in Abbildung 2 und wie im Ergebnisteil geordnet; die letzte Spalte (Total) gibt die Höhenverteilung aller Vegetationsaufnahmen in der biogeographischen Region an. Biogeographische Regionen: **Med**, Mediterran; **Din**, Dinarisch; **Pan**, Prä-Pannonisch; **Tra**, Übergang Illyrisch-Moesisch.

Hieracium murorum, Hieracium racemosum, Luzula luzuloides and *Pteridium aquilinum*, but the many thermophilous species with high abundance give it a distinct character: *Carex flacca* s.l., *Festuca heterophylla, Lathyrus niger, Melittis melissophyllum, Potentilla micrantha, Tanacetum corymbosum* etc. Although *Festuca drymeja* can be important for some relevés, it is not as frequent as in the former association and mesophilous *Carex pilosa* and *Epimedium alpinum* are completely absent. These are mainly high, productive forests.

4.4.6 *Seslerio autumnalis-Quercetum petraeae* Poldini ex Poldini 1982 (Table 5, column 6)

Orig. (POLDINI 1982): *Seslerio autumnalis-Quercetum petraeae*

Syn.: *Seslerio autumnalis-Quercetum petraeae* Poldini 1964 nom. nud. [Art. 2b]

Cocktail definition: *Quercus petraea* agg. >25% AND *Sesleria autumnalis* >0% AND Group Luzula luzuloides

This submediterranean association of *Quercus petraea* has been described on flysch of the border area of Italy and Slovenia (POLDINI 1964, 1982); it is also known from western Istria in Croatia (TRINAJSTIĆ 2008). In B&H it is found in southern B&H (Mediterranean region) on the gabbro complex near Jablanica (VOJNIKOVIĆ 2001) (Fig. 2r) at altitudes between 400 and 700 m and very steep (35–40°) south and west facing slopes. *Quercus petraea* agg. dominates the tree layer, while *Sesleria autumnalis* is most abundant in the herb layer. The shrub layer is composed of thermophilous *Fraxinus ornus*, *Acer obtusatum* and *Sorbus torminalis*, as well as acidophilous *Genista tinctoria* and *Genista pilosa*. The herb layer is a mixture of thermophilous and acidophilous elements: *Asplenium adiantum-nigrum*, *Campanula persicifolia*, *Genista pilosa*, *Hieracium murorum*, *Lathyrus niger*, *Luzula luzuloides*, *Lychnis viscaria*, *Melittis melissophyllum*, *Potentilla micrantha*, *Pteridium aquilinum*, *Tanacetum corymbosum*, *Thymus pulegioides*, *Trifolium rubens* etc. There are also some meso-neutrophilous species: *Dactylis glomerata* s.l., *Fagus sylvatica*, *Milium effusum*, *Mycelis muralis*, *Solidago virgaurea* etc. These are mainly degraded high forests or coppices, occasionally used as wood pasture.

5. Discussion

5.1 General overview of syntaxa

The analysis of thermophilous deciduous forests of B&H provided a syntaxonomical scheme that ecologically and floristically depicts phytosociological relations within this group in B&H and neighboring countries, as well as their relations with other vegetation types in this region.

The most thermophilous association, one that is in contact with the evergreen Mediterranean vegetation of *Quercetea ilicis*, is the ***Querco pubescenti-Carpinetum orientalis*** (Fig. 4). It is a zonal vegetation of submediterranean Croatia, B&H and Montenegro (HORVAT 1950, 1963). To a much lesser extent it also occurs in Slovenia (ZUPANČIČ 1999). At the present time, this association covers a relatively modest proportion of what is potentially its domain, mostly because of various negative anthropogenic influences (fires, coppicing, browsing etc.), but, ironically, the preserved stands are for the most part those preserved by man (private old groves). A similar situation is reported for Croatia (VUKELIĆ 2012), where the highest proportion of this association is presented by its secondary succession stage, i.e., scrub dominated by *Carpinus orientalis*. As suggested by SURINA (2014), this secondary stage does not represent zonal vegetation in the NW Adriatic, which supported our decision to limit the understanding of *Querco pubescenti-Carpinetum orientalis* to old growth stands that obviously represent climax stages, which is congruent with the original diagnosis (HORVATIĆ 1939, 1963, HORVAT 1950). Additionally, it supported the acceptance of ***Rusco aculeati-Carpinetum orientalis***, a scrub association that results from degradation of *Querco pubescenti-Carpinetum orientalis* and occupies the greater part of its potential habitats. It was originally described from southern Montenegro (BLEČIĆ & LAKUŠIĆ 1967) and later from the Neretva River canyon in southern B&H (MURATSPAHIĆ et al. 1991). It was confirmed by field research from various localities in southern B&H (lower Herzegovina). This type of vegetation alternates with *šibljak* vegetation, dry grasslands and vegetation of rocky habitats, with which it often makes vegetation mosaics that are very hard to circumscribe and delimit.

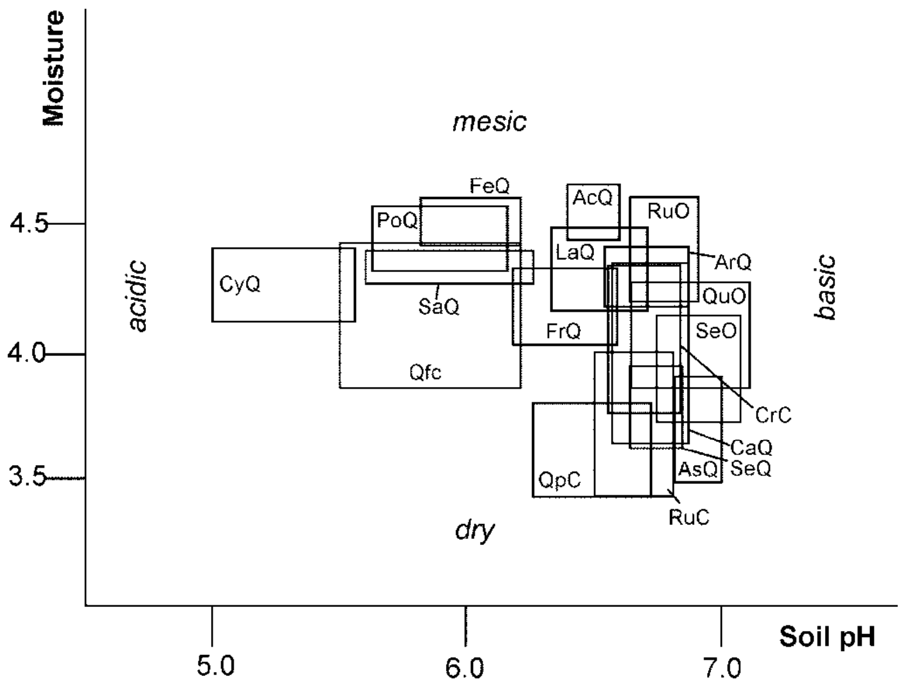

Fig. 4. Ecogram of associations of thermophilous deciduous forests of B&H using unweighted average species indicator values of the relevés for soil reaction and moisture (PIGNATTI et al. 2005). Figures for the drawing were taken from boxplot diagrams considering the first and third quartile (BAUER & BERGMEIER 2011). Association names abbreviated as in Figure 2.

Abb. 4. Ökogramm der Assoziationen thermophiler Laubwälder von B&H auf der Grundlage ungewichteter mittlerer Zeigerwerte von Vegetationsaufnahmen für Bodenreaktion und -feuchte (PIGNATTI et al. 2005). Die beruhen auf den ersten und dritten Quartilen von Boxplot-Diagrammen (BAUER & BERGMEIER 2011). Die Assoziationsnamen sind abgekürzt wie in Abbildung 2.

Deeper in the continent, on warm southerly exposed limestone and dolomite foothills, or in river canyons of central B&H (on mild to moderate slopes with not too shallow soil), we encountered an extrazonal variant of forest of *Quercus pubescens* and *Carpinus orientalis* and named it ***Carici hallerianae-Quercetum pubescentis***. Compared to *Querco pubescenti-Carpinetum orientalis* this type is poor in mediterranean elements (Table 2 and Supplement S1), but is also degraded and reduced to small patches, which was probably why it was not recognized earlier as an independent association in B&H. The largest proportion of its potential distribution is nowadays under secondary succession stages dominated by *Carpinus orientalis* i.e., ***Cruciato glabrae-Carpinetum orientalis,*** which is known from B&H mainly as *Carpinetum orientalis illyricum* and *Fraxino orni-Carpinetum orientalis* (FABIJANIĆ et al. 1963, STEFANOVIĆ 1964b, 1983, 1989). This degraded scrub has a relatively heterogenous floristic structure, since it is represented by various development phases and forms as a secondary succession stage on the habitats of several different forest types, i.e.: *Carici hallerianae-Quercetum pubescentis, Fraxino orni-Quercetum cerridis, Lathyro nigri-Quercetum petraeae, Aceri obtusati-Quercetum petraeae and Quercetum frainetto-cerridis.* The possible diversity of this association should be investigated by further research.

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While forests of ***Seslerio autumnalis-Quercetum pubescentis*** in Slovenia occur on decalcified deep soil over flysch (ZUPANČIČ 1999), in southern B&H they mainly form an altitudinal belt between *Querco pubescenti-Carpinetum orientalis* and beech forests at higher altitudes (700–1000 m; Fig. 3), also on deeper soil but over limestone and dolomite. Stands similar to these, but with significant cover of *Ostrya carpinifolia* in the tree layer found on steeper rocky slopes, were classified as ***Aristolochio luteae-Quercetum pubescentis***. This association was originally described as the subassociation *quercetosum pubescentis* of *Seslerio autumnalis-Ostryetum carpinifoliae* (HORVAT 1950) and later raised to association level *Ostryo-Quercetum pubescentis* (TRINAJSTIĆ 1977). Similar type was described from Italy (southern Alps) under the name *Fraxino orni-Ostryetum carpinifoliae* (BRAUN-BLANQUET 1961). Although traditionally understood as a mesothermophilous submediterranean association of *Quercus pubescens* without *Carpinus orientalis* and mediterranean elements, but with *Ostrya carpinifolia* (TRINAJSTIĆ 1977, ZUPANČIČ 1999), there has recently been no consensus about its circumscription. SURINA (2014) classified relevés similar to the *Querco-Carpinetum orientalis* (but with *Ostrya carpinifolia*) from the NW Adriatic region (W Croatia) into the *Aristolochio luteae-Quercetum pubescentis* and marked this ssociation as zonal for this region. On the other hand, VUKELIĆ (2012) included the complete association of *Seslerio autumnalis-Ostryetum carpinifoliae* (*Ostrya carpinifolia* dominated forests) along with all subassociations, not just *quercetosum pubescentis*, in the *Aristolochio luteae-Quercetum pubescentis*. While it can be argued whether typical stands of the *Seslerio autumnalis-Ostryetum carpinifoliae* just form secondary succession stages of the *Aristolochio-Quercetum pubescentis*, they are nevertheless floristically, physiognomically and ecologically distinct. What is the syntaxonomical position of the *Aristolochio luteae-Quercetum pubescentis* and its relation to the *Seslerio autumnalis-Quercetum pubescentis*, *Seslerio autumnalis-Ostryetum carpinifoliae* and *Querco pubescenti-Carpinetum orientalis* remains to be answered by systematic and comprehensive investigation of this type of vegetation in the whole submediterranean eastern Adriatic region.

Asparago tenuifolii-Quercetum pubescentis is a specific type of *Quercus pubescens* forest without *Carpinus orientalis* and submediterranean elements (Table 2, column 7, Supplement S2), which is found on flat to moderate slopes on limestone and dolomite of the mountains of northern B&H (Fig. 2g). This association shows a certain similarity to Central European *Quercus pubescens* forests of *Quercion pubescenti-petraeae* (WILLNER & GRABHERR 2007, CHYTRÝ 2013) and *Fraxino orni-Quercenion pubescentis* (BORHIDI et al. 2012). A similar association was reported from Dilj Mt. (Slavonia, NE Croatia) (ŠKVORC 2006), so we think that further studies of this forest type should be continued, but with greater focus on similar communities from Hungary, Slovakia, Czech Republic and Austria.

The *Asparago-Quercetum* is spatially connected to the ***Querco pubescenti-Ostryetum carpinifoliae,*** which is found on very steep, rocky southern slopes of limestone and dolomite outcrops of the northern Bosnian mountains (Fig. 2j), and also in central B&H (STEFANOVIĆ 1964b, LAKUŠIĆ et al. 1982a). HORVAT (1950, 1963) states that this association can be found in N B&H and NW Croatia, but it is also present in Slovenia (ZUPANČIČ et al. 2009) and in NW Serbia (JOVANOVIĆ 1967). Stands on milder slopes with deeper soil were distinguished as subass. *quercetosum petraeae* (HORVAT 1938) and later raised to the level of association, ***Lathyro nigri-Quercetum petraeae*** (HORVAT 1959). According to the original diagnosis, this association corresponds to mesothermophilous *Quercus petraea* forests on deeper soils (Fig. 4). Thermophilous and basophilous species, including *Ostrya carpinifolia* are dominant in floristic composition, but also several neutrophilous species and those that are slight acidity indicators can occur (Table 5, column 1). Some authors (VUKELIĆ 1990, BARIČEVIĆ et al. 2006b) included some stands of acido-thermophilous forests of the *Festuco drymejae-Quercetum petraeae lathyretosum nigrae* within the scope of this association, which is in opposition to the traditional concept of this syntaxon. In B&H, this type of forest often forms an altitudinal belt beneath thermophilous beech forests (*Aceri obtusati-Fagetum*) (REDŽIĆ 1986).

In NW B&H, in the zone in which continental and mediterranean climates interface, one rather peculiar community occurs (Fig. 2n). It brings together two species that stand for two opposing ecologies: mesophilous *Carpinus betulus* and xerothermophilous *Carpinus orientalis*. This newly described association, ***Aceri obtusati-Quercetum petraeae***, is regarded as a transitional association between thermophilous *Carpinion orientalis* and mesoneutrophilous *Carpinion betuli* (Table 5, column 2, Supplement S3). Similar communities had not previously been reported for B&H, probably because oak forests of this part of B&H were poorly studied in the past.

Pure *Ostrya carpinifolia* forests are represented by two associations, ***Seslerio autumnalis-Ostryetum carpinifoliae*** and ***Rusco aculeati-Ostryetum carpinifoliae***. The first is mainly considered to be a secondary succession stage either of *Aristolochio-Quercetum pubescentis* or *Seslerio-Fagetum* (TRINAJSTIĆ 1977, TRINAJSTIĆ & CEROVEČKI 1978, PUNCER & ZUPANČIČ 1982). Others consider it to be zonal (STEFANOVIĆ 1979a), or zonal only on steep dolomite slopes, where it is competitively stronger than *Quercus pubescens* or *Fagus sylvatica* (TRINAJSTIĆ 1977). Mesothermophilous *Rusco aculeati-Ostryetum carpinifoliae* (Fig. 4) develops as a permanent stage in the humid conditions of the canyons of W B&H, on very steep slopes over shallow and extremely rocky soil. It has been known from B&H and Serbia (STEFANOVIĆ 1964b, 1979a, TOMIĆ 2000, 2006) mainly under the pseudonym *Fraxino orni-Ostryetum carpinifoliae*. These communities are in spatial and syngenetic connection with polydominant ravine forests (STEFANOVIĆ 1979b).

In E B&H, with exclaves in central and southern areas of the country, the zonal central Balkan community of ***Quercetum frainetto-cerridis*** occurs (Fig. 2k). It can be considered to be zonal in E Bosnia (Transitional Illyrian-Moesian region), while in other parts it is extrazonal. This rather heterogenous association was originally described by RUDSKI (1949) for central Serbia, with three subassociations. Many subassociations and geographical variants were later described for the region of Serbia (JOVANOVIĆ & DUNJIĆ 1951, JOVANOVIĆ 1956, 1967, VUKIĆEVIĆ 1959). Their syntaxonomical status was not resolved until the present, since some authors gave them association status (JOVANOVIĆ 1997), while others only the status of geographical variants within *Quercetum frainetto-cerridis* (TOMIĆ & RAKONJAC 2013). As B&H authors treated it in the latter manner, we also accepted that view. Several variants have been reported in B&H (GLIŠIĆ 1956, FABIJANIĆ et al. 1967, STEFANOVIĆ & MANUŠEVA 1971, FUKAREK et al. 1974, STEFANOVIĆ 1988). This association was also reported from Croatia by TRINAJSTIĆ et al. (1996), who corrected its original illegitimate name "*Quercetum confertae-cerris serbicum*". In the southern B&H, FUKAREK (1966) described *Quercetum frainetto hercegovinum*, but analysis could not separate it from other *Quercetum frainetto-cerridis* forests.

The association ***Fraxino orni-Quercetum cerridis*** is the main type of forest vegetation in dry karst fields of W. and S. B&H (Fig. 2l). This main area of distribution has radiations in Croatia (TRINAJSTIĆ 2008, VUKELIĆ 2012). The association was originally described by STEFANOVIĆ (1968) in western B&H but, over time, it was repeatedly described from different localities in western and southern B&H by different names (FUKAREK 1970a, LAKUŠIĆ et al. 1978, Lakušić & Redžić 1989, 1991, Redžić & Barudanović 2010, Redžić 2011). A similar association has been reported from Hungary, where it primarily occurs on limestone and dolomite, but also on basalt (Kevey 2008, Borhidi et al. 2012). Forests in Serbia that are attributed to this association (Tomić et al. 2006, Tomić & Rakonjac 2013) are of different floristic composition and ecology and represent another community, i.e., *Quercetum cerris* (Vukićević 1966).

Finally, we included in the vegetation of thermophilous deciduous forests acido-thermophilous *Quercus petraea* forests, for the reasons already discussed in the introduction. They show the lowest values of the soil pH expresed through the floristic composition (Fig. 4). ***Cytiso hirsuti-Quercetum petraeae,*** formerly known as *Quercetum montanum illyricum* (Stefanović 1964a, 1984, Stefanović & Manuševa 1966, 1971, Stefanović et al. 1977a), is related to zonal dry-acidophilous *Quercion petraeo-cerridis* of central Balkan (Čarni et al. 2009). It is found on shallow dry soils of silicate bedrock (andesite, dacite, siliceous sandstone and schists) of E and C B&H, and Palaeozoic sediments (siliceous sandstone and schists) of N B&H (Fig. 2o). The association ***Festuco drymejae-Quercetum petraeae*** was originally described from Fruška gora (Serbia) (Janković & Mišić 1960, Janković 1968) and later reported from northern Croatia (Hruška-Dell'Uomo 1975, Baričević et al. 2006a). Some stands from northern Croatia reported as *Lathyro nigri-Quercetum petraeae* also belong to this association (Vukelić 1990, Baričević et al. 2006b). This association shows certain simmilarities to the slightly dryer and more acidophilous ***Potentillo micranthae-Quercetum petraeae*** (Fig. 4). It was originally described from Zrinska Gora (Croatia) (Vukelić et al. 2010), but some stands from NW Croatia, of what was formerly known as meso-acidophilous *Hieracio racemosi-Quercetum petraeae* sensu Vukelić 1991 (Vukelić 2012), also enter the scope of this association. The latter two associations comprise the group of north Dinaric-south Pannonian acido-thermophilous forests, which are widely distributed on siliceous low mountains and hills of peripannonian Croatia, B&H and Serbia. The association ***Seslerio autumnalis-Quercetum petraeae*** is known from only one locality in B&H (Vojniković 2001; Fig. 2r). It is interesting that it is found here on ultrabasic gabbro bedrock, while in Croatia, Slovenia and Italy it occurs on flysch (Poldini 1964, Zupančič 1999, Vukelić 2012). While this association has an acido-thermophilous character, its submediterranean distribution made most authors include it in *Quercion pubescenti-petraeae* (Vojniković 2001, Trinajstić 2008, Šilc & Čarni 2012, Vukelić 2012). More work is needed in B&H, as well in Croatia, in order to reveal its correct syntaxonomical position.

5.2 Problematic syntaxa

A thorough survey of the relevant literature yielded a list of syntaxa that had been reported for thermophilous deciduous forests of B&H, but could not be recognized during the analysis, either because they were mistakenly attributed to different syntaxa, or they do not belong to thermophilous deciduous forests, or there were no relevés in the database, or they simply do not exist on the territory of B&H.

Aceri paradoxi-Carpinetum orientalis Blečić et Lakušić 1967

The association of *Acer paradoxum* (= *Acer hyrcanum* subsp. *intermedium*) and *Carpinus orientalis* was originally described from the canyon of the Piva River in Montenegro (Blečić & Lakušić 1967). This association has been reported from several sites in B&H

(LAKUŠIĆ & REDŽIĆ 1991), where this name was mistakenly ascribed to *Cruciato glabrae-Carpinetum orientalis* (*Carpinetum orientalis illyricum*). Field research in the area of eastern B&H did not confirm this association but, bearing in mind that Piva canyon forms the borderline between B&H and Montenegro, the existence of *Aceri Carpinetum orientalis* should not be ruled out for the territory of B&H.

***Seslerio angustifoliae-Ostryetum carpinifoliae* Lakušić ex Lakušić et Redžić 1989**

Syn.: *Seslerio angustifoliae-Ostryetum carpinifoliae* Lakušić 1975 nom. ined. [Art. 1], *Seslerio angustifoliae-Ostryetum carpinifoliae* Lakušić et al. 1978 nom. nud. [Art. 2b], *Seslerio angustifoliae-Ostryetum carpinifoliae* Lakušić et al. 1982 nom. inval. [Art. 2b]

This association was reported for the river canyons around the city of Sarajevo (Miljacka, Željeznica and Prača), but without phytosociological relevés (LAKUŠIĆ et al. 1978). LAKUŠIĆ et al. (1982b) presented a synoptic table based on five relevés from the same localities. LAKUŠIĆ & REDŽIĆ (1989) eventually presented one relevé of this association, but from Derventa River canyon in western Serbia. The existence of this association in B&H is highly probable, but we did not conduct field research since these localities are mine contaminated.

***Carpino betuli-Ostryetum carpinifoliae* Lakušić et Redžić 1989**

This association was classified into thermophilous deciduous forests (REDŽIĆ 2011), but the only published relevé, together with the description (LAKUŠIĆ & REDŽIĆ 1989), suggest that this association belongs to ravine forests of *Tilio-Acerion*.

***Melampyro doerfleri-Ostryetum carpinifoliae* Lakušić et Redžić 1989**

Syn.: *Melampyro doerfleri-Ostryetum carpinifoliae* Lakušić 1968 nom. ined. [Art. 1]

Although REDŽIĆ (2011) listed this association for B&H, its occurence here is highly unlikely. The only relevé of this association was published from Montenegro (LAKUŠIĆ & REDŽIĆ 1989), and the species *Melampyrum doerfleri* is not reported for B&H.

***Corylo colurnae-Ostryetum carpinifoliae* Blečić 1958 nom. inval. [Art. 3b]**

This association could not be recognized from the data set. Some indications of its presence in B&H on Mt. Gatačka Bjelašnica (NE Herzegovina) were given by LAKUŠIĆ et al. (1978), but without relevés. It has been described from Montenegro, where it occurs at 1000–1200 m beneath beech-fir forests in karst sinkholes (BLEČIĆ 1958). It was designated as provisional, and its uncertain syntaxonomical position was pointed out. The herb layer for the most part consists of mesophilous species of beech-fir forests, while there are 16 species in the tree layer. It is probably connected to polydominant ravine forests of *Tilio-Acerion*.

Although without relevés, three associations of *Quercus trojana* forests were indicated for B&H (REDŽIĆ 2011): *Quercetum macedonicae* Em ex Horvat 1959, which was described from central Macedonia, *Quercetum trojanae montenegrinum* Blečić et Lakušić 1975 nom. nud. [Art. 2b], from south-eastern Montenegro, and *Pistacio-Quercetum trojanae* Redžić 2011 nom. nud. [Art. 2b]. However, although *Quercus trojana* is distributed in SE B&H, we could not confirm forests of it during the field research. It was found only as admixed species in other associations (*Seslerio-Quercetum pubescentis, Rusco-Carpinetum orientalis, Seslerio-Ostryetum*), but this certainly does not mean that such forests should be ruled out for B&H.

Finally, we provide a list of *nomina nuda* that were obtained from the literature, but could not be ascribed to synonymy with any of the previously treated syntaxa: *Rusco aculeati-Quercetum mixtum* Stefanović 1977, *Fraxino orni-Quercetum dalechampii* Lakušić et al. 1978, *Frangulo rupestris-Ostryetum carpinifoliae* Redžić, Barudanović et Đug in Redžić 2007, *Coronillo-Fraxinetum orni* Redžić, Đug et Barudanović in Redžić 2007, *Aceri obtusati-Ostryetum carpinifoliae* Redžić 2007, *Aceri obtusati-Quercetum dalechampii* Redžić 2007, *Quercetum pubescentis-dalechampii* Redžić 2011, *Asparago officinali-Quercetum roboris* Redžić 2011, *Seslerio autumnalis-Quercetum pubescentis* Redžić 2011, *Carpino orientalis-Quercetum pubescentis* Redžić 2011, *Rusco-Quercetum pubescentis* Redžić 2011, *Ostryo-Quercetum petraeae* Redžić 2011, *Melampyro trichocalycinae-Carpinetum orientalis* Redžić 2011, *Seslerio autumnalis-Carpinetum orientalis* Redžić 2011.

Erweiterte deutsche Zusammenfassung

Einleitung – Thermophile Laubwälder der Ordnung *Quercetalia pubescentis* nehmen etwa 20% der Waldfläche und 11 % der Landesfläche von Bosnien und Herzegowina (B&H) ein. Trotz ihrer großen Bedeutung hinsichtlich Fläche und Diversität gibt es zahlreiche bisher ungelöste Probleme bei der Gliederung und Benennung dieser Wälder, hauptsächlich wegen der schlechten pflanzensoziologischen Bearbeitung (vor dieser Studie waren aus dem ganzen Land nur 274 Vegetationsaufnahmen dieser Ordnung publiziert worden, und einige Waldtypen waren noch nicht nachgewiesen worden) und wegen der ungeklärten syntaxonomischen und nomenklatorischen Fragen. Die Hauptziele dieser Studie: durch intensive Geländearbeit Bearbeitungslücken von thermophilen Laubwäldern in B&H füllen; die Vegetationsaufnahmen nach formalen Kriterien klassifizieren; die Gültigkeit und Legitimität der existierenden Namen der Pflanzengesellschaften prüfen und ihre Namen gemäß der Regeln des ICPN korrigieren und typisieren.

Methoden – Die Cocktail-Methode (BRUELHEIDE 2000) wurde verwendet, um alle 673 Vegetationsaufnahmen der *Quercetalia pubescentis* aus B&H nach formalen Kriterien zu klassifizieren. Auf der Basis von Expertenwissen stellten wir 18 soziologische Artengruppen zusammen, die in Kombination mit den Deckungsanteilen einiger Arten und verknüpft mit den logischen Operatoren Und, Oder und Nicht formale Definitionen von 17 Zielassoziationen ergaben. Zu ihnen gehörten 483 Vegetationsaufnahmen des Ausgangsdatensatzes. Um auch die übrigen Aufnahmen, die durch Cocktail nicht oder nicht eindeutig klassifiziert werden konnten, zuordnen zu können, benutzten wir das Prinzip einer „teilkontrollierten" Klassifikation („*semi-supervised classification*", TICHÝ et al. 2014). Treuemaße der Arten – dafür verwendeten wir den phi-Koeffizienten (CHYTRÝ et al. 2002) – waren die Berechnungsgrundlage für die diagnostischen Arten, die zur Qualitätsbeurteilung der formalen Definitionen benutzt wurden.

Bei der Nomenklatur der Pflanzengesellschaften wie auch bei der Beschreibung neuer Syntaxa folgen wir strikt den Regeln des ICPN (WEBER et al. 2000). Der korrekte Name jeder Assoziation wurde ermittelt und die gesamte Synonymie verzeichnet. Für noch nicht typisierte Syntaxa wurden Lektotypten beziehungsweise Neotypen ausgewählt. Für nach Art. 5 ICPN ungültige Syntaxonnamen wurden Holotypen bezeichnet. Eine modifizierte Namensform – z. B. *nomen mutatum* – wurde anstelle eines Syntaxonnamens verwendet, der ursprünglich nach Taxonnamen gebildet worden war, die nicht mehr im Einklang mit der gegenwärtigen taxonomischen und floristischen Literatur sind. Die Diagnosen der neuen Assoziationen werden begleitet von Beschreibungen und pflanzensoziologischen Tabellen mit Angabe des Holotypus.

Ergebnisse und Diskussion – Mittels der Cocktail-Methode ließen sich die thermophilen Laubwälder von B&H in 17 Zielassoziationen klassifizieren. Der „teilkontrollierte" Ansatz erbrachte zusätzlich eine weitere ökologisch und floristisch klar definierte Assoziation, welche als neu erkannt und als *Aceri obtusati-Quercetum petraeae* beschrieben wurde. Da es das Hauptziel dieser Arbeit war, die thermophilen Laubwälder von B&H formal zu klassifizieren, sind wir den Verbandszugehörigkeiten der Assoziationen nicht nachgegangen; dies bleibt einer geographisch breiter angelegten Studie jenseits unserer Fragestellung vorbehalten. Wir haben die Assoziationen stattdessen auf der Basis der dominierenden Baumarten gruppiert, um so Unterschiede in der Artenzusammensetzung von Assoziationen mit gleicher Hauptbaumart aufzuzeigen. Die Assoziationen gehören vier Gruppen an: (*i*) Assoziationsgruppe dominiert von *Quercus pubescens* und/oder *Carpinus orientalis*, (*ii*) Assoziationsgruppe dominiert von *Ostrya carpinifolia*, (*iii*) Assoziationsgruppe dominiert von *Quercus frainetto* und/oder *Quercus cerris* and (*iv*) Assoziationsgruppe dominiert von *Quercus petraea* agg.

Zusätzlich zu einer kurzen Beschreibung jeder Assoziation verdeutlichen Übersichtstabellen (Tabellen 2–5) die floristischen Unterschiede und Ähnlichkeiten zwischen den Assoziationen und Gruppen. Die Verteilung der Vegetationsaufnahmen der einzelnen Assoziationen zeigt eine Karte (Fig. 2). Die Höhenzonierung und die Verbreitung der Assoziationen in den biogeographischen Regionen von B&H wird in Figure 3 veranschaulicht. Die größte Zahl an Assoziationen (13) gibt es in der mediterranen Region; die dinarische und die prä-pannonische Region weisen jeweils 10 Assoziationen auf, während es in der illyrisch-moesischen Übergangsregion nur 5 Assoziationen sind. Die größte Höhenspanne – sie schließt die höchstgelegenen thermophilen Laubwälder ein – hat die mediterrane Region (130–1030 m), gefolgt von der dinarischen (310–1000 m), illyrisch-moesischen (190–880 m) und der prä-pannonischen Region (250–780 m). Figure 4 zeigt ein Ökogramm mit der relativen ökologischen Einnischung jeder Assoziation entlang von Bodenazidität und -feuchte. Gruppe *i* umfasst thermophil-basiphytische Wälder, Gruppe *ii* ist mesophil-basiphytisch, Gruppe *iii* intermediär, und Gruppe *iv* mesophil und tendenziell azidophytisch.

Syntaxonomische Synopsis:

Assoziationen dominiert von *Quercus pubescens* und/oder *Carpinus orientalis*

1. *Querco pubescenti-Carpinetum orientalis* Horvatić 1939
2. *Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967
3. *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco
4. *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. ass. nov. hoc loco
5. *Seslerio autumnalis-Quercetum pubescentis* Zupančič 1999
6. *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini 2008
7. *Asparago tenuifolii-Quercetum pubescentis* Lakušić et Redžić 1991

Assoziationen dominiert von *Ostrya carpinifolia*

8. *Seslerio autumnalis-Ostryetum carpinifoliae* Horvat et Horvatić ex Horvat 1959
9. *Rusco aculeati-Ostryetum carpinifoliae* Lakušić et Redžić ex Stupar et al. ass. nov. hoc loco
10. *Querco pubescenti-Ostryetum carpinifoliae* Horvat 1938

Assoziationen dominiert von *Quercus frainetto* und/oder *Quercus cerris*

11. *Quercetum frainetto-cerridis* (Rudski 1949) Trinajstić et al. 1996
12. *Fraxino orni-Quercetum cerridis* Stefanović 1968

Assoziationen dominiert von *Quercus petraea* agg.

13. *Lathyro nigri-Quercetum petraeae* Horvat (1938) 1959
14. *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco
15. *Cytiso hirsuti-Quercetum petraeae* (Stefanović 1964) Pallas in Bohn et Neuhäusl 2004
16. *Festuco drymejae-Quercetum petraeae* (Janković et Mišić 1960) Janković 1968
17. *Potentillo micranthae-Quercetum petraeae* Vukelić et al. ex Vukelić, Baričević et Šapić ass. nov. hoc loco
18. *Seslerio autumnalis-Quercetum petraeae* Poldini ex Poldini 1982

Obwohl diese Studie der thermophilen Laubwälder von B&H ein Schema ergeben hat, bei dem die Syntaxa in ökologischer und floristischer Hinsicht die pflanzensoziologischen Beziehungen innerhalb von B&H wie auch zu benachbarten Ländern widerspiegeln, bleiben eine Reihe von Problemen, denen man sich zuwenden sollte. Weitere Forschung ist insbesondere nötig, um die Diversitätsmuster der eher heterogenen Assoziationen *Quercetum frainetto-cerridis* und *Cruciato glabrae-Carpinetum orientalis* zu erhellen. Der syntaxonomische Status und die Umschreibung des *Aristolochio luteae-Quercetum pubescentis* bedürfen der Neubewertung.

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Supplements

Supplement S1. *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco, holotypus: relevé 4.

Beilage S1. *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco, Holotypus: Aufnahme 4.

Supplement S2. *Asparago tenuifolii-Quercetum pubescentis.*

Beilage S2. *Asparago tenuifolii-Quercetum pubescentis.*

Supplement S3. *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco, holotypus: relevé 9.

Beilage S3. *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco, Holotypus: Aufnahme 9.

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.

Supplement E1. List of species merged to aggregates (agg.), broadly defined taxa (s.l.) or taxa deviating from TUTIN et al. (1968–1993) or not included therein.

Anhang E1. Liste der zu Aggregaten (agg.) zusammengefassten, weit definierten (s.l.) oder von TUTIN et al. (1968–1993) abweichenden bzw. dort nicht enthaltenen Taxa.

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3 DISCUSSION AND CONCLUSIONS

3.1 DISCUSSION

3.1.1 TDF communities in the framework of the zonal forest vegetation of B&H

Floristic analysis of ZFPCs in B&H showed that seven ZFPCs can be clearly separated. **Community 1** (*Quercus ilex* maquis) that occupies only a small area (about 20 km^2) in the coastal region of B&H is represented by the secondary succession stage of the eastern Adriatic eu-Mediterranean zonal association *Fraxino orni-Quercetum ilicis* (Kutleša and Lakušić, 1964). Diagnostic species are mainly of Stenomediterranean, Eurimediterranean and south and southeast European chorotypes. Diagnostic herb species are mainly indicators of rocky habitats due to structural degradation. **Community 2** (*Quercus pubescens-Carpinus orientalis* forests) is represented by high, not degraded stands of zonal thermophilous deciduous forest of the association *Querco pubescenti-Carpinetum orientalis* found in the lowlands and hilly area of sub-Mediterranean B&H. Diagnostic species are thermophilous and xerophilous plants of mainly S/SE European or Eurimediterranean distribution, although some widespread nemoral forest herbs and shrubs appear with high frequency, e.g.: *Brachypodium sylvaticum, Dactylis glomerata, Veronica chamaedrys, Crataegus monogyna, Hedera helix* etc., which indicate more mesophilous microclimatic conditions under the closed canopy. **Community 3** (*Quercus frainetto* forests) is characteristic for the colline belt of the eastern parts of B&H, where the influence of the continental dryer climate increases. It is a zonal community of Central Balkans lowlands and hilly areas (Horvat et al., 1974) and it is represented by the fairly heterogeneous association *Quercetum frainetto-cerridis* (Tomić and Rakonjac, 2013). They are dominated by a mixture of thermophilous, acid tolerant and widespread nemoral forest species, as well as some more light-demanding herbs, indicating wood-pasture and cutting. **Community 4** is represented by sessile oak-common hornbeam forests, which are considered a zonal forest vegetation community for the area of NW Balkans (*Quercus petraea-Carpinus betulus* forests). In B&H they are found mainly in the hilly area of northern parts of the country but can also penetrate deeper into south (e.g., Central Bosnian basin). They are often, due to bad management, structurally degraded to *Carpinus betulus* coppice. Diagnostic species are mainly represented by mesophilous European and Eurasian elements. **Community 5** (pure *Fagus* / mixed *Fagus-Abies* forests) represents the first altitudinal belt above oak forests and is made up of mesoneutrophilous montane pure beech, as well as mixed fir-beech forests. Floristically and ecologically similar to this type is **Community 6** (mixed *Picea-Abies-Fagus* forests), which also has a considerable amount of Boreal and south European orophytic elements. In the view of Beus (1984), which is supported by our results, the main difference between Community 6 and the previous one is that Community 6 has a higher proportion of spruce (100% frequency) and acidophilous *Vaccinio-Piceetea* species, while the proportion of mesoneutrophilous

Aremonio-Fagion species is remarkably lower. **Community 7** is the highest altitudinal belt, represented by subalpine *Fagus sylvatica* forests. These are mainly mesoneutrophilous pure beech forests found mainly on the mountains of the central and southern chains of Dinaric Alps (Fig.1). This community harbors the highest proportion (32%) of Boreal and south European orophytic elements.

While for the main part this classification of ZFPCs in B&H is congruent with the views of the main authorities (Horvat et al., 1974; Stefanović et al., 1983; Beus, 1984), there are still some issues that need to be addressed, in particular the position and scope of Communities 5 and 6. In the view of Stefanović et al. (1983), there are three altitudinal belts in this group, i.e., they split Community 5 into two zonal communities: pure beech (*Fagetum montanum illyricum*) and mixed beech-fir (*Abieti-Fagetum dinaricum*) forests. However, Beus (1984) suggests that pure beech forests are only of a secondary origin, i.e., they appeared after removal of fir from the mixed beech-fir forests. He argues that there are no significant floristic differences between two communities, which is also supported by our results. Furthermore, he stresses the difference between Community 6 (mixed beech-fir-spruce forests) and Community 5. Community 6 has a higher proportion of spruce (100% frequency) and acidophilous *Vaccinio-Piceetea* species, while the proportion of mesoneutrophilous *Aremonio-Fagion* species is remarkably lower. This is also congruent with our results. However, it should be pointed out that Horvat et al. (1974) took different approach, differentiating pure beech forests as a separate belt, and joining beech-fir forests with beech-fir-spruce forests.

Functional analysis of ecological strategies showed small overall differences between ZFPCs. Based on the communities' location on the CSR triangle, competitive strategy (C) is dominant in all seven communities, followed by CSR and SC strategies. Considering the course of succession, site production is high (Grime, 1974), while the importance of ruderality is insignificant, which indicates late stages of succession (except in the case of *Quercus ilex* maquis), as pointed out by Prévosto et al. (2011).

The most significant differences in functional traits of a life form were detected for Phanerophytes, Geophytes and Hemicryptophytes. There is a greater share of woody species in the more thermophilous vegetation types, which corresponds with the statement that 'the Phanerophyte is the plant type that belongs to warm regions' (Raunkiaer, 1934). Similar results were obtained in the study of the gradient from warm to mesic temperate forests on the Galičica mountain range in Macedonia (Čarni et al., 2015). The proportion of Geophytes is higher in Communities 5–7 (beech dominated forests), which are besides spring ephemerals (mainly bulbous Geophytes), abundant also in the oak communities (Popović et al., 2015), harbor a considerable number of non-ephemeral rhizomatous ferns and species from the family Liliaceae. This is congruent with the notion that rhizomatous

Geophytes are adapted to life in regions with a severe unfavorable period (e.g., hard winters), but have at the same time a long period of vegetation (Raunkiaer, 1934).

Our study strongly suggests macro-climatically based differentiation of ZFPCs in B&H. While gradient analysis reveales a major influence of climatic factors on the species turnover, there is little or no impact of topographic (slope and aspect) or edaphic conditions, which is congruent with the traditional understanding of zonal vegetation (Dierschke, 1994; Ellenberg, 2009; Surina, 2014). Macro-climatic gradient is supported by the significant correlation with the geographic factors (altitude, longitude and latitude), which are all determinants of climate on a larger scale (Ellenberg, 2009; Adams, 2010).

3.1.2 Syntaxonomical position of transitional acido-thermophilous communities dominated by *Quercus petraea* agg. in Pre-Pannonian Western Balkans

Numerical classification of all available relevés from Western Balkans assigned by their authors both to the TDF of the class *Quercetea pubescentis* as well as to the mesic-acidophilous forests of alliance *Quercion roboris* from the class *Quercetea robori-petraeae* (around 2500 relevés from literature supplemented by our 399 unpublished relevés taken in the field in TDF in B&H) yielded nine ecologically sound clusters of relevés (vegetation types) (Figure 4). They formed three major ecological groups: 1) basophilous and thermophilous communities dominated by *Quercus pubescens, Carpinus orientalis* and *Ostrya carpinifolia* (clusters 1–3); 2) slightly to moderately acidophilous and thermophilous communities of *Quercus frainetto, Q. petraea* agg. and *Q. cerris* (clusters 4–6, with cluster 6 being a group of transitional acido-thermophilous relevés); and 3) mesophilous and meso-acidophilous communities on acidic bedrock from the western part of the region with higher precipitation, dominated by *Quercus petraea* agg.*, Castanea sativa* and *Betula pendula* (clusters 7–9).

Transitional acido-thermophilous communities (cluster 6 inside the group 2) are represented by highly productive forests of *Quercus petraea* agg. with relatively closed canopy (mostly over 80%). The shrub layer is poorly developed, with the exception of *Fraxinus ornus* and sometimes *Sorbus torminalis*. These forests floristically combine attributes of thermophilous, acidophilous and mesophilous *Quercus petraea* forests. Besides *Quercus petraea* agg. and *Fraxinus ornus, Dactylis glomerata* s.l., *Lathyrus niger* and *Festuca heterophylla* are constant. Comparison of diagnostic species of these communities with meso-acidophilous and mesophilous communities (group 3) showed that the former are characterized by species that are mostly thermophilous and/or have a southeast European distribution (e.g. *Fraxinus ornus, Dactylis glomerata* s.l.*, Lathyrus niger, Festuca drymeja, Sorbus torminalis, Melittis melissophyllum* s.l.*, Campanula persicifolia, Vincetoxicum hirundinaria, Tanacetum corymbosum*) with a lack of indicators of highly acidic soils, while the latter are characterized by species indicating strongly acidic soil and somewhat lower air temperature, generally with a wider European or Eurasian distribution pattern (e.g. *Calluna vulgaris, Vaccinium myrtillus, Betula pendula, Potentilla erecta, Pteridium aquilinum*). These results supported the view that transitional acido-thermophilous communities (cluster 6) should be, together with clusters 1–5, classified within TDF of the class *Quercetea pubescentis.* Acido-thermophilous communities are also transitional to mesophilous beech or oak-hornbeam forests and often occur nearby. Usually they occupy warmer aspects and the upper parts of moderate to steep slopes above beech or oak-hornbeam forests, which suggests that they represents an edaphic climax. The fact that mesophilous trees *Carpinus betulus, Fagus sylvatica* and *Prunus avium* are frequent in this type, but always in the sapling or lower shrub layer with poor vitality and very low coverage, supports the assumption that the edaphic conditions are not favorable for mesophilous communities to develop even though the canopy is usually relatively closed. Similar transitional communities are known from Central Europe (e.g. the associations *Sorbo torminalis-Quercetum petraeae* and *Melico pictae-Quercetum roboris*), where they are also classified into the class *Quercetea pubescentis* (alliance *Quercion petraeae*; Roleček, 2013), from which our communities are differentiated by some characteristic species with a southeast European distribution pattern, e.g., *Fraxinus ornus, Hieracium racemosum* and *Festuca drymeja.*

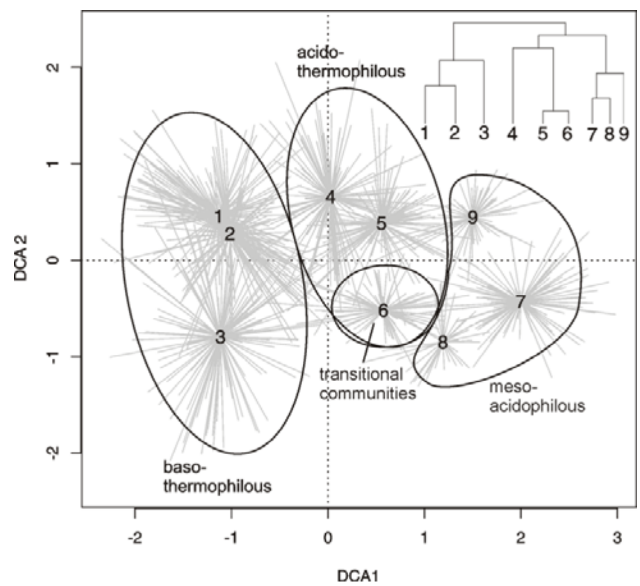

Figure 4: DCA spider plot of the resampled dataset (968 relevés). Centroids of clusters are indicated by their numbers. The classification dendrogram is shown in the upper right corner.

3.1.3 Vegetation types of TDF in the Western Balkans

Our analysis classified TDF of the Western Balkans into six types reflecting the main broad-scale ecological and phytogeographical patterns in species composition within the study area:

Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis*. This type includes mainly structurally degraded coppices of *Quercus pubescens* and *Carpinus orientalis,* which are often further degraded to pure *Carpinus orientalis* scrub. Very rarely can they be found as high forests. Two variants can be distinguished within this cluster, based on the floristic composition and spatial distribution: 1) zonal sub-Mediterranean communities with several species characteristic of the warmer belt closer to the Adriatic coast (e.g. *Asparagus acutifolius, Clematis flammula, Cyclamen hederifolium, Juniperus oxycedrus, Smilax aspera, Phillyrea latifolia, Pistacia terebinthus*); and 2) extrazonal, continental communities, which are also found in warmer sites (typically river canyons and gorges) but lack the aforementioned species (Fukarek, 1975; Stefanović, 1989). This type is widespread on calcareous bedrock in the sub-Mediterranean regions of the Balkan and Apennine peninsulas (Horvat et al., 1974; Lakušić et al., 1982b; Stefanović, 1983; Poldini, 1988; Blasi et al., 2004; Čarni et al., 2009). All published relevés classified to this type were originally assigned to the alliance *Carpinion orientalis*.

Type 2: Sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis*. This type comprises relevés similar to the extrazonal variant of **type 1** but generally without *Carpinus orientalis*. They are represented by structurally degraded high forests or coppices and characterized by species of more open habitats, such as *Helleborus multifidus* s.l.*, Brachypodium pinnatum* s.l.*, Geranium sanguineum, Inula hirta, Carex humilis, Teucrium chamaedrys*. Other diagnostic species are *Sesleria autumnalis* and *Carex flacca* s.l., while constant species are *Quercus pubescens*, *Fraxinus ornus* and *Crataegus monogyna*. It appears on southerly exposed sites on carbonate bedrock in continental regions, while in the sub-Mediterranean regions it appears as zonal at lower altitudes in the north (especially in Slovenia) but can reach up to 1100 m a.s.l. on south facing slopes in B&H. Published relevés classified to this type were originally assigned mostly to *Carpinion orientalis*, but also to *Quercion pubescenti-petraeae* (particularly those from more continental regions).

Type 3: Meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*. Although these forests are mainly coppices, they tend to maintain closed canopy and similar floristic composition as natural non-coppiced stands, if not heavily disturbed. As they usually occupy steep rocky limestone and dolomite slopes with thin soil layer, where *Ostrya* is competitively stronger than *Quercus pubescens*, they are regarded as edaphic climax communities. In canyon systems along the Dinaric arc, where they are accompanied by various local endemic relict species (Tomić, 1980, 2000) they are also considered natural relict communities. In sub-Mediterranean region they can be found as an altitudinal belt above *Quercus pubescens-Carpinus orientalis* communities, or even as secondary successional stages of those forests (Trinajstić and Cerovečki, 1978; Puncer and Zupančič, 1982; Trinajstić, 1982). On carbonate outcrops in continental regions (northern parts of Slovenia, Croatia and B&H), they are found as a more mesophilous edaphic climax (association *Querco-Ostryetum*; Horvat, 1963). There are many diagnostic species for this type, some of them indicating limestone outcrops, some are relicts and local endemics and others are related to dolomite bedrock and the class *Erico-Pinetea*. *Ostrya carpinifolia, Fraxinus ornus* and *Cornus mas* are constant species of the tree and shrub layer. Published relevés were originally assigned to the alliances *Fraxino orni-Ostryion* or *Carpinion orientalis,* depending on the adopted syntaxonomical concept: while some authors consider *Fraxino orni-Ostryion* to be an independent alliance (Tomić, 1980; Lakušić et al., 1982b; Čarni et al., 2009; Tomić and Rakonjac, 2013), others consider it to be a part of or synonymous with *Carpinion orientalis* sensu lato (Stefanović, 1979a; Trinajstić, 2008; Šilc and Čarni, 2012; Vukelić, 2012).

Type 4: Thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris*. Forests of this type are usually structurally degraded high forests and coppices. *Physospermum cornubiense, Acer tataricum* and *Paeonia mascula* are diagnostic species, while *Quercus frainetto*, *Quercus cerris, Fraxinus ornus, Crataegus monogyna* and *Fragaria vesca* are constant. This type is found at lower altitudes (200–500 m), mainly on bedrock with a slightly acidic to neutral soil reaction. The stands are warm and open, with the center of distribution in the central Balkans (Serbia, Bulgaria, Macedonia), where they form climax vegetation (Horvat et al., 1974; Jovanović, 1997). Typical communities dominated by *Quercus frainetto* can be found in the eastern and northeastern parts of B&H and in eastern Slavonia in Croatia, as the last outposts of the *Quercus frainetto* in the northwestern direction (Glišić, 1956; Fukarek et al., 1974; Stefanović, 1988; Trinajstić et al., 1996). They also occur extrazonally on deeper soils in the sub-Mediterranean Herzegovina (B&H; Fukarek, 1966), while they reach their westernmost limit probably in northern Dalmatia (Croatia; Trinajstić, 2008). Most relevés of this type are traditionally classified within the *Quercion frainetto* alliance.

Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* agg. and/or *Quercus cerris*. This type comprises relevés of structurally degraded high forests or coppices dominated by *Quercus petraea* agg. and *Quercus cerris*, mainly over siliceous bedrock. Species characteristic for this type (e.g. *Veronica officinalis, Chamaespartium sagittale, Genista pilosa, Hieracium praealtum* subsp. *bauhinii*) indicate dry soils with low pH and low nutrient content. *Quercus petraea* agg., *Quercus cerris, Fraxinus ornus* and *Fragaria vesca* are constant. Similarly to **type 4***,* this type is of central Balkan distribution

(Serbia, Macedonia, eastern B&H), and contains a significant percentage of endemic Balkan chorotypes. While in the northern and northwestern parts of the distribution area this type occupies warmer sites at lower altitudes (500–800 m), in the central and southern parts of its range it forms the altitudinal belt above forests of *Quercion frainetto* (**type 4**; Em, 1964; Tomić et al., 2006). It can reach up to 1400 m and is characterized by a cooler and damper microclimate and more acidic soil reaction compared to **type 4**. Relevés of this type mainly correspond to the alliance *Quercion petraeo-cerridis* (Čarni et al., 2009).

Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests. Since this transitional type floristically combines attributes of thermophilous, acidophilous and mesophilous *Quercus petraea* forests, diagnostic species (inside TDF of the Western Balkans) are mainly mesophilous and acidophilous (e.g. *Hieracium racemosum, Festuca drymeja, Carpinus betulus* (only with very low abundance in the sapling layer), *Melampyrum pratense, Carex pilosa* and *Luzula luzuloides*). Relevés of this group have traditionally been mainly assigned to the meso-acidophilous *Quercion roboris* (Stefanović et al., 1977a; Stefanović, 1984; Vukelić, 1991; Kevey and Borhidi, 2005; Baričević et al., 2006a; Vukelić et al., 2010) and relevés of more thermophilous stands to *Quercion pubescenti-petraeae* (Baričević et al., 2006b). However, our results suggest that syntaxonomical position of these forests should be revised (considering their relations to central European *Quercion petraeae* and central Balkan *Quercion petraeo-cerridis*).

3.1.4 Ecological gradients within TDF in the Western Balkans

Detrended correspondence analysis (DCA) of TDF relevés showed that variation in species composition mainly follows the geographical southwest-northeast gradient, reflecting the broad-scale ecological (macroclimatic and geological) and phytogeographical (turnover of dominant tree species) gradients. The first DCA axis can be interpreted as a complex geographical southwest-northeast gradient (Figure 5), expressed by the turnover of the dominant tree species, climate and geological substrates (which is reflected through the calculated EIVs (ecological indicator values) for soil reaction). It runs from basophilous forests dominated by *Quercus pubescens, Carpinus orientalis* and *Ostrya carpinifolia* (**types 1–3**), occurring in the southern and western parts of the investigated area on carbonate bedrock to slightly to moderately acidophilous forests dominated by *Quercus frainetto, Q. petraea* and *Q. cerris* (**types 4–6**), occurring in the northern and eastern parts of the investigated area with acidic, siliceous bedrock. This gradient is also positively correlated with annual precipitation and negatively with the temperature annual range. However, since the majority of rainfall in southwestern part falls during the winter, we suggest this variable is not connected with the variation in the floristic composition and it merely corresponds to the southwest-northeast geographical gradient. Another variable that probably derives from southwest-northeast geographical pattern is temperature annual range (i.e., the difference between the maximum temperature of the warmest month and the minimum temperature of the coldest month). This is basically a measure of climatic continentality and runs from smaller differences in southern and western parts of the area to larger differences (i.e., pronounced continentality) in eastern and northern parts of the investigated area.

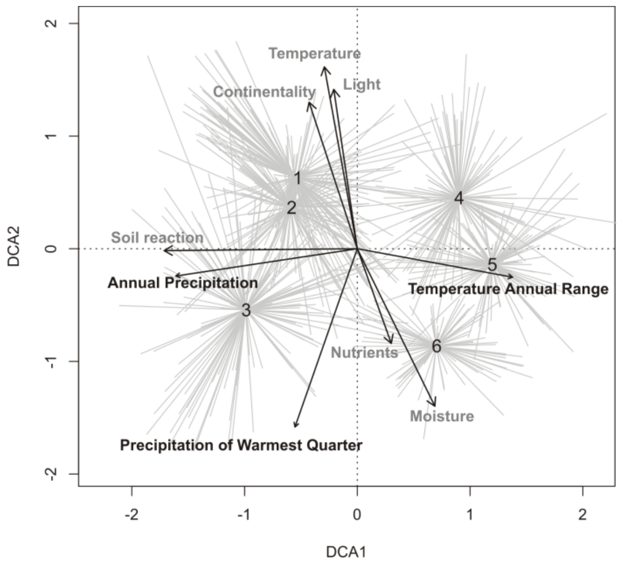

Figure 5: DCA spider plot of 735 classified relevés of TDF with EIVs and climatic variables passively projected. Centroids of clusters are indicated by TDF type numbers.

The gradient along the second DCA axis runs from meso-thermophilous closed canopy forests to xero-thermophilous open canopy forests. It can be interpreted as a microclimatic light/humidity/temperature gradient which mainly reflects local management practice, level of disturbance and the hemeroby of particular sites. **Types 1, 2** and **4**, which are often overexploited, coppiced, grazed and browsed, susceptible to fires etc., thus have more open canopies (Horvat et al., 1974; Stefanović et al., 1977b; Jovanović, 1997; Vukelić, 2012) are on the lighter, dryer and warmer end of this gradient. Due to the macroclimatic conditions of these communities (mostly summer drought), these forests are more easily degraded and maintained in open-canopy state than forests in more humid macroclimatic conditions. Acido-thermophilous *Quercus petraea* dominated communities (**type 6**), on the other hand, which are mostly well managed, with a closed canopy (mostly over 80%), are at the darker end of the light gradient, so they can be perceived as the least disturbed TDF. Forests of *Ostrya carpinifolia* (**type 3**) are also less light demanding (Tomić, 2006). They either thrive on north facing slopes or are found in inaccessible places, such as canyons, and thus are not subjected to exploitation of any kind. As a result they have preserved canopies, which contributes to their pronounced mesophilous character.

3.1.5 Formalized classification of TDF in B&H

The analysis of thermophilous deciduous forests of B&H provided syntaxonomical scheme with 18 associations that ecologically and floristically depicts phytosociological relations within this group in B&H and neighboring countries, as well as their relations with other vegetation types in this region.

***Querco pubescenti-Carpinetum orientalis* Horvatić 1939** is the most thermophilous association, one that is in contact with the evergreen mediterraenean vegetation of *Quercetea ilicis*. It is zonal vegetation of submediterranean Croatia, B&H and Montenegro (Horvat, 1950, 1963). To a much lesser extent it also occurs in Slovenia (Zupančič, 1999). At the present time, this association covers a relatively modest proportion of what is potentially its domain, mostly because of various negative anthropogenic influences (fires, coppicing, browsing etc.), but, ironically, the preserved stands are for the most part those preserved by man (private old groves). A similar situation is reported for Croatia (Vukelić, 2012), where the highest proportion of this association is presented by its secondary succession stage, i.e., scrub dominated by *Carpinus orientalis*.

***Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967** is a scrub association that results from degradation of *Querco pubescenti-Carpinetum orientalis* and occupies the greater part of its potential habitats. It was originally described from southern Montenegro (Blečić and Lakušić, 1967) and later from the Neretva River canyon in southern B&H (Muratspahić et al., 1991). It was confirmed by field research from various localities in southern B&H (lower Herzegovina). This type of vegetation alternates with *šibljak* vegetation, dry grasslands and vegetation of rocky habitats, with which it often makes vegetation mosaics that are very hard to circumscribe and delimit.

***Carici hallerianae-Quercetum pubescentis* Stupar et al. 2015** is an extrazonal variant of forest of *Quercus pubescens* and *Carpinus orientalis* which occurs deeper in the continent, on warm southerly exposed limestone and dolomite foothills, or in river canyons of central B&H (on mild to moderate slopes with not too shallow soil). Compared to *Querco pubescenti-Carpinetum orientalis* this type is poor in mediterranean elements, but is also degraded and reduced to small patches, which is probably why it was not recognized earlier as an independent association in B&H.

***Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015** presents continental secondary succession stages dominated by *Carpinus orientalis*. This degraded scrub has a relatively heterogeneous floristic structure, since it is represented by various development phases and forms as a secondary succession stage on the habitats of several different forest types, i.e.: *Carici hallerianae-Quercetum pubescentis, Fraxino orni-Quercetum cerridis, Lathyro nigri-Quercetum petraeae, Aceri obtusati-Quercetum* *petraeae and Quercetum frainetto-cerridis*. The possible diversity of this association should be investigated by further research.

Seslerio autumnalis-Quercetum pubescentis **Zupančič 1999** occur on decalcified deep soil over flysch in Slovenia (Zupančič, 1999), yet in southern B&H they are found also on deeper soil but over limestone and dolomite. They mainly form an altitudinal belt between *Querco pubescenti-Carpinetum orientalis* and beech forests at higher altitudes (700-1000 m).

Aristolochio luteae-Quercetum pubescentis **(Horvat 1959) Poldini 2008** is association similar to *Seslerio autumnalis-Quercetum pubescentis*, but with significant cover of *Ostrya carpinifolia* in the tree layer, and usually found on steeper rocky slopes. This association was originally described as the subassociation *quercetosum pubescentis* of *Seslerio autumnalis-Ostryetum carpinifoliae* (Horvat, 1950) and later raised to association level *Ostryo-Quercetum pubescentis* (Trinajstić, 1977). Its syntaxonomical position and its relation to *Seslerio autumnalis-Quercetum pubescentis*, *Seslerio autumnalis-Ostryetum carpinifoliae* and *Querco pubescenti-Carpinetum orientalis* are not clear (Trinajstić, 1977; Zupančič, 1999; Surina, 2014) and remain to be answered by systematic and comprehensive investigation of this type of vegetation in the whole submediterranean eastern Adriatic region.

Asparago tenuifolii-Quercetum pubescentis **Lakušić et Redžić 1991** is a specific type of *Quercus pubescens* forest without *Carpinus orientalis* and submediterranean elements, which is found on flat to moderate slopes on limestone and dolomite of the mountains of northern B&H. This association shows a certain similarity to Central European *Quercus pubescens* forests of *Quercion pubescenti-petraeae* (Willner and Grabherr, 2007; Chytrý, 2013) and *Fraxino orni-Quercenion pubescentis* (Borhidi et al., 2012). A similar association was reported from Dilj Mt. (Slavonia, NE Croatia) (Škvorc, 2006), so the further studies of this forest type should be continued, but with greater focus on similar communities from Hungary, Slovakia, Czech Republic and Austria.

Seslerio autumnalis-Ostryetum carpinifoliae **Horvat et Horvatić ex Horvat 1959** is a pure *Ostrya carpinifolia* association mainly considered to be a secondary succession stage either of *Aristolochio-Quercetum pubescentis* or *Seslerio-Fagetum* (Trinajstić, 1977; Trinajstić and Cerovečki, 1978; Puncer and Zupančič, 1982). Others consider it to be zonal (Stefanović, 1979a), or zonal only on steep dolomite slopes, where it is competitively stronger than *Quercus pubescens* or *Fagus sylvatica* (Trinajstić, 1977).

Rusco aculeati-Ostryetum carpinifoliae **Lakušić et Redžić ex Stupar et al. 2015** is mesothermophilous pure *Ostrya carpinifolia* association that develops as a permanent stage in the humid conditions of the canyons of W B&H, on very steep slopes over shallow and extremely rocky soil. It has been known from B&H and Serbia (Stefanović, 1964b, 1979a; Tomić, 2000, 2006) mainly under the pseudonym *Fraxino orni-Ostryetum carpinifoliae*. These communities are in spatial and syngenetic connection with polydominant ravine forests (Stefanović, 1979b).

Querco pubescenti-Ostryetum carpinifoliae **Horvat 1938** is found on very steep, rocky southern slopes of limestone and dolomite outcrops of the northern Bosnian mountains, and also in central B&H (Stefanović, 1964b; Lakušić et al., 1982a). Horvat (1950, 1963) states that this association can be found in N B&H and NW Croatia, but it is also present in Slovenia (Zupančič et al., 2009) and in NW Serbia (Jovanović, 1967).

Quercetum frainetto-cerridis **(Rudski 1949) Trinajstić et al. 1996** is zonal central Balkan community of *Quercus frainetto* often with *Q. cerris* and *Q. petraea* which occurs in eastern B&H, with exclaves in central and southern areas of the country. It can be considered to be zonal in E Bosnia (Transitional Illyrian-Moesian region), while in other parts it is extrazonal. This rather heterogenous association was originally described by Rudski (1949) for central Serbia, with three subassociations. Many subassociations and geographical variants were later described for the region of Serbia (Jovanović and Dunjić, 1951; Jovanović, 1956, 1967; Vukićević, 1959). Several variants have been reported in B&H (Glišić, 1956; Fabijanić et al., 1967; Stefanović and Manuševa, 1971; Fukarek et al., 1974; Stefanović, 1988). This association was also reported from Croatia by Trinajstić et al. (1996), who corrected its original illegitimate name "*Quercetum confertae-cerris serbicum"*. In the southern B&H, (Fukarek, 1966) described *Quercetum frainetto hercegovinum*, but analysis could not separate it from other *Quercetum frainetto-cerridis* forests.

Fraxino orni-Quercetum cerridis **Stefanović 1968** is the pure *Quercus cerris* forest which is main type of forest vegetation in dry karst fields of W and S B&H. This main area of distribution has radiations in Croatia (Trinajstić, 2008; Vukelić, 2012). The association was originally described by (Stefanović, 1968) in western B&H but, over time, it was repeatedly described from different localities in western and southern B&H by different names (Fukarek, 1970; Lakušić et al., 1978; Lakušić and Redžić, 1989, 1991; Redžić and Barudanović, 2010; Redžić, 2011). A similar association has been reported from Hungary, where it primarily occurs on limestone and dolomite, but also on basalt (Kevey, 2008; Borhidi et al., 2012). Forests in Serbia that are attributed to this association (Tomić et al., 2006; Tomić and Rakonjac, 2013) are of different floristic composition and ecology and represent another community, i.e., *Quercetum cerris* (Vukićević, 1966).

Lathyro nigri-Quercetum petraeae Horvat (1938) 1959 is *Quercus petraea* agg. dominated community found on milder slopes with deeper soil over carbonate bedrock. It was distinguished as subass. *quercetosum petraeae* of the *Querco pubescenti-Ostryetum* *carpinifoliae* (Horvat, 1938) and later raised to the level of association (Horvat, 1959). According to the original diagnosis, this association corresponds to mesothermophilous *Quercus petraea* forests on deeper soils. Thermophilous and basophilous species, including *Ostrya carpinifolia* are dominant in floristic composition, but also several neutrophilous species and those that are slight acidity indicators can occur. Some authors (Vukelić, 1990; Baričević et al., 2006b) included some stands of acido-thermophilous forests of *Festuco drymejae-Quercetum petraeae lathyretosum nigrae* within the scope of this association, which is in opposition to the traditional concept of this syntaxon. In B&H, this type of forest often forms an altitudinal belt beneath thermophilous beech forests (*Aceri obtusati-Fagetum*) (Redžić, 1986).

***Aceri obtusati-Quercetum petraeae* Stupar et al. 2015** represents rather peculiar newly described *Quercus petraea* agg. dominated association which is found in NW B&H, in the zone in which continental and mediterranean climates interface. It brings together two species that stand for two opposing ecologies: mesophilous *Carpinus betulus* and xerothermophilous *Carpinus orientalis.* This association is regarded as a transitional between thermophilous *Carpinion orientalis* and mesoneutrophilous *Carpinion betuli*. This community had not previously been reported for B&H, probably because oak forests of this part of B&H were poorly studied in the past.

***Cytiso hirsuti-Quercetum petraeae* (Stefanović 1964) Pallas in Bohn et Neuhäusl 2004** formerly known as *Quercetum montanum illyricum* (Stefanović, 1964a, 1984; Stefanović and Manuševa, 1966, 1971; Stefanović et al., 1977a), is *Quercus petraea* agg. dominated association related to zonal dry-acidophilous *Quercion petraeo-cerridis* of central Balkan (Čarni et al., 2009). It is found on shallow dry soils of silicate bedrock (andesite, dacite, siliceous sandstone and schists) of E and C B&H, and Palaeozoic sediments (siliceous sandstone and schists) of N B&H.

***Festuco drymejae-Quercetum petraeae* (Janković et Mišić 1960) Janković 1968** was originally described from Fruška gora (Serbia) (Janković and Mišić, 1960; Janković, 1968) and later reported from northern Croatia (Hruška-Dell'Uomo, 1975; Baričević et al., 2006a). Some stands from northern Croatia reported as *Lathyro nigri-Quercetum petraeae* also belong to this association (Vukelić, 1990; Baričević et al., 2006b).

***Potentillo micranthae-Quercetum petraeae* Vukelić et al. ex Vukelić, Baričević et Šapić in Stupar et al. 2015** is similar to *Festuco drymejae-Quercetum petraeae* but slightly dryer and more acidophilous. It was originally described from Zrinska Gora (Croatia) (Vukelić et al., 2010), but some stands from NW Croatia, of what was formerly known as meso-acidophilous *Hieracio racemosi-Quercetum petraeae* sensu Vukelić 1991 (Vukelić, 2012), also enter the scope of this association. The latter two associations comprise the group of north Dinaric-south Pannonian acido-thermophilous forests dominated by *Quercus petraea* agg., which are widely distributed on siliceous low mountains and hills of peripannonian Croatia, B&H and Serbia.

Seslerio autumnalis-Quercetum petraeae **Poldini ex Poldini 1982** is known from only one locality in B&H (Vojniković, 2001). It is interesting that it is found here on basic gabbro bedrock, while in Croatia, Slovenia and Italy it occurs on flysch (Poldini, 1964; Zupančič, 1999; Vukelić, 2012). While this association dominated by *Quercus petraea* agg. has an acido-thermophilous character, its submediterranean distribution made most authors include it in *Quercion pubescenti-petraeae* (Vojniković, 2001; Trinajstić, 2008; Šilc and Čarni, 2012; Vukelić, 2012). More work is needed in B&H, as well in Croatia, in order to reveal its correct syntaxonomical position.

A thorough survey of the relevant literature yielded a list of eight syntaxa that had been reported for thermophilous deciduous forests of B&H, but could not be recognized during the analysis, either because they were mistakenly attributed to different syntaxa, or they do not belong to thermophilous deciduous forests, or there were no relevés in the database, or they simply do not exist on the territory of B&H: *Aceri paradoxi-Carpinetum orientalis* Blečić et Lakušić 1967, *Seslerio angustifoliae-Ostryetum carpinifoliae* Lakušić ex Lakušić et Redžić 1989, *Carpino betuli-Ostryetum carpinifoliae* Lakušić et Redžić 1989, *Melampyro doerfleri-Ostryetum carpinifoliae* Lakušić et Redžić 1989, *Corylo colurnae-Ostryetum carpinifoliae* Blečić 1958 nom. inval. [Art. 3b], *Quercetum macedonicae* Em ex Horvat 1959, *Quercetum trojanae montenegrinum* Blečić et Lakušić 1975 nom. nud. [Art. 2b], and *Pistacio-Quercetum trojanae* Redžić 2011 nom. nud. [Art. 2b].

3.1.6 Notes on classification

While trying to differentiate the types of TDF in the Western Balkans and in B&H we used the numerical methods supported by expert knowledge. This way we were able to, at the coarser level of resolution of classification, provide a synthetic classification reflecting main patterns (ecological and phytogeographical) in species composition over a larger area rather than local small-scale heterogeneities. Defined types are closest to the syntaxonomical level of alliance, yet we did not explicitly relate types to already established or new alliances, thus avoiding to tackle some issues which would otherwise require analysis of data on the larger scale and broader level of consensus of vegetation scientists. On the other hand, for the classification of the TDF in B&H at the association level we decided to use a formalized classification approach (i.e., the Cocktail method). This method was used for classification of TDF in Czech Republic (Roleček, 2007; Chytrý, 2013), and is used increasingly for classification of other vegetation types on the national level (Kočí et al., 2003; Šilc and Čarni, 2007; Chytrý, 2013; Rodríguez-Rojo et al., 2014). This method appears to be the most suitable for producing a stable and formally defined classification system for the vegetation of large areas (Chytrý, 2007). Although it has been tested and applied mainly on large national data sets that, beside relevés of analyzed vegetation types, consist of relevés of all other vegetation types of the researched area (typically national territory), some works have been published that demonstrate its usability on data sets consisting of only one vegetation type, e.g., mesic grasslands (Rodríguez-Rojo et al., 2014). As the concept of an association in the Central European phytosociological school has changed over time, from relatively large and broadly defined associations to more narrow units that were able to provide a more suitable description of the many variations in habitat and geographic locations (Mueller-Dombois and Ellenberg, 1974), we had a decision to make about how big our concept of association would be. One possible way of classifying our relevés could have been lumping them into eight to ten broader groups, which would be interpretable using large-scale ecological (macroclimatic) parameters. However, in that way we would lose a lot of information that differentiates communities on a more local scale (topographical and geological patterns, management type etc.), which are very useful on a national scale, e.g., in forest management or nature conservation. On the other hand, we could have continued splitting some of the vegetation units, using their small-scale peculiarities of intrinsic (e.g., different cover values of the same species in different localities of the same community; presence/absence of species in different localities of the same community due to species' geographic limits etc.) or methodological nature (e.g., some of the relevés were taken during inadequate time of the year, thus missing some species; some authors were prone to under-record the species count, underestimate species cover etc.), all of which would probably have led us to associations (or sub-associations) that are poorly defined and hard to interpret, making them useless in a broader scope. Following (Bergmeier and Dimopoulos, 2001), we made what we believe to be a well-founded compromise that provides manageable units for national and supra-national surveys. Additionally, we tried not to create more confusion in an already tangled situation in the syntaxonomy of thermophilous deciduous forests in the region, so we made definitions of associations to be as close to the traditionally accepted vegetation concepts (in B&H and neighboring countries) (Horvat, 1938; Lakušić et al., 1978; Lakušić et al., 1982b; Lakušić and Redžić, 1991; Muratspahić et al., 1991; Sarić, 1997; Škorić, 2006; Trinajstić, 2008; Redžić, 2011; Vukelić, 2012; Tomić and Rakonjac, 2013) as possible, and we disregarded only associations that could not be defined by means of their own diagnostic species or where no sociological species group or dominant species could be found to create a formal definition. Thus, our decision to accept 18 associations of TDF for B&H is mainly based on our expert judgment and could undoubtedly be argued.

3.2 CONCLUSIONS

In order to fill in the gap in available data about TDF in B&H we made 399 relevés through extensive field research. Synthesis of these relevés with those from the literature allowed us to tackle complex phytosociological issues related to classification, ecology and distribution of TDF in B&H and Western Balkans.

Our research showed that zonal forest vegetation in B&H is an expression of macro-climatic conditions with little or no impact of topographic (slope and aspect) or edaphic conditions, but on the other hand there were no remarkable differences in CSR plant strategies between ZFPCs. Also, we provided criteria for the separation of acidophilous forest (class *Quercetea robori-petraeae*) from TDF (class *Quercetea pubescentis*) in the Pre-Pannonian area of the Western Balkans. We showed that TDF of the Western Balkans can be classified into six floristically and ecologically well-defined types, approximately at the level of alliance, some of which more, while others less well relate to the established syntaxonomical schemes. At the level of association TDF of B&H were classified into 18 types.

Problems that remained to be answered are related to syntaxonomical status of some TDF types in the Western Balkans. This especially relates to meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*, sub-Mediterranean and continental *Quercus pubescens* woodland without *Carpinus orientalis*, as well as acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests. There is also need for the revision of rather heterogeneous associations *Quercetum frainetto-cerridis* and *Cruciato glabrae-Carpinetum orientalis*, while syntaxonomical position and circumscription of *Aristolochio luteae-Quercetum pubescentis* needs to be reassessed.

4 SUMMARY

4.1 SUMMARY

This work explores the phytosociological characteristics of thermophilous deciduous forests (TDF) of the class *Quercetea pubescentis* in Bosnia and Herzegovina (B&H) within the framework of the forest vegetation of the Western Balkans. Also, it deals with the classification of all zonal forest plant communities (ZFPCs) in B&H, as two out of seven ZFPCs in B&H belong to TDF.

Area of the Western Balkans, in terms of our study, includes B&H, Croatia, Montenegro, Serbia and Slovenia. It encompasses the entire range of the Dinaric Alps, southeastern fringes of the Alps in Slovenia, southwestern fringes of the Carpathian Mountains and the western fringes of the Balkan Mountains in Serbia and the hills and low mountains of the southern margin of the Pannonian Plain in Slovenia, Croatia, B&H and Serbia. In addition to its diverse topography, it comprises a great variety of bedrock and soils. Carbonate bedrock prevails in the southern and western parts of the study area (southwestern Dinaric Alps), while it is mostly siliceous in the northern and eastern parts (northeastern Dinaric Alps, Carpathian and Balkan Mountains, and the hills and low mountains of the southern margin of the Pannonian Plain). The climate is also diverse, since two major climatic zones overlap in the Western Balkans: central European from the north and Mediterranean from the south. The borderline between these two climate types is not distinct and lies in the transitional zone of the Dinaric Alps, being highly influenced by mountain massifs. River valleys and canyons also have a significant role in climate modification, since the Mediterranean climate penetrates through them deep into the continent. This part of Europe has been under intensive anthropogenic influence since the early Neolithic, especially the sub-Mediterranean and Pannonian regions. Large portions of this land were altered, mainly deforested, quite early because of the early spread of agriculture.

As B&H is situated in the central part of the Western Balkans area the majority of characteristics stated for Western Balkans (climate, geology, geomorphology) applies also for B&H. Biogeographically, B&H is divided into four regions: Pre-Pannonian (continental, northern B&H), Dinaric (mountainous, central B&H), Mediterranean (southern and south-western B&H), and Transitional Illyrian-Moesian (eastern B&H). Northern B&H embraces the southern outcrops of the Pannonian Plain and the northern foothills of the Dinaric Alps and is an area of predominantly low mountains, hills and the alluvial plains of the Sava River and lower reaches of the rivers Una, Vrbas, Bosna and Drina. The major part of the central (Dinaric) region is mountainous, with the high Dinaric Alps spreading in a NW-SE direction. Deep limestone river canyons and valleys, which generally have a north-south direction, are a prominent feature of this mountainous region. The southern, Mediterranean part of the country is highly influenced by the Mediterranean climate and mainly belongs to the sub-Mediterranean zone, while the Eu-Mediterranean zone occupies only a narrow belt around the short Adriatic coastline. The eastern, Transitional Illyrian-Moesian biogeographical region comprises a relatively narrow belt along the River Drina at the border with Serbia. It is a biogeographical and climatic transition between the western more humid Illyrian zone and the eastern, dryer Central Balkans.

TDF of the class *Quercetea pubescentis* are dominated by deciduous oaks, mostly *Quercus pubescens, Q. frainetto* and *Q. cerris* much less by *Q. petraea* and *Q. robur*. Other tree species may be admixed or even dominate, particularly *Carpinus orientalis, Fraxinus ornus* and *Ostrya carpinifolia*. They are broadly distributed in the southern parts of Europe, with the highest diversity in the Balkan and Apennine peninsulas. This is also true for the area of Western Balkans as well as B&H, where they form zonal vegetation particularly in the southern and eastern parts of Western Balkans and B&H. Zonal plant vegetation is a large-scale expression of climate dominating a particular area, while it is not confined to specific soil conditions, i.e., it most precisely reflects the macroclimatic conditions of particular region. Following the macro-climatic diversity, there is a general agreement that seven zonal forest plant communities (ZFPCs) can be distinguished for the territory of B&H. Four communities are represented by various oak forests, which occupy the lowlands and hilly region of B&H, while the other three are altitudinal belts (montane, altimontane and subalpine) above the oak forests, mainly built by various types of beech forests (pure and mixed). Among these seven ZFPCs two belong to thermophilous deciduous forests: 1) sub-Mediterranean *Quercus pubescens-Carpinus orientalis* forests (major part of lowland and hilly region in southern B&H); and 2) Central Balkans *Quercus frainetto* forests (relatively narrow lowland and hilly belt of eastern B&H). However, owing to steep biogeographical and ecological gradients, other than macro-climatic, and a variety of human impact over time TDF in B&H and Western Balkans do not just come as ZFPCs, but there is a variety of extrazonal and azonal communities as well as their secondary succession stages.

Although the study of TDF has a long tradition in the Western Balkans, numerous ecological and syntaxonomical issues remained unresolved until now. There was evident lack of available phytosociological data from the central part of the Western Balkans. In this area, including southern B&H, Croatia and Montenegro, zonal *Quercus pubescens-Carpinus orientalis* communities remained to date uninvestigated in terms of phytosociology.

Another issue is the classification of vegetation transitional between thermophilous *Quercetea pubescentis* and mesic acidophilous *Quercetea robori-petraeae* forests. Oak forests of *Quercetea robori-petraeae* (acidophilous species-poor oak, oak-birch and beech-dominated deciduous woods on mesic nutrient-poor soils) extend within the temperate zone of Europe from the Atlantic coast to western Russia, and reach their south-easternmost limit in the Western Balkans. Their characteristic species combination gradually changes towards the south, where thermophilous oak forests become dominant. Syntaxonomical position of the transitional acido-thermophilous communities, mainly dominated by *Quercus petraea*, was often considered ambiguous. In the study area, these communities are found particularly on acidic soils on southern slopes of hills and low mountains on the southern margins of the Pannonian Plain and northern Dinaric Alps (northern B&H, northern Croatia - Slavonia), which are rich in thermophilous species of southeast European, as well as wider distribution. Also in this region authors differ in their syntaxonomical treatment: in B&H, they were classified to *Quercetea robori-petraeae*, in Serbia to *Quercetea pubescentis*, while in Croatia and Hungary different associations were classified to different classes. The complexity of this problem and necessity of further study have been highlighted by many local and regional studies.

Vegetation of TDF occupies about 20% of the forest area and 11% of total area of B&H. Despite the great significance in terms of their area and diversity, lots of problems related to classification and nomenclature have been recognized, which can be mainly related to already mentioned poor coverage by phytosociological relevés and unsettled syntaxonomy and nomenclature. Only 274 relevés were published for the B&H before our study, while some types of thermophilous deciduous forests were not sampled at all. Most studies dealing with this type of vegetation in B&H have been carried out at the small number of localities in the canyon systems of the Dinaric Alps, along the major roads, focusing, above all, on secondary succession stages dominated by *Carpinus orientalis*. Furthermore, original literature is overcrowded with pseudonyms, invalidly published names, new names for already validly published syntaxa and a plethora of *nomina nuda*. Some syntaxa from neighboring regions have been uncritically included in B&H syntaxonomical overviews. This can be illustrated by the fact that in the first overview of this type of vegetation in B&H (from 1978), the number of different associations was 14, while in the last (from 2011), in which all names that occurred in published or unpublished sources were listed, the number of associations was 44.

The aims of our study were to 1) evaluate ecological factors that drive the separation of ZFPCs in B&H and to test how different plant traits reflect the differences in floristic composition of the ZFPCs; 2) formally separate thermophilous oak forests from the complex feature of oak forests in northern B&H; and 3) formally classify thermophilous deciduous forests of *Quercetea pubescentis* in B&H and integrate it in the forest vegetation framework of the Western Balkans.

We hypothesized that 1) ecological, structural and chorological differences expressed through site ecology, plant functional types and plant chorotypes reflect the differences in floristic composition of the forests plant communities of *Aremonio-Fagion*, *Erythronio-*

Carpinion and *Quercetea pubescentis* that form zonal forest vegetation of the region (H1); 2) due to the complex ecological gradients, oak forests of northern B&H represent a mixture of thermophilous, mesophilous and acidophilous communities; within this complex feature the main pattern can be defined (H2); 3) floristic composition within TDF enables to build a logical system and to integrate it in a wider framework of the forest vegetation of the Western Balkans (H3).

In order to test the hypotheses several methods of numerical analysis were used on the dataset of around 3500 phytosociological relevés made by the standard Braun-Blanquet's method.

H1 was tested by analysis of ecological gradients, floristic composition and plant traits (life forms, CSR plant strategies and chorotypes) within seven ZFPCs that were *a priori* identified for the area of B&H. Relevés were extracted from the Forest Vegetation Database of Bosnia and Herzegovina stored in the Global Index of Vegetation-Plot Databases (GIVD) with the ID EU-BA-001. All 612 relevés that were assigned to one of the seven ZFPCs were compiled and analyzed. To avoid geographic overrepresentation of some vegetation types due to oversampling of certain regions, we performed geographical stratification and resampling of the initial data set in a geographical grid with 1 km^2 size (only 1 relevé of the same type per 1 km^2). The resulting stratified data set contained 398 relevés. To extract the main gradients in species composition, 398 relevés, together with the selected ecological variables were projected onto the two-dimensional ordination space of DCA. Unweighted average species ecological indicator values for soil reaction and selected climatic variables with the best explanatory value available from the WorldClim database were used as explanatory ecological variables. Other explanatory variables (altitude, inclination of slope, aspect, chorotypes, latitude and longitude, life forms and CSR plant strategies) were also analyzed. The significances of correlations between explanatory variables and DCA relevé scores were calculated using the Kendall tau coefficient. Floristic differences among the seven ZFPCs, were expressed through diagnostic species in the resampled data set using phi coefficient. Chorological spectra of the zonal forest communities were calculated for each relevé using presence-absence data. The functional study of zonal forest communities was performed using data on plant life forms and CSR plant strategies. Ecological strategy scores for each group of relevés were calculated and presented on a CSR ternary plot. Life forms spectra was calculated for each relevé using presence-absence data, and mean proportions were compared between ZFPCs.

To test H2 we made hierarchical classification of all available relevés from Western Balkans assigned by their authors both to the thermophilous deciduous forests of the class *Quercetea pubescentis* as well as mesic-acidophilous forests of alliance *Quercion roboris* from the class *Quercetea robori-petraeae*. For Croatia and B&H, relevés were collected from GIVD (EU-BA-001, EU-HR-002), while for Slovenia, Serbia, Montenegro and

Hungary (only three asociations) from the literature. We recorded additional 399 relevés in the field (all in TDF in B&H), mainly in areas that were overall very poorly sampled. The resulting data set consisted of 2946 relevés which was then stratified by means of numerical classification using Twinspan algorithm. Within 16 strata, a total of 968 relevés were resampled using heterogeneity-constrained random (HCR) resampling. The resampled data set was then subjected to hierarchical classification were we accepted nine clusters of relevés, because they were ecologically and floristically best interpretable. All relevés were projected onto the two-dimensional ordination space of DCA, with centroids calculated for each of the nine clusters. In order to better understand the relationship between *Quercetea pubescentis* and *Quercetea robori-petraeae* and to determine the position of the transitional acido-thermophilous communities, two separate analyses of the clusters were made: 1) we calculated diagnostic species for all nine clusters (using phi coefficient), in order to reveal the floristic differences and indicate ecological characteristics of the respective types; 2) then we combined three clusters of meso-acidophilous and mesophilous communities in one group and compared it to the cluster of transitional acido-thermophilous oak forests to identify the differential species.

Testing of H3 was performed in two separate analysis: 1) differentiation of the main types of TDF of Western Balkans, which was done at the coarser level of resolution of classification (approximately level of the alliance) in order to provide a synthetic classification reflecting large scale ecological and phytogeographical patterns in species composition over a larger area of Western Balkans; and 2) classification of TDF at the level of associations for the area of B&H.

First analysis was performed immediately after separation of *Quercetea pubescentis* from *Quercetea robori-petraeae*. After exclusion of 233 relevés of three meso-acidophilous and mesophilous forest types, we were able to analyze 735 relevés of TDF in the Western Balkans and calculate diagnostic species for the six distinguished types. All 735 relevés, together with the selected explanatory variables (species ecological indicator values (EIVs) for temperature, light, moisture, continentality, soil reaction and nutrients, and selected bioclimatic variables available from the WorldClim database), were projected onto a DCA plot. The significances of their correlation with the DCA relevé scores were calculated in order to reveal which ecological factor best explains the variation in floristic composition of TDF.

In order to perform the second analysis, i.e., formally classify TDF of B&H at the level of association, we performed supervised classification of all 673 relevés of *Quercetalia pubescentis* from B&H using Cocktail method. All relevés were obtained from the GIVD ID EU-BA-001. According to the expert knowledge we created 18 sociological species groups, which in combination with the cover percentage of some species and connected by logical operators AND, OR and NOT, yielded 17 formal definitions of target associations to which 483 relevés of the original data set were classified. In order to assign relevés that remained unclassified after Cocktail classification or were assigned to more than one association, we used semi-supervised classification. Species' fidelity measure, for which we used the phi coefficient, was used for calculation of diagnostic species, which were used for assessment of quality of formal definitions. In order to check the validity and legitimacy of the existing nomenclature, to correct and typify syntaxa, and to validly legitimately describe new syntaxa, we strictly followed the rules of ICPN (International Code of Phytosociological Nomenclature). Correct name for every association was determined, and complete synonymy was listed. For the syntaxa not yet typified, lectotypes and neotypes were chosen. For the syntaxa that were invalid according to Art. 5 of ICPN, holotypes were indicated. Modified form of name, i.e., *nomen mutatum* was used as a replacement of the syntaxon name which was originally formed from the names of taxa not used in the recent taxonomic and floristic literature, with syntaxon names that include the names of taxa that are in accordance with the contemporary taxonomic literature. Diagnoses of new associations were accompanied by descriptions of associations and phytosociological tables with holotypes indicated.

Differences in floristic composition of the seven ZFPCs of B&H were mainly reflected through differences in macro-climatic factors, particularly annual mean temperature, mean temperature of the coldest quarter and precipitation of the warmest quarter. Variation in floristic composition was also correlated with altitude, longitude and latitude, while correlation with soil, aspect and soil reaction of the site were not statistically significant. There was also statistically significant correlation with the proportions of south- and southeast European, Eurimediterranean, Stenomediterranean, Boreal and south European orophytic chorotypes, while the correlation with the most abundant European and Eurasian was not statistically significant. Correlations with life forms were significant only for the proportions of phanerophytes and geophytes, while there was no significant correlation with CSR plant strategies. Also, our results suggest that there are no remarkable differences in CSR plant strategies between ZFPCs in B&H, which indicates that our first hypothesis (H1) was only partially confirmed.

Numerical analysis of relevés of *Quercetea pubescentis and Quercetea robori-petraeae* from the Western Balkans grouped together yielded nine ecologically sound clusters that formed three major ecological groups: 1) basophilous thermophilous communities dominated by *Quercus pubescens, Carpinus orientalis* and *Ostrya carpinifolia* (clusters 1–3); 2) slightly to moderately acidophilous thermophilous communities of *Quercus frainetto, Q. petraea* agg. and *Q. cerris* (clusters 4–6, with cluster 6 being a group of transitional acido-thermophilous relevés); and 3) mesophilous and meso-acidophilous communities on acidic bedrock from the western part of the region with higher precipitation, dominated by *Quercus petraea* agg., *Castanea sativa* and *Betula pendula* (clusters 7–9). This division reflects the pH gradient from basophilous to acidophilous forests. Comparison of diagnostic species of transitional acido-thermophilous communities (cluster 6) and meso-acidophilous and mesophilous communities (clusters 7–9 grouped together) showed that the former are characterized by species that are mostly thermophilous and/or have a southeast European distribution (e.g. *Fraxinus ornus, Dactylis glomerata* s.l.*, Lathyrus niger, Festuca drymeja, Sorbus torminalis, Melittis melissophyllum* s.l.*, Campanula persicifolia, Vincetoxicum hirundinaria, Tanacetum corymbosum*), while the latter are characterized by species indicating strongly acidic soil and somewhat lower air temperature, generally with a wider European or Eurasian distribution pattern (e.g. *Calluna vulgaris, Vaccinium myrtillus, Betula pendula, Potentilla erecta, Pteridium aquilinum*. This supported the view that transitional acido-termophilous communities (cluster 6) should be, together with clusters 1–5, classified within TDF of the class *Quercetea pubescentis.* These results also support our second hypothesis (H2) as northern B&H and northern Croatia (Slavonia) are areas where forests of cluster 6 and clusters 7–9 occur together and often, mistakenly, were not syntaxonomicaly separated from each other.

Our third hypothesis (H3) was supported by analysis of floristic composition of TDF which showed a clear differentiation of TDF types for the area of Western Balkans, and TDF associations for the area of B&H that were logically integrated into wider framework of forest vegetation of the Western Balkans. TDF of the Western Balkans were classified into six types reflecting the main broad-scale ecological and phytogeographical patterns in species composition within the study area: type 1 – sub-Mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis*; type 2 – sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis*; type 3 – meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*; type 4 – thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris*; type 5 – acido-thermophilous continental forests dominated by *Quercus petraea* and/or *Quercus cerris*; type 6 – acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests. The variation in floristic composition was best explained by soil reaction, annual precipitation and precipitation of the warmest quarter, as well as temperature, which all more or less reflect geographical southwest-northeast gradient in the Western Balkans.

Although we classified TDF of the Western Balkans into six floristically and ecologically well defined types using numerical methods, some types relate well to the established syntaxonomical schemes, while the status of others, especially meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia*, sub-Mediterranean and continental *Quercus pubescens* woodland without *Carpinus orientalis*, as well as acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests, is not very clear and requires further investigation.

Cocktail method classified thermophilous deciduous forests of B&H into 17 associations. Additionally, semi-supervised classification yielded one more ecologically and floristically well defined association, which was recognized as new, and described as *Aceri obtusati-Quercetum petraeae*. The associations were grouped following the criterion of dominant species in a tree layer, in order to present differences in floristic composition between associations of the same type, i.e., dominated by the same tree species. All associations were separated into four groups: 1) group of associations dominated by *Quercus pubescens* and/or *Carpinus orientalis*; 2) group of associations dominated by *Ostrya carpinifolia*; 3) group of associations dominated by *Quercus frainetto* and/or *Quercus cerris*; and 4) group of associations dominated by *Quercus petraea* agg. The largest number of associations (13) occurs in the Mediterranean region; the Dinaric and pre-Pannonian regions each harbour ten associations, while there are only five associations in the Transitional Illyrian-Moesian region. The biggest altitudinal range, with the highest altitudes of relevés, occurs in the Mediterranean region (130-1030 m), followed by the Dinaric (310-1000 m), Transitional Illyrian-Moesian (190-880 m) and Pre-Pannonian (250-780 m).

Syntaxonomical synopsis:

Associations dominated by *Quercus pubescens* and/or *Carpinus orientalis*

1. *Querco pubescenti-Carpinetum orientalis* Horvatić 1939
2. *Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967
3. *Carici hallerianae-Quercetum pubescentis* Stupar et al. 2015
4. *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015
5. *Seslerio autumnalis-Quercetum pubescentis* Zupančič 1999
6. *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini 2008
7. *Asparago tenuifolii-Quercetum pubescentis* Lakušić et Redžić 1991

Associations dominated by *Ostrya carpinifolia*

8. *Seslerio autumnalis-Ostryetum carpinifoliae* Horvat et Horvatić ex Horvat 1959
9. *Rusco aculeati-Ostryetum carpinifoliae* Lakušić et Redžić ex Stupar et al. 2015
10. *Querco pubescenti-Ostryetum carpinifoliae* Horvat 1938

Associations dominated by *Quercus frainetto* and/or *Quercus cerris*

11. *Quercetum frainetto-cerridis* (Rudski 1949) Trinajstić et al. 1996
12. *Fraxino orni-Quercetum cerridis* Stefanović 1968

Associations dominated by *Quercus petraea* agg.

13. *Lathyro nigri-Quercetum petraeae* Horvat (1938) 1959
14. *Aceri obtusati-Quercetum petraeae* Stupar et al. 2015
15. *Cytiso hirsuti-Quercetum petraeae* (Stefanović 1964) Pallas in Bohn et Neuhäusl 2004

16. *Festuco drymejae-Quercetum petraeae* (Janković et Mišić 1960) Janković 1968
17. *Potentillo micranthae-Quercetum petraeae* Vukelić et al. ex Vukelić, Baričević et Šapić in Stupar et al. 2015
18. *Seslerio autumnalis-Quercetum petraeae* Poldini ex Poldini 1982

Although analysis of thermophilous deciduous forests of B&H provided syntaxonomical scheme with 18 associations that ecologically and floristically depicts phytosociological relations within this group in B&H and neighboring countries, as well as their relations with other vegetation types in this region, there are still some problems that should be addressed in the future. In particular, further research is needed in order to reveal the diversity patterns inside the rather heterogeneous associations *Quercetum frainetto-cerridis* and *Cruciato glabrae-Carpinetum orientalis*, while syntaxonomical position and circumscription of *Aristolochio luteae-Quercetum pubescentis* need to be reassessed.

4.2 POVZETEK

Doktorska disertacija obravnava fitocenološke značilnosti termofilnih listopadnih gozdov, ki jih uvrščamo v razred *Quercetea pubescentis* v Bosni in Hercegovini (BiH) v okviru gozdne vegetacije zahodnega dela Balkanskega polotoka. Prav tako smo se ukvarjali tudi z zonalnimi gozdnimi združbami (ZFCP), med katerimi dve od sedmih, ki se pojavljajo v BiH, uvrščamo med termofilne listopadne gozdove (TDF).

Uvod. Območje zahodnega dela Balkanskega polotoka, kot ga obravnavamo v naši raziskavi, obsega ozemlje Slovenije, Hrvaške, BiH, Srbije in Črne gore. Obsega celotno območje Dinarskega gorstva, jugovzhodno obrobje Alp, jugozahodno obrobje Karpatov in zahodno obrobje gorovja Balkan v Srbiji ter hribovje in sredogorje na južnem obrobju Panonske nižine v Sloveniji, na Hrvaškem, v BiH in Srbiji. Območje ima zelo razgibano topografijo in ga gradijo različne kamnine, na katerih se razvijejo specifični talni tipi. Karbonatne kamnine gradijo južne in zahodne predele raziskovanega območja (jugozahodne Dinaride), medtem ko prevladujejo v severnih in vzhodnih predelih (severovzhodni del Dinaridov, Karpatov in Balkana, v hribovju in sredogorju na južnem obrobju Panonske nižine) večinoma silikati. Podnebje je prav tako raznoliko, saj se na zahodnem delu Balkanskega polotoka prekrivata dve glavni podnebni območji: srednjeevropsko s severa in sredozemsko z juga. Ti dve podnebni območji nista jasno ločni, ampak poteka meja med njima v prehodnem območju na Dinarskem gorstvu, kjer je močan vpliv gorske klime. Rečne doline in kanjoni imajo tudi pomembno vlogo pri spremembah podnebja, saj mediteranska klima prodira po njih globoko v celino. V tem delu Evrope je bil človekov vpliv na okolje zelo močan že od začetka neolitika, predvsem na submediteranskem in panonskem območju, ko so ljudje začeli krčiti gozdove za poljedelstvo.

Ker se BiH nahaja v osrednjem delu zahodnega dela Balkanskega polotoka, tudi večina značilnosti, ki jih navajamo za zahodni del Balkanskega polotoka (podnebje, geologija, geomorfologija) velja tudi za ozemlje BiH. Biogeografsko je BiH razdeljena na štiri regije: (1) predpanonsko (celinska, severna BiH), (2) dinarsko (gorato območje, osrednji del BiH), (3) sredozemsko (južni in jugozahodni del BiH) in (4) prehodno ilirsko-mezijsko (vzhodni del BiH). Predpanonka regija obsega južni del Panonske nižina in severna vznožja Dinarskega gorstva; to je območje pretežno nizkih gorovij, hribov in aluvialnih ravnic ob reki Savi in spodnjih tokovih rek Une, Vrbasa, Bosne in Drine. Pretežni del dinarske (osrednje) regije je gorski, z visokim gorovjem Dinaridov, ki se širijo v smeri severozahod-jugovzhod. Globoki kanjoni in doline, ki so vrezani v karbonatno pogorje so ena od značilnosti te regije. Sredozemska (južna) regija je pod vplivom sredozemskega podnebja in v glavnem pripada submediteranskemu območju, medtem ko najdemo evmediteransko območje le v ozkem pasu neposredno ob Jadranskem morju. Vzhodna, prehodna ilirsko-mezijska biogeografska regija obsega relativno ozek pas ob reki Drini na meji s Srbijo, ki je podnebno in biogeografsko prehod med zahodnim, bolj vlažnim, ilirskim območjem in vzhodnim, mezijskim območjem, ki obsega osrednji del Balkanskega polotoka, ki je pod vplivom kontinentalne (bolj suhe) klime.

V termofilnih listopadnih gozdovih razreda *Quercetea pubescentis* prevladujejo listopadne vrste hrastov, predvsem puhasti hrast (*Quercus pubescens*), sladun (*Q. frainetto*) in cer (*Q. cerris*), manj pogosta pa sta graden (*Q. petraea* agg.) in dob (*Q. robur*). Druge drevesne vrste kot so predvsem kraški gaber (*Carpinus orientalis*), mali jesen (*Fraxinus ornus*) in črni gaber (*Ostrya carpinifolia*) se v sestojih pojavljajo ali v njih celo prevladujejo. Tovrstna vegetacija se pojavlja v vseh predelih južne Evrope, najbolj raznolika pa je na Balkanu in Apeninih. To velja tudi za območje zahodnega dela Balkanskega polotoka vključno z BiH, kjer termofilni listopadni gozdovi gradijo tudi conalno vegetacijo v južnih in vzhodnih predelih. Conalne združbe so odraz podnebja, ki prevladuje na določenem območju, medtem ko talni tipi in druge ekološke razmer pa na conalno vegetacijo nimajo velikega vpliva. Tako conalne združbe natančno odražajo makroklimatske razmere v posamezni regiji. Splošno je sprejeto, da na ozemlju BiH, glede na makroklimatske razmere, lahko ločimo sedem conalnih gozdnih združb. V štirih od njih so prevladujejo različne vrste hrastov in jih najdemo v nižinah in v gričevnatem svetu, ostale tri pa so višinski pasovi (gorski, visokogorski in subalpinski) nad hrastovimi gozdovi, ki jih gradijo čisti ali mešani bukovi gozdovi. Med sedmimi conalnimi združbami, dve uvrščamo med termofilne listnate gozdove: (1) submediteranske gozdove, kjer prevladujeta puhasti hrast (*Quercus pubescens*) in kraški gaber (*Carpinus orientalis*) (v nižinskih in gričevnatih območjih na jugu BiH) in (2) osrednjebalkanski in panonski sladunovi (*Quercus frainetto*) gozdovi (v relativno ozkem pas v nižinskem in hribovitem pasu na vzhodu BiH). Vendar pa se zaradi različnih ekoloških in biogeografskih gradientov in različnih človekovih vplivov termofilni listopadni gozdovi pojavljajo ne le kot conalni gozdovi, ampak gradijo tudi številne ekstraconalne in aconalne združbe, kakor tudi številne sekundarne stadije.

Čeprav imajo na zahodnem delu Balkanskega polotoka raziskave termofilnih listopadnih gozdov dolgo tradicijo, so ostala številna ekološka in sintaksonomska vprašanja nerešena. Eden od razlogov je verjetno pomanjkanje fitocenoloških podatkov (vegetacijskih popisov) iz osrednjega dela zahodnega dela Balkanskega polotoka. Na tem področju, v južnem delu BiH, na Hrvaškem in v Črni gori, je ostal v vegetacijskem smislu neraziskan celo conalni gozd, ki ga gradita puhasti hrast (*Quercus pubescens*) in kraški gaber (*Carpinus orientalis*).

Drug problem je sinsistematska uvrstitev gozdov, ki po floristični zgradbi in ekoloških razmerah prehajajo med termofilnimi gozdovi razreda *Quercetea pubescentis* in mezofilnimi, acidofilnimi gozdovi razreda *Quercetea robori-petraeae*. Hrastovi gozdovi razreda *Quercetea robori-petraeae* (kisloljubni, vrstno revni hrastovi, brezovi in bukovi gozdovi na vlažnih in s hranili revnih tleh) so razširjeni v zmernem pasu Evrope od atlantske obale do zahodnega dela Rusije, svojo jugovzhodno mejo razširjenosti pa dosežejo na zahodnem delu Balkanskega polotoka. Njihova značilna kombinacija rastlinskih vrst se postopoma spreminja v smeri proti jugu, kjer postanejo vrste iz termofilnih hrastovih gozdov prevladujoče. Sintaksonomski položaj teh prehodnih termo-acidofilnih združb, kjer v glavnem prevladuje graden (*Quercus petraea* agg.), je pogosto nejasen. Na območju raziskav se takšne združbe pojavljajo predvsem na kislih tleh na južnih pobočjih vzpetin v sredogorju na južnem obrobju Panonske nižine in severnem obrobju Dinaridov (severna BiH, severna Hrvaška – Slavonija, Srbija). V teh združbah najdemo številne jugovzhodnoevropke in širokorazširjene termofilne vrste. V regiji avtorji te združbe različno uvrščajo: v BiH jih uvrščajo v razred *Quercetea robori-petraeae*, v Srbiji v razred *Quercetea pubescentis*, na Hrvaškem in na Madžarskem pa so različne združbe razvrščene v različne razrede. V številnih lokalnih in regionalnih študijah je nakazana kompleksnost problema in potreba za nadaljnjimi poglobljenimi raziskavami.

Vegetacija termofilnih listopadnih gozdov zavzema okrog 20 % površine gozdov in 11 % celotne površine BiH. Kljub velikemu pomenu zaradi njihove velike površine in raznolikosti, je odprto še veliko problemov v zvezi z njihovo sintaksonomsko uvrstitvijo in nomenklaturo. Eden od poglavitnih vzrokov za takšno stanje je pomanjkanje fitocenološkega materiala (popisov) s tega območja. Le 274 popisov teh gozdov je bilo objavljenih z območja BiH pred našo raziskavo, pri čemer nekateri tipi sploh niso bili vzorčeni. Večina raziskav, ki se ukvarjajo s tovrstno vegetacijo v BiH, je bila narejena na majhnem številu lokalitet v kanjonskih sistemih Dinaridov ali pa ob glavnih cestah ter se ukvarja predvsem s sekundarno sukcesijo gozdov, kjer dominira kraški gaber (*Carpinus orientalis*). Poleg tega pa lahko najdemo v delih veliko psevdonimov, neveljavno objavljenih imen združb, novih imen za že veljavno opisane sintaksone in veliko imen brez zadostnih opisov (*nomina nuda*). Nekateri sintaksoni iz sosednjih regij so bili nekritično vključeni v sintaksonomske preglede BiH. To je mogoče ponazoriti z dejstvom, da je bilo v prvem pregledu vegetacije v BiH iz leta 1978 število različnih asociacij termofilnih listopadnih gozdov 14, medtem ko je v zadnjem seznamu iz leta 2011, ki obsega vsa tiskana ali rokopisna imena, število asociacij 44.

Namen naše raziskave je bil (1) opredeliti, kateri ekološki dejavniki vplivajo na pojavljanje in vrstno sestavo conalne gozdne vegetacije v BiH in testirati, kako se različna floristična sestava odraža v rastlinskih znakih (potezah) in ekoloških strategijah (CSR), (2) oddeliti termofilne hrastove gozdove v kompleksu hrastovih gozdov v severnem delu BiH in (3) izdelati formalizirano klasifikacijo termofilnih listopadnih gozdov razreda *Quercetea pubescentis* v BiH in jih vključiti v okvir gozdne vegetacije zahodnega dela Balkanskega polotoka.

Predvidevali smo, da (1) ekološke, strukturne in horološke razlike, ki jih opredelimo z ekološkimi razmerami, rastlinskimi funkcionalnimi tipi, ekološkimi stategijami in horotipi, odražajo razlike v floristični sestavi gozdov, ki gradijo conalno gozdno vegetacijo (H1); 2) zaradi kompleksnih ekoloških gradientov v različnih tipih hrastovih gozdovih v severni BiH lahko najdemo termofilne, mezofilne in kisloljubne vrste, na podlagi katerih združbe lahko uvrstimo v različne sintaksone; predvidevamo, da je mogoče najti poglavitni vzorec v tem zapletenem sistemu in ga opredeliti (H2); 3) floristična sestava termofilnih listopadnih gozdov omogoča zgraditi logično sinsistematsko uvrstitev in jo je mogoče integrirati v širši okvir gozdne vegetacije na zahodnem delu Balkanskega polotoka (H3).

Metode. Hipoteze smo testirali z različnimi metodami numeričnih analiz. Kot osnovo smo uporabili okoli 3500 fitocenoloških popisov, ki so bili narejeni v skladu s standardno Braun-Blanquetovo metodo.

H1 smo testirali z analizo ekoloških gradientov, floristične sestave in rastlinskih znakov (potez) (življenjske oblike, ekološke strategije CSR in horotipov) v sedmih conalnih gozdnih združbah, ki gradijo conalno gozdno vegetacijo na območju BiH. Popise smo pridobljeni iz podatkovne baze gozdne vegetacije Bosne in Hercegovine, ki je shranjena v globalnem seznamu podatkovnih baz Vegetacija-ploskev (GIVD) pod številko EU-BA-001. Vseh 612 popisov, ki so bili uvrščeni v eno izmed sedmih conalnih gozdnih združb, smo izbrali in analizirani. Glede na to, da so bili nekateri popisi narejeni na ozkem geografskem območju in bi takšna prevelika zastopanost določenih območij lahko povzročila napake pri analizah, smo s teh območji izbrali samo nekaj popisov, in sicer smo izvedli geografski izbor na način, da smo v vsakem 1 km^2 izbrali samo 1 popis določene gozdne združbe. Po izboru je podatkovni niz obsegal 398 popisov. Glave gradiente, ki vplivajo na vrstno sestavo združb, smo pridobili s projekcijo vseh vegetacijskih popisov skupaj z izbranimi ekološkimi spremenljivkami na dvodimenzionalni diagram korespendenčne analize z odstranjenim trendom (DCA). Kot pojasnjevalne spremenljivke smo uporabili neponderirane povprečne bioindiktorske vrednosti za reakcijo tal in izbrane klimatske spremenljivke, smo jih pridobili iz podatkovne baze WorldCim in imajo največjo pojasnjevalno vrednost. Analizirali smo tudi druge pojasnjevalne spremenljivke (nadmorska višina, nagib, ekspozicija, zemljepisno širino in dolžino, delež posameznih horotipov, življenjske oblike in strategije rastlinskih vrst). Značilnost korelacije med pojasnjevalnimi spremenljivkami in projekcijo rezultatov korespondenčne analize z odstranjenim trendom na prvo os smo izračunali s pomočjo Kendall tau koeficienta. Floristične razlike med sedmimi conalnimi gozdnimi združbami so bile izražene z diagnostičnimi vrstami vsake skupine, ki so bile izračunane s pomočjo phi koeficienta. Horološki spektri conalnih gozdnih združb so bili izračunani za vsak popis posebej na podlagi prisotnosti vrst. Študija funkcionalnih znakov v conalnih gozdnih združbah je bila izvedena na podlagi podatkov o življenjskih oblikah. Spekter življenjskih oblik smo izračunali za vsak popis posebej na podlagi prisotnosti vrst; primerjava pa je narejena s pomočjo primerjave povprečij v vsaki skupini. Ekološke strategije so bile izračunane za vsako skupino popisov in predstavljene na trikomponentnem CSR diagramu.

V skladu z drugo predpostavko (H2) smo izdelali hierarhično klasifikacijo vseh razpoložljivih popisov z zahodnega dela Balkanskega polotoka, ki jih njihovi avtorji uvrstili med termofilne listopadne gozdove razreda *Quercetea pubescentis* ali med mezofilno-acidofilne gozdove iz razreda *Quercetea robori-petraeae*. Na Hrvaškem in v BiH smo popise izbrali iz zgoraj navedene baze GIVD s številkama EU-BA-001 in EU-HR-002, medtem ko smo popise za Slovenijo, Srbijo, Črno goro in Madžarsko (le tri asociacije) pridobili iz literaturnih virov. Dodatnih 399 popisov smo pridobili neposredno na terenu s popisovanjem (vse v termofilnih listopadnih gozdovih v BiH), predvsem na območjih, ki so bila pred tem slabo vzorčena. Nastali podatkovni niz je bil sestavljen iz 2946 popisov, ki je bil nato stratificiran in numerično obdelan. Z uporabo Twinspan algoritma smo podatkovno bazo razdelili v 16 snopov in jih stratificirali na podlagi algoritma, ki naključno omejuje heterogenost (heterogeneity-constrained random - HCR). Stratificiane podatke smo potem obdelali s pomočjo hierarhične klasifikacije in jih razdelili v devet snopov, ki smo jih ekološko in floristično obdelali. Vse popise smo projicirali na dvodimenzionalen diagram, katerega osi predstavljata prvi dve osi korespondenčne analize z odstranjenim trendom (DCA), s pomočjo centroidov, ki smo jih izračunali za vsako od devetih skupin. Za razjasnitev odnosov med vegetacijo razredov *Quercetea pubescentis* in *Quercetea robori-petraeae* in za določanje položaja prehodnih acido-termofilnih združb, sta bili opravljeni še dve ločeni analizi: 1) izračunali smo diagnostične vrste vseh devetih skupin (z uporabo phi koeficienta), da bi ugotovili floristične razlike in ekološke značilnosti vsake od devetih skupin; 2), nato pa smo združili tri snope mezo-acidofilnih in mezofilnih združbe v eno skupino, in jo primerjali s snopom prehodnih acido-termofilni hrastovih gozdovih. Tako smo ugotovili diagnostične vrste obeh skupin.

Pri iskanju odgovora na tretjo predpostavko (H3) smo izvedli dve ločeni analizi. (1) Najprej smo ugotovili, kateri so glavni tipov termofilnih listopadnih gozdov na zahodnem delu Balkanskega polotoka. Analiza je pokazala bolj grobo opredelitev posameznih skupin (približno na nivoju zveze), na podlagi katerega smo sklepali na klasifikacijo, ki je odražala makroekološke in fitogeografske vzorce termofilnih listopadnih gozdov na zahodnem delu Balkanskega polotoka. 2) Klasifikacijo termofilnih listopadnih gozdov na ravni asociacij za območje BiH.

Prva analiza je bila opravljena takoj po ločitvi vegetacije razreda *Quercetea pubescentis* od razreda *Quercetea robori-petraeae*. Po izključitvi 233 popisov, ki so bili uvrščeni v enega od treh snopov mezo-acidofilnih in mezofilnih tipov gozdov, smo analizirali 735 popisov termofilnih listopadnih gozdov na zahodnem delu Balkanskega polotoka in izračunali diagnostične vrste za šest preostalih snopov. Vseh 735 popisov, skupaj z izbranimi pojasnjevalnimi spremenljivkami (bioindikatorske vrednosti za temperaturo, svetlobo, vlago, kontinentalnost, reakcijo tal in hranila v tleh in izbranih bioklimatskih spremenljivk, ki so na voljo v bazi WorldClim), smo projicirali na diagram prve in druge osi korespondenčne analize z odstranjenim trendom (DCA). Pomembnost njihove korelacije s projekcijo popisov na prvo os korespondenčne analize z odstranjenim trendom (DCA) smo izračunali, da bi ugotovili, kateri ekološki dejavnik najbolje pojasnjuje razlike v floristični sestavi termofilnih listopadnih gozdov.

Kot drugo analizo, to je formalizirana klasifikacije na ravni asociacij, smo izvedli nadzorovano klasifikacijo vseh 673 popisov razreda *Quercetea pubescentis* iz BiH z metodo Cocktail. Vsi popisi so bili pridobljeni baze GIVD številka EU-BA-001. V skladu z literaturnimi viri in lastnim poznavanjem teh gozdov, smo izdelali 18 socioloških skupin vrst, ki so v kombinaciji s pokrovnostjo nekaterih vrst, in povezane z logičnimi operaterji AND, OR in NOT, opredelile 17 formalizirano opredeljenih ciljnih asociacij, v katere je bilo uvrščeno 483 popisov iz prvotnega nabora podatkov. Da bi opredelili tudi popise, ki so ostali neuvrščeni po Coctail klasifikaciji ali pa so bili uvrščeni v več kot eno asociacijo smo uporabili delno-nadzorovano klasifikacijo. Navezanost vrst, ki smo jo izračunali s phi koeficientom, je bila uporabljena za izračun diagnostičnih vrst posameznih asociacij, ki so bile uporabljene za oceno kakovosti formalnih definicij. Preverili smo veljavnost in legitimnost obstoječe nomenklature termofilnih listopadnih gozdov, pri čemer smo natančno upoštevati pravila ICPN (Mednarodni kodeks fitocenološke nomenklature). Pri tem smo imena sintaksonov popravili, tipificirali ali opisali nove, če je bilo to potrebno. Pri netipificiranih sintaksonih smo določili lektotipe in neotipe; pri sintaksonih, ki so neveljavni v skladu s členom 5 (ICPN) pa smo določili holotip. Spremenjeno obliko imena, to je *nomen mutandum*, smo uporabili v primerih, če je bilo v imenih uporabljeno ime rastlinskih vrst oziroma taksonov, ki se ne uporabljajo več v moderni taksonomski in floristični literaturi. Opisi novih asociacij so opremljeni z opisom asociacije in fitocenološko tabelo, v kateri je označen holotip. Tako smo ugotovili, katera imena so veljavna in pripravili kompletno listo sinonimov.

<u>Rezultati.</u> Različno floristično sestavo sedmih conalnih gozdnih združb v BiH povzročajo predvsem makroklimatski dejavniki, predvsem povprečne letne temperature, povprečna temperatura najhladnejšega četrtletja in padavine v najtoplejšem četrtletju. Razlike floristične sestave conalnih gozdnih združb so odvisne tudi od nadmorske višine, zemljepisne dolžine in širine, medtem ko korelacija s tlemi, aspektom in reakcijo tal rastišča ni statistično značilna. Prav tako je statistično značilna tudi korelacija z horotipi, in sicer z deleži vrst iz jugovzhodne in jugovzhodne Evrope ter deleži evrimediteranskih, stenomediternskih, borealnih in južnoevropskih gorskih vrst, medtem ko je korelacija z najbolj pogostimi vrstami v sestojih, kot so evropske in evrazijske vrste, ni statistično značilna. Korelacije različnih življenjskih oblik je statistično pomembna samo za deleže fanerofitov in geofitov. Nismo na našli statistično pomembnih razlik med ekološkimi strategijami (CSR), kar pomeni, da ni razlike v strategijah v conalnih gozdnih združbah. Tako lahko delno potrdimo našo prvo predpostavko (H1).

Numerična analiza popisov razredov *Quercetea pubescentis* in *Quercetea robori-petraeae* zahodnega dela Balkanskega polotoka je pokazala devet floristično utemeljenih snopov, ki gradijo tri glavne ekološke skupine: 1) bazifilno-termofilne združbe, v katerih prevladujejo puhasti hrast (*Quercus pubescens*), kraški gaber (*Carpinus orientalis*) in črni gaber (*Ostrya carpinifolia*) (snop 1-3); 2) rahlo do zmerno acidofilno-termofilne združbe, v katerih prevladujejo sladun (*Quercus frainetto*), graden (*Q. petraea* agg.) in cer (*Q. cerris*) (snopi 4-6, v to skupino uvrščamo snop 6, ki ima prehodni značaj k mezo-acidofilnim gozdovom); in 3) mezofilne in mezo-acidofilne združbe na kislih kamninah iz zahodnega delu regije, kjer večje količine padavin prevladujejo graden (*Quercus petraea* agg.), kostanj (*Castanea sativa*) in breza (*Betula pendula*) (snopi 7-9). Ta delitev odraža predvsem pH gradient od bazifilnih do acidofilnih gozdov. Primerjava diagnostičnih vrst prehodnih acido-termofilnih združb (snopa 6) z mezo-acidofilnimi in mezofilnimi gozdovi (združeni snopi 7-9), je pokazala, da so acido-termofilni gozdovi (snop 6) označeni s termofilnimi oz. jugovzhodnoevropskimi vrstami (npr. *Campanula persicifolia, Dactylis glomerata, Festuca drymeja, Sorbus torminalis, Fraxinus ornus, Lathyrus niger, Melittis melissophyllum, Tanacetum corymbosum, Vincetoxicum hirundinaria*), medtem ko so mezo-acidofilni in mezofilnimi gozdovi označeni s vrstami, ki uspevajo na zelo kislih tleh in hladnejših rastiščih. Te vrste imajo predvsem evropski ali evrazijski vzorec razširjenosti (npr. *Calluna vulgaris, Vaccinium myrtillus, Betula pendula, Poetntilla erecta, Pteridium aquilinum*). To potrjuje mnenje, da moramo prehodne acido-termofilne gozdove (snop 6), skupaj z snopi 1-5 uvrstiti med termofilne listopadne gozdove razreda *Quercetea pubescentis*. Ti rezultati podpirajo tudi našo drugo predpostavko (H2), ki pravi, da se v severni BiH in severni Hrvaški (Slavonija) na istem območju pojavljajo acido-termofilni (snop 6) in mezo-acidofilni gozdovi (snop 7-9), ki jih pogosto zmotno uvrščamo v isto katergorijo.

Naša tretja predpostavka (H3) je podprta z analizo floristične sestave termofilnih listopadnih gozdov, ki je pokazala, da se jasno diferenciacijo posamezni tipi teh gozdov na območju zahodnega dela Balkanskega polotoka. Tako so bili tudi gozdovi z ozemlja BiH smiselno vključen v širši okvir gozdne vegetacije zahodnega dela Balkanskega polotoka. Termofilni listopadni gozdovi na zahodnem delu Balkanskega polotoka so razvrščeni v šest skupin, ki odražajo glavne ekološke in fitogeografske vzorce v njihovi vrstni sestavi na obravnavanem območju: tip 1 - submediteranski gozdovi, v katerih prevladujeta puhasti hrast (*Quercus pubescens*) in/ali kraški gaber (*Carpinus orientalis*); tip 2 - submediteranski in celinski gozdovi s puhastim hrastom (*Quercus pubescens*) brez kraškega gabra (*Carpinus orientalis*); tip 3 - mezo-termofilni supramediteranski in/ali relikti gozdovi, v katerih prevladuje črni gaber (*Ostrya carpinifolia*); tip 4 - termofilni celinski gozdovi na globokih, nevtralnih do rahlo kislih tleh, v katerih prevladujta sladun (*Quercus frainetto*) in/ali cer (*Q. cerris*); tip 5 - acido-termofilni celinski gozdovi, v katerih prevladujeta graden (*Quercus petraea* agg.) in/ali cer (*Q. cerris*); tip 6 - acido-termofilni severno dinarsko-južno panonski gozdovi, kjer prevladuje graden (*Quercus petraea agg.*). Razlike v floristični sestavi je najlaže pojasniti z reakcijo tal, letno količino padavin in padavin v najtoplejšem četrtletju, pa tudi temperaturo. Vsi klimatski dejavniki bolj ali manj jasno odražajo geografski jugozahodni-severovzhodni gradient na zahodnem delu Balkanskega polotoka.

Termofilne listopadne gozdove na zahodnem delu Balkanskega polotoka smo s pomočjo numeričnih metod razdelili v šest floristično in ekološko dobro opredeljenih skupin, ki se razmeroma dobro ujemajo z uveljavljenimi sintaksonomskimi shemami. Odprta pa ostaja še uvrstitev v obstoječe sheme nekaterih gozdov, kot so mezo-termofilni supramediteranski in/ali reliktni gozdovi, v katerih prevladuje črni gaber (*Ostrya carpinifolia*) ali submediteranski in celinski gozdovi, kjer prevladuje puhasti hrast (*Quercus pubescens*) brez kraškega gabra (*Carpinus orientalis*). Prav tako pa še ni povsem jasna uvrstitev acido-termofilnih severno dinarsko-južno panonskih gozdov, v katerih prevladuje graden (*Quercus petraea* agg.).

Z Cocktail metodo smo razvrstili termofilne listopadne gozdove v BiH v 17 asociacij. Poleg tega je delno-nadzorovana uvrstitev pokazala še eno ekološko in floristično dobro opredeljeno asociacijo, ki smo jo opisali kot novo, in sicer *Aceri obtusati-Quercetum petraeae*. Vse asociacije smo razvrstili po kriteriju prevladujočih vrst v drevesni plasti, tako da bi predstavil razlike v floristični sestavi med asociacijami istega tipa, se pravi, med gozdovi, kjer prevladuje ista drevesna vrsta. Vse gozdove smo razdelili v štiri skupine: 1) skupina asociacij, kjer prevladujeta puhasti hrast (*Quercus pubescens*) in/ali kraški gaber (*Carpinus orientalis*); 2) skupina asociaciji, kjer prevladuje črni gaber (*Ostrya carpinifolia*); 3) skupina asociacij, kjer prevldujeta sladun (*Quercus frainetto*) in/ali cer (*Q. cerris*); in 4) skupina asociacij, kjer prevladuje graden (*Quercus petraea* agg.). Največje število asociacij (13) se pojavlja v sredozemski regiji; v dinarskem in predpanonskem prostoru se pojavlja po 10 asociacij, medtem ko v prehodni ilirsko-mezijski regiji najdemo le pet asociacij. Največji višinski razpon med najvišjimi in najnižjimi popisi najdemo v sredozemskem območju (130-1030 m), ki mu sledi dinarsko (310-1000 m), prehodno ilirsko-mezijsko (190-880 m) in predpanonsko območje (250-780 m).

Sintaksonomski pregled:

(1) Asociacije, kjer prevladujeta puhasti hrast (*Quercus pubescens*) in/ali kraški gaber (*Carpinus orientalis*)
1. *Querco pubescenti-Carpinetum orientalis* Horvatić 1939
2. *Rusco aculeati-Carpinetum orientalis* Blečić et Lakušić 1967
3. *Carici hallerianae-Quercetum pubescentis* Stupar et al. 2015
4. *Cruciato glabrae-Carpinetum orientalis* Šugar et Trinajstić ex Stupar et al. 2015
5. *Seslerio autumnalis-Quercetum pubescentis* Zupančič 1999
6. *Aristolochio luteae-Quercetum pubescentis* (Horvat 1959) Poldini 2008

7. *Asparago tenuifolii-Quercetum pubescentis* Lakušić et Redžić 1991

(2) Asociacije, kjer prevladuje črni gaber (*Ostrya carpinifolia*)
8. *Seslerio autumnalis-Ostryetum carpinifoliae* Horvat et Horvatić ex Horvat 1959
9. *Rusco aculeati-Ostryetum carpinifoliae* Lakušić et Redžić ex Stupar et al. 2.015
10. *Querco pubescenti-Ostryetum carpinifoliae* Horvat 1938

(3) asociacije, kjer prevladujeta sladun (*Quercus frainetto*) in cer (*Q. cerris*)
11. *Quercetum frainetto-cerridis* (Rudski 1949) Trinajstić et al. 1996
12. *Fraxino orni-Quercetum cerridis* Stefanović 1968

(4) Asociacije, kjer prevladuje graden (*Quercus petraea* agg.)
13. *Lathyro nigri-Quercetum petraeae* Horvat (1938) 1959
14. *Aceri obtusati-Quercetum petraeae* Stupar et al. 2015
15. *Cytiso hirsuti-Quercetum petraeae* (Stefanović 1964) Pallas in Bohn et Neuhäusl 2004
16. *Festuco drymejae-Quercetum petraeae* (Janković et Mišić 1960) Janković 1968
17. *Potentillo micranthae-Quercetum petraeae* Vukelić et al. ex Vukelić, Baričević et Šapić in Stupar et al. 2015
18. *Seslerio autumnalis-Quercetum petraeae* Poldini ex Poldini 1982

Analiza termofilnih listopadnih gozdov v BiH prikazuje sintaksonomske shemo 18 ekološko in floristično jasno ločenih asociacij, njihove medsebojne fitocenološke odnose v BiH in sosednjih državah, kot tudi svoje odnose z drugimi vegetacijskimi tipi v regiji. Vendar pa je še vedno nekaj problemov, ki bi jih bilo potrebno obdelati v prihodnje. Zlasti so potrebne nadaljnje raziskave, da bi ugotovile vzorce raznolikosti znotraj nekaterih dokaj heterogenih asociacij, kot sta asociaciji *Quercetum frainetto-cerridis* in *Cruciato glabrae-Carpinetum orientalis*, medtem ko je potrebno ponovno oceniti sintaksonomski položaj in razmere v asociaciji *Aristolochio luteae-Quercetum pubescentis*.

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ANNEXES

ANNEX A

Full version of frequency-fidelity table of ZFPCs in B&H presented in chapter 2.1 (therein reffered to as On-line Suppl. Tab. 1.). Diagnostic species (phi values higher than 0.25) for each community are shaded.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
No. of relevés	**5**	**16**	**24**	**26**	**162**	**123**	**42**
ZFPC 1							
Quercus ilex	$100^{96.5}$	6^{-}	.	.	.	.	.
Arbutus unedo	80^{88}	.	.	.	.	.	.
Teucrium polium ssp. *capitatum*	$80^{84.1}$	6^{-}	.	.	.	.	.
Centaurium erythraea	$80^{83.2}$	.	.	8^{-}	.	.	.
Pistacia terebinthus	$100^{82.6}$	$38^{18.3}$	.	.	.	.	.
Juniperus phoenicea	60^{75}	.	.	.	.	.	.
Pistacia lentiscus	60^{75}	.	.	.	.	.	.
Juniperus oxycedrus ssp. *macrocarpa*	$40^{60.3}$	.	.	.	.	.	.
Crepis sancta	$40^{60.3}$	.	.	.	.	.	.
Cistus salvifolius	$40^{60.3}$	.	.	.	.	.	.
Cyclamen repandum	$40^{60.3}$	.	.	.	.	.	.
Cistus incanus	$40^{60.3}$	.	.	.	.	.	.
Biscutella laevigata	$40^{60.3}$	.	.	.	.	.	.
Iberis umbellata	$40^{60.3}$	.	.	.	.	.	.
Rubia peregrina	$40^{60.3}$	.	.	.	.	.	.
Salvia officinalis	$40^{60.3}$	.	.	.	.	.	.
Satureja montana	$40^{60.3}$	.	.	.	.	.	.
Micromeria juliana	$40^{60.3}$	.	.	.	.	.	.
Helianthemum nummularium ssp. *obscurum*	$40^{60.3}$	.	.	.	.	.	.
Smilax aspera	$40^{60.3}$	.	.	.	.	.	.
Thymus longicaulis	$40^{54.9}$	6^{-}	.	.	.	.	.
Koeleria splendens	$40^{54.9}$	6^{-}	.	.	.	.	.
ZFPC 2							
Quercus pubescens	20^{-}	$100^{84.5}$	12^{-}	.	.	.	.
Cornus mas	.	$88^{83.6}$	8^{-}	8^{-}	.	.	.
Acer monspessulanum	.	$62^{76.7}$	.	.	.	.	.
Sesleria autumnalis	20^{-}	$81^{76.5}$	.	.	1^{-}	1^{-}	.
Frangula rupestris	.	$56^{72.4}$	.	.	.	.	.
Viola hirta	.	$75^{69.4}$	17^{-}	12^{-}	.	.	.
Rubus ulmifolius	.	$50^{67.9}$	.	.	.	.	.
Carex halleriana	20^{-}	$62^{64.2}$	.	.	.	.	.
Brachypodium sylvaticum	.	$75^{61.1}$	12^{-}	19^{-}	5^{-}	6^{-}	7^{-}
Juniperus oxycedrus	40^{-}	69^{60}	.	.	.	.	.
Ptilostemon strictus	.	$38^{58.3}$	.	.	.	.	.
Hieracium tommasinianum	.	$38^{58.3}$	.	.	.	.	.
Bromus erectus agg.	.	50^{58}	12^{-}	.	1^{-}	.	.
Ruscus aculeatus	40^{-}	$75^{57.4}$	21^{-}	.	.	.	.
Petteria ramentacea	.	31^{53}	.	.	.	.	.
Asperula purpurea	.	31^{53}	.	.	.	.	.
Carex flacca s.l.	.	$38^{52.5}$	.	4^{-}	2^{-}	1^{-}	.
Paliurus spina-christi	40^{-}	$56^{50.4}$	.	.	.	.	.
Thalictrum minus	.	$31^{48.2}$	.	.	.	.	5^{-}
Lathyrus venetus	.	$38^{47.5}$	8^{-}	4^{-}	1^{-}	.	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Asplenium ceterach	.	$25^{47.1}$	.	.	.	.	.
Viola alba	.	$25^{47.1}$	.	.	.	.	.
Carex humilis	.	$25^{47.1}$	.	.	.	.	.
Tamus communis	40^{-}	$62^{46.1}$	17^{-}	8^{-}	3^{-}	.	.
Hedera helix	.	$56^{45.8}$	17^{-}	15^{-}	17^{-}	4^{-}	.
Festuca pseudovina agg.	.	$38^{41.1}$	$21^{17.1}$	4^{-}	.	.	.
Dictamnus albus	.	$19^{40.6}$	.	.	.	.	.
Genista sylvestris	.	$19^{40.6}$	.	.	.	.	.
Filipendula vulgaris	.	$19^{40.6}$	.	.	.	.	.
Prunus mahaleb	.	$19^{40.6}$	.	.	.	.	.
Cotinus coggygria	.	$19^{40.6}$	.	.	.	.	.
Piptatherum miliaceum	.	$19^{40.6}$	.	.	.	.	.
Anacamptis pyramidalis	.	$19^{40.6}$	.	.	.	.	.
Brachypodium pinnatum	20^{-}	$50^{40.2}$	$33^{21.1}$	.	1^{-}	.	.
Helleborus multifidus	.	19^{39}	.	.	1^{-}	.	.
Dactylis glomerata	40^{-}	$69^{38.1}$	$50^{20.9}$	23^{-}	3^{-}	1^{-}	5^{-}
Rosa canina	.	$25^{34.1}$	8^{-}	4^{-}	2^{-}	.	.
Silene vulgaris s.l.	.	$25^{32.7}$	.	8^{-}	1^{-}	1^{-}	7^{-}
Stachys officinalis	.	$31^{32.1}$	4^{-}	$23^{20.4}$	4^{-}	.	.
Eryngium amethystinum	.	$19^{31.5}$	8^{-}	.	.	.	.
Coronilla emerus s.l.	20^{-}	$25^{30.9}$	.	.	.	.	.
Carex distachya	20^{-}	$25^{30.9}$	$.^{-}$	.	.	.	.
Lotus corniculatus	20^{-}	$31^{28.4}$	12^{-}	8^{-}	.	.	.
Vincetoxicum hirundinaria	20^{-}	$31^{26.7}$	$25^{18.5}$	.	.	.	.
Teucrium chamaedrys	40^{-}	$38^{25.1}$	$29^{15.7}$	.	1^{-}	.	.
ZFPC 3							
Quercus frainetto	.	19^{-}	$100^{90.3}$	.	.	.	.
Chamaecytisus hirsutus agg.	.	.	$58^{70.4}$	4^{-}	.	1^{-}	.
Quercus cerris	.	50^{23}	$100^{69.8}$	27^{-}	1^{-}	1^{-}	.
Thymus pulegioides	.	.	$54^{65.7}$	.	4^{-}	1^{-}	2^{-}
Lychnis coronaria	.	.	$46^{64.8}$	.	.	.	.
Lathyrus niger	.	12^{-}	58^{63}	4^{-}	.	.	.
Euphorbia cyparissias	.	19^{-}	$58^{61.7}$	.	.	.	.
Dianthus armeria	.	.	$42^{61.6}$	.	.	.	.
Carex caryophyllea	.	19^{-}	$58^{57.8}$	8^{-}	.	.	.
Silene viridiflora	.	12^{-}	$46^{55.4}$	.	.	.	.
Trifolium arvense	.	.	$29^{51.1}$	.	.	.	.
Physospermum cornubiense	.	.	$29^{51.1}$	.	.	.	.
Scabiosa cinerea ssp. *cinerea*	.	.	$29^{48.4}$	.	2^{-}	.	.
Hypericum perforatum	.	6^{-}	$42^{47.6}$	8^{-}	3^{-}	2^{-}	.
Stachys recta	.	.	$25^{47.1}$	.	.	.	.
Tilia tomentosa	.	.	$25^{47.1}$	.	.	.	.
Vulpia myuros	.	.	$25^{47.1}$	.	.	.	.
Juniperus communis	.	.	$42^{45.2}$	15^{-}	3^{-}	3^{-}	2^{-}
Viburnum lantana	.	.	25^{45}	.	2^{-}	.	.
Origanum vulgare	.	.	25^{45}	.	2^{-}	.	.
Rosa tomentosa	.	6^{-}	$29^{44.9}$	.	.	.	.
Clinopodium vulgare	.	25^{-}	$46^{44.7}$	4^{-}	2^{-}	2^{-}	.
Genista pilosa	.	.	$29^{43.7}$	8^{-}	.	.	.
Verbascum densiflorum	.	.	$21^{42.9}$	.	.	.	.
Coronilla varia	.	.	$21^{42.9}$	.	.	.	.
Cerastium brachypetalum	.	.	$21^{42.9}$	.	.	.	.
Sorbus domestica	.	.	$21^{42.9}$	.	.	.	.
Euonymus europaeus	.	.	$21^{42.1}$	.	1^{-}	.	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Leontodon hispidus	.	.	$25^{41.5}$	.	1^{-}	2^{-}	2^{-}
Hieracium hoppeanum	.	6^{-}	$25^{40.6}$	.	.	.	.
Potentilla micrantha	.	$31^{21.5}$	46^{39}	15^{-}	.	1^{-}	.
Galium pseudaristatum	.	.	$17^{38.3}$	.	.	.	.
Setaria viridis	.	.	$17^{38.3}$	.	.	.	.
Koeleria macrantha	.	.	$17^{38.3}$	.	.	.	.
Campanula lingulata	.	.	$17^{38.3}$	.	.	.	.
Astragalus glycyphyllos	.	.	$17^{36.2}$	.	1^{-}	1^{-}	.
Dorycnium pentaphyllum ssp. *germanicum*	.	6^{-}	$21^{35.9}$	.	.	.	.
Buglossoides purpurocaerulea	.	12^{-}	$25^{35.6}$	.	.	.	.
Betula pendula	.	.	$25^{35.6}$	8^{-}	.	5^{-}	.
Galium lucidum	.	19^{-}	$33^{35.4}$	8^{-}	.	2^{-}	.
Hieracium sabaudum	.	.	$21^{34.6}$	8^{-}	.	.	.
Asplenium adiantum-nigrum	.	6^{-}	$29^{34.2}$	12^{-}	1^{-}	1^{-}	2^{-}
Hieracium pilosella	.	.	$29^{33.8}$	19^{-}	4^{-}	.	.
Ligustrum vulgare	.	12^{-}	$33^{33.3}$	19^{-}	1^{-}	.	.
Logfia arvensis	.	.	12^{33}	.	.	.	.
Aira elegantissima	.	.	12^{33}	.	.	.	.
Myosotis arvensis	.	.	12^{33}	.	.	.	.
Thesium bavarum	.	.	12^{33}	.	.	.	.
Crataegus laevigata	.	.	$17^{32.6}$	4^{-}	1^{-}	.	.
Carex montana	.	.	$21^{31.1}$	8^{-}	1^{-}	1^{-}	2^{-}
Silene italica	.	12^{-}	$21^{30.8}$	.	.	.	.
Trifolium rubens	.	6^{-}	$17^{30.7}$	.	.	.	.
Poa angustifolia	.	.	$21^{29.9}$	12^{-}	1^{-}	2^{-}	$.^{-}$
Prunus spinosa	.	6^{-}	$25^{27.8}$	$19^{18.7}$	1^{-}	$.^{-}$	$.^{-}$
Primula vulgaris	.	6^{-}	$33^{27.5}$	$31^{24.2}$	7^{-}	4^{-}	$.^{-}$
Festuca heterophylla	.	12^{-}	$29^{26.3}$	12^{-}	2^{-}	9^{-}	5^{-}
Campanula persicifolia	.	.	$17^{25.8}$	12^{-}	1^{-}	.	.
Cornus sanguinea	.	6^{-}	$21^{25.7}$	12^{-}	3^{-}	.	.
ZFPC 4							
Carpinus betulus	.	.	$42^{19.6}$	$100^{77.3}$	11^{-}	.	.
Cruciata glabra	.	.	4^{-}	$69^{67.5}$	11^{-}	8^{-}	.
Prunus avium	.	.	25^{-}	$65^{60.7}$	6^{-}	1^{-}	.
Luzula luzuloides	.	.	.	$58^{59.9}$	1^{-}	8^{-}	12^{-}
Pteridium aquilinum	.	.	38^{-}	$77^{57.7}$	12^{-}	15^{-}	.
Stellaria holostea	.	.	8^{-}	$50^{56.6}$	1^{-}	.	7^{-}
Melampyrum pratense	.	.	17^{-}	$50^{54.5}$	.	1^{-}	2^{-}
Erythronium dens-canis	.	.	.	27^{49}	.	.	.
Crataegus monogyna	.	44^{-}	29^{-}	$69^{45.3}$	15^{-}	2^{-}	.
Hieracium racemosum	.	.	.	$23^{45.2}$	.	.	.
Danthonia decumbens	.	.	.	$23^{45.2}$	.	.	.
Tilia cordata	.	.	4^{-}	$27^{43.4}$	1^{-}	.	.
Potentilla erecta	.	.	.	$23^{43.3}$	.	2^{-}	.
Rosa arvensis	.	12^{-}	$25^{16.1}$	$46^{42.6}$	1^{-}	.	.
Corylus avellana	.	.	25^{-}	$54^{38.8}$	26^{-}	19^{-}	.
Hieracium praealtum ssp. *bauhinii*	.	.	12^{-}	$27^{37.7}$	.	.	.
Chamaespartium sagittale	.	.	$25^{23.6}$	$35^{37.6}$	1^{-}	.	.
Carex pilosa	.	.	17^{-}	27^{35}	.	.	.
Agrostis stolonifera	.	.	.	$12^{31.7}$	.	.	.
Silene nutans	.	.	.	$12^{31.7}$	.	.	.
Quercus robur	.	.	4^{-}	$15^{31.2}$	.	.	.
Campanula trachelium	.	.	.	$12^{30.6}$	1^{-}	.	.
Veronica chamaedrys	.	44^{-}	42^{-}	65^{29}	16^{-}	18^{-}	40^{-}

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Vicia cracca	.	.	12^{-}	$19^{28.8}$	.	.	.
Galium mollugo agg.	.	.	17^{-}	$23^{26.1}$	4^{-}	$.^{-}$	5^{-}
Luzula pilosa	.	.	8^{-}	$15^{25.7}$	.	2^{-}	.
ZFPC 5							
Galium odoratum	.	.	.	12^{-}	$76^{46.5}$	59^{-}	36^{-}
Acer pseudoplatanus	.	.	.	12^{-}	$81^{44.6}$	69^{-}	52^{-}
Cardamine bulbifera	.	.	.	12^{-}	$67^{42.3}$	30^{-}	55^{-}
Lonicera xylosteum	.	.	.	.	$31^{38.9}$	15^{-}	2^{-}
Cardamine enneaphyllos	.	.	.	.	$62^{38.1}$	35^{-}	62^{-}
Daphne mezereum	.	.	.	.	$51^{35.1}$	37^{-}	38^{-}
Salvia glutinosa	.	.	4^{-}	4^{-}	$31^{34.9}$	14^{-}	2^{-}
Glechoma hirsuta	.	.	17^{-}	19^{-}	$50^{34.6}$	26^{-}	12^{-}
Rubus hirtus	.	.	12^{-}	42^{-}	$57^{33.1}$	36^{-}	14^{-}
Cardamine trifolia	.	.	.	.	$28^{32.9}$	20^{-}	2^{-}
Cardamine waldsteinii	.	.	.	.	$23^{30.7}$	11^{-}	5^{-}
Anemone nemorosa	.	.	.	35^{-}	$60^{30.3}$	49^{-}	48^{-}
Mycelis muralis	.	.	4^{-}	23^{-}	58^{28}	57^{-}	50^{-}
Euonymus latifolius	.	.	.	.	$11^{27.2}$	2^{-}	.
Polygonatum multiflorum	.	.	.	15^{-}	$23^{25.8}$	9^{-}	2^{-}
Acer platanoides	.	.	.	8^{-}	$16^{25.2}$	4^{-}	.
Arum maculatum	.	.	4^{-}	4^{-}	$15^{25.2}$	2^{-}	.
Circaea lutetiana	.	.	.	.	$12^{25.2}$	6^{-}	.
ZFPC 6							
Picea abies	.	.	.	.	51^{-}	$100^{59.7}$	69^{-}
Abies alba	.	.	.	8^{-}	73^{-}	$98^{52.5}$	76^{-}
Athyrium filix-femina	.	.	.	8^{-}	38^{-}	63^{49}	14^{-}
Galium rotundifolium	.	.	.	.	9^{-}	$41^{46.5}$	12^{-}
Oxalis acetosella	.	.	.	.	64^{-}	$83^{46.1}$	69^{-}
Lonicera nigra	.	.	.	.	19^{-}	$46^{43.9}$	17^{-}
Sorbus aucuparia	.	.	.	.	33^{-}	$63^{42.1}$	50^{-}
Senecio nemorensis s.l.	.	.	.	.	38^{-}	$59^{40.8}$	38^{-}
Prenanthes purpurea	.	.	.	4^{-}	46^{-}	$68^{38.9}$	67^{-}
Lamiastrum galeobdolon	.	.	.	27^{-}	56^{-}	$73^{38.8}$	52^{-}
Lonicera alpigena	.	.	.	.	46^{-}	$61^{36.2}$	57^{-}
Festuca altissima	.	.	.	4^{-}	12^{-}	$36^{35.9}$	17^{-}
Rubus idaeus	.	.	.	.	15^{-}	$41^{35.8}$	31^{-}
Aremonia agrimonoides	.	.	.	27^{-}	68^{-}	$74^{35.2}$	64^{-}
Carex sylvatica	.	.	12^{-}	23^{-}	44^{-}	$54^{34.9}$	7^{-}
Rhamnus alpinus ssp. *fallax*	.	.	.	.	35^{-}	$50^{33.9}$	40^{-}
Dryopteris filix-mas	.	.	4^{-}	27^{-}	60^{-}	$66^{33.7}$	43^{-}
Dryopteris dilatata	.	.	.	.	12^{-}	$23^{33.6}$	.
Sanicula europaea	.	.	4^{-}	27^{-}	54^{-}	$63^{33.1}$	43^{-}
Geranium robertianum	.	.	.	8^{-}	44^{-}	$50^{33.1}$	26^{-}
Sambucus racemosa	.	.	.	.	19^{-}	28^{32}	5^{-}
Hordelymus europaeus	.	.	.	.	9^{-}	$28^{31.9}$	14^{-}
Asarum europaeum	.	.	4^{-}	.	38^{-}	$47^{31.3}$	36^{-}
Rubus fruticosus agg.	.	.	17^{-}	15^{-}	7^{-}	$36^{30.6}$	7^{-}
Ajuga reptans	.	.	12^{-}	50^{-}	46^{-}	$55^{27.1}$	19^{-}
Euphorbia amygdaloides	.	6^{-}	12^{-}	38^{-}	54^{-}	63^{27}	52^{-}
Maianthemum bifolium	.	.	.	.	5^{-}	$20^{26.3}$	12^{-}
Rosa pendulina	.	.	.	.	12^{-}	$32^{26.3}$	36^{-}
ZFPC 7							
Saxifraga rotundifolia	.	.	.	.	12^{-}	24^{-}	$76^{66.7}$
Luzula sylvatica	.	.	.	.	3^{-}	20^{-}	$67^{65.6}$

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Adenostyles alliariae	.	.	.	.	5^{-}	23^{-}	$64^{61.8}$
Valeriana montana	.	.	.	.	4^{-}	8^{-}	$45^{55.3}$
Cicerbita alpina	.	.	.	.	1^{-}	10^{-}	$43^{53.9}$
Veronica urticifolia	.	.	.	.	4^{-}	23^{-}	$52^{52.8}$
Ranunculus platanifolius	.	.	.	.	2^{-}	5^{-}	$38^{52.4}$
Astrantia major	.	.	.	.	.	1^{-}	$31^{51.8}$
Homogyne alpina	.	.	.	.	.	.	$29^{50.5}$
Veratrum lobelianum	.	.	.	.	.	.	24^{46}
Poa alpina	.	.	.	.	.	.	19^{41}
Hypericum richeri ssp. *grisebachii*	.	.	.	.	.	.	19^{41}
Pimpinella serbica	.	.	.	.	.	.	19^{41}
Thalictrum aquilegiifolium	.	.	.	.	1^{-}	7^{-}	$26^{40.4}$
Doronicum columnae	.	.	.	.	2^{-}	6^{-}	$26^{40.2}$
Senecio rupestris	.	.	.	.	.	$.^{-}$	$17^{38.3}$
Phyteuma spicatum	.	.	.	.	2^{-}	10^{-}	$26^{37.1}$
Hieracium murorum	.	.	12^{-}	12^{-}	4^{-}	24^{-}	$45^{36.8}$
Aconitum lycoctonum s.l.	.	.	.	.	2^{-}	8^{-}	$24^{35.7}$
Euphorbia dulcis	.	.	.	.	1^{-}	1^{-}	$14^{33.2}$
Galanthus nivalis	.	.	.	.	4^{-}	1^{-}	$17^{32.5}$
Geranium sylvaticum	.	.	.	.	.	.	$12^{32.2}$
Plantago reniformis	.	.	.	.	.	.	$12^{32.2}$
Rubus saxatilis	.	.	.	.	.	.	$12^{32.2}$
Viola biflora	.	.	.	.	.	.	$12^{32.2}$
Solidago virgaurea	.	.	4^{-}	.	4^{-}	12^{-}	$26^{32.2}$
Symphytum tuberosum	.	12^{-}	4^{-}	35^{-}	35^{-}	44^{-}	$62^{31.6}$
Doronicum austriacum	.	.	.	.	1^{-}	6^{-}	$17^{30.1}$
Cirsium erisithales	.	.	.	.	1^{-}	7^{-}	$17^{29.3}$
Arabis alpina	.	.	.	.	.	2^{-}	$12^{28.4}$
Deschampsia flexuosa	.	.	4^{-}	4^{-}	.	1^{-}	$17^{28.4}$
Dactylorhiza maculata	.	.	.	.	.	6^{-}	14^{28}
Laserpitium krapfii ssp. *krapfii*	.	.	.	4^{-}	3^{-}	7^{-}	19^{28}
Species diagnostic for more than one community							
Phillyrea latifolia	$100^{78.2}$	$50^{28.4}$	.	.	.	.	.
Clematis flammula	$80^{64.5}$	50^{33}	.	.	.	.	.
Asparagus acutifolius	$60^{40.5}$	$81^{62.1}$	.	.	.	.	.
Carpinus orientalis	.	$88^{68.3}$	$54^{34.5}$	.	.	.	.
Fraxinus ornus	60^{-}	$100^{50.4}$	$83^{36.5}$	31^{-}	2^{-}	1^{-}	.
Genista tinctoria	.	.	$54^{50.6}$	$35^{26.7}$	1^{-}	.	.
Quercus petraea	.	.	$71^{43.7}$	$100^{71.3}$	1^{-}	1^{-}	.
Acer tataricum	.	.	$42^{37.3}$	$42^{38.1}$	.	.	.
Pyrus pyraster	.	.	$38^{32.6}$	$38^{33.8}$	6^{-}	1^{-}	.
Veronica officinalis	.	.	$50^{32.3}$	$54^{36.4}$	9^{-}	13^{-}	7^{-}
Galium schultesii	.	.	$29^{31.4}$	$27^{28.1}$	.	1^{-}	.
Helleborus odorus	.	.	$33^{28.2}$	$35^{29.9}$	9^{-}	.	2^{-}
Acer campestre	.	12^{-}	$42^{27.5}$	$58^{45.1}$	4^{-}	.	.
Fagus sylvatica	.	.	12^{-}	46^{-}	$100^{39.8}$	$100^{39.8}$	100^{-}
Vaccinium myrtillus	.	.	.	4^{-}	12^{-}	$57^{40.3}$	$57^{40.6}$
Other species							
Aposeris foetida	.	.	8^{-}	19^{-}	6^{-}	2^{-}	$24^{22.8}$
Allium scorodoprasum s.l.	.	12^{-}	.	.	.	.	.
Rhamnus intermedius	20^{-}	.	.	.	.	.	.
Ulmus minor	.	.	8^{-}	8^{-}	.	1^{-}	.
Poa stiriaca	.	.	.	.	1^{-}	2^{-}	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Serratula tinctoria	.	.	4^{-}	.	.	.	.
Laserpitium latifolium	.	.	.	.	.	2^{-}	2^{-}
Vicia oroboides	.	.	.	.	10^{-}	2^{-}	10^{-}
Carduus crispus	.	.	.	.	.	.	5^{-}
Oenanthe pimpinelloides	.	12^{-}	.	.	.	.	.
Silene dioica	.	.	.	4^{-}	3^{-}	10^{-}	12^{-}
Poa bulbosa	20^{-}	6^{-}	.	.	1^{-}	.	.
Bunium alpinum ssp. *montanum*	.	12^{-}	.	.	.	.	.
Acanthus spinosus	.	6^{-}	.	.	.	.	.
Lilium martagon	.	.	.	4^{-}	$24^{24.9}$	12^{-}	14^{-}
Mercurialis perennis	.	.	.	.	$28^{24.5}$	15^{-}	29^{-}
Ulmus glabra	.	.	.	4^{-}	$20^{24.3}$	14^{-}	5^{-}
Cystopteris montana	.	.	.	.	1^{-}	2^{-}	5^{-}
Chrysosplenium alternifolium	.	.	.	.	2^{-}	6^{-}	.
Asperula taurina	.	.	.	.	3^{-}	.	.
Gentiana asclepiadea	.	.	.	.	19^{-}	27^{-}	31^{-}
Centaurea napulifera ssp. *tuberosa*	.	12^{-}	.	.	.	.	.
Staphylea pinnata	.	.	.	.	1^{-}	.	.
Amelanchier ovalis	.	6^{-}	.	.	.	2^{-}	.
Ranunculus thora	.	.	.	.	.	.	2^{-}
Rumex alpestris	.	.	.	.	.	.	7^{-}
Rorippa lippizensis	.	6^{-}	.	.	.	.	.
Viburnum tinus	20^{-}	.	.	.	.	.	.
Rumex alpinus	.	.	.	.	.	.	7^{-}
Viola reichenbachiana	.	.	.	42^{-}	59^{-}	59^{-}	67^{-}
Agrostis castellana	.	12^{-}	.	.	.	.	.
Polystichum lonchitis	.	.	.	.	6^{-}	7^{-}	19^{-}
Achillea millefolium agg.	.	.	4^{-}	.	1^{-}	.	.
Trifolium repens	.	.	.	.	1^{-}	.	.
Saxifraga blavii	.	.	.	.	.	2^{-}	.
Rhamnus orbiculatus	.	6^{-}	.	.	.	.	.
Vicia sylvatica	.	.	.	.	1^{-}	.	.
Aconitum variegatum	.	.	.	.	.	1^{-}	2^{-}
Myosotis alpestris	.	.	.	.	.	.	5^{-}
Acer obtusatum	.	.	.	12^{-}	6^{-}	2^{-}	.
Polygonatum latifolium	.	.	4^{-}	.	.	.	.
Euphorbia angulata	.	.	.	.	.	1^{-}	.
Sorbus chamaemespilus	.	.	.	.	.	.	7^{-}
Sedum hispanicum	.	.	.	.	.	.	2^{-}
Lonicera etrusca	.	12^{-}	.	.	.	.	.
Malus sylvestris	.	6^{-}	12^{-}	8^{-}	1^{-}	.	.
Hypericum androsaemum	.	.	.	.	1^{-}	.	.
Cerinthe glabra	.	.	.	.	.	.	2^{-}
Sedum album	40^{-}	.	12^{-}	.	.	1^{-}	.
Alchemilla xanthochlora	.	.	.	.	.	1^{-}	.
Clematis recta	.	12^{-}	4^{-}	.	.	.	.
Epimedium alpinum	.	.	12^{-}	15^{-}	2^{-}	.	.
Agrostis capillaris	.	.	8^{-}	12^{-}	.	.	.
Sorbus graeca	.	.	.	.	1^{-}	.	.
Trifolium alpestre	.	.	12^{-}	.	.	2^{-}	.
Dianthus ferrugineus ssp. *liburnicus*	.	6^{-}	.	.	.	.	.
Peucedanum austriacum	.	.	.	.	.	.	2^{-}
Lathyrus pratensis	.	6^{-}	.	.	.	.	.
Cardamine kitaibelii	.	.	.	.	9^{-}	3^{-}	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Petasites albus	.	.	.	.	2^{-}	1^{-}	.
Cnidium silaifolium	.	12^{-}	.	.	.	.	.
Prunella laciniata	.	6^{-}	.	.	.	.	.
Cotoneaster nebrodensis	.	.	.	.	1^{-}	4^{-}	.
Galium verum	.	.	4^{-}	.	.	.	.
Dianthus barbatus	.	.	.	.	1^{-}	.	.
Cardamine maritima	.	6^{-}	.	.	.	.	.
Cirsium waldsteinii	.	.	.	.	.	2^{-}	2^{-}
Trifolium montanum	.	.	.	8^{-}	.	.	.
Silene pusilla	.	.	.	.	.	.	2^{-}
Iris graminea	.	.	.	.	1^{-}	1^{-}	2^{-}
Cyclamen purpurascens	.	.	.	8^{-}	2^{-}	1^{-}	.
Clematis vitalba	.	25^{-}	17^{-}	.	4^{-}	.	.
Moehringia muscosa	.	.	.	.	5^{-}	13^{-}	10^{-}
Tanacetum macrophyllum	.	.	.	.	1^{-}	1^{-}	.
Hypericum tetrapterum	.	.	.	.	.	.	2^{-}
Lycopus europaeus	.	.	.	.	1^{-}	.	.
Peltaria alliacea	.	.	.	8^{-}	1^{-}	.	2^{-}
Ostrya carpinifolia	.	6^{-}	.	.	2^{-}	.	.
Angelica sylvestris	.	.	.	.	1^{-}	3^{-}	5^{-}
Corydalis cava	.	.	.	.	4^{-}	1^{-}	.
Campanula witasekiana	.	.	.	.	.	2^{-}	.
Carex ornithopoda	.	.	4^{-}	.	1^{-}	$.^{-}$	.
Chaerophyllum aureum	.	.	.	.	.	1^{-}	5^{-}
Carlina vulgaris	.	12^{-}	.	.	.	.	.
Lembotropis nigricans	.	.	12^{-}	8^{-}	.	.	.
Carex brizoides	.	.	.	4^{-}	.	.	.
Chaerophyllum hirsutum	.	.	.	4^{-}	.	.	.
Cystopteris fragilis	.	.	.	.	$18^{21.3}$	8^{-}	14^{-}
Ruscus hypoglossum	.	.	4^{-}	15^{-}	$11^{13.4}$	.	.
Allium ursinum	.	.	.	.	$7^{22.1}$	2^{-}	.
Urtica dioica	.	.	.	.	6^{-}	6^{-}	5^{-}
Galium aparine	.	.	.	.	1^{-}	1^{-}	.
Sambucus nigra	.	.	.	8^{-}	$14^{21.8}$	4^{-}	.
Aquilegia nigricans	.	.	.	.	.	1^{-}	.
Rubus canescens	.	6^{-}	8^{-}	.	.	.	.
Cephalaria leucantha	.	6^{-}	.	.	.	.	.
Quercus trojana	.	6^{-}	.	.	.	.	.
Brachypodium retusum	20^{-}	6^{-}	.	.	.	.	.
Agrimonia eupatoria	.	19^{-}	12^{-}	4^{-}	1^{-}	2^{-}	.
Euonymus verrucosus	.	19^{-}	4^{-}	8^{-}	4^{-}	1^{-}	.
Picris hieracioides	.	6^{-}	$12^{24.8}$	.	.	.	.
Rumex obtusifolius	.	.	.	.	2^{-}	1^{-}	.
Micromeria thymifolia	.	.	8^{-}	.	.	.	.
Huperzia selago	.	.	.	.	.	2^{-}	.
Phyteuma pseudorbiculare	.	.	.	.	.	.	2^{-}
Fraxinus excelsior	.	.	.	4^{-}	14^{-}	6^{-}	7^{-}
Chamaecytisus tommasinii	.	12^{-}	.	.	.	.	.
Holcus mollis	.	.	.	4^{-}	.	2^{-}	.
Polygala comosa	.	6^{-}	.	.	.	.	.
Solanum dulcamara	.	.	.	.	6^{-}	2^{-}	.
Scilla bifolia	.	.	.	4^{-}	1^{-}	1^{-}	.
Geum urbanum	.	12^{-}	4^{-}	12^{-}	5^{-}	2^{-}	2^{-}
Chamaecytisus austriacus	.	.	8^{-}	.	.	.	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Polystichum setiferum	.	.	.	.	8^{-}	5^{-}	10^{-}
Carduus personata	.	.	.	.	.	4^{-}	.
Rosa sempervirens	20^{-}	.	.	.	.	.	.
Taxus baccata	.	.	.	.	2^{-}	1^{-}	.
Centaurea cyanus	.	.	4^{-}	.	.	.	.
Digitalis grandiflora	.	.	4^{-}	4^{-}	1^{-}	3^{-}	.
Leontodon autumnalis	.	.	.	4^{-}	.	.	2^{-}
Sambucus ebulus	.	.	.	.	4^{-}	2^{-}	.
Pinus sylvestris	.	.	.	.	1^{-}	1^{-}	.
Circaea alpina	.	.	.	.	1^{-}	2^{-}	.
Eupatorium cannabinum	.	.	.	.	2^{-}	1^{-}	.
Mercurialis ovata	.	6^{-}	.	.	1^{-}	.	.
Anthriscus nitida	.	.	.	.	1^{-}	4^{-}	.
Juglans regia	.	6^{-}	.	4^{-}	1^{-}	.	.
Telekia speciosa	.	.	.	.	2^{-}	3^{-}	.
Bellis perennis ssp. *sylvestris*	20^{-}	.	.	.	.	.	.
Euphorbia helioscopia	.	.	.	4^{-}	.	.	.
Chamaecytisus supinus	.	.	8^{-}	.	.	.	.
Euphrasia rostkoviana	.	.	.	.	.	1^{-}	.
Ranunculus repens	.	.	.	8^{-}	1^{-}	2^{-}	.
Hypericum hirsutum	.	.	.	.	1^{-}	.	.
Trifolium resupinatum	20^{-}	.	.	.	.	.	.
Sorbus aria	.	.	.	.	7^{-}	8^{-}	.
Orlaya grandiflora	.	6^{-}	4^{-}	.	.	.	.
Vicia hirsuta	.	12^{-}	.	.	.	.	.
Stachys alpina	.	.	.	.	1^{-}	1^{-}	.
Ophrys scolopax ssp. *cornuta*	20^{-}	.	.	.	.	.	.
Carum carvi	.	6^{-}	.	.	.	.	.
Gladiolus illyricus	.	12^{-}	.	.	.	.	.
Buphthalmum salicifolium	.	.	.	.	2^{-}	1^{-}	.
Anemone ranunculoides	.	.	.	.	8^{-}	3^{-}	.
Pyrus amygdaliformis	.	6^{-}	.	.	.	.	.
Melica uniflora	.	.	4^{-}	8^{-}	7^{-}	1^{-}	.
Rhamnus catharticus	.	.	8^{-}	.	.	.	.
Alnus glutinosa	.	.	.	4^{-}	.	.	.
Stipa bromoides	.	6^{-}	.	.	.	.	.
Valantia muralis	20^{-}	.	.	.	.	.	.
Petrorhagia saxifraga	.	12^{-}	12^{-}	.	.	.	.
Lamium orvala	.	.	.	.	1^{-}	.	.
Lathyrus laevigatus	.	.	.	.	.	4^{-}	5^{-}
Rumex acetosella	.	.	8^{-}	8^{-}	.	.	.
Epilobium lanceolatum	.	.	.	.	1^{-}	.	.
Knautia dinarica	.	.	.	.	.	2^{-}	2^{-}
Dorycnium pentaphyllum ssp. *herbaceum*	.	6^{-}	8^{-}	.	.	.	.
Homogyne sylvestris	.	.	.	.	.$^{-}$	2^{-}	2^{-}
Lapsana communis	.	.	12^{-}	.	3^{-}	2^{-}	.
Cirsium vulgare	.	.	.	.	1^{-}	.	.
Actaea spicata	.	.	.	.	27^{-}	34^{-}	33^{-}
Verbascum chaixii ssp. *austriacum*	.	.	4^{-}	.	.	.	.
Moneses uniflora	.	.	.	.	1^{-}	4^{-}	.
Calluna vulgaris	.	.	8^{-}	.	.	.	.
Lonicera caprifolium	.	.	.	8^{-}	.	.	.
Trifolium campestre	20^{-}	6^{-}	4^{-}	.	.	.	.
Melica ciliata	20^{-}	12^{-}	.	.	.	.	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Cirsium palustre	.	.	.	.	1^{-}	.	.
Spiraea cana	.	.	.	.	.	2^{-}	.
Tussilago farfara	.	.	.	.	4^{-}	3^{-}	2^{-}
Hippocrepis comosa	.	6^{-}	.	.	.	1^{-}	.
Silene latifolia ssp. *alba*	.	6^{-}	.	.	.	.	.
Festuca rubra	.	.	4^{-}	.	.	1^{-}	.
Centaurea pannonica	.	6^{-}	.	.	.	.	.
Punica granatum	.	6^{-}	.	.	.	.	.
Corallorhiza trifida	.	.	.	.	1^{-}	.	7^{-}
Galeopsis tetrahit	.	.	.	.	6^{-}	2^{-}	.$^{-}$
Aegopodium podagraria	.	.	.	.	7^{-}	8^{-}	5^{-}
Epipactis helleborine	.	.	.	.	2^{-}	.	7^{-}
Cirsium acaule	.	.	4^{-}	.	1^{-}	.	.
Chrysopogon gryllus	20^{-}	.	4^{-}	.	.	.	.
Asperula scutellaris	.	6^{-}	.	.	.	.	.
Sorbus austriaca	.	.	.	.	3^{-}	4^{-}	.
Clematis viticella	20^{-}	.	.	.	.	.	.
Knautia sarajevensis	.	.	.	.	1^{-}	3^{-}	5^{-}
Asplenium scolopendrium	.	.	.	.	9^{-}	5^{-}	5^{-}
Chamaecytisus heuffelii	.	.	8^{-}	12^{-}	.	.	.
Ophrys sphegodes	20^{-}	.	.	.	.	.	.
Centaurea jacea	.	6^{-}	.	.	.	1^{-}	.
Ranunculus montanus	.	.	.	.	1^{-}	1^{-}	.
Inula hirta	.	6^{-}	4^{-}	.	.	.	.
Poa nemoralis	.	.	17^{-}	12^{-}	14^{-}	11^{-}	12^{-}
Myrrhis odorata	.	.	.	.	3^{-}	2^{-}	7^{-}
Laser trilobum	.	.	.	.	.	1^{-}	5^{-}
Heracleum sphondylium s.l.	.	.	.	4^{-}	4^{-}	11^{-}	17^{-}
Juniperus communis ssp. *alpina*	.	.	.	.	.	.	7^{-}
Phytolacca americana	.	.	.	.	1^{-}	.	.
Vaccinium vitis-idaea	.	.	.	.	.	.	7^{-}
Milium effusum	.	.	.	.	4^{-}	1^{-}	5^{-}
Hieracium umbellatum	.	.	.	12^{-}	3^{-}	.	.
Knautia drymeia	.	.	.	.	2^{-}	4^{-}	5^{-}
Petasites hybridus	.	.	.	4^{-}	.	.	.
Salvia pratensis	.	12^{-}	.	.	.	.	.
Pinus mugo	.	.	.	.	.	.	2^{-}
Cardamine impatiens	.	.	.	.	6^{-}	2^{-}	.
Orthilia secunda	.	.	.	.	5^{-}	11^{-}	14^{-}
Medicago sativa ssp. *falcata*	.	12	.	.	.	.	.
Campanula rapunculus	.	.	4^{-}	.	.	.	.
Aquilegia vulgaris	.	.	.	.	1^{-}	.	.
Glechoma hederacea	.	.	.	4^{-}	2^{-}	.	.
Medicago lupulina	.	.	4^{-}	.	.	.	.
Verbascum nigrum s.l.	.	6	.	.	1^{-}	1^{-}	.
Acanthus balcanicus	.	12	.	.	.	.	.
Fragaria moschata	.	12	8^{-}	4^{-}	1^{-}	1^{-}	.
Prunella vulgaris	.	.	38^{-}	31^{-}	10^{-}	9^{-}	12^{-}
Poa trivialis	.	.	.	4^{-}	.	.	.
Asplenium trichomanes	60^{-}	.	.	.	14^{-}	7^{-}	17^{-}
Crepis biennis	.	.	.	4^{-}	.	.	.
Listera ovata	.	.	.	.	.	2^{-}	2^{-}
Asplenium ruta-muraria	.	.	.	.	2^{-}	.	.
Lathraea squamaria	.	.	.	.	2^{-}	.	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Phleum pratense	.	.	.	.	.	1^{-}	.
Serapias lingua	20^{-}	.	.	.	.	.	.
Listera cordata	.	.	.	.	.	2^{-}	.
Plantago media	.	.	.	.	1^{-}	1^{-}	.
Phegopteris connectilis	.	.	.	.	.	6^{-}	2^{-}
Orobanche alba	.	.	.	.	.	2^{-}	.
Tanacetum cinerariifolium	.	6^{-}	.	.	.	.	.
Polygala vulgaris	.	.	8^{-}	.	.	.	.
Veronica scardica	.	.	.	.	.	1^{-}	.
Cicerbita pancicii	.	.	.	.	.	2^{-}	5^{-}
Veronica serpyllifolia	.	.	.	.	2^{-}	2^{-}	.
Elymus repens	.	12^{-}	.	.	1^{-}	.	.
Pulmonaria officinalis	.	.	8^{-}	35^{-}	13^{-}	10^{-}	14^{-}
Polypodium vulgare	.	.	.	.	10^{-}	11^{-}	.
Colchicum autumnale	.	6^{-}	.	4^{-}	.	.	.
Spiraea media	.	.	.	.	.	2^{-}	.
Neottia nidus-avis	.	.	.	4^{-}	9^{-}	7^{-}	.
Aristolochia clematitis	.	.	4^{-}	.	.	.	.
Cirsium eriophorum	.	.	.	.	1^{-}	.	.
Carex digitata	.	.	12^{-}	.	8^{-}	6^{-}	.
Galium sylvaticum	.	.	.	19^{-}	15^{-}	13^{-}	19^{-}
Plantago major	.	.	.	.	1^{-}	.	.
Convolvulus cantabrica	.	6^{-}	.	.	.	.	.
Festuca drymeja	.	.	.	12^{-}	14^{-}	20^{-}	14^{-}
Alliaria petiolata	.	.	.	.	2^{-}	.	.
Sedum telephium ssp. *maximum*	.	.	.	4^{-}	.	.	.
Osyris alba	.	6^{-}	.	.	.	.	.
Lathyrus linifolius	.	.	.	.	1^{-}	.	.
Cephalanthera longifolia	.	.	4^{-}	8^{-}	1^{-}	2^{-}	.
Galeopsis speciosa	.	.	.	.	.	2^{-}	.
Trifolium angustifolium	.	6^{-}	.	.	.	.	.
Chaerophyllum temulentum	.	.	.	.	.	1^{-}	.
Athyrium distentifolium	.	.	.	.	.	2^{-}	7^{-}
Arctium lappa	.	.	.	.	1^{-}	.	.
Stellaria media	.	.	4^{-}	.	2^{-}	.	.
Scabiosa columbaria	.	6^{-}	.	.	.	.	.
Melittis melissophyllum	.	12^{-}	21^{-}	15^{-}	3^{-}	2^{-}	12^{-}
Hepatica nobilis	.	.	.	.	2^{-}	.	.
Dryopteris carthusiana	.	.	.	.	.	1^{-}	.
Aruncus dioicus	.	.	.	.	2^{-}	5^{-}	12^{-}
Anthemis tinctoria	.	.	8^{-}	.	.	.	.
Berberis vulgaris	.	.	.	.	.	.	2^{-}
Juncus effusus	.	.	.	4^{-}	.	.	.
Melica nutans	.	.	.	8^{-}	4^{-}	7^{-}	.
Sorbus torminalis	.	12^{-}	17^{-}	23^{24}	1^{-}	.	.
Luzula forsteri	.	25^{-}	12^{-}	19$^{16.4}$	.	1^{-}	.
Eryngium alpinum	.	.	.	.	.	.	2^{-}
Aethionema saxatile	40^{-}	19$^{15.2}$	.	.	.	.	.
Fritillaria messanensis ssp. *gracilis*	.	12^{-}	.	.	.	.	.
Aristolochia lutea	.	12^{-}	.	4^{-}	.	.	.
Prunus cerasifera	.	.	4^{-}	.	.	.	.
Juncus conglomeratus	.	.	.	4^{-}	.	.	.
Arctostaphylos uva-ursi	.	.	.	.	1^{-}	.	.
Scrophularia canina ssp. *hoppii*	.	.	.	.	1^{-}	1^{-}	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Epilobium montanum	.	.	.	.	30^{-}	31^{-}	31^{-}
Cephalanthera rubra	.	6^{-}	.	.	1^{-}	.	.
Pimpinella saxifraga	.	.	8^{-}	.	.	.	.
Lycopodium annotinum	.	.	.	.	.	$6^{22.2}$	$.^{-}$
Myosotis sylvatica	.	.	.	.	8^{-}	20^{22}	19^{-}
Sorbus aucuparia ssp. *glabrata*	.	.	.	.	.	$7^{20.7}$	2^{-}
Luzula luzulina	.	.	.	.	1^{-}	$7^{22.3}$	.
Phyteuma spicatum ssp. *coeruleum*	.	.	.	.	.	$6^{22.2}$	.
Dactylorhiza saccifera	.	.	.	.	.	$6^{22.2}$	.
Blechnum spicant	.	.	.	.	.	$5^{20.5}$	.
Colutea arborescens	20^{-}	$19^{23.6}$	.	.	.	.	.
Cardamine flexuosa	.	.	.	.	.	.	2^{-}
Impatiens noli-tangere	.	.	.	.	1^{-}	2^{-}	.
Epilobium angustifolium	.	.	.	.	2^{-}	10^{20}	5^{-}
Ribes alpinum	.	.	.	.	4^{-}	$14^{19.6}$	12^{-}
Gymnocarpium robertianum	.	.	.	4^{-}	.	7^{16}	2^{-}
Torilis arvensis	.	6^{-}	.	.	1^{-}	.	.
Dactylorhiza cordigera ssp. *bosniaca*	20^{-}	.	.	.	.	.	.
Taraxacum officinale agg.	.	.	.	.	2^{-}	1^{-}	.
Campanula pichleri	.	.	.	.	.	.	7^{-}
Pyrola rotundifolia	.	.	.	.	.	.	2^{-}
Adoxa moschatellina	.	.	4^{-}	.	2^{-}	4^{-}	7^{-}
Rosa pimpinellifolia	.	.	.	.	1^{-}	.	.
Calamintha sylvatica	.	.	.	.	1^{-}	.	.
Polystichum aculeatum	.	.	.	8^{-}	35^{-}	34^{-}	45^{-}
Viburnum opulus	.	.	.	4^{-}	.	.	.
Cynosurus cristatus	.	.	.	4^{-}	.	1^{-}	.
Paris quadrifolia	.	.	.	.	39^{-}	45^{-}	36^{-}
Moehringia trinervia	.	.	.	.	3^{-}	2^{-}	2^{-}
Cardamine graeca	.	.	.	.	1^{-}	.	.
Holcus lanatus	.	.	.	8^{-}	.	.	.
Melampyrum sylvaticum	.	.	.	.	.	4^{-}	2^{-}
Cerastium fontanum ssp. *vulgare*	.	.	4^{-}	.	1^{-}	.	.
Trifolium stellatum	20^{-}	.	.	.	.	.	.
Geranium sanguineum	.	.	4^{-}	.	.	.	.
Polygonatum verticillatum	.	.	.	.	30^{-}	41^{-}	50^{-}
Veratrum album	.	.	.	.	7^{-}	9^{-}	14^{-}
Ononis reclinata	.	6^{-}	.	.	.	.	.
Caltha palustris	.	.	.	.	.	1^{-}	.
Monotropa hypopitys	.	.	.	.	.	1^{-}	.
Asplenium trichomanes-ramosum	.	.	.	.	6^{-}	13^{-}	14^{-}
Gymnocarpium dryopteris	.	.	.	.	2^{-}	6^{-}	.
Calamagrostis varia	.	.	.	.	.	4^{-}	5^{-}
Inula salicina	.	6^{-}	8^{-}	.	.	.	.
Geranium molle	.	.	.	.	.	1^{-}	.
Anthoxanthum odoratum	.	6^{-}	8^{-}	4	.	.	.
Arabis hirsuta	.	.	.	.	.	1^{-}	.
Platanthera chlorantha	.	.	4^{-}	.	.	.	.
Ribes petraeum	.	.	.	.	.	1^{-}	5^{-}
Vicia montenegrina	.	.	.	.	1^{-}	.	.
Calamintha nepeta ssp. *glandulosa*	.	6^{-}	.	.	.	.	.
Euphorbia characias ssp. *wulfenii*	.	6^{-}	.	.	.	.	.
Cypripedium calceolus	.	.	.	.	.	1^{-}	.
Convallaria majalis	.	.	.	.	1^{-}	.	5^{-}

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Epipactis atrorubens	.	.	.	.	1^-	2^-	.
Galeopsis pubescens	.	.	.	4	.	.	.
Valeriana officinalis	.	.	.	.	1^-	2^-	.
Cardaminopsis arenosa	.	.	.	.	1^-	.	.
Bromus ramosus	.	.	.	.	.	1^-	.
Soldanella alpina	.	.	.	.	.	.	2^-
Anthericum ramosum	.	6^-	.	4	.	.	.
Ranunculus acris	.	.	.	.	3^-	1^-	.
Campanula glomerata	.	.	8^-	.	.	.	2^-
Polygonatum odoratum	.	.	4^-	.	1^-	.	.
Sedum acre	.	.	4^-	.	.	.	.
Allium carinatum	.	6^-	.	.	.	.	.
Convolvulus althaeoides ssp. *tenuissimus*	.	6^-	.	.	.	.	.
Cerastium ligusticum ssp. *trichogynum*	20^-	.	.	.	.	.	.
Plantago lanceolata	.	.	.	4	.	.	.
Senecio vulgaris	.	.	.	.	1^-	.	.
Populus tremula	.	.	8^-	4	2^-	6^-	.
Valerianella locusta	20^-	.	.	.	.	.	.
Leucanthemum vulgare	.	.	.	.	2^-	3^-	.
Tozzia alpina ssp. *carpathica*	.	.	.	.	.	.	2^-
Tanacetum corymbosum	.	12^-	8^-	.	2^-	1^-	.
Athamanta turbith ssp. *haynaldii*	.	.	.	.	.	.	2^-
Allium sphaerocephalon	.	6^-	.	.	.	.	.
Rosa glauca	.	.	.	.	2^-	.	2^-
Digitalis lanata	.	.	4^-	.	.	.	.
Lysimachia nummularia	.	.	.	8^-	.	.	.
Geranium phaeum	.	.	.	4^-	2^-	1^-	.
Platanthera bifolia	.	.	.	8^-	12^-	8^-	.
Scrophularia nodosa	.	.	.	.	6^-	5^-	.
Geranium macrorrhizum	.	.	.	.	.	.	5^-
Inula conyza	.	.	4^-	.	.	.	.
Erica herbacea	.	.	.	.	.	1^-	.
Carex divulsa s.l.	.	12^-	4^-	4^-	.	.	.
Polygala nicaeensis	20^-	.	.	.	.	.	.
Fragaria vesca	.	12^-	42^-	46^-	45^-	47^-	38^-
Sedum sexangulare	20^-	.	.	.	.	.	.
Valeriana tripteris	.	.	.	.	.	1^-	.
Peucedanum cervaria	.	6^-	8^-	.	.	.	.
Euphorbia carniolica	.	.	.	4^-	4^-	8^-	7^-
Laburnum anagyroides	.	.	.	.	.	.	2^-
Stachys sylvatica	.	.	.	4^-	1^-	1^-	.
Calystegia silvatica	.	.	4^-	.	.	.	.
Muscari neglectum	.	12^-	.	.	.	.	.
Hypericum montanum	.	.	.	.	.	2^-	.
Lamium maculatum	.	.	.	.	2^-	.	.
Epipactis microphylla	.	12^-	.	.	.	.	.
Goodyera repens	.	.	.	.	1^-	6^-	.
Veronica montana	.	.	4^-	.	6^-	7^-	.
Rumex sanguineus	.	.	.	.	.	1^-	.
Psoralea bituminosa	20^-	.	.	.	.	.	.
Stellaria nemorum s.l.	.	.	.	.	17^-	14^-	14^-
Viola odorata	.	.	4^-	.	1^-	$.^-$	.
Crepis pulchra	.	.	.	.	1^-	$.^-$	.
Gymnadenia conopsea	.	.	.	.	1^-	1^-	.

Community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Peucedanum oreoselinum	.	6^{-}	8^{-}	.	1^{-}	2^{-}	.
Scorpiurus muricatus	20^{-}	.	.	.	.	.	.
Trifolium dubium	.	.	8^{-}	.	.	.	.
Selinum carvifolia	.	6^{-}	.	.	.	.	.
Salix caprea	.	.	.	.	4^{-}	7^{-}	.
Potentilla heptaphylla	.	6^{-}	.	.	.	.	.
Isopyrum thalictroides	.	.	.	.	2^{-}	.	2^{-}
Cruciata laevipes	.	.	.	4^{-}	4^{-}	3^{-}	.
Thesium arvense	.	6^{-}	.	.	.	.	.
Veronica austriaca	.	6^{-}	4^{-}	.	.	1^{-}	.
Vicia incana	.	.	.	.	.	2^{-}	.
Vicia cassubica	.	.	4^{-}	.	.	.	.
Sedum rubens	.	.	8^{-}	.	.	.	2^{-}
Ranunculus ficaria	.	.	4^{-}	.	.	.	.
Ranunculus sardous	.	.	.	.	.	1^{-}	.
Asperula cynanchica	.	6^{-}	.	.	.	.	.
Campanula patula s.l.	.	.	.	.	2^{-}	2^{-}	5^{-}
Arabis turrita	.	.	.	.	1^{-}	2^{-}	2^{-}
Crocus vernus	.	.	.	4^{-}	$.^{-}$	1^{-}	2^{-}
Ilex aquifolium	.	.	.	4^{-}	4^{-}	1^{-}	.
Primula veris ssp. *columnae*	.	.	4^{-}	.	.	2^{-}	.
Tilia platyphyllos	.	.	8^{-}	12^{-}	5^{-}	.	.
Dipsacus pilosus	.	.	.	.	1^{-}	.	.
Daphne laureola	.	.	.	.	2^{-}	2^{-}	.
Lathyrus vernus	.	6^{-}	4^{-}	19^{-}	22^{-}	19^{-}	14^{-}
Lunaria rediviva	.	.	.	.	1^{-}	2^{-}	5^{-}
Viola collina	.	.	.	4^{-}	.	2^{-}	.
Hieracium lachenalii	.	.	.	.	.	1^{-}	.
Viola riviniana	.	6^{-}	.	.	4^{-}	2^{-}	.
Ranunculus lanuginosus	.	.	.	.	5^{-}	6^{-}	12^{-}
Pulmonaria obscura	.	.	.	.	.	.	2^{-}
Atropa bella-donna	.	.	.	4^{-}	7^{-}	6^{-}	.
Cynosurus echinatus	.	6^{-}	.	.	.	.	.
Cephalanthera damasonium	.	.	.	.	1^{-}	.	.
Lactuca saligna	.	6^{-}	.	.	.	.	.
Carex flava	.	.	.	.	.	1^{-}	.
Luzula campestris	.	.	.	.	1^{-}	.	.
Smyrnium perfoliatum	.	6^{-}	.	.	.	.	.
Hieracium piloselloides	.	12^{-}	.	.	.	.	.
Hieracium cymosum	.	.	8^{-}	.	.	.	.
Polystichum x *illyricum*	.	.	.	.	.	2^{-}	.

ANNEX B

List of species merged to aggregates (agg.), broadly defined taxa (s.l.) or taxa deviating from Tutin et al. (1968-1993) or not included therein used in chapter 2.1 (therein referred to as On-line Suppl. 1).

Aconitum lycoctonum s.l.: *A. lycoctonum* subsp. *lycoctonum* and subsp. *vulparia*
Allium scorodoprasum s.l.: *A. scorodoprasum* subsp. *rotundum* and subsp. *scorodoprasum*
Bromus erectus agg.: *B. erectus* subsp. *erectus, B. pannonicus* and *B. riparius*
Campanula patula s.l.: *C. patula* subsp. *abietina* and subsp. *patula*
Campanula pichleri: *Campanula pichleri* sensu The Plant List (2013) [= *Campanula pichleri* Vis.]
Carex divulsa s.l.: *C. divulsa* subsp. *divulsa* and subsp. *leersii*
Carex flacca s.l.: *C. flacca* subsp. *flacca* and subsp. *serrulata*
Chamaecytisus hirsutus agg.: *C. ciliatus* and *C. hirsutus*
Coronilla emerus s.l.: *C. emerus* subsp. *emeroides* and subsp. *emerus*
Festuca pseudovina agg.: *F dalmatica, F. ovina* and *F. pseudovina*
Galium mollugo agg.: *G. album* and *G. mollugo*
Heracleum sphondylium s.l.: *H. sphondylium* subsp. o*rsinii*, subsp. *sphondylium* and subsp. *ternatum*
Hieracium lachenalii: *Hieracium lachenalii* sensu The Plant List (2013) [= *Hieracium lachenalii* Suter]
Lathyrus linifolius: *Lathyrus linifolius* sensu The Plant List (2013) [=*Lathyrus linifolius* (Reichard) Bassler]
Quercus petraea agg.: *Q. dalechampii* and *Q. petraea*
Senecio nemorensis s.l.: *S. nemorensis* subsp. *fuchsii* and subsp. *nemorensis*
Silene vulgaris s.l.: *S. vulgaris* subsp. *commutata* and subsp. *vulgaris*
Stellaria nemorum s.l.: *S. nemorum* subsp. *glochidisperma* and subsp. *nemorum*
Verbascum nigrum s.l.: *V. nigrum* subsp. *abietinum* and subsp. *nigrum*

References

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Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., & Webb, D. A. (Eds.). (1968-1993). Flora Europaea (Vols. 1–5). Cambridge University Press.

ANNEX C

Sources of data used for the analysis presented in chapter 2.2 (therein reffered to as Supplement S1). Type numbers refer to Tables 1-2 and Figures 2 and 5.

Type 1

Fabijanić et al. 1963, *Fraxino orni-Carpinetum orientalis*, Table 3 (relevés 1, 4, 6), **Jovanović 1955a**, *Quercetum confertae-cerris carpinetosum orientalis*, Table 9 (relevés 8, 19), **Krasniqi 1972**, *Carpinetum orientalis scardicum*, Table 1 (relevés 2, 5, 13, 18, 19, 33), **Krasniqi 1972**, *Dioscoro-Carpinetum orientalis*, Table 2 (relevé 14), **Mišić et al. 1978**, *Quercetum cerris* subas. *carpinetum orientalis*, Table 18 (relevés 1, 6-7), **Stefanović 1968**, *Orno-Quercetum cerris carpinetosum orientalis*, Table 1 (relevés 17, 19), **Janković & Mišić 1980**, *Orno-Quercetum petraeae pubescentis*, Table 1 (relevé 1), **Janković & Mišić 1980**, *Cotino-Quercetum petraeae*, Table 2 (relevé 6), **Jovanović 1960**, *Carpineto orientalis-Quercetum*, Table 1 (relevés 2, 6-7, 11), **Lakušić & Redžić 1991**, *Aceri-Carpinetum orientalis*, Table 5 (relevés 5, 7), **Muratspahić et al. 1991**, *Rusco-Carpinetum orientalis petterietosum*, Table 2 (relevés 13(3), 10'(3), 17(4), 12(4)), **Muratspahić et al. 1991**, *Rusco-Carpinetum orientalis paliuretosum*, Table 3 (relevé 15(3)), **Rudski 1949**, *Carpinetum orientalis serbicum quercetosum pubescentis*, Table 5 (relevés 4-6, 8, 11), **Rudski 1949**, *Carpinetum orientalis serbicum quercetosum frainetto*, Table 5 (relevés 13, 20), **Šugar & Trinajstić 1988**, *Cruciato-Carpinetum orientalis*, Table 1 (relevés 2, 6-7), **Trinajstić 1965**, *Carpinetum orientalis croaticum carpinetosum betuli*, Table 42 (relevé 2), **Trinajstić 1965**, *Carpinetum orientalis croaticum ostryetosum*, Table 42 (relevés 3-4, 6-7), **Trinajstić 1965**, *Carpinetum orientalis croaticum typicum*, Table 42 (relevés 9, 13-14), **Trinajstić 1988**, *Carpino orientalis-Quercetum virgilianae*, Table 1 (relevés 1, 4, 6), **Rauš 1995**, *Querco-Carpinetum orientalis*, 1relevé, **Bucalo 1999**, *Fraxino orni-Carpinetum orientalis*, Table 1 (relevés 1, 4), **Stefanović & Manuševa 1971**, *Carpinetum orientalis*, Table 2 (relevés 2, 4), **Stefanović 1989**, *Fraxino orni-Carpinetum orientalis*, Table 1 (relevés 2, 10, 14, 19), **Redžić et al. 1992**, Seslerio-Ostryetum, Table 1 (relevé 1(3)), **Redžić et al. 1992**, *Quercetum frainetto hercegovinum*, Table 1 (relevé 18(6)), **Blečić & Lakušić 1967**, *Aceri-Carpinetum orientalis*, Table 4 (relevés 1, 3-5, 11-12), **Blečić & Lakušić 1967**, *Dioscoro-Carpinetum orientalis*, Table 4 (relevés 16, 20, 23), **Blečić & Lakušić 1967**, *Rusco-Carpinetum orientalis quercetosum trojanae*, Table 4 (relevés 25-27, 29, 31, 34-36), **Blečić & Lakušić 1967**, *Rusco-Carpinetum orientalis myrtetosum*, Table 4 (relevés 40-42), **Kaćanski 1983**, *Seslerio-Ostryetum carpinetosum orientalis*, Table 2 (relevé 2), **Kaćanski 1983**, *Carpinetum orientalis illyricum*, Table 2 (relevés 5, 8-9), **Šegulja 1990**, *Querco-Carpinetum orientalis*, Table 3 (relevés 1, 3, 6), **Birač 1971**, *Querco-Carpinetum orientalis*, Table 14 (relevés 2-5, 8), **Šegulja 1967**, *Carpinetum orientalis croaticum*, Table 16 (relevés 1-2, 4-5, 7-8, 11-13), **Šegulja 1967**, *Seslerio-Ostryetum*, Table 17 (relevés 8, 10, 12), **Brujić 2013**, *Aceri obtusati-Quercetum petraeae*, Table 10 (relevé 10), **Brujić 2013**, *Carpino betuli-Aceretum obtusati*, Table 10 (relevé 5), **Brujić 2013**, *Carpino orientalis-Crataegetum*, Table 7 (relevés 17, 19), **Brujić 2013**, *Carpino orientalis-Fraxinetum orni*, Table 7 (relevé 12), **Brujić 2013**, *Carpino orientalis-Quercetum daleschampii*, Table 7 (relevés 1, 9), **Brujić 2013**, *Querco daleschampii-Ostryetum carpinifoliae*, Table 10 (relevé 187), **Brujić 2013**, *Seslerio-Carpinetum betuli-orientalis*, Table 8 (relevé 21), **unpublished relevés stored in EU-BH-001** (relevés 17, 21, 22, 23, 30, 119, 122, 124, 247, 251, 272, 276, 310, 313, 314, 320, 321, 436, 444, 499, 503, 1007, 1019, 1075, 1099).

Type 2

Šugar 1972, *Querco-Ostryetum carpinifoliae typicum*, Table 44 (relevés 9-11), **Šugar 1972**, *Erico carneae-Ostryetum*, Table 46 (relevé 1), **Horvat 1938**, *Querco-Ostryetum carpinifoliae typicum*, Table 1 (relevé 5), **Zupančič 1999**, *Ostryo-Quercetum pubescentis*, Table 1 (relevés 1-3, 8, 11, 13, 15), **Zupančič 1999**, *Seslerio-Ostryetum*, Table 2 (relevés 1-2, 4), **Zupančič 1999**, *Querco-Carpinetum orientalis*, Table 3 (relevé 9), **Zupančič 1999**, *Seslerio-Quercetum pubescentis*, Table 4 (relevés 1-2, 5, 8-10, 13, 16), **Zupančič 1999**, *Seslerio-Quercetum petraeae*, Table 5 (relevé 7), **Šugar et al. 1995**, *Molinio-Quercetum pubescentis*, Table 1 (relevés 8, 10, 13), **Dakskobler 2003**, *Amelanchiero-Quercetum*, Table 3 (relevé 2), **Dakskobler 2004**, *Seslerio-Ostryetum*, Table 5 (relevé 4), Dakskobler **2004**, *Ostryo-Quercetum pubescentis*, Table 7 (relevé 6), **Zupančič & Žagar 2002**, *Ostryo-Carpinion*, Table 1 (relevés 3, 5-6, 8), **Zupančič & Žagar 1996**, *Seslerio-Ostryetum*, Table (relevé 6), **Regula-Bevilacqua 1978**, *Querco-Ostryetum carpinifoliae*, Table 43 (relevés 6, 10), **Rexhepi 1985**, *Quercetum pubescentis-cerris*, Table (relevés 1, 6, 11-12), **Stefanović 1968**, *Orno-Quercetum cerris ostryetosum carpinifoliae*, Table 1 (relevés 10-11), **Gajić 1952**, *Quercetum conferte-cerris aculeatetosum*, Table 1 (relevé 1), **Gajić 1952**, *Quercus pubescens-Fraxinus ornus*, Table 3 (relevé 4), **Škvorc 2006**, *Orno-Quercetum pubescentis*, Table 16 (relevés 1-2, 5, 10), **Trinajstić 1965**, *Seslerio-Ostryetum quercetosum pubescentis*, Table 43 (relevés 5, 8), **Trinajstić 1982**, *Ostryo-Quercetum pubescentis*, Table 1 (relevés 3-5, 7-8, 10), **Zupančič et al. 2009**, *Querco-Ostryetum genistetosum januensis*, Table 1 (relevés 4, 12), **Medak 2006**, *Orno-Quercetum pubescentis*, Table 3 (relevé 4), **Tomašić 1997**, *Orno-Quercetum pubescentis*, Table 1 (relevé 1), **Cvjetićanin & Knežević 2000**, *Orno-Quercetum cerris virgilianae*, Table 1 (relevé 15), **Vukićević 1959**, *Quercetum confertae-cerris* with *Quercus pubescens*, Table 4 (relevés 3, 5, 9), **Trinajstić 1985**, *Orno-Quercetum virgilianae*, Table 1 (relevés 1-2), **Šegulja 1967**, *Seslerio-Ostryetum*, Table 17 (relevés 2, 5), **unpublished relevés stored in EU-BH-001** (relevés 3, 38, 39, 45, 57, 58, 60, 66, 67, 70, 72, 86, 87, 90, 116, 176, 185, 192, 221, 227, 238, 240, 242, 244, 256, 257, 260, 261, 281, 285, 287, 288, 291, 293, 294, 298, 318, 322, 418, 434, 440, 451, 459, 464, 465, 471, 500, 1009, 1041, 1042, 1046).

Type 3

Šugar 1972, *Cytisantho-Ostryetum*, Table 48 (relevé 1), **Marinček & Šilc 1999**, *Hacquetio-Quercetum cerris*, Table 1 (relevés 1, 6-7), **Čarni 1994**, *Querco-Ostryetum*, Table 17 (relevés 1, 9), **Dakskobler 2003**, *Amelanchiero-Quercetum*, Table 3 (relevé 1), **Zupančič 1997**, *Corydalo ochroleucae-Ostryetum*, Table (relevé 3), **Marinček & Seliškar 1982**, *Querco-Ostryetum*, Table 1 (relevé 11), **Cimperšek 2005**, *Querco-Ostryetum*, Table 2 (relevé 4), **Dakskobler 2004**, *Seslerio autumnalis-Ostryetum* var. geogr. *Anemone trifolia tilietosum platyphylli* var. *Quercus cerris*, Table 2 (relevés 3-4, 9, 13-14, 16, 18), **Dakskobler 2004**, *Seslerio autumnalis-Ostryetum* var. geogr. *Anemone trifolia tilietosum platyphylli*, Table 3 (relevés 5, 7, 17, 19, 21, 26-27), **Dakskobler 2004**, *Seslerio albicantis-Ostryetum* var. geogr. *Anemone trifolia*, Table 4 (relevés 3, 5, 7, 9, 17-18, 25, 27), **Dakskobler 2004**, *Seslerio albicantis-Ostryetum* var. geogr. *Anemone trifolia* var. *Medicago pironae*, Table 5 (relevés 7, 10, 15, 19, 22), **Dakskobler 2004**, *Amelanchiero ovalis-Ostryetum* var. *Anemone trifolia*, Table 6 (relevés 2-4, 7-8, 12, 18, 23), **Dakskobler 2004**, *Ostryo-Quercetum pubescentis* var. geogr. *Anemone trifolia typicum*, Table 7 (relevés 7-8, 15, 18, 20, 22), **Dakskobler 2004**, *Ostryo-Quercetum pubescentis* var. geogr. *Anemone trifolia tilietosum platyphylli*, Table 8 (relevés 3-4), **Dakskobler 2004**, *Ostryo-Quercetum pubescentis*, Table 9 (relevés 4-6, 8-9, 13), **Dakskobler 1997**, *Ostryo-Quercetum pubescentis*, Table 1 (relevés 1, 3), **Dakskobler 1997**, *Ostryo-Quercetum pubescentis*, Table 2 (relevés 3-5), **Zupančič & Žagar 1996**, *Corydalo ochroleucae-Ostryetum*, Table (relevé 14), **Wraber 1961**, *Cytisantho-Ostryetum*, Table 1 (relevés 1, 7, 11, 17), **Krasniqi 1972**, *Colurno-Ostryetum dioscoretosum*, Table 3 (relevés 1, 3), **Krasniqi 1972**, *Colurno-Ostryetum typicum*, Table 3 (relevé 14), **Vukićević 1971**, *Quercetum cerris ostryetosum*, Table (relevés 2, 6-7), **Blečić 1958**, *Seslerio-Ostryetum*, Table 2 (relevés 6-7), **Blečić 1958**, *Colurno-Ostryetum*, Table 3 (relevés 9-10), **Cerovečki 2006**, *Seslerio sadlerianae-Ostryetum*, Table 1 (relevé 9), **Fukarek 1970**, *Seslerio-Ostryetum colurnetosum*, Table 1 (relevés 3-4), **Fukarek 1970**, *Seslerio-Ostryetum tilietosum*, Table 1 (relevés 6, 8), **Lakušić & Redžić 1991**, *Seslerio autumnalis-Ostryetum carpinifoliae*, Table 6 (relevé L-3(4)), **Lakušić & Redžić 1991**, *Seslerio autumnalis-Ostryetum carpinifoliae caricetosum humilis*, Table 6 (relevé L-15(8)), **Stefanović 1964b**, *Ostryeto-Fraxinetum orni*, Table 2 (relevés 1, 7), **Trinajstić 1965**, *Seslerio-Ostryetum quercetosum pubescentis*, Table 43 (relevés 2-3), **Trinajstić 1982**, *Ostryo-Quercetum pubescentis*, Table 1 (relevés 1-2), **Fukarek 1979,** *Orneto-Ostryetum*, Table (relevés 1, 3), **Tomić 2000b**, *Orno-Ostryetum pinetosum nigrae*, Table 1 (relevés 4, 6, 12), **Tomić 2000b**, *Orno-Ostryetum coronilletosum emeroides*, Table 1 (relevés 16, 23), **Tomić 2000b**, *Orno-Ostryetum aceretosum intermediae*, Table 1 (relevés 25-27), **Gajić et al. 1954**, *Fraxino orni-Ostryetum*, Table 7 (relevés 3-4), **Jovanović 1967**, *Helleboro-Querco-Ostryetum*, Table 2 (relevés 5-8), **Tomić 1980**, *Querco-Ostryetum carpinifoliae*, Table 1 (relevé 8), **Tomić 1980**, *Helleboro-Ostryo-Quercetum cotinetosum*, Table 3 (relevés 1-2), **Tomić 1980**, *Helleboro-Ostryo-Quercetum typicum*, Table 3 (relevés 19, 21-22), **Trinajstić 1987**, *Ostryo-Quercetum virgilianae*, Table 7 (relevé 4), **Bertović 1975**, *Seslerio-Ostryetum quercetosum*, relevé, **Brujić 2013**, *Fraxino orni-Ostryetum*, Table 2 (relevés 12-13), **unpublished relevés stored in EU-BH-001** (relevés 212, 337, 448, 997, 1003, 1004).

Type 4

Gajić 1959, *Quercetum confertae-cerris nudum*, Table 1 (relevé 4), **Gajić 1959**, *Quercetum confertae-cerris typicum*, Table 1 (relevés 5,7, 13), **Gajić 1959**, *Quercetum confertae-cerris carpinetosum orientalis*, Table 1 (relevé 20), **Gajić 1961**, *Quercetum montanum*, Table 7 (relevés 16-17), **Jovanović 1955a**, *Quercetum confertae-cerris typicum*, Table 9 (relevés 5-6), **Jovanović 1955a**, *Quercetum confertae-cerris carpinetosum orientalis*, Table 9 (relevés 9-11), **Krasniqi 1972**, *Quercetum farnetto-cerris scardicum moltkaetosum*, Table 5 (relevés 5, 7, 14-15), **Krasniqi 1972**, *Quercetum montanum*, Table 6 (relevés 8, 15), **Rexhepi & Ranđelović 1984**, *Lembotropo-Quercetum cerris*, Table (relevé 5), **Rexhepi & Ružić 1985**, *Ostryo-Quercetum cerris*, Table (relevé 4), **Stefanović 1968**, *Orno-Quercetum cerris quercetosum petraeae*, Table 1 (relevé 4), **Vukićević 1966**, *Quercetum montanum genistetosum*, Table 4 (relevé 14), **Vukićević 1966**, *Quercetum cerris*, Table 5 (relevés 3, 6-8), **Vukićević 1966**, *Quercetum confertae-cerris aculeatetosum*, Table 6 (relevé 5), **Vukićević 1966**, *Quercetum confertae-cerris hieracietosum*, Table 6 (relevés 7-9), **Vukićević 1971**, *Quercetum cerris ostryetosum*, Table (relevé 4), **Baričević 2002**, *Lathyro-Quercetum petraeae quercetosum cerris*, Table 13 (relevés 11, 17), **Gajić 1952**, *Quercetum conferte-cerris typicum*, Table 1 (relevés 4-5), **Gajić 1954**, *Quercetum confertae-cerris*, Table 1 (relevé 1), **Jovanović et al. 1982**, *Quercetum frainetto typicum*, Table 4 (relevés 3, 6, 13), **Jovanović et al. 1982**, *Quercetum frainetto carpinetosum orientalis*, Table 4 (relevés 15-17), **Knapp 1944**, *Quercetum cerris-confertae timokense*, Table 1 (relevé 1), **Rudski 1949**, *Quercetum confertae-cerris serbicum*, Table 4 (relevés 1, 3-4, 6, 16-17, 19-20, 25-26, 28, 36), **Rudski 1949**, *Carpinetum orientalis serbicum quercetosum petraeae*, Table 5 (relevés 26, 28, 30), **Škvorc 2006**, *Lathyro-Quercetum quercetosum cerris*, Table 17 (relevés 17, 20, 22), **Stefanović & Manuševa 1966**, *Quercetum confertae-cerris carpinus orientalis*, Table 3 (relevés 6-7, 12), **Trinajstić et al. 1996**, *Quercetum frainette-cerris*, Table 1 (relevés 2, 4, 7), **Veljović 1967**, *Quercetum confertae-cerris*, Table 11 (relevés 5-6, 15, 23), **Fabijanić et al. 1967**, *Quercetum frainetto-cerris hieracietosum*, Table 3 (relevé 5), **Stefanović & Manuševa 1971**, *Quercetum farnetto-cerris hieracietosum*, Table 1 (relevé 4), **Glišić 1968**, *Quercetum frainetto-cerris* *aculeatetosum*, Table 1 (relevé 2), **Gajić 1989**, *Quercetum cerris*, Table 2 (relevés 3, 5), **Tomić 2000a**, *Quercetum frainetto-cerris scardicum petraetosum*, Table 1 (relevé 15), **Cvjetićanin & Knežević 2000**, *Quercetum frainetto-cerris-virgilianae*, Table 1 (relevés 23-24), **Topalović et al. 1996**, *Quercetum frainetto-cerris potenilletosum albae*, Table 1 (relevé 2), **Vukićević 1959**, *Quercetum confertae-cerris carpinetosum betuli*, Table 2 (relevé 4), **Vukićević 1959**, *Quercetum confertae-cerris aculeatetosum,* Table 3 (relevé 2), **Vukićević 1959**, *Quercetum confertae-cerris hieracietosum*, Table 3 (relevés 10, 12), **Vukićević 1959**, *Quercetum confertae-cerris* with *Quercus pubescens*, Table 4 (relevés 2, 6, 8), **Gajić et al. 1954**, *Quercetum frainetto-cerris*, Table 1 (relevé 1), **Jovanović 1967**, *Quercetum frainetto-cerris hieracietosum*, Table 5 (relevés 1-7, 9), **Jovanović 1968**, *Quercetum frainetto-cerris comandretosum*, Table (relevé 1), **Amidžić & Krivošej 2001**, *Querco-Paonietum officinalis-masculae*, Table (relevés 1-13), **Ružić 1985**, *Quercetum cerris*, Table (relevés 2-3), **Kevey, B. 2008**, *Fraxino orni-Quercetum cerris*, Table 52 (relevés 2-3, 6, 10-11, 13, 22, 25), **unpublished relevés stored in EU-BH-001** (relevés 48, 62, 81, 84, 142, 229, 425, 428, 1012).

Type 5

Borisavljević et al. 1955, *Quercetum montanum serbicum ornetosum*, Table 2 (relevés 1, 3-5), **Gajić 1961**, *Quercetum montanum*, Table 7 (relevés 2-4, 6-10, 12-14), **Gajić 1961**, *Quercetum montanum carpinetosum orientalis*, Table 7 (relevé 21), **Jovanović 1955a**, *Ouercetum montanum*, Table 12 (relevés 3-5, 10, 12, 14-17, 19-20, 22), **Mišić et al. 1978**, *Quercetum montanum serbicum*, Table 14 (relevés 2-3, 9-10), **Tomić 1988**, *Quercetum petraeae-cerris*, Table (relevés 1-3, 5-9, 12-14), **Vukićević 1966**, *Quercetum montanum ruscetosum*, Table 4 (relevé 8), **Vukićević 1966**, *Quercetum montanum genistetosum*, Table 4 (relevés 9-12), **Baričević 2002**, *Lathyro-Quercetum petraeae quercetosum cerris*, Table 13 (relevé 19), **Janković & Mišić 1980**, *Carici digitate-Quercetum cerris-petraeae*, Table 4 (relevé 2), **Janković & Mišić 1980**, *Rumex acetosella-Quercetum petraeae*, Table 6 (relevés 1-8), **Stefanović & Manuševa 1966**, *Quercetum montanum cerretosum*, Table 2 (relevés 1-8, 10-11), **Stefanović & Manuševa 1966**, *Quercetum montanum aceretosum obtusati*, Table 2 (relevés 13, 15-16, 18-19, 21-23), **Stefanović 1964a**, *Quercetum montanum illyricum fraxinetosum orni*, Table 2 (relevés 1-8, 11, 13), **Lakušić et al. 1987**, *Quercetum montanum montenegrinum*, Table 1 (relevé 2(4)), **Stefanović & Manuševa 1971**, *Quercetum montanum illyricum ericetosum*, Table 3 (relevés 1, 4), **Stefanović & Manuševa 1971**, *Quercetum montanum illyricum fraxinetosum orni*, Table 3 (relevés 5, 7, 9), **Redžić 1988**, *Quercetum montanum*, Table 11 (relevé 5), **Redžić & Barudanović 2010**, *Quercetum petraeae-cerris*, Table 1 (relevés 1, 3), **Redžić et al. 1992**, *Quercetum montanum*, Table 1 (relevé 9), **Pekanović 1991**, *Quercetum petraeae-cerris*, Table 6 (relevés 1-2), **Pekanović 1991**, *Poo nemoralis-Quercetum polycarpae*, Table 7 (relevés 1, 6, 9), **Pekanović 1991**, *Rusco aculeati-Quercetum montanum*, Table 8 (relevés 2, 4-5), **Pekanović 1991**, *Carpino orientalis-Quercetum montanum*, Table 10 (relevé 2), **Pekanović 1991**, *Orno-Quercetum petraeae*, Table 11 (relevés 3, 5), **Medarević 2005**, *Quercetum montanum poetosum nemoralis*, Table 2 (relevé 3), **Medarević 2005**, *Quercetum montanum festucetosum heterophyllae*, Table 2 (relevé 6), **Medarević 2005**, *Carpino orientalis-Quercetum montanum*, Table 3 (relevé 2), **Medarević 2005**, *Orno-Quercetum montanum*, Table 4 (relevé 2), **Gajić 1989**, *Quercetum montanum*, Table 3 (relevés 4-5), **Topalović et al. 1996**, *Potentillo albae-Quercetum petraeae caricetosum hallerianae*, Table 9 (relevé 6), **Vojniković 2001**, *Seslerio autumnalis-Quercetum petraeae genistetosum pilosae*, Table 1 (relevés 5-10), **Brujić 2003**, *Quercetum montanum illyricum cytisetosum procumbentis*, Table (relevé 58), **unpublished relevés stored in EU-BA-001** (relevés 152, 178, 182, 415-417).

Type 6

Šugar 1972, *Lathyro-Quercetum petraeae typicum*, Table 50 (relevés 1, 4), **Šugar 1972**, *Lathyro-Quercetum petraeae luzuletosum nemorosae*, Table 50 (relevé 5), **Horvat 1938**, *Querco-Ostryetum carpinifoliae quercetosum sessiliflorae*, Table 1 (relevés 14-15), **Zupančič 1999**, *Seslerio-Quercetum petraeae*, Table 5 (relevés 4, 10, 14), **Dakskobler 1987**, *Carici umbrosae-Quercetum petraeae*, Table 1 (relevés 1-5, 7-10, 12, 14-15, 17-22, 24), **Zupančič & Žagar 1996**, *Carici umbrosae-Quercetum petraeae*, Table (relevé 7), **Regula-Bevilacqua 1978**, *Lathyro-Quercetum petraeae*, Table 44 (relevés 5, 8, 12-13), **Baričević 2002**, *Querco-Castanetum*, Table 14 (relevé 6), **Baričević 2002**, *Festuco drymeiae-Quercetum petraeae lathyretosum nigrae*, Table 16 (relevés 1, 8), **Janković & Mišić 1980**, *Festuco drymeiae-Quercetum petraeae*, Table 5 (relevé 6), **Škvorc 2006**, *Lathyro-Quercetum petraeae typicum*, Table 17 (relevés 8, 10-11, 14), **Stefanović & Manuševa 1966**, *Quercetum montanum aceretosum obtusati*, Table 2 (relevé 20), **Vukelić 1991**, *Hieracio racemosi-Quercetum petraeae typicum*, Table 2 (relevé 8), **Cimperšek 2008**, *Lathyro-Quercetum petraeae*, Table 2 (relevés 2, 8, 12), **Vukelić et al. 1991**, *Hieracio racemosi-Quercetum petraeae*, Table 1 (relevé 1), **Bucalo 1999**, *Aceri obtusati-Quercetum petraeae*, Table 3 (relevés 2, 5), **Hruška-Dell'Uomo 1974**, *Festuco-Quercetum petraeae typicum*, Table 41 (relevé 5), **Hruška-Dell'Uomo 1974**, *Festuco-Quercetum petraeae luzuletosum nemorosae*, Table 41 (relevé 12), **Hruška-Dell'Uomo 1974**, *Festuco-Quercetum petraeae lathyretosum nigrae*, Table 41 (relevés 15, 17), **Rizovski 1969**, *Quercetum petraeae croaticum*, Table (relevé 69), **Vukelić et al. 2010**, *Potentillo micranthae-Quercetum petraeae*, Table 1 (relevés 7, 11, 15), **Pekanović 1991**, *Festuco drymeiae-Quercetum petraeae*, Table 9 (relevé 3), **Mišić et al. 1997**, *Festuco drymeiae-Quercetum petraeae*, Table 1 (relevés 2, 4), **Kevey 2008**, *Luzulo forsterii-Quercetum petraeae*, Table 46 (relevés 4, 6-7, 9, 12, 17, 20, 22, 25), **Kevey 2008**, *Viscario-Quercetum polycarpae*, Table 50 (relevés 5, 9-11), **Šapić 2012**, *Potentillo micranthae-Quercetum petraeae*, Table 29 (relevés 4, 6, 14, 16), **Brujić 2003**, *Quercetum montanum illyricum typicum*, Table (relevés 19), **unpublished relevés stored in EU-BA-001** (relevés 31, 146, 162, 168, 195, 204, 1035, 1050, 1051, 1063, 1065), **unpublished relevés stored in EU-HR-002** (relevés 2553, 2570).

Type 7

Šugar 1972, *Molinio-Quercetum petraeae*, Table 33 (relevés 1, 3-5, 7-9, 12, 14-15), **Šugar 1972**, *Querco-Castanetum croaticum*, Table 35 (relevés 5, 7, 11, 14, 16, 18, 20, 23-25), **Marinček 1973**, *Leucobryo-Quercetum*, Table 3 (relevés 5-6, 9, 11), **Marinček 1973**, *Melampyro vulgati-Quercetum*, Table 4 (relevés 2-4, 6-7, 9), **Marinček 1973**, *Calluno-Quercetum*, Table 5 (relevés 1-3, 6), **Puncer & Zupančič 1981**, *Melampyro-Quercetum petraeae* var. geogr. *submediterraneum*, Table 1 (relevés 2, 4-6, 8-9, 12, 14-15, 17, 19), **Puncer & Zupančič 1981**, *Melampyro-Quercetum petraeae* var. geogr. *praedinaricum*, Table 2 (relevés 1-2, 4-5, 7-8, 11, 13), **Horvat 1938**, *Querco-Castanetum croaticum myrtillosum*, Table 7 (relevés 1, 7), **Horvat 1938**, *Querco-Castanetum croaticum typicum*, Table 7 (relevés 8, 10-12, 14), **Čarni et al. 1992**, *Melampyro vulgati-Quercetum*, Table 1 (relevé 3), **Regula-Bevilacqua 1978**, *Querco-Castanetum illyricum typicum*, Table 37 (relevés 2-14), **Regula-Bevilacqua 1978**, *Querco-Castanetum illyricum fraxinetosum orni*, Table 37 (relevé 15), **Šegulja 1974**, *Querco-Castanetum croaticum*, Table 38 (relevé 2), **Vukelić 1991**, *Querco-Castanetum*, Table 1 (relevés 4, 7, 12), **Vukelić 1991**, *Hieracio racemosi-Quercetum petraeae myrtilletosum*, Table 2 (relevés 16-20), **Cimperšek 2008**, *Asplenio adianti-nigri-Quercetum petraeae*, Table 3 (relevés 3, 12-13), **Šilc et al. 2008**, *Molinio-Quercetum*, Table 4 (relevés 31-35), **Zorn 1973**, *Molinio-Quercetum*, Table 3 (relevé 3), **Anić 1940**, *Castaneetum sativae*, Table 14 (relevés 13, 15-16, 24-25, 41-45, 48), **Brujić 2003**, *Quercetum montanum illyricum cytisetosum procumbentis*, Table (relevés 6, 7, 74), **Brujić 2003**, *Quercetum montanum illyricum pteridio-callunetosum*, Table (relevés 21, 36, 64), **Brujić 2003**, *Quercetum montanum illyricum typicum*, Table (relevés 23, 49, 106), **unpublished relevés stored in EU-BH-001** (relevés 1037, 1164-1165), **unpublished relevés stored in EU-HR-002** (relevé 2557).

Type 8

Šugar 1972, *Querco-Castanetum croaticum*, Table 35 (relevés 2, 4, 13), **Šugar 1972**, *Querco-Ostryetum carpinifoliae quercetosum petraeae*, Table 44 (relevé 20), **Šugar 1972**, *Lathyro-Quercetum petraeae typicum*, Table 50 (relevé 2), **Wraber 1958**, *Querco-Castanetum croaticum*, Table 1 (relevés 27-30, 33), **Horvat 1938**, *Querco-Castanetum croaticum myrtillosum*, Table 7 (relevés 3, 5), **Horvat 1938**, *Querco-Castanetum croaticum typicum*, Table 7 (relevé 21), **Vukelić 1991**, *Querco-Castanetum*, Table 1 (relevés 2-3, 5), **Anić 1940**, *Castaneetum sativae*, Table 14 (relevés 1, 3, 5, 7-9, 11-12, 17, 22, 31-33, 36-37, 40), **Poslončec 1990**, *Querco-Castanetum*, Table 1 (relevé 1), **Šapić 2012**, *Querco-Castanetum*, Table 28 (relevés 1, 3-4).

Type 9

Fabijanić et al 1963, *Betulo-Quercetum myrtilletosum*, Table 8 (relevés 1-4, 6-10), **Fabijanić et al 1963**, *Betulo-Quercetum ericetosum*, Table 9 (relevés 1-10), **Trinajstić 2004**, *Pteridio-Betuletum*, Table 1 (relevés 1, 3), **Trinajstić 2004**, *Populo tremulae-Betuletum*, Table 1 (relevés 4-6), **Regula-Bevilacqua 1978**, *Querco-Betuletum*, Table 38 (relevés 1-2), **Šegulja 1974**, *Querco-Betuletum*, Table 39 (relevés 1-15), **Vukelić & Španjol 1990**, *Betulo-Quercetum petraeae illyricum*, Table 1 (relevés 1-3), **Rauš & Matić 1994**, *Pteridio-Betuletum*, Table 2 (relevés 1-2, 4), **Šilc et al. 2008**, *Pteridio-Betuletum*, Table 4 (relevés 1-11, 14-21, 23, 26-30), **Stefanović 1964a**, *Quercetum montanum illyricum calluno-betuletosum*, Table 2 (relevés 14-20).

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ANNEX D

List of species merged to aggregates (agg.), broadly defined taxa (s.l.) or taxa deviating from Tutin et al. (1968-1993) or not included therein used in chapter 2.2 (therein referred to as Supplement S2).

Acer hyrcanum subsp. *intermedium* = *Acer hyrcanum* subsp. *intermedium* sensu The Plant List (2013) [= *Acer hyrcanum* subsp. *intermedium* (Pančić) Palam.]
Achillea millefolium agg.: *A. millefolium* and *A. collina*
Achillea nobilis s.l.: *A. nobilis* subsp. *neilreichii* and subsp. *nobilis*
Acinos alpinus s.l.: *A. alpinus* subsp. *alpinus*, subsp. *majoranifolius* and subsp. *meridionalis*
Allium carinatum s.l.: *A. carinatum* subsp. *carinatum* and subsp. *pulchellum*
Allium schoenoprasum agg.: *A. montanum* and *A. schoenoprasum*
Anthyllis vulneraria s.l.: *A. vulneraria* subsp. *alpestris,* subsp. *polyphylla* and subsp. *vulneraria*
Arenaria serpyllifolia s.l.: *A. serpyllifolia* subsp. *leptoclados* and subsp. *serpyllifolia*
Arum besserianum: *Arum besserianum* sensu The Plant List (2013) [= *Arum besserianum* Schott]
Asarum europaeum s.l.: *A. europaeum* subsp. *caucasicum* and subsp. *europaeum*
Athamanta turbith s.l.: *A. turbith* subsp. *turbith* and subsp. *haynaldii*
Brachypodium pinnatum s.l.: *B. pinnatum* subsp. *pinnatum* and subsp. *rupestre*
Bromus erectus agg.: *B. erectus* subsp. *condensatus, B. erectus* and *B. pannonicus*
Bromus ramosus agg.: *B. benekenii* and *B. ramosus*
Calamintha nepeta s.l.: *C. nepeta* subsp. *glandulosa* and subsp. *nepeta*
Campanula sparsa s.l.: *C. sparsa* subsp. *sparsa* and subsp. *sphaerothrix*
Carex divulsa s.l.: *C. divulsa* subsp. *divulsa* and subsp. *leersii*
Carex flacca s.l.: *C. flacca* subsp. *flacca* and subsp. *serrulata*
Carex muricata s.l.: *C. muricata* subsp. *muricata* and subsp. *lamprocarpa*
Centaurea jacea agg.: *C. bracteata, C. jacea* and *C. macroptilon*
Centaurea scabiosa agg.: *C. scabiosa* and *C. grinensis* subsp. *fritschii*
Centaurea triumfetti s.l.: *C. triumfetti* subsp. *aligera,* subsp. *adscendens* and subsp. *triumfetti*
Chamaecytisus hirsutus agg.: *C. ciliatus* and *C. hirsutus*
Coronilla emerus s.l.: *C. emerus* subsp. *emeroides* and subsp. *emerus*
Dactylis glomerata s.l.: *D. glomerata* subsp. *aschersoniana* and subsp. *glomerata*
Fagus sylvatica agg.: *F. moesiaca* and *F. sylvatica*
Festuca filiformis: *Festuca filiformis* sensu The Plant List (2013) [= *Festuca filiformis* Pourr.]
Festuca pseudovina agg.: *F. rupicola, F dalmatica, F. ovina, F. pseudovina* and *F. valesiaca*
Galium mollugo agg.: *G. album* and *G. mollugo*
Helianthemum oelandicum s.l.: *H. oelandicum* subsp. *alpestre* and subsp. *rupifragum*
Helleborus dumetorum s.l.: *H. dumetorum* subsp. *atrorubens* and subsp. *dumetorum*
Helleborus multifidus s.l.: *H. multifidus* subsp. *istriacus,* subsp. *multifidus* and subsp. *serbicus*
Helleborus niger s.l.: *H. niger* subsp. *niger* and subsp. *macranthus*
Hieracium boreale: *Hieracium boreale* sensu The Plant List (2013) [= *Hieracium boreale* Kitt. ex Walp.]
Hieracium florentinum: *Hieracium florentinum* sensu The Plant List (2013) [= *Hieracium florentinum* Spreng.]
Hieracium lachenalii: *Hieracium lachenalii* sensu The Plant List (2013) [= *Hieracium lachenalii* Suter]
Hieracium levicaule: *Hieracium levicaule* sensu The Plant List (2013) [= *Hieracium levicaule* Jord.]
Knautia drymeia s.l.: *K. drymeia* subsp. *drymeia* and subsp. *tergestina*
Lamiastrum galeobdolon s.l.: *L. galeobdolon* subsp. *flavidum,* subsp. *galeobdolon* and subsp. *montanum*
Laserpitium siler s.l.: *L. siler* subsp. *garganicum* and subsp. *siler*
Lathyrus pannonicus s.l.: *L. pannonicus* subsp. *collinus* and subsp. *pannonicus*
Lathyrus pratensis agg.: *L. hallersteinii* and *L. pratensis*
Leontodon hispidus s.l.: *L. hispidus* subsp. *danubialis* and subsp. *hispidus*
Melittis melissophyllum s.l.: *M. melissophyllum* subsp. *albida,* subsp. *carpatica* and subsp. *melissophyllum*
Minuartia verna s.l.: *M. verna* subsp. *collina* and subsp. *verna*

Muscari racemosum: *Muscari racemosum* sensu The Plant List (2013) [= *Muscari racemosum* Mill.]
Poa trivialis s.l.: *P. trivialis* subsp. *sylvicola* and subsp. *trivialis*
Polygala nicaeensis s.l.: *P. nicaeensis* subsp. *forojulensis* and subsp. *mediterranea*
Potentilla tommasiniana: *Potentilla tommasiniana* sensu The Plant List (2013) [= *Potentilla tommasiniana* F.W.Schultz]
Primula veris s.l.: *P. veris* subsp. *canescens,* subsp. *columnae* and subsp. *veris*
Pseudofumaria alba s.l.: *P. alba* subsp. *alba* and subsp. *leiosperma*
Quercus petraea agg.: *Q. dalechampii, Q. petraea* and *Q. polycarpa*
Quercus robur agg.: *Q. robur* and *Q. pedunculiflora*
Ranunculus ficaria s.l.: *R. ficaria* subsp. *calthifolius* and subsp. *ficaria*
Rhamnus saxatilis s.l.: *R. saxatilis* subsp. *saxatilis* and subsp. *tinctorius*
Rosa canina agg.: *R. andegavensis, R. canina, R. corymbifera* and *R. nitidula*
Rosa rubiginosa agg.: *R. agrestis, R. glutinosa, R. micrantha* and *R. rubiginosa*
Rubus fruticosus agg.: *R. bifrons, R. candicans, R. discolor, R. fruticosus, R. montanus* and *R. plicatus*
Sanguisorba minor s.l.: *S. minor* subsp. *minor* and subsp. *muricata*
Satureja montana s.l.: *S. montana* subsp. *illyrica,* subsp. *kitaibelii,* subsp. *montana* and subsp. *variegata*
Scabiosa columbaria s.l.: *S. columbaria* subsp. *columbaria* and subsp. *portae*
Scilla lakusicii: *Scilla lakusicii* sensu The Plant List (2013) [= *Scilla lakusicii* Šilić]
Sesleria albicans s.l.: *S. albicans* subsp. *albicans* and subsp. *angustifolia*
Sesleria tenuifolia s.l.: *S. tenuifolia* subsp. *kalnikensis* and subsp. *tenuifolia*
Silene vulgaris s.l.: *S. vulgaris* subsp. *commutata* and subsp. *vulgaris*
Stachys recta s.l.: *S. recta* subsp. *recta* and subsp. *subcrenata*
Stipa pennata s.l.: *S. pennata* subsp. *eriocaulis* and subsp. *pennata*
Symphytum tuberosum s.l.: *S. tuberosum* subsp. *nodosum* and subsp. *tuberosum*
Thymus praecox s.l.: *T. praecox* subsp. *polytrichus*, subsp. *skorpilii* and subsp. *praecox*
Thymus serpyllum agg.: *T. serpyllum* and *T. glabrescens*
Trifolium medium s.l.: *T. medium* subsp. *balcanicum* and subsp. *medium*
Ulmus minor agg.: *U. minor* and *U. canescens*
Valeriana officinalis s.l.: *V. officinalis* subsp. *collina* and subsp. *officinalis*
Verbascum nigrum s.l.: *V. nigrum* subsp. *abietinum* and subsp. *nigrum*
Vicia sativa s.l.: *V. sativa* subsp. *cordata*, subsp. *nigra* and subsp. *sativa*
Vicia tenuifolia agg.: *V. dalmatica* and *V. tenuifolia*
Vicia villosa s.l.: *V. villosa* subsp. *varia* and subsp. *villosa*
Viola alba s.l.: *V. alba* subsp. *alba* and subsp. *dehnhardtii*
Viola canadensis: *Viola canadensis* sensu The Plant List (2013) [= *Viola canadensis* L.]
Viola tricolor s.l.: *V. tricolor* subsp. *macedonica* and subsp. *tricolor*

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ANNEX E

Full synoptic table of the *Quercetea pubescentis* supplemented by *Quercetea robori-petraeae* relevés (as assigned by their authors) in the W Balkans. Referres to chapter 2.2 (therein referred to as Supplement S3). Frequency values of species in each of the 9 clusters (columns) obtained from the unsupervised classification of 968 resampled relevés are shown. Species with phi values higher than 0.25 are shaded and those species are considered diagnostic for particular cluster.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
No. of relevés	140	121	124	129	131	90	117	37	79
Type 1: Sub-mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis*									
Carpinus orientalis	96	22	5	19	12	.	1	.	.
Acer monspessulanum	46	21	23	2	1	.	.	.	.
Pistacia terebinthus	23	3	2	.	.	.	.	.	.
Paliurus spina-christi	25	8	1	.	.	.	.	.	.
Clematis flammula	25	9	1	.	.	.	.	.	.
Asparagus acutifolius	34	21	14	.	.	.	.	.	.
Cyclamen hederifolium	14	.	.	1	.	.	.	.	.
Ruscus aculeatus	44	10	23	8	6	19	.	.	.
Cornus mas	64	45	50	33	9	20	.	.	.
Juniperus oxycedrus	25	12	6	1	4	.	.	.	.
Smilax aspera	8	.	.	.	.	.	.	.	.
Phillyrea latifolia	10	2	.	.	.	.	.	.	.
Type 2: Sub-mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis*									
Helleborus multifidus s.l.	11	37	5	2	2	.	.	.	.
Geranium sanguineum	10	37	19	2	1	6	.	.	3
Brachypodium pinnatum s.l.	20	55	34	18	5	8	1	.	27
Teucrium chamaedrys	41	55	35	17	11	7	.	.	8
Peucedanum cervaria	1	24	7	4	1	7	.	.	.
Filipendula vulgaris	10	31	4	16	2	2	.	.	3
Inula hirta	1	19	2	5	.	.	.	.	3
Carex humilis	8	30	19	.	1	3	.	.	4
Carex flacca s.l.	8	37	8	2	.	28	2	5	9
Viola hirta	31	48	17	22	11	16	.	8	.
Bunium alpinum subsp. *montanum*	1	10	1	.	.	.	.	.	.
Bromus erectus agg.	21	26	11	2	5	.	.	.	.
Type 3: Meso-thermophilous supra-mediterranean and/or relict communities dominated by *Ostrya carpinifolia*									
Ostrya carpinifolia	32	45	100	2	1	13	1	5	.
Asplenium ruta-muraria	4	2	44	.	.	.	.	.	.
Asplenium trichomanes	13	6	57	2	8	1	2	.	3
Galium laevigatum	.	2	30	.	.	2	.	.	.
Sorbus aria	8	13	56	.	1	9	12	8	.
Cyclamen purpurascens	13	9	52	.	.	10	2	14	3
Campanula pyramidalis	1	1	25	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Moehringia muscosa	1	2	27	2	.	.	.	.	.
Campanula rapunculoides	2	2	31	2	5	1	.	.	.
Anemone trifolia	.	1	23	.	.	3	.	.	.
Veratrum nigrum	7	3	30	2	.	2	.	.	.
Amelanchier ovalis	4	6	26	.	.	.	1	.	.
Mercurialis ovata	6	15	31	.	1	.	.	.	.
Phyteuma scheuchzeri subsp. *columnae*	.	2	18	.	.	.	.	.	.
Calamagrostis varia	1	6	25	.	1	3	.	.	.
Arabis turrita	7	2	27	1	1	4	.	.	.
Hepatica nobilis	10	4	30	.	.	7	.	.	.
Spiraea chamaedryfolia	.	.	15	.	.	.	.	.	.
Carex digitata	6	4	43	2	11	28	.	.	8
Lamiastrum galeobdolon s.l.	4	2	23	1	.	3	.	3	.
Laburnum alpinum	.	.	15	.	.	.	.	3	.
Tilia platyphyllos	4	2	29	2	5	4	.	11	.
Vincetoxicum hirundinaria	26	32	58	19	16	27	1	3	.
Euonymus verrucosus	22	8	33	4	1	3	.	.	.
Cardamine enneaphyllos	.	.	11	.	.	.	.	.	.
Athamanta turbith s.l.	.	.	11	.	.	.	.	.	.
Cotoneaster nebrodensis	2	3	16	.	.	.	.	.	.
Mercurialis perennis	4	.	18	1	1	3	.	.	.
Clematis vitalba	18	25	42	9	1	14	2	5	.
Polypodium vulgare	4	2	27	2	1	4	9	3	4
Geranium robertianum	9	4	30	13	2	1	.	5	3
Lonicera xylosteum	9	2	23	2	.	1	.	5	1
Asplenium ceterach	19	2	23	.	.	.	.	.	.
Dianthus monspessulanus	.	3	15	.	.	.	3	.	.
Cotinus coggygria	25	21	32	1	2	1	.	.	.
Frangula rupestris	15	14	26	.	2	.	.	.	.
Melittis melissophyllum s.l.	20	41	49	14	7	33	1	5	.
Sesleria tenuifolia s.l.	1	1	10	.	.	.	.	.	.
Sesleria albicans s.l.	.	3	11	.	.	.	.	.	.
Rhamnus catharticus	16	13	33	11	.	9	.	5	4
Iberis linifolia	.	.	8	.	.	.	.	.	.
Polygonatum odoratum	14	12	30	9	3	10	1	.	.
Ulmus glabra	1	.	16	4	1	3	1	3	.
Asplenium scolopendrium	1	.	8	.	.	.	.	.	.
Vinca minor	.	.	18	.	.	14	.	3	.
Carex alba	.	2	9	.	.	.	.	.	.
Prunus mahaleb	15	11	21	.	.	.	.	.	.
Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Cluster number	1	2	3	4	5	6	7	8	9
Type 4: Thermophilous continental forests of deep, slightly acidic soil dominated by *Quercus frainetto* and/or *Quercus cerris*									
Quercus frainetto	4	6	1	71	9	.	.	.	.
Quercus cerris	31	55	27	92	51	33	12	.	19
Physospermum cornubiense	6	.	6	33	5	.	.	.	.
Acer tataricum	9	2	.	27	8	4	1	.	1
Paeonia mascula	.	.	.	10	.	.	.	.	.
Geum urbanum	13	10	8	28	5	4	.	.	.
Festuca pseudovina agg.	16	19	10	36	18	.	1	3	.
Galium aparine	4	2	.	19	11	2	.	.	.
Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* and/or *Quercus cerris*									
Poa nemoralis	8	3	8	25	50	23	2	8	3
Hieracium praealtum subsp. *bauhinii*	6	3	.	26	34	6	3	3	3
Sedum cepaea	2	.	2	6	17	1	.	.	.
Myosotis ramosissima	.	.	.	1	8	.	.	.	.
Rumex acetosella	1	.	.	12	18	3	.	.	.
Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests									
Festuca drymeja	1	.	.	2	5	36	2	.	.
Hieracium racemosum	1	10	.	3	3	59	40	8	11
Robinia pseudacacia	1	3	.	1	.	30	4	14	1
Galium schultesii	6	2	2	8	14	32	1	3	3
Prunus avium	11	12	6	26	11	61	11	51	16
Carex pilosa	1	.	1	1	4	27	3	3	20
Lathyrus niger	17	40	6	36	22	54	13	14	.
Type 7: Mesic acidophilous forests dominated by *Quercus petraea* agg.									
Vaccinium myrtillus	.	.	2	.	5	1	83	19	15
Luzula luzulina	.	2	.	1	2	7	27	.	3
Hieracium murorum	2	8	15	9	26	50	73	57	13
Prenanthes purpurea	.	.	2	.	1	1	25	8	4
Fagus sylvatica agg.	6	9	20	16	29	54	77	65	39
Deschampsia flexuosa	1	.	.	.	11	17	31	.	18
Picea abies	.	.	3	2	.	1	26	3	23
Type 8: Mesophilous forests dominated by *Castanea sativa*									
Aposeris foetida	3	1	4	1	1	9	13	89	.
Scrophularia nodosa	.	.	.	3	1	2	4	57	.
Sanicula europaea	6	3	2	5	.	6	2	51	6
Corylus avellana	16	15	19	17	16	26	17	89	42
Euphorbia dulcis	.	2	8	.	1	26	10	54	4
Viburnum opulus	1	1	.	.	.	3	6	38	6
Dryopteris filix-mas	4	.	7	1	1	4	5	43	5
Galium sylvaticum	2	2	2	6	3	31	19	57	4
Circaea lutetiana	.	.	.	2	2	2	.	24	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Primula vulgaris	27	17	17	5	2	21	3	59	5
Athyrium filix-femina	.	1	1	.	.	1	4	27	6
Carpinus betulus	11	6	9	29	23	70	24	86	68
Polygonatum multiflorum	4	6	8	6	2	23	6	43	.
Glechoma hederacea	.	.	.	2	.	2	1	19	.
Pulmonaria officinalis	6	3	2	6	2	10	.	32	3
Cornus sanguinea	12	23	17	16	2	18	2	51	4
Aegopodium podagraria	1	.	.	.	.	.	.	14	.
Luzula campestris	1	2	.	5	8	2	8	32	10
Rubus fruticosus agg.	5	5	4	6	14	6	9	46	30
Lonicera caprifolium	4	8	6	5	1	12	1	32	.
Lathyrus montanus	.	1	.	.	.	3	13	30	15
Convallaria majalis	3	3	23	3	.	14	28	43	4
Fragaria vesca	33	19	30	52	51	27	17	84	65
Vicia oroboides	.	.	.	.	2	1	.	14	1
Crataegus laevigata	5	1	8	9	2	8	1	27	4
Aruncus dioicus	.	.	2	.	.	2	3	14	.
Moehringia trinervia	.	.	1	5	2	4	.	16	.
Hieracium umbellatum	.	3	2	7	12	3	21	35	20
Ajuga reptans	13	7	7	14	11	21	2	41	18
Type 9: Acidophilous pioneer *Betula pendula* or *B. pendulalPopulus tremula* communities									
Betula pendula	.	.	.	2	10	.	16	5	97
Populus tremula	.	1	4	2	1	6	12	5	71
Carex pallescens	.	.	1	.	.	.	1	.	30
Danthonia decumbens	.	.	.	.	8	.	5	.	39
Festuca filiformis	.	.	.	.	.	.	.	.	28
Potentilla erecta	.	1	2	1	12	7	27	35	66
Agrostis capillaris	.	.	.	9	6	1	13	11	47
Hypochoeris radicata	1	.	1	1	3	.	.	.	23
Cytisus procumbens	.	1	.	1	1	.	6	.	23
Pteridium aquilinum	14	13	4	21	50	38	68	76	87
Centaurea jacea agg.	5	9	4	.	2	2	.	.	25
Leontodon hispidus s.l.	1	4	.	1	.	.	.	3	18
Viola canadensis	.	.	.	.	.	.	.	.	10
Chamaespartium sagittale	.	4	1	5	26	1	4	.	30
Pyrola rotundifolia	.	.	.	.	.	.	.	.	9
Veronica officinalis	1	2	.	32	47	12	22	46	58
Holcus lanatus	.	.	.	2	.	.	1	.	11
Crepis biennis	1	.	.	.	.	.	.	.	9
Hieracium pilosella	9	2	1	20	27	2	1	3	34
Juniperus communis	18	27	18	19	21	23	42	30	62
Eupatorium cannabinum	.	.	.	1	.	1	.	3	11

Cluster number	1	2	3	4	5	6	7	8	9
Quercus robur agg.	.	.	.	3	.	.	.	.	10
Species diagnostic for more than one type									
Quercus pubescens	71	93	44	14	1	3	.	3	.
Coronilla emerus s.l.	34	19	34	.	2	1	.	.	.
Calluna vulgaris	.	.	.	.	7	4	79	22	67
Castanea sativa	1	4	3	3	4	40	73	100	9
Melampyrum pratense	3	2	2	5	15	43	68	68	43
Pinus sylvestris	.	.	.	.	.	.	25	.	22
Frangula alnus	1	2	4	.	.	18	51	43	51
Gentiana asclepiadea	.	.	1	.	.	8	41	57	18
Luzula luzuloides	1	.	.	2	23	39	56	54	33
Sesleria autumnalis	57	65	56	.	8	17	.	.	.
Quercus petraea agg.	22	8	31	46	100	100	98	76	91
Other species									
Fraxinus ornus	96	94	92	62	69	96	28	73	9
Crataegus monogyna	64	68	35	68	48	36	7	41	58
Hedera helix	41	29	37	5	5	42	10	32	8
Dactylis glomerata s.l.	39	47	15	46	36	59	2	5	19
Helleborus odorus	38	17	36	40	34	6	.	.	13
Tamus communis	38	36	21	19	7	20	1	35	.
Acer campestre	34	35	18	49	24	37	3	30	8
Brachypodium sylvaticum	34	26	17	33	21	26	3	5	13
Ligustrum vulgare	34	36	19	34	2	21	.	35	19
Sorbus torminalis	33	36	18	30	23	67	21	65	9
Veronica chamaedrys	32	23	15	46	41	34	9	57	13
Clinopodium vulgare	27	36	19	35	27	26	1	14	25
Euphorbia cyparissias	21	36	27	29	16	8	.	.	30
Stachys officinalis	17	36	10	8	2	28	2	.	28
Rosa arvensis	23	31	18	27	26	36	9	14	13
Viburnum lantana	27	18	35	20	1	10	2	19	1
Chamaecytisus hirsutus agg.	19	22	31	13	33	27	5	3	37
Festuca heterophylla	16	26	10	48	27	50	24	24	11
Pyrus pyraster	25	26	17	44	25	37	15	35	24
Genista tinctoria	6	13	10	31	42	43	46	62	47
Prunus spinosa	19	23	10	30	6	9	1	16	13
Hypericum perforatum	14	7	10	26	35	12	1	8	16
Potentilla micrantha	25	12	14	24	35	31	3	8	24
Hieracium sabaudum	7	6	3	14	35	20	21	.	30
Euphorbia amygdaloides	18	3	22	10	35	13	1	5	18
Thymus pulegioides	21	7	7	19	34	1	.	.	24
Serratula tinctoria	1	22	11	10	2	43	20	43	4
Solidago virgaurea	4	11	27	.	4	39	38	41	32

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Rubus hirtus	5	2	6	18	20	38	12	41	8
Campanula persicifolia	19	17	11	19	15	38	6	3	5
Tanacetum corymbosum	24	28	22	27	12	37	5	5	8
Cruciata glabra	21	24	6	24	20	33	9	46	48
Symphytum tuberosum s.l.	24	23	17	16	6	32	2	27	.
Viola reichenbachiana	24	10	10	23	24	30	9	19	27
Acer pseudoplatanus	1	2	24	1	3	30	11	16	10
Melica uniflora	22	5	13	16	6	26	.	8	3
Carex montana	.	11	4	8	14	23	3	.	8
Silene nutans	6	15	15	4	21	19	3	5	.
Chamaecytisus supinus	5	13	2	13	2	28	39	43	8
Molinia caerulea subsp. *arundinacea*	.	6	5	.	.	21	29	3	18
Genista germanica	.	7	.	.	.	8	26	27	23
Lembotropis nigricans	3	10	1	6	19	11	23	19	15
Calamagrostis arundinacea	.	2	3	.	.	17	20	3	.
Luzula pilosa	1	.	1	8	12	13	19	24	8
Asarum europaeum s.l.	8	4	23	4	.	4	2	27	6
Epimedium alpinum	4	4	2	7	2	7	9	24	4
Luzula forsteri	9	7	2	19	18	22	7	24	19
Knautia drymeia s.l.	.	9	5	5	.	20	3	24	4
Carex sylvatica	6	2	.	3	.	11	3	24	13
Campanula trachelium	8	15	20	5	5	16	2	24	4
Malus sylvestris	6	8	3	13	6	10	9	22	3
Anemone nemorosa	6	2	5	2	3	19	5	22	3
Stellaria holostea	14	6	5	8	11	26	1	22	6
Hypericum montanum	4	7	3	5	1	21	9	19	5
Campanula patula	.	.	1	14	17	3	5	19	9
Cardamine bulbifera	6	2	4	2	4	13	2	19	.
Daphne mezereum	.	1	15	1	.	2	2	19	1
Salvia glutinosa	2	7	17	2	2	27	3	16	11
Prunella vulgaris	9	2	1	19	21	3	1	14	33
Peucedanum oreoselinum	3	12	14	.	2	17	1	3	20
Galium mollugo agg.	18	11	12	8	15	19	1	5	16
Genista pilosa	.	.	.	2	21	4	12	.	15
Pimpinella saxifraga	4	9	2	1	2	7	.	.	15
Omalotheca sylvatica	.	.	.	.	9	.	1	3	14
Anthoxanthum odoratum	1	2	.	5	9	1	8	8	13
Achillea millefolium agg.	6	3	6	12	5	.	.	.	13
Berberis vulgaris	.	6	23	3	.	7	3	14	11
Platanthera bifolia	4	1	6	2	2	16	13	11	11
Alnus glutinosa	.	.	.	.	.	.	3	3	11
Salix caprea	.	.	2	2	.	.	3	8	10

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Centaurium erythraea	4	.	.	4	6	.	1	8	10
Teucrium scordium	.	.	.	.	.	.	6	.	10
Lotus corniculatus	11	18	6	8	8	.	.	.	10
Carlina vulgaris	1	3	.	.	3	.	.	.	10
Lathyrus venetus	22	11	11	11	13	1	.	.	.
Acer obtusatum	21	27	10	2	8	10	.	5	4
Buglossoides purpurocaerulea	21	27	10	16	4	8	.	.	.
Glechoma hirsuta	19	8	5	15	5	2	.	3	9
Aremonia agrimonoides	19	15	18	12	17	7	.	14	6
Rubus ulmifolius	18	10	15	2	.	.	.	.	.
Asparagus tenuifolius	16	17	25	3	1	3	.	.	.
Asperula purpurea	16	10	11	.	2	1	.	.	.
Galium lucidum	15	28	17	2	8	12	5	.	.
Carex caryophyllea	14	7	2	22	8	1	2	.	6
Lathyrus vernus	14	1	19	9	2	22	2	16	.
Sanguisorba minor s.l.	14	7	6	5	2	1	.	.	.
Colutea arborescens	14	7	3	3	1	.	.	.	.
Rosa canina agg.	13	12	13	16	2	8	.	.	5
Viola alba s.l.	13	7	12	5	1	12	.	.	.
Stachys recta s.l.	13	10	16	2	2	1	.	.	.
Calamintha sylvatica	12	9	16	6	8	8	.	.	.
Satureja montana s.l.	12	8	14	.	.	.	.	.	.
Sedum telephium subsp. *maximum*	11	7	28	6	8	17	2	.	.
Silene viridiflora	11	4	8	20	6	12	.	.	.
Silene vulgaris s.l.	11	7	8	5	5	2	.	.	.
Lonicera etrusca	11	14	2	.	.	1	.	.	.
Dorycnium pentaphyllum subsp. *germanicum*	10	20	8	5	2	3	.	.	5
Lilium martagon	10	3	16	1	1	6	1	8	.
Trifolium alpestre	10	26	2	19	11	2	.	.	.
Petteria ramentacea	10	4	2	.	.	.	.	.	.
Trifolium rubens	7	25	7	2	8	7	1	8	.
Buphthalmum salicifolium	6	20	19	.	.	13	.	3	.
Thalictrum minus	7	18	22	1	.	2	.	.	3
Dorycnium pentaphyllum subsp. *herbaceum*	9	17	1	5	5	.	1	.	4
Anthericum ramosum	4	17	24	2	1	13	2	.	.
Cnidium silaifolium	1	16	15	.	.	.	.	.	1
Sorbus domestica	6	13	.	18	3	9	1	.	.
Iris graminea	9	12	9	6	2	9	.	.	.
Carex hallerana	9	12	3	1	1	.	.	.	.
Astragalus glycyphyllos	5	12	1	19	5	7	2	3	1
Fragaria moschata	4	12	2	4	2	9	.	.	1

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Aristolochia lutea	4	12	8	3	.	1	.	.	.
Inula salicina	2	12	1	5	.	1	.	.	.
Valeriana officinalis s.l.	1	12	15	1	.	3	.	.	.
Hieracium tommasinii	1	12	.	.	5	.	.	.	.
Bromus ramosus agg.	.	12	.	5	1	4	.	.	.
Dictamnus albus	8	10	11	5	.	.	.	.	.
Thymus longicaulis	4	10	3	.	4	.	.	.	.
Eryngium amethystinum	4	10	1	.	.	.	.	.	.
Genista sylvestris	3	10	2	.	.	.	.	.	.
Euonymus europaeus	5	9	19	9	2	6	.	14	.
Mycelis muralis	6	6	19	5	8	10	2	11	4
Origanum vulgare	9	8	16	2	3	8	1	.	3
Digitalis grandiflora	5	2	16	5	4	3	3	.	8
Allium carinatum s.l.	6	9	15	1	2	3	.	3	.
Tilia cordata	1	4	15	2	.	10	3	8	9
Primula veris s.l.	3	3	15	7	7	2	.	.	4
Melica nutans	6	1	14	1	.	9	.	3	.
Acer platanoides	1	2	13	2	1	6	2	5	.
Clematis recta	5	7	12	1	.	1	.	.	.
Inula conyza	4	2	12	3	1	2	1	.	.
Erica herbacea	.	3	10	.	2	.	15	.	9
Asplenium adiantum-nigrum	9	.	10	3	8	1	1	.	.
Rubus canescens	4	7	7	19	15	4	3	.	1
Lapsana communis	2	2	2	17	11	4	.	.	.
Poa angustifolia	3	3	2	16	8	2	.	.	8
Lychnis coronaria	2	3	1	16	18	.	.	.	.
Galium pseudoaristatum	4	1	6	15	21	.	.	.	.
Galium verum	1	4	3	12	5	3	.	.	9
Ulmus minor agg.	6	8	2	12	2	4	.	8	.
Chamaecytisus austriacus	1	.	1	11	10	.	.	.	.
Carex divulsa s.l.	1	2	.	11	5	4	.	.	.
Cruciata laevipes	9	7	1	10	10	.	.	.	1
Tilia tomentosa	7	5	2	8	15	22	.	3	.
Digitalis lanata	4	.	2	7	11	.	.	.	.
Aira elegantissima	1	.	.	8	10	.	.	.	.
Vulpia myuros	1	.	.	3	10	.	.	.	4
Cephalanthera longifolia	4	5	5	5	2	18	3	5	.
Melampyrum nemorosum	2	7	2	2	1	10	1	3	.
Dianthus barbatus	.	.	.	1	1	10	3	16	4
Lychnis viscaria	.	.	.	.	7	9	4	8	.
Ilex aquifolium	2	1	.	.	.	9	2	5	9
Potentilla alba	.	1	3	2	1	8	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ornithogalum pyrenaicum	1	5	1	2	1	7	.	.	.
Galium odoratum	1	2	2	6	1	6	1	11	.
Epipactis helleborine	1	3	6	2	1	6	.	.	3
Peucedanum austriacum	3	6	7	.	1	6	2	.	.
Achillea distans	.	1	6	.	1	6	.	.	8
Lamium orvala	.	.	3	.	.	6	.	8	.
Laserpitium latifolium	.	.	2	.	.	6	.	.	.
Abies alba	1	.	1	.	.	6	10	5	.
Euphorbia angulata	.	2	.	.	.	6	.	.	.
Campanula glomerata	1	2	5	1	3	4	.	.	3
Alliaria petiolata	2	.	.	8	2	4	.	.	.
Fallopia dumetorum	1	.	.	6	2	4	.	.	.
Pinus nigra	.	7	5	.	2	4	.	.	.
Leucanthemum vulgare	3	2	3	4	1	4	1	.	9
Neottia nidus-avis	3	4	2	3	1	4	1	3	.
Ruscus hypoglossum	1	.	.	2	.	4	1	5	.
Hieracium lachenalii	.	.	.	2	2	3	3	8	.
Erythronium dens-canis	4	2	2	1	2	3	3	8	.
Coronilla varia	4	7	6	5	1	3	.	.	.
Sorbus mougeotii	.	.	.	.	1	3	.	.	.
Vicia sepium	1	1	1	3	.	3	2	3	.
Erigeron annuus	1	.	.	1	.	3	1	.	4
Viola riviniana	1	3	4	.	.	3	3	8	.
Cirsium pannonicum	1	4	.	.	.	3	.	.	1
Crocus vernus	.	1	.	.	.	3	.	5	.
Mespilus germanica	.	.	.	.	.	3	.	.	.
Verbascum nigrum s.l.	3	9	2	5	8	2	1	.	.
Poa pratensis	1	2	.	9	4	2	.	.	1
Carex ornithopoda	1	.	2	.	3	2	.	.	.
Trifolium medium s.l.	1	4	2	7	2	2	2	.	5
Vicia incana	3	7	5	5	2	2	.	.	.
Galeopsis pubescens	.	.	.	4	2	2	2	5	.
Taraxacum officinale	6	2	2	7	1	2	.	.	5
Campanula bononiensis	4	7	2	5	1	2	.	.	.
Melampyrum sylvaticum	1	1	.	2	1	2	.	.	.
Myosotis arvensis	.	.	1	1	1	2	.	.	.
Cephalanthera damasonium	1	3	2	.	1	2	1	3	3
Rubus idaeus	1	1	2	5	.	2	.	.	9
Orchis purpurea	1	3	.	5	.	2	.	.	.
Dianthus armeria	.	.	.	3	.	2	2	.	.
Heracleum sphondylium	1	2	6	2	.	2	.	.	.
Sambucus nigra	.	.	5	2	.	2	1	3	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Calystegia sepium	.	.	.	2	.	2	.	.	.
Ferulago sylvatica	1	7	.	1	.	2	.	.	.
Oxalis acetosella	.	.	.	1	.	2	3	3	.
Rhamnus saxatilis s.l.	2	4	4	.	.	2	.	.	1
Euphorbia brittingeri	.	7	2	.	.	2	.	.	1
Cardaminopsis arenosa	.	1	2	.	.	2	.	.	.
Calamagrostis villosa	.	1	1	.	.	2	.	.	.
Hierochloë australis	.	2	.	.	.	2	.	.	.
Ranunculus serpens	1	1	.	.	.	2	.	3	6
Scabiosa cinerea subsp. *hladnikiana*	.	1	.	.	.	2	.	.	.
Hieracium rotundatum	.	.	.	.	.	2	.	.	.
Aconitum lycoctonum subsp. *vulparia*	.	.	.	.	.	2	.	.	.
Polygala comosa	3	3	1	2	9	1	.	.	4
Epilobium montanum	.	.	.	.	7	1	2	14	9
Galeopsis speciosa	.	.	1	2	6	1	1	.	.
Hieracium piloselloides	.	4	1	1	5	1	.	.	.
Torilis japonica	2	2	.	5	4	1	.	.	.
Vicia hirsuta	2	3	1	2	4	1	.	.	.
Hieracium cymosum	.	.	.	.	4	1	1	.	.
Lamium maculatum	.	1	1	2	3	1	.	.	.
Cephalanthera rubra	.	5	.	2	3	1	.	.	.
Ajuga genevensis	2	2	5	1	3	1	1	.	.
Milium effusum	2	.	1	1	3	1	1	.	.
Trifolium montanum	1	4	1	8	2	1	.	.	6
Arabis hirsuta	6	1	6	3	2	1	.	.	.
Prunella laciniata	4	1	2	2	2	1	.	.	1
Polygala vulgaris	1	2	.	2	2	1	8	8	6
Staphylea pinnata	3	1	8	.	2	1	.	5	.
Silene italica subsp. *nemoralis*	1	2	2	.	2	1	.	.	.
Myosotis sylvatica	1	1	1	.	2	1	.	8	.
Hypericum hirsutum	1	.	1	7	1	1	.	.	.
Veronica hederifolia	1	.	.	7	1	1	.	.	.
Polygonatum latifolium	1	.	.	3	1	1	.	.	.
Colchicum autumnale	6	2	2	2	1	1	.	.	.
Poa trivialis s.l.	2	7	.	2	1	1	.	.	3
Allium oleraceum	.	.	.	2	1	1	.	.	.
Senecio nemorensis	.	.	1	1	1	1	.	.	4
Juglans regia	3	3	.	1	1	1	.	.	.
Lysimachia punctata	.	.	.	1	1	1	.	.	.
Thalictrum aquilegiifolium	7	6	6	.	1	1	.	.	.
Polystichum setiferum	1	.	2	.	1	1	.	3	.
Echinops ritro	.	.	1	.	1	1	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Paeonia officinalis	.	5	.	9	.	1	.	.	.
Helianthemum nummularium	9	6	5	5	.	1	.	.	1
Hypochoeris maculata	.	7	.	5	.	1	.	.	.
Rosa gallica	1	2	.	3	.	1	.	.	1
Pulmonaria mollis	.	1	1	2	.	1	.	.	.
Stellaria media	2	.	.	2	.	1	1	.	.
Listera ovata	1	2	5	1	.	1	1	.	.
Scabiosa columbaria s.l.	2	.	2	1	.	1	.	.	.
Digitalis laevigata	5	1	1	1	.	1	.	.	.
Limodorum abortivum	.	4	.	1	.	1	.	.	.
Rosa pimpinellifolia	.	8	8	.	.	1	.	.	.
Aster amellus	.	7	6	.	.	1	.	.	.
Rosa pendulina	.	1	6	.	.	1	1	.	.
Senecio nemorensis subsp. *fuchsii*	.	.	6	.	.	1	.	.	3
Aethionema saxatile	6	6	2	.	.	1	.	.	.
Polystichum aculeatum	1	.	2	.	.	1	.	.	1
Genista januensis	3	3	1	.	.	1	.	.	.
Allium sphaerocephalon	.	2	1	.	.	1	.	.	.
Silene dioica	1	1	1	.	.	1	.	.	.
Stachys sylvatica	1	.	1	.	.	1	1	.	1
Dianthus ferrugineus subsp. *liburnicus*	.	2	.	.	.	1	.	.	.
Lactuca serriola	.	2	.	.	.	1	.	.	.
Seseli libanotis	.	2	.	.	.	1	.	.	.
Helleborus dumetorum s.l.	1	1	.	.	.	1	.	5	4
Campanula rotundifolia	1	.	.	.	.	1	.	.	4
Monotropa hypopitys	1	.	.	.	.	1	.	.	.
Allium schoenoprasum s.l.	1	.	.	.	.	1	.	.	.
Ranunculus acris	.	.	.	.	.	1	.	.	8
Calamagrostis epigejos	.	.	.	.	.	1	.	.	6
Maianthemum bifolium	.	.	.	.	.	1	3	.	5
Lycopodium clavatum	.	.	.	.	.	1	3	.	4
Hieracium praecurrens	.	.	.	.	.	1	2	.	4
Dryopteris carthusiana	.	.	.	.	.	1	.	3	1
Doronicum austriacum	.	.	.	.	.	1	2	3	.
Festuca gigantea	.	.	.	.	.	1	.	3	.
Doronicum orientale	.	.	.	.	.	1	.	.	.
Medicago carstiensis	.	.	.	.	.	1	.	.	.
Linum flavum	.	.	.	.	.	1	.	.	.
Vicia sylvatica	.	.	.	.	.	1	.	.	.
Trifolium campestre	6	1	1	3	9	.	.	.	.
Poa bulbosa	1	3	1	1	9	.	.	.	.
Hieracium hoppeanum	.	1	1	2	8	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Epilobium lanceolatum	.	.	.	3	7	.	.	.	.
Achillea nobilis s.l.	1	.	.	.	7	.	.	.	.
Cardamine glauca	.	.	.	.	6	.	1	.	.
Agrimonia eupatoria	9	7	2	7	5	.	.	3	6
Vicia cracca	.	3	3	5	5	.	.	.	8
Bellis perennis	1	.	.	4	5	.	.	.	5
Chamaecytisus heuffelii	.	.	.	3	5	.	.	.	.
Trifolium pratense	1	2	.	2	5	.	.	.	8
Scleranthus annuus	.	1	.	2	5	.	.	.	.
Campanula lingulata	7	.	.	2	5	.	.	.	.
Silene armeria	.	.	.	2	5	.	.	.	.
Rosa rubiginosa agg.	5	1	3	1	5	.	.	.	.
Lychnis flos-cuculi	1	.	.	.	5	.	.	.	.
Cerastium decalvans	.	.	.	.	5	.	.	.	3
Cerastium brachypetalum	3	2	1	3	4	.	.	.	.
Silene italica	4	7	1	2	4	.	2	.	.
Lathyrus pratensis agg.	1	2	5	1	4	.	.	.	4
Euphrasia rostkoviana	.	.	.	.	4	.	.	.	1
Viola odorata	2	2	.	5	3	.	.	.	1
Trifolium arvense	1	1	.	4	3	.	.	.	6
Trifolium repens	1	.	.	4	3	.	.	3	3
Medicago lupulina	4	1	3	2	3	.	.	.	.
Centaurea phrygia	.	2	.	2	3	.	.	.	.
Vicia grandiflora	1	.	.	2	3	.	.	.	.
Galium tenuissimum	.	.	.	2	3	.	.	.	.
Linaria genistifolia	.	.	.	2	3	.	.	.	.
Logfia arvensis	.	.	.	1	3	.	.	.	.
Acinos arvensis	1	.	1	.	3	.	.	.	.
Plantago media	7	2	1	8	2	.	.	.	5
Stachys scardica	3	2	2	6	2	.	.	.	.
Stachys germanica	2	.	.	6	2	.	.	.	.
Potentilla argentea	1	2	.	5	2	.	.	.	.
Fraxinus excelsior	1	.	2	4	2	.	.	.	.
Fallopia convolvulus	.	.	.	4	2	.	.	.	.
Lathyrus laxiflorus	1	6	2	3	2	.	.	.	.
Smyrnium perfoliatum	4	2	2	3	2	.	.	.	.
Arenaria serpyllifolia s.l.	1	.	1	3	2	.	.	.	.
Vicia cassubica	.	2	.	3	2	.	.	.	.
Ranunculus auricomus	.	.	1	2	2	.	.	.	.
Cynosurus echinatus	.	2	.	2	2	.	.	.	.
Verbascum phlomoides	.	1	.	2	2	.	.	.	1
Chaerophyllum temulentum	1	.	.	2	2	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Filago lutescens	.	.	.	2	2	.	.	.	.
Sedum rubens	.	.	.	2	2	.	.	.	.
Digitalis ferruginea	.	3	2	1	2	.	.	.	.
Petrorhagia saxifraga	7	2	2	1	2	.	.	.	.
Thymus serpyllum agg.	1	3	1	1	2	.	1	3	1
Sedum acre	4	2	1	1	2	.	.	.	1
Potentilla recta	2	2	.	1	2	.	.	.	.
Convolvulus cantabrica	1	2	.	1	2	.	.	.	.
Plantago lanceolata	6	1	.	1	2	.	.	.	.
Aira caryophyllea	1	.	.	1	2	.	.	.	.
Vicia tetrasperma	1	.	.	1	2	.	.	.	.
Vicia lathyroides	1	.	.	1	2	.	.	.	.
Cerastium arvense	.	.	.	1	2	.	.	.	4
Trifolium dubium	.	.	.	1	2	.	.	.	.
Rubus caesius	.	2	6	.	2	.	.	.	1
Sorbus aucuparia	1	1	2	.	2	.	8	.	1
Veronica urticifolia	1	.	2	.	2	.	.	.	1
Cardamine hirsuta	1	.	2	.	2	.	.	.	.
Arabidopsis thaliana	.	.	1	.	2	.	.	.	.
Hieracium bifidum	.	.	1	.	2	.	.	.	.
Thlaspi kovatsii	.	.	1	.	2	.	.	.	.
Luzula multiflora	.	6	.	.	2	.	1	.	.
Holcus mollis	.	1	.	.	2	.	.	.	8
Coronilla vaginalis	.	1	.	.	2	.	.	.	.
Bromus squarrosus	1	.	.	.	2	.	.	.	.
Veronica arvensis	1	.	.	.	2	.	.	.	.
Rorippa pyrenaica	1	.	.	.	2	.	.	.	.
Erophila verna	1	.	.	.	2	.	.	.	.
Cruciata pedemontana	1	.	.	.	2	.	.	.	.
Draba muralis	1	.	.	.	2	.	.	.	.
Cerastium semidecandrum	1	.	.	.	2	.	.	.	.
Poa annua	.	.	.	.	2	.	.	.	1
Bellardiochloa violacea	.	.	.	.	2	.	.	.	.
Senecio rupestris	.	.	.	.	2	.	.	.	.
Herniaria glabra	.	.	.	.	2	.	.	.	.
Bromus hordeaceus	.	.	.	.	2	.	.	.	.
Erysimum diffusum	.	.	.	.	2	.	.	.	.
Hieracium prenanthoides	.	.	.	.	2	.	.	.	.
Veronica verna	.	.	.	.	2	.	.	.	.
Ranunculus cassubicus	.	.	.	.	2	.	.	.	.
Onopordum acanthium	.	.	.	.	2	.	.	.	.
Campanula sparsa s.l.	.	.	.	.	2	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Crucianella angustifolia	.	.	.	.	2	.	.	.	.
Carex muricata s.l.	1	.	2	5	1	.	.	.	.
Scutellaria altissima	3	.	4	4	1	.	.	.	.
Ranunculus ficaria s.l.	1	2	.	4	1	.	.	.	.
Verbascum phoeniceum	.	.	.	4	1	.	.	.	.
Campanula cervicaria	1	4	1	3	1	.	1	.	.
Sedum hispanicum	.	.	2	2	1	.	.	.	.
Daucus carota	.	2	.	2	1	.	.	.	9
Myosotis discolor	2	1	.	2	1	.	.	.	.
Ornithogalum umbellatum	4	.	.	2	1	.	.	.	.
Muscari comosum	2	.	.	2	1	.	.	.	.
Agrostis stolonifera	.	.	.	2	1	.	.	.	6
Conyza canadensis	.	.	.	2	1	.	.	.	.
Melampyrum cristatum	.	.	.	2	1	.	.	.	.
Sedum album	2	.	3	1	1	.	.	.	.
Urtica dioica	.	.	2	1	1	.	.	3	.
Cerastium glomeratum	2	.	1	1	1	.	.	.	.
Arum maculatum	8	2	.	1	1	.	.	.	.
Anemone ranunculoides	3	1	.	1	1	.	.	.	.
Sherardia arvensis	3	.	.	1	1	.	.	.	.
Epipactis microphylla	1	.	.	1	1	.	.	.	.
Viola tricolor s.l.	1	.	.	1	1	.	.	.	.
Epipactis atrorubens	.	7	2	.	1	.	.	.	1
Chamaecytisus tommasinii	1	6	2	.	1	.	.	.	.
Laserpitium krapfii subsp. *krapfii*	1	2	2	.	1	.	.	.	4
Convolvulus arvensis	.	.	2	.	1	.	.	.	.
Primula elatior	.	.	2	.	1	.	.	.	.
Helianthemum oelandicum s.l.	.	.	2	.	1	.	.	.	.
Scilla bifolia	4	1	1	.	1	.	.	.	.
Trifolium ochroleucon	.	1	1	.	1	.	.	.	.
Sedum dasyphyllum	1	.	1	.	1	.	.	.	.
Koeleria pyramidata	.	.	1	.	1	.	.	.	3
Phleum pratense	.	.	1	.	1	.	.	.	1
Chelidonium majus	.	.	1	.	1	.	.	.	.
Medicago minima	.	.	1	.	1	.	.	.	.
Potentilla hirta	2	1	.	.	1	.	.	.	.
Rorippa lippizensis	.	1	.	.	1	.	.	.	.
Silene otites	1	.	.	.	1	.	.	.	.
Lunaria rediviva	1	.	.	.	1	.	.	.	.
Arabis glabra	1	.	.	.	1	.	.	.	.
Vicia villosa s.l.	1	.	.	.	1	.	.	.	.
Petrorhagia prolifera	1	.	.	.	1	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Linaria vulgaris	1	.	.	.	1	.	.	.	.
Nardus stricta	.	.	.	.	1	.	1	.	4
Carex pendula	.	.	.	.	1	.	1	.	3
Festuca curvula	.	.	.	.	1	.	.	.	1
Thymus striatus	.	.	.	.	1	.	.	.	.
Achillea grandifolia	.	.	.	.	1	.	.	.	.
Nepeta nuda	.	.	.	.	1	.	.	.	.
Solanum nigrum	.	.	.	.	1	.	.	.	.
Alyssum markgrafii	.	.	.	.	1	.	.	.	.
Hypericum richeri subsp. *grisebachii*	.	.	.	.	1	.	.	.	.
Euphorbia epithymoides	.	1	2	5	.	.	.	.	.
Ranunculus bulbosus	1	3	1	5	.	.	.	.	3
Rumex sanguineus	.	.	1	5	.	.	.	.	.
Chrysopogon gryllus	5	7	.	5	.	.	.	.	.
Carex michelii	.	2	.	5	.	.	.	.	.
Carex tomentosa	1	1	.	5	.	.	.	.	.
Lysimachia nummularia	.	.	.	5	.	.	.	8	5
Arum besserianum	.	.	.	5	.	.	.	.	.
Dianthus cruentus	.	.	.	5	.	.	.	.	.
Lathyrus pannonicus s.l.	.	.	.	5	.	.	.	.	.
Hieracium boreale	.	.	.	5	.	.	.	.	.
Rhinanthus rumelicus	.	.	.	5	.	.	.	.	.
Trifolium pignantii	2	.	3	4	.	.	.	.	.
Anthyllis vulneraria s.l.	2	.	2	4	.	.	.	.	.
Laser trilobum	4	.	1	4	.	.	.	.	4
Lithospermum officinale	.	.	1	4	.	.	.	.	.
Euphorbia platyphyllos	.	.	1	4	.	.	.	.	.
Briza media	1	2	.	4	.	.	.	.	.
Urtica urens	.	.	.	4	.	.	.	.	.
Sambucus racemosa	.	.	.	4	.	.	.	.	.
Piptatherum virescens	.	1	3	3	.	.	.	.	.
Campanula rapunculus	2	2	1	3	.	.	.	.	.
Elymus repens	2	2	.	3	.	.	.	.	.
Carex brizoides	1	.	.	3	.	.	.	.	.
Lathyrus sylvestris	.	.	.	3	.	.	1	.	.
Verbascum chaixii subsp. *austriacum*	.	.	.	3	.	.	.	.	.
Gentiana cruciata	.	.	.	3	.	.	.	.	.
Corydalis pumila	.	.	.	3	.	.	.	.	.
Moltkia doerfleri	.	.	.	3	.	.	.	.	.
Gymnadenia conopsea	.	.	.	3	.	.	.	.	.
Centaurea triumfetti s.l.	1	3	8	2	.	.	.	.	.
Eryngium palmatum	5	.	6	2	.	.	.	.	.

Cluster number	1	2	3	4	5	6	7	8	9
Prunella grandiflora	.	2	5	2	.	.	.	.	.
Leontodon crispus	2	5	3	2	.	.	.	.	.
Poa compressa	1	2	2	2	.	.	1	.	1
Picris hieracioides	1	2	2	2	.	.	.	.	.
Viola mirabilis	1	.	2	2	.	.	.	.	.
Veronica spicata	.	.	2	2	.	.	1	.	1
Solanum dulcamara	.	.	2	2	.	.	.	.	.
Corydalis cava	2	1	1	2	.	.	.	.	.
Dichanthium ischaemum	1	1	1	2	.	.	.	.	.
Lepidium campestre	.	1	1	2	.	.	.	.	.
Dianthus carthusianorum	.	.	1	2	.	.	.	.	.
Acanthus balcanicus	7	2	.	2	.	.	.	.	.
Rosa tomentosa	1	2	.	2	.	.	.	.	.
Rumex acetosa	.	2	.	2	.	.	.	.	3
Carum carvi	.	2	.	2	.	.	.	.	.
Ranunculus polyanthemos	1	1	.	2	.	.	.	.	.
Viola suavis	3	.	.	2	.	.	.	.	.
Cirsium vulgare	1	.	.	2	.	.	.	.	3
Astrantia major	1	.	.	2	.	.	.	.	.
Galium glaucum	1	.	.	2	.	.	.	.	.
Reseda lutea	1	.	.	2	.	.	.	.	.
Cynosurus cristatus	.	.	.	2	.	.	.	.	5
Luzula sylvatica	.	.	.	2	.	.	.	.	4
Verbascum glabratum subsp. *bosnense*	.	.	.	2	.	.	.	.	.
Silene flavescens	.	.	.	2	.	.	.	.	.
Achillea pannonica	.	.	.	2	.	.	.	.	.
Prunus cerasifera	.	.	.	2	.	.	.	.	.
Cynoglossum officinale	.	.	.	2	.	.	.	.	.
Helleborus purpurascens	.	.	.	2	.	.	.	.	.
Anthriscus cerefolium	.	.	.	2	.	.	.	.	.
Crataegus nigra	.	.	.	2	.	.	.	.	.
Lactuca quercina	.	.	.	2	.	.	.	.	.
Euphrasia salisburgensis	.	.	.	2	.	.	.	.	.
Hieracium echioides	.	.	.	2	.	.	.	.	.
Allium ursinum	.	.	.	2	.	.	.	.	.
Hieracium maculatum	.	.	.	2	.	.	.	.	.
Bromus sterilis	.	.	.	2	.	.	.	.	.
Daphne laureola	.	.	6	1	.	.	.	.	.
Scabiosa cinerea	4	2	3	1	.	.	.	.	1
Galanthus nivalis	7	.	3	1	.	.	.	.	.
Koeleria splendens	6	5	2	1	.	.	.	.	.
Salvia pratensis	6	4	2	1	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Veronica austriaca	1	4	2	1	.	.	.	.	.
Muscari botryoides	1	2	2	1	.	.	.	.	.
Dioscorea balcanica	3	1	2	1	.	.	.	.	.
Scutellaria columnae	1	.	2	1	.	.	.	.	.
Veronica montana	.	.	2	1	.	.	.	5	1
Lysimachia vulgaris	.	.	2	1	.	.	.	.	.
Platanthera chlorantha	2	7	1	1	.	.	2	.	1
Lactuca saligna	.	1	1	1	.	.	.	.	.
Coronilla elegans	.	.	1	1	.	.	.	.	.
Oenanthe pimpinelloides	9	5	.	1	.	.	.	.	.
Medicago sativa subsp. *falcata*	3	2	.	1	.	.	.	.	.
Torilis arvensis	2	2	.	1	.	.	.	.	.
Asperula taurina	1	2	.	1	.	.	.	.	.
Plantago major	1	1	.	1	.	.	.	3	3
Symphytum officinale	.	1	.	1	.	.	.	.	.
Thlaspi perfoliatum	6	.	.	1	.	.	.	.	.
Viola elatior	1	.	.	1	.	.	.	.	.
Asphodeline liburnica	1	.	.	1	.	.	.	.	.
Epipactis palustris	1	.	.	1	.	.	.	.	.
Muscari racemosum	1	.	.	1	.	.	.	.	.
Lamium purpureum	1	.	.	1	.	.	.	.	.
Valerianella dentata	1	.	.	1	.	.	.	.	.
Ranunculus millefoliatus	1	.	.	1	.	.	.	.	.
Lathyrus nissolia	1	.	.	1	.	.	.	.	.
Comandra elegans	1	.	.	1	.	.	.	.	.
Euphorbia serrulata	.	.	.	1	.	.	.	.	5
Euphrasia stricta	.	.	.	1	.	.	.	.	1
Selinum carvifolia	.	.	.	1	.	.	.	5	.
Carex spicata	.	.	.	1	.	.	.	3	.
Adonis vernalis	.	.	.	1	.	.	.	.	.
Verbascum glabratum	.	.	.	1	.	.	.	.	.
Elymus caninus	.	.	.	1	.	.	.	.	.
Sedum sexangulare	.	.	.	1	.	.	.	.	.
Artemisia alba	.	.	.	1	.	.	.	.	.
Paeonia peregrina	.	.	.	1	.	.	.	.	.
Allium scorodoprasum	.	.	.	1	.	.	.	.	.
Physalis alkekengi	.	.	.	1	.	.	.	.	.
Ailanthus altissima	.	.	.	1	.	.	.	.	.
Erysimum odoratum	.	.	.	1	.	.	.	.	.
Anthemis tinctoria	.	.	.	1	.	.	.	.	.
Bromus commutatus	.	.	.	1	.	.	.	.	.
Alopecurus pratensis	.	.	.	1	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Orchis papilionacea	.	.	.	1	.	.	.	.	.
Hordelymus europaeus	.	.	.	1	.	.	.	.	.
Medicago orbicularis	.	.	.	1	.	.	.	.	.
Vicia sativa s.l.	.	.	.	1	.	.	.	.	.
Carthamus lanatus	.	.	.	1	.	.	.	.	.
Medicago arabica	.	.	.	1	.	.	.	.	.
Osyris alba	3	2	8	.	.	.	.	.	.
Saxifraga rotundifolia	3	.	8	.	.	.	.	.	.
Helleborus niger s.l.	.	2	7	.	.	.	.	.	.
Melica ciliata	6	4	6	.	.	.	.	.	.
Quercus ilex	4	2	6	.	.	.	.	.	.
Festuca rubra	.	2	6	.	.	.	.	.	6
Lilium bulbiferum	.	2	6	.	.	.	.	.	.
Ruta graveolens	1	1	6	.	.	.	.	.	.
Rhamnus alpinus subsp. *fallax*	1	.	6	.	.	.	.	.	.
Aconitum angustifolium	.	.	6	.	.	.	.	.	.
Corylus colurna	.	.	6	.	.	.	.	.	.
Campanula carnica	.	.	6	.	.	.	.	.	.
Saxifraga petraea	.	.	6	.	.	.	.	.	.
Primula auricula	.	.	6	.	.	.	.	.	.
Sorbus austriaca	.	.	6	.	.	.	.	.	.
Molopospermum peloponnesiacum	.	.	6	.	.	.	.	.	.
Teucrium montanum	6	3	5	.	.	.	.	.	.
Coronilla coronata	1	1	5	.	.	.	.	.	.
Euonymus latifolius	.	1	5	.	.	.	.	3	1
Laserpitium siler s.l.	.	1	5	.	.	.	.	.	.
Stachys alopecuros	.	.	5	.	.	.	.	.	.
Lilium carniolicum	.	.	5	.	.	.	.	.	.
Asperula cynanchica	1	7	4	.	.	.	.	.	.
Sedum ochroleucum	4	1	4	.	.	.	.	.	.
Polygala chamaebuxus	.	1	4	.	.	.	2	.	.
Inula spiraeifolia	.	1	4	.	.	.	.	.	.
Doronicum columnae	1	.	4	.	.	.	.	.	.
Genista radiata	.	.	4	.	.	.	.	.	.
Sempervivum tectorum	.	.	4	.	.	.	.	.	.
Valeriana tripteris	.	.	4	.	.	.	.	.	.
Helianthemum nummularium subsp. *obscurum*	.	3	3	.	.	.	.	.	.
Thesium bavarum	.	2	3	.	.	.	1	.	.
Lonicera alpigena	.	1	3	.	.	.	.	.	.
Globularia cordifolia	.	1	3	.	.	.	.	.	.
Daphne blagayana	.	1	3	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Orchis mascula subsp. *signifera*	2	.	3	.	.	.	.	.	.
Micromeria thymifolia	1	.	3	.	.	.	.	.	.
Sideritis montana	.	.	3	.	.	.	.	.	.
Verbascum chaixii	.	.	3	.	.	.	.	.	.
Cystopteris fragilis	.	.	3	.	.	.	.	.	.
Allium ericetorum	.	.	3	.	.	.	.	.	.
Laburnum anagyroides	.	.	3	.	.	.	.	.	.
Sorbus umbellata	.	.	3	.	.	.	.	.	.
Spiraea cana	.	.	3	.	.	.	.	.	.
Genista sericea	1	4	2	.	.	.	.	.	.
Ferulago campestris	.	4	2	.	.	.	.	.	.
Centaurea scabiosa agg.	.	3	2	.	.	.	.	.	.
Arum italicum	6	2	2	.	.	.	.	.	.
Linum tenuifolium	3	2	2	.	.	.	.	.	.
Centaurea rupestris	1	2	2	.	.	.	.	.	.
Potentilla tommasiniana	1	2	2	.	.	.	.	.	.
Peucedanum carvifolia	1	2	2	.	.	.	.	.	.
Scabiosa triandra	.	2	2	.	.	.	.	.	.
Asphodelus albus	.	2	2	.	.	.	.	.	.
Achnatherum calamagrostis	5	1	2	.	.	.	.	.	.
Hieracium glaucum	1	1	2	.	.	.	.	.	.
Geranium lucidum	1	1	2	.	.	.	.	.	.
Calamintha nepeta s.l.	.	1	2	.	.	.	1	.	.
Dryopteris pallida	.	1	2	.	.	.	.	.	.
Dianthus seguieri subsp. *glaber*	.	1	2	.	.	.	.	.	.
Veratrum album	.	1	2	.	.	.	.	.	.
Salvia officinalis	8	.	2	.	.	.	.	.	.
Acer hyrcanum subsp. *intermedium*	6	.	2	.	.	.	.	.	.
Quercus trojana	5	.	2	.	.	.	.	.	.
Celtis australis	4	.	2	.	.	.	.	.	.
Lactuca perennis	2	.	2	.	.	.	.	.	.
Thymus praecox s.l.	1	.	2	.	.	.	.	.	.
Arabis alpina	1	.	2	.	.	.	.	.	.
Minuartia verna s.l.	1	.	2	.	.	.	.	.	.
Dianthus petraeus	1	.	2	.	.	.	.	.	.
Melampyrum hoermannianum	1	.	2	.	.	.	.	.	.
Symphyandra hofmannii	1	.	2	.	.	.	.	.	.
Orchis simia	1	.	2	.	.	.	.	.	.
Dorycnium hirsutum	1	.	2	.	.	.	.	.	.
Omphalodes verna	.	.	2	.	.	.	.	.	1
Actaea spicata	.	.	2	.	.	.	.	8	.
Hacquetia epipactis	.	.	2	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Aurinia petraea	.	.	2	.	.	.	.	.	.
Silene saxifraga	.	.	2	.	.	.	.	.	.
Pseudofumaria alba s.l.	.	.	2	.	.	.	.	.	.
Scabiosa lucida	.	.	2	.	.	.	.	.	.
Seseli elatum subsp. *gouanii*	.	.	2	.	.	.	.	.	.
Saxifraga cuneifolia	.	.	2	.	.	.	.	.	.
Arabis collina	.	.	2	.	.	.	.	.	.
Teucrium flavum	.	.	2	.	.	.	.	.	.
Carduus defloratus	.	.	2	.	.	.	.	.	.
Paederota lutea	.	.	2	.	.	.	.	.	.
Campanula justiniana	.	.	2	.	.	.	.	.	.
Cerastium tomentosum	.	.	2	.	.	.	.	.	.
Acinos alpinus s.l.	.	.	2	.	.	.	.	.	.
Geranium macrorrhizum	.	.	2	.	.	.	.	.	.
Polypodium interjectum	.	.	2	.	.	.	.	.	.
Saxifraga hostii	.	.	2	.	.	.	.	.	.
Saxifraga paniculata	.	.	2	.	.	.	.	.	.
Melampyrum scardicum	.	.	2	.	.	.	.	.	.
Spiraea media	.	.	2	.	.	.	.	.	.
Sesleria caerulea	.	.	2	.	.	.	.	.	.
Rosa glauca	.	.	2	.	.	.	.	.	.
Calamintha brauneana	.	.	2	.	.	.	.	.	.
Hieracium glabratum	.	.	2	.	.	.	.	.	.
Euphorbia esula	.	.	2	.	.	.	.	.	.
Betula pubescens	.	.	2	.	.	.	.	.	.
Centaurea angustifolia	.	.	2	.	.	.	.	.	.
Campanula thyrsoides	.	.	2	.	.	.	.	.	.
Saxifraga crustata	.	.	2	.	.	.	.	.	.
Cardamine impatiens	.	.	2	.	.	.	.	.	.
Lathyrus sphaericus	.	.	2	.	.	.	.	.	.
Potentilla heptaphylla	3	7	1	.	.	.	.	.	.
Cephalaria leucantha	4	4	1	.	.	.	.	.	.
Asperula scutellaris	.	4	1	.	.	.	.	.	.
Serratula radiata subsp. *cetingensis*	.	4	1	.	.	.	.	.	.
Knautia arvensis	4	3	1	.	.	.	.	.	.
Vitis vinifera subsp. *sylvestris*	1	3	1	.	.	.	.	.	.
Scilla lakusicii	1	2	1	.	.	.	.	.	.
Leontodon incanus	1	2	1	.	.	.	.	.	.
Euphorbia fragifera	.	2	1	.	.	.	.	.	.
Iris illyrica	.	2	1	.	.	.	.	.	.
Scabiosa fumarioides	.	2	1	.	.	.	.	.	.
Knautia integrifolia	.	2	1	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Asperula aristata s.l.	4	1	1	.	.	.	.	.	.
Centaurea pannonica	1	1	1	.	.	.	.	.	8
Tanacetum cinerariifolium	1	1	1	.	.	.	.	.	.
Thesium divaricatum	1	1	1	.	.	.	.	.	.
Corydalis solida	1	1	1	.	.	.	.	.	.
Euphorbia carniolica	.	1	1	.	.	.	1	.	4
Hieracium caespitosum	.	1	1	.	.	.	.	.	.
Euphorbia myrsinites	.	1	1	.	.	.	.	.	.
Phleum phleoides	.	1	1	.	.	.	.	.	.
Fragaria viridis	4	.	1	.	.	.	.	.	.
Rhamnus intermedius	4	.	1	.	.	.	.	.	.
Calystegia silvatica	2	.	1	.	.	.	.	.	.
Marrubium incanum	1	.	1	.	.	.	.	.	.
Euphorbia spinosa	1	.	1	.	.	.	.	.	.
Veronica austriaca subsp. *teucrium*	1	.	1	.	.	.	.	.	.
Calamintha grandiflora	1	.	1	.	.	.	.	.	.
Peltaria alliacea	1	.	1	.	.	.	.	.	.
Geranium pusillum	1	.	1	.	.	.	.	.	.
Polygala amara	1	.	1	.	.	.	.	.	.
Eryngium campestre	1	.	1	.	.	.	.	.	.
Phyteuma ovatum	.	.	1	.	.	.	.	.	.
Sesleria sadleriana	.	.	1	.	.	.	.	.	.
Geranium nodosum	.	.	1	.	.	.	.	.	.
Centaurea haynaldii	.	.	1	.	.	.	.	.	.
Arabis nova	.	.	1	.	.	.	.	.	.
Senecio ovirensis	.	.	1	.	.	.	.	.	.
Iberis sempervirens	.	.	1	.	.	.	.	.	.
Cleistogenes serotina	.	.	1	.	.	.	.	.	.
Trinia glauca	.	.	1	.	.	.	.	.	.
Centaurea cyanus	.	.	1	.	.	.	.	.	.
Jovibarba heuffelii	.	.	1	.	.	.	.	.	.
Veronica fruticans	.	.	1	.	.	.	.	.	.
Dactylorhiza maculata	.	.	1	.	.	.	.	.	.
Edraianthus graminifolius	.	.	1	.	.	.	.	.	.
Peucedanum officinale	.	.	1	.	.	.	.	.	.
Linum viscosum	.	.	1	.	.	.	.	.	.
Trifolium diffusum	.	.	1	.	.	.	.	.	.
Scorzonera austriaca	.	.	1	.	.	.	.	.	.
Campanula crassipes	.	.	1	.	.	.	.	.	.
Ribes uva-crispa	.	.	1	.	.	.	.	.	.
Erysimum sylvestre	.	.	1	.	.	.	.	.	.
Erysimum crepidifolium	.	.	1	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Rubus saxatilis	.	.	1	.	.	.	.	.	.
Cachrys alpina	.	.	1	.	.	.	.	.	.
Sesleria robusta	.	.	1	.	.	.	.	.	.
Arabis serpillifolia	.	.	1	.	.	.	.	.	.
Pimpinella major	.	.	1	.	.	.	.	.	.
Ribes alpinum	.	.	1	.	.	.	.	.	.
Verbascum densiflorum	.	.	1	.	.	.	.	.	.
Stipa pennata s.l.	.	.	1	.	.	.	.	.	.
Hieracium caesium	.	.	1	.	.	.	.	.	.
Parietaria judaica	.	.	1	.	.	.	.	.	.
Carlina acaulis	.	.	1	.	.	.	.	.	.
Ptilostemon strictus	3	6	.	.	.	.	.	.	.
Rosa sempervirens	1	6	.	.	.	.	.	.	.
Centaurea napulifera subsp. *tuberosa*	1	6	.	.	.	.	.	.	.
Hippocrepis comosa	3	5	.	.	.	.	.	.	.
Polygala nicaeensis s.l.	2	5	.	.	.	.	.	.	.
Agrostis castellana	1	5	.	.	.	.	.	.	.
Scorzonera villosa	1	4	.	.	.	.	.	.	.
Euphorbia nicaeensis	.	3	.	.	.	.	.	.	.
Knautia illyrica	.	3	.	.	.	.	.	.	.
Danthonia alpina	.	3	.	.	.	.	.	.	.
Tragopogon tommasinii	.	3	.	.	.	.	.	.	.
Cyclamen repandum	7	2	.	.	.	.	.	.	.
Spartium junceum	6	2	.	.	.	.	.	.	.
Leucanthemum atratum subsp. *platylepis*	6	2	.	.	.	.	.	.	.
Fritillaria messanensis subsp. *gracilis*	4	2	.	.	.	.	.	.	.
Teucrium polium subsp. *capitatum*	3	2	.	.	.	.	.	.	.
Piptatherum miliaceum	2	2	.	.	.	.	.	.	.
Silene latifolia subsp. *alba*	2	2	.	.	.	.	.	.	.
Cirsium erisithales	1	2	.	.	.	.	.	.	.
Orlaya grandiflora	1	2	.	.	.	.	.	.	.
Vicia tenuifolia agg.	1	2	.	.	.	.	.	.	.
Melampyrum arvense	1	2	.	.	.	.	.	.	.
Inula oculus-christi	1	2	.	.	.	.	.	.	.
Anthericum liliago	1	2	.	.	.	.	.	.	.
Orchis tridentata	1	2	.	.	.	.	.	.	.
Geranium purpureum	1	2	.	.	.	.	.	.	.
Muscari neglectum	1	2	.	.	.	.	.	.	.
Crataegus laciniata	.	2	.	.	.	.	.	.	.
Hypericum barbatum	.	2	.	.	.	.	.	.	.
Salvia argentea	.	2	.	.	.	.	.	.	.
Satureja cuneifolia	.	2	.	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ajuga laxmannii	.	2	.	.	.	.	.	.	.
Pulmonaria angustifolia	.	2	.	.	.	.	.	.	.
Thlaspi praecox	.	2	.	.	.	.	.	.	.
Anacamptis pyramidalis	.	2	.	.	.	.	.	.	.
Coronilla scorpioides	.	2	.	.	.	.	.	.	.
Rubia peregrina	4	1	.	.	.	.	.	.	.
Anemone apennina	4	1	.	.	.	.	.	.	.
Ranunculus neapolitanus	4	1	.	.	.	.	.	.	.
Alyssum alyssoides	2	1	.	.	.	.	.	.	.
Dianthus sylvestris subsp. *tergestinus*	1	1	.	.	.	.	.	.	.
Rhamnus orbiculatus	1	1	.	.	.	.	.	.	.
Plantago holosteum	1	1	.	.	.	.	.	.	.
Pyrus amygdaliformis	1	1	.	.	.	.	.	.	.
Bupleurum praealtum	1	1	.	.	.	.	.	.	.
Gladiolus illyricus	1	1	.	.	.	.	.	.	.
Convolvulus altheoides subsp. *tenuissimus*	1	1	.	.	.	.	.	.	.
Inula ensifolia	1	1	.	.	.	.	.	.	.
Thesium linophyllon	1	1	.	.	.	.	.	.	.
Dianthus giganteus subsp. *croaticus*	1	1	.	.	.	.	.	.	.
Cirsium acaule	1	1	.	.	.	.	.	.	.
Orchis militaris	1	1	.	.	.	.	.	.	.
Linum catharticum	1	1	.	.	.	.	.	.	.
Bromus arvensis	.	1	.	.	.	.	.	.	.
Astragalus illyricus	.	1	.	.	.	.	.	.	.
Huetia cynapioides	.	1	.	.	.	.	.	.	.
Micromeria juliana	.	1	.	.	.	.	.	.	.
Cerinthe minor	.	1	.	.	.	.	.	.	.
Taraxacum hoppeanum	.	1	.	.	.	.	.	.	.
Onobrychis arenaria	.	1	.	.	.	.	.	.	.
Fumana procumbens	.	1	.	.	.	.	.	.	.
Sedum rupestre	.	1	.	.	.	.	.	.	.
Plantago argentea	.	1	.	.	.	.	.	.	.
Hierochloë odorata	.	1	.	.	.	.	.	.	.
Achillea crithmifolia	.	1	.	.	.	.	.	.	.
Acanthus spinosus	.	1	.	.	.	.	.	.	.
Chaerophyllum coloratum	.	1	.	.	.	.	.	.	.
Thalictrum flavum	4	.	.	.	.	.	.	.	.
Bupleurum baldense subsp. *gussonei*	4	.	.	.	.	.	.	.	.
Carex distachya	4	.	.	.	.	.	.	.	.
Euphorbia characias subsp. *wulfenii*	4	.	.	.	.	.	.	.	.
Myrtus communis	3	.	.	.	.	.	.	.	.

Cluster number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Erica arborea	3	.	.	.	.	.	.	.	.
Geranium columbinum	3	.	.	.	.	.	.	.	.
Bromus japonicus	3	.	.	.	.	.	.	.	.
Hieracium florentinum	3	.	.	.	.	.	.	.	.
Medicago prostrata	2	.	.	.	.	.	.	.	.
Punica granatum	2	.	.	.	.	.	.	.	.
Orchis pallens	2	.	.	.	.	.	.	.	.
Verbascum lychnitis	2	.	.	.	.	.	.	.	.
Festuca altissima	1	.	.	.	.	.	.	.	8
Viola canina	1	.	.	.	.	.	.	.	3
Achillea virescens	1	.	.	.	.	.	.	.	1
Reichardia picroides	1	.	.	.	.	.	.	.	.
Trifolium dalmaticum	1	.	.	.	.	.	.	.	.
Malus florentina	1	.	.	.	.	.	.	.	.
Poa stiriaca	1	.	.	.	.	.	.	.	.
Campanula sibirica	1	.	.	.	.	.	.	.	.
Stipa bromoides	1	.	.	.	.	.	.	.	.
Taraxacum erythrospermum	1	.	.	.	.	.	.	.	.
Linum austriacum	1	.	.	.	.	.	.	.	.
Brachypodium retusum	1	.	.	.	.	.	.	.	.
Fumana ericoides	1	.	.	.	.	.	.	.	.
Asplenium onopteris	1	.	.	.	.	.	.	.	.
Carlina corymbosa	1	.	.	.	.	.	.	.	.
Cistus incanus subsp. *creticus*	1	.	.	.	.	.	.	.	.
Carduus nutans	1	.	.	.	.	.	.	.	.
Globularia punctata	1	.	.	.	.	.	.	.	.
Cardamine graeca	1	.	.	.	.	.	.	.	.
Muscari tenuiflorum	1	.	.	.	.	.	.	.	.
Centaurea alba subsp. *deusta*	1	.	.	.	.	.	.	.	.
Bupleurum glumaceum	1	.	.	.	.	.	.	.	.
Potentilla cinerea	1	.	.	.	.	.	.	.	.
Vinca herbacea	1	.	.	.	.	.	.	.	.
Carex praecox	1	.	.	.	.	.	.	.	.
Scabiosa ochroleuca	1	.	.	.	.	.	.	.	.
Thlaspi goesingense	1	.	.	.	.	.	.	.	.
Bupleurum affine	1	.	.	.	.	.	.	.	.
Cynodon dactylon	1	.	.	.	.	.	.	.	.
Geranium molle	1	.	.	.	.	.	.	.	.
Isopyrum thalictroides	1	.	.	.	.	.	.	.	.
Knautia dipsacifolia	1	.	.	.	.	.	.	.	.
Elymus hispidus	1	.	.	.	.	.	.	.	.
Carduus acanthoides	1	.	.	.	.	.	.	.	.

Cluster number	1	2	3	4	5	6	7	8	9
Delphinium fissum	1	.	.	.	.	.	.	.	.
Echium vulgare	1	.	.	.	.	.	.	.	.
Trifolium scabrum	1	.	.	.	.	.	.	.	.
Vicia pannonica	1	.	.	.	.	.	.	.	.
Lathyrus aphaca	1	.	.	.	.	.	.	.	.
Desmazeria rigida	1	.	.	.	.	.	.	.	.
Parietaria officinalis	1	.	.	.	.	.	.	.	.
Linum trigynum	1	.	.	.	.	.	.	.	.
Colchicum hungaricum	1	.	.	.	.	.	.	.	.
Allium flavum	1	.	.	.	.	.	.	.	.
Euphorbia falcata	1	.	.	.	.	.	.	.	.
Silybum marianum	1	.	.	.	.	.	.	.	.
Ballota nigra	1	.	.	.	.	.	.	.	.
Galium boreale	.	.	.	.	.	.	.	.	6
Juncus effusus	.	.	.	.	.	.	.	.	5
Stellaria graminea	.	.	.	.	.	.	.	.	5
Succisa pratensis	.	.	.	.	.	.	.	3	4
Carex pilulifera	.	.	.	.	.	.	3	.	4
Hypericum maculatum	.	.	.	.	.	.	.	.	3
Teucrium scorodonia	.	.	.	.	.	.	3	3	1
Blechnum spicant	.	.	.	.	.	.	8	.	1
Paris quadrifolia	.	.	.	.	.	.	.	5	.
Phyteuma spicatum	.	.	.	.	.	.	.	5	.
Oreopteris limbosperma	.	.	.	.	.	.	5	3	.
Phyteuma zahlbruckneri	.	.	.	.	.	.	4	.	.
Vaccinium vitis-idaea	.	.	.	.	.	.	2	.	.
Festuca pallens	.	.	.	.	.	.	2	.	.
Asplenium septentrionale	.	.	.	.	.	.	2	.	.
Galium rotundifolium	.	.	.	.	.	.	1	.	.
Hieracium levicaule	.	.	.	.	.	.	1	.	.

ANNEX F

Full version of synoptic table of the *Quercetea pubescentis* forest vegetation types in the W Balkans presented in chapter 2.2 (therein referred to as Supplement S4). Frequency values of species in each of the six types are shown. Species with phi values higher than 0.25 are shaded and those species are considered diagnostic for particular type.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
No. of relevés	140	121	124	129	131	90
Type 1: Sub-mediterranean forests dominated by *Quercus pubescens* and/or *Carpinus orientalis*						
Carpinus orientalis	96	22	5	19	12	.
Acer monspessulanum	46	21	23	2	1	.
Pistacia terebinthus	23	3	2	.	.	.
Paliurus spina-christi	25	8	1	.	.	.
Clematis flammula	25	9	1	.	.	.
Cyclamen hederifolium	14	.	.	1	.	.
Asparagus acutifolius	34	21	14	.	.	.
Ruscus aculeatus	44	10	23	8	6	19
Juniperus oxycedrus	25	12	6	1	4	.
Smilax aspera	8	.	.	.	.	.
Type 2: Sub-mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis*						
Helleborus multifidus s.l.	11	37	5	2	2	.
Brachypodium pinnatum s.l.	20	55	34	18	5	8
Geranium sanguineum	10	37	19	2	1	6
Inula hirta	1	19	2	5	.	.
Carex flacca s.l.	8	37	8	2	.	28
Sesleria autumnalis	57	65	56	.	8	17
Filipendula vulgaris	10	31	4	16	2	2
Peucedanum cervaria	1	24	7	4	1	7
Carex humilis	8	30	19	.	1	3
Teucrium chamaedrys	41	55	35	17	11	7
Bunium alpinum subsp. *montanum*	1	10	1	.	.	.
Type 3: Meso-thermophilous supra-mediterranean and/or relict communities dominated by *Ostrya carpinifolia*						
Ostrya carpinifolia	32	45	100	2	1	13
Asplenium ruta-muraria	4	2	44	.	.	.
Asplenium trichomanes	13	6	57	2	8	1
Sorbus aria	8	13	56	.	1	9
Cyclamen purpurascens	13	9	52	.	.	10
Galium laevigatum	.	2	30	.	.	2
Campanula pyramidalis	1	1	25	.	.	.
Moehringia muscosa	1	2	27	2	.	.
Campanula rapunculoides	2	2	31	2	5	1
Anemone trifolia	.	1	23	.	.	3
Veratrum nigrum	7	3	30	2	.	2

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Amelanchier ovalis	4	6	26	.	.	.
Polypodium vulgare	4	2	27	2	1	4
Phyteuma scheuchzeri subsp. *columnae*	.	2	18	.	.	.
Tilia platyphyllos	4	2	29	2	5	4
Laburnum alpinum	.	.	15	.	.	.
Calamagrostis varia	1	6	25	.	1	3
Mercurialis ovata	6	15	31	.	1	.
Spiraea chamaedryfolia	.	.	15	.	.	.
Arabis turrita	7	2	27	1	1	4
Lamiastrum galeobdolon s.l.	4	2	23	1	.	3
Hepatica nobilis	10	4	30	.	.	7
Carex digitata	6	4	43	2	11	28
Dianthus monspessulanus	.	3	15	.	.	.
Lonicera xylosteum	9	2	23	2	.	1
Athamanta turbith s.l.	.	.	11	.	.	.
Cardamine enneaphyllos	.	.	11	.	.	.
Berberis vulgaris	.	6	23	3	.	7
Geranium robertianum	9	4	30	13	2	1
Cotoneaster nebrodensis	2	3	16	.	.	.
Daphne mezereum	.	1	15	1	.	2
Mercurialis perennis	4	.	18	1	1	3
Euonymus verrucosus	22	8	33	4	1	3
Vincetoxicum hirundinaria	26	32	58	19	16	27
Asarum europaeum s.l.	8	4	23	4	.	4
Clematis vitalba	18	25	42	9	1	14
Asplenium ceterach	19	2	23	.	.	.
Ulmus glabra	1	.	16	4	1	3
Iberis linifolia	.	.	8	.	.	.
Sesleria tenuifolia s.l.	1	1	10	.	.	.
Convallaria majalis	3	3	23	3	.	14
Sesleria albicans s.l.	.	3	11	.	.	.
Rhamnus catharticus	16	13	33	11	.	9
Type 4: Thermophilous continental forests of deep, slightly acidic soil dominated by *Quercus frainetto* and/or *Quercus cerris*						
Quercus frainetto	4	6	1	71	9	.
Quercus cerris	31	55	27	92	51	33
Physospermum cornubiense	6	.	6	33	5	.
Acer tataricum	9	2	.	27	8	4
Paeonia mascula	.	.	.	10	.	.
Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* and/or *Quercus cerris*						
Veronica officinalis	1	2	.	32	47	12
Chamaespartium sagittale	.	4	1	5	26	1
Genista pilosa	.	.	.	2	21	4

Vegetation type	1	2	3	4	5	6
Poa nemoralis	8	3	8	25	50	23
Hieracium praealtum subsp. *bauhinii*	6	3	.	26	34	6
Omalotheca sylvatica	.	.	.	.	9	.
Pteridium aquilinum	14	13	4	21	50	38
Hieracium sabaudum	7	6	3	14	35	20
Sedum cepaea	2	.	2	6	17	1
Hieracium pilosella	9	2	1	20	27	2
Danthonia decumbens	.	.	.	.	8	.
Myosotis ramosissima	.	.	.	1	8	.
Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests						
Hieracium racemosum	1	10	.	3	3	59
Festuca drymeja	1	.	.	2	5	36
Castanea sativa	1	4	3	3	4	40
Carpinus betulus	11	6	9	29	23	70
Robinia pseudacacia	1	3	.	1	.	30
Melampyrum pratense	3	2	2	5	15	43
Prunus avium	11	12	6	26	11	61
Carex pilosa	1	.	1	1	4	27
Luzula luzuloides	1	.	.	2	23	39
Galium sylvaticum	2	2	2	6	3	31
Euphorbia dulcis	.	2	8	.	1	26
Hieracium murorum	2	8	15	9	26	50
Serratula tinctoria	1	22	11	10	2	43
Fagus sylvatica agg.	6	9	20	16	29	54
Solidago virgaurea	4	11	27	.	4	39
Molinia caerulea subsp. *arundinacea*	.	6	5	.	.	21
Galium schultesii	6	2	2	8	14	32
Calamagrostis arundinacea	.	2	3	.	.	17
Frangula alnus	1	2	4	.	.	18
Sorbus torminalis	33	36	18	30	23	67
Rubus hirtus	5	2	6	18	20	38
Acer pseudoplatanus	1	2	24	1	3	30
Salvia glutinosa	2	7	17	2	2	27
Dianthus barbatus	.	.	.	1	1	10
Hypericum montanum	4	7	3	5	1	21
Polygonatum multiflorum	4	6	8	6	2	23
Species diagnostic for more than one type						
Quercus pubescens	71	93	44	14	1	3
Quercus petraea agg.	22	8	31	46	100	100
Other species						
Fraxinus ornus	96	94	92	62	69	96
Crataegus monogyna	64	68	35	68	48	36

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Cornus mas	64	45	50	33	9	20
Hedera helix	41	29	37	5	5	42
Dactylis glomerata s.l.	39	47	15	46	36	59
Tamus communis	38	36	21	19	7	20
Helleborus odorus	38	17	36	40	34	6
Acer campestre	34	35	18	49	24	37
Coronilla emerus s.l.	34	19	34	.	2	1
Ligustrum vulgare	34	36	19	34	2	21
Brachypodium sylvaticum	34	26	17	33	21	26
Fragaria vesca	33	19	30	52	51	27
Veronica chamaedrys	32	23	15	46	41	34
Viola hirta	31	48	17	22	11	16
Melittis melissophyllum s.l.	20	41	49	14	7	33
Lathyrus niger	17	40	6	36	22	54
Clinopodium vulgare	27	36	19	35	27	26
Euphorbia cyparissias	21	36	27	29	16	8
Stachys officinalis	17	36	10	8	2	28
Rosa arvensis	23	31	18	27	26	36
Viburnum lantana	27	18	35	20	1	10
Cotinus coggygria	25	21	32	1	2	1
Chamaecytisus hirsutus agg.	19	22	31	13	33	27
Polygonatum odoratum	14	12	30	9	3	10
Sedum telephium subsp. *maximum*	11	7	28	6	8	17
Frangula rupestris	15	14	26	.	2	.
Asparagus tenuifolius	16	17	25	3	1	3
Anthericum ramosum	4	17	24	2	1	13
Tanacetum corymbosum	24	28	22	27	12	37
Thalictrum minus	7	18	22	1	.	2
Euphorbia amygdaloides	18	3	22	10	35	13
Prunus mahaleb	15	11	21	.	.	.
Campanula trachelium	8	15	20	5	5	16
Festuca heterophylla	16	26	10	48	27	50
Pyrus pyraster	25	26	17	44	25	37
Festuca pseudovina agg.	16	19	10	36	18	.
Genista tinctoria	6	13	10	31	42	43
Prunus spinosa	19	23	10	30	6	9
Hypericum perforatum	14	7	10	26	35	12
Potentilla micrantha	25	12	14	24	35	31
Thymus pulegioides	21	7	7	19	34	1
Campanula persicifolia	19	17	11	19	15	38
Cruciata glabra	21	24	6	24	20	33
Symphytum tuberosum s.l.	24	23	17	16	6	32

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Viola reichenbachiana	24	10	10	23	24	30
Chamaecytisus supinus	5	13	2	13	2	28
Corylus avellana	16	15	19	17	16	26
Stellaria holostea	14	6	5	8	11	26
Melica uniflora	22	5	13	16	6	26
Juniperus communis	18	27	18	19	21	23
Carex montana	.	11	4	8	14	23
Luzula forsteri	9	7	2	19	18	22
Tilia tomentosa	7	5	2	8	15	22
Lathyrus vernus	14	1	19	9	2	22
Ajuga reptans	13	7	7	14	11	21
Primula vulgaris	27	17	17	5	2	21
Knautia drymeia s.l.	.	9	5	5	.	20
Lathyrus venetus	22	11	11	11	13	1
Acer obtusatum	21	27	10	2	8	10
Buglossoides purpurocaerulea	21	27	10	16	4	8
Bromus erectus agg.	21	26	11	2	5	.
Aremonia agrimonoides	19	15	18	12	17	7
Glechoma hirsuta	19	8	5	15	5	2
Galium mollugo agg.	18	11	12	8	15	19
Rubus ulmifolius	18	10	15	2	.	.
Asperula purpurea	16	10	11	.	2	1
Galium lucidum	15	28	17	2	8	12
Carex caryophyllea	14	7	2	22	8	1
Sanguisorba minor s.l.	14	7	6	5	2	1
Colutea arborescens	14	7	3	3	1	.
Viola alba s.l.	13	7	12	5	1	12
Rosa canina agg.	13	12	13	16	2	8
Geum urbanum	13	10	8	28	5	4
Stachys recta s.l.	13	10	16	2	2	1
Cornus sanguinea	12	23	17	16	2	18
Calamintha sylvatica	12	9	16	6	8	8
Satureja montana s.l.	12	8	14	.	.	.
Silene viridiflora	11	4	8	20	6	12
Silene vulgaris s.l.	11	7	8	5	5	2
Lonicera etrusca	11	14	2	.	.	1
Lotus corniculatus	11	18	6	8	8	.
Lilium martagon	10	3	16	1	1	6
Dorycnium pentaphyllum subsp. *germanicum*	10	20	8	5	2	3
Trifolium alpestre	10	26	2	19	11	2
Petteria ramentacea	10	4	2	.	.	.
Phillyrea latifolia	10	2	.	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Trifolium rubens	7	25	7	2	8	7
Buphthalmum salicifolium	6	20	19	.	.	13
Dorycnium pentaphyllum subsp. *herbaceum*	9	17	1	5	5	.
Cnidium silaifolium	1	16	15	.	.	.
Silene nutans	6	15	15	4	21	19
Sorbus domestica	6	13	.	18	3	9
Iris graminea	9	12	9	6	2	9
Carex hallerana	9	12	3	1	1	.
Astragalus glycyphyllos	5	12	1	19	5	7
Fragaria moschata	4	12	2	4	2	9
Aristolochia lutea	4	12	8	3	.	1
Peucedanum oreoselinum	3	12	14	.	2	17
Inula salicina	2	12	1	5	.	1
Valeriana officinalis s.l.	1	12	15	1	.	3
Hieracium tommasinii	1	12	.	.	5	.
Bromus ramosus agg.	.	12	.	5	1	4
Dictamnus albus	8	10	11	5	.	.
Thymus longicaulis	4	10	3	.	4	.
Eryngium amethystinum	4	10	1	.	.	.
Lembotropis nigricans	3	10	1	6	19	11
Genista sylvestris	3	10	2	.	.	.
Euonymus europaeus	5	9	19	9	2	6
Mycelis muralis	6	6	19	5	8	10
Vinca minor	.	.	18	.	.	14
Origanum vulgare	9	8	16	2	3	8
Digitalis grandiflora	5	2	16	5	4	3
Allium carinatum s.l.	6	9	15	1	2	3
Tilia cordata	1	4	15	2	.	10
Primula veris s.l.	3	3	15	7	7	2
Melica nutans	6	1	14	1	.	9
Acer platanoides	1	2	13	2	1	6
Clematis recta	5	7	12	1	.	1
Inula conyza	4	2	12	3	1	2
Erica herbacea	.	3	10	.	2	.
Asplenium adiantum-nigrum	9	.	10	3	8	1
Rubus canescens	4	7	7	19	15	4
Prunella vulgaris	9	2	1	19	21	3
Galium aparine	4	2	.	19	11	2
Lapsana communis	2	2	2	17	11	4
Poa angustifolia	3	3	2	16	8	2
Lychnis coronaria	2	3	1	16	18	.
Galium pseudaristatum	4	1	6	15	21	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Campanula patula	.	.	1	14	17	3
Malus sylvestris	6	8	3	13	6	10
Achillea millefolium agg.	6	3	6	12	5	.
Galium verum	1	4	3	12	5	3
Ulmus minor agg.	6	8	2	12	2	4
Rumex acetosella	1	.	.	12	18	3
Chamaecytisus austriacus	1	.	1	11	10	.
Carex divulsa s.l.	1	2	.	11	5	4
Cruciata laevipes	9	7	1	10	10	.
Rubus fruticosus agg.	5	5	4	6	14	6
Luzula pilosa	1	.	1	8	12	13
Hieracium umbellatum	.	3	2	7	12	3
Potentilla erecta	.	1	2	1	12	7
Digitalis lanata	4	.	2	7	11	.
Deschampsia flexuosa	1	.	.	.	11	17
Aira elegantissima	1	.	.	8	10	.
Vulpia myuros	1	.	.	3	10	.
Betula pendula	.	.	.	2	10	.
Anemone nemorosa	6	2	5	2	3	19
Cephalanthera longifolia	4	5	5	5	2	18
Platanthera bifolia	4	1	6	2	2	16
Cardamine bulbifera	6	2	4	2	4	13
Lonicera caprifolium	4	8	6	5	1	12
Carex sylvatica	6	2	.	3	.	11
Pulmonaria officinalis	6	3	2	6	2	10
Melampyrum nemorosum	2	7	2	2	1	10
Lychnis viscaria	.	.	.	.	7	9
Aposeris foetida	3	1	4	1	1	9
Ilex aquifolium	2	1	.	.	.	9
Crataegus laevigata	5	1	8	9	2	8
Potentilla alba	.	1	3	2	1	8
Gentiana asclepiadea	.	.	1	.	.	8
Genista germanica	.	7	.	.	.	8
Epimedium alpinum	4	4	2	7	2	7
Pimpinella saxifraga	4	9	2	1	2	7
Luzula luzulina	.	2	.	1	2	7
Ornithogalum pyrenaicum	1	5	1	2	1	7
Galium odoratum	1	2	2	6	1	6
Epipactis helleborine	1	3	6	2	1	6
Populus tremula	.	1	4	2	1	6
Peucedanum austriacum	3	6	7	.	1	6
Achillea distans	.	1	6	.	1	6

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Sanicula europaea	6	3	2	5	.	6
Lamium orvala	.	.	3	.	.	6
Laserpitium latifolium	.	.	2	.	.	6
Abies alba	1	.	1	.	.	6
Euphorbia angulata	.	2	.	.	.	6
Calluna vulgaris	.	.	.	.	7	4
Campanula glomerata	1	2	5	1	3	4
Alliaria petiolata	2	.	.	8	2	4
Fallopia dumetorum	1	.	.	6	2	4
Moehringia trinervia	.	.	1	5	2	4
Pinus nigra	.	7	5	.	2	4
Leucanthemum vulgare	3	2	3	4	1	4
Neottia nidus-avis	3	4	2	3	1	4
Dryopteris filix-mas	4	.	7	1	1	4
Ruscus hypoglossum	1	.	.	2	.	4
Hieracium lachenalii	.	.	.	2	2	3
Erythronium dens-canis	4	2	2	1	2	3
Coronilla varia	4	7	6	5	1	3
Sorbus mougeotii	.	.	.	.	1	3
Vicia sepium	1	1	1	3	.	3
Erigeron annuus	1	.	.	1	.	3
Viola riviniana	1	3	4	.	.	3
Cirsium pannonicum	1	4	.	.	.	3
Viburnum opulus	1	1	.	.	.	3
Lathyrus montanus	.	1	.	.	.	3
Crocus vernus	.	1	.	.	.	3
Mespilus germanica	.	.	.	.	.	3
Verbascum nigrum s.l.	3	9	2	5	8	2
Luzula campestris	1	2	.	5	8	2
Poa pratensis	1	2	.	9	4	2
Carex ornithopoda	1	.	2	.	3	2
Trifolium medium s.l.	1	4	2	7	2	2
Vicia incana	3	7	5	5	2	2
Galeopsis pubescens	.	.	.	4	2	2
Circaea lutetiana	.	.	.	2	2	2
Centaurea jacea agg.	5	9	4	.	2	2
Taraxacum officinale	6	2	2	7	1	2
Campanula bononiensis	4	7	2	5	1	2
Scrophularia nodosa	.	.	.	3	1	2
Melampyrum sylvaticum	1	1	.	2	1	2
Myosotis arvensis	.	.	1	1	1	2
Cephalanthera damasonium	1	3	2	.	1	2

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Rubus idaeus	1	1	2	5	.	2
Orchis purpurea	1	3	.	5	.	2
Dianthus armeria	.	.	.	3	.	2
Heracleum sphondylium	1	2	6	2	.	2
Sambucus nigra	.	.	5	2	.	2
Glechoma hederacea	.	.	.	2	.	2
Calystegia sepium	.	.	.	2	.	2
Ferulago sylvatica	1	7	.	1	.	2
Oxalis acetosella	.	.	.	1	.	2
Rhamnus saxatilis s.l.	2	4	4	.	.	2
Euphorbia brittingeri	.	7	2	.	.	2
Cardaminopsis arenosa	.	1	2	.	.	2
Aruncus dioicus	.	.	2	.	.	2
Calamagrostis villosa	.	1	1	.	.	2
Hierochloë australis	.	2	.	.	.	2
Ranunculus serpens	1	1	.	.	.	2
Scabiosa cinerea subsp. *hladnikiana*	.	1	.	.	.	2
Hieracium rotundatum	.	.	.	.	.	2
Aconitum lycoctonum subsp. *vulparia*	.	.	.	.	.	2
Anthoxanthum odoratum	1	2	.	5	9	1
Polygala comosa	3	3	1	2	9	1
Epilobium montanum	.	.	.	.	7	1
Agrostis capillaris	.	.	.	9	6	1
Galeopsis speciosa	.	.	1	2	6	1
Hieracium piloselloides	.	4	1	1	5	1
Vaccinium myrtillus	.	.	2	.	5	1
Torilis japonica	2	2	.	5	4	1
Vicia hirsuta	2	3	1	2	4	1
Hieracium cymosum	.	.	.	.	4	1
Lamium maculatum	.	1	1	2	3	1
Cephalanthera rubra	.	5	.	2	3	1
Ajuga genevensis	2	2	5	1	3	1
Milium effusum	2	.	1	1	3	1
Trifolium montanum	1	4	1	8	2	1
Arabis hirsuta	6	1	6	3	2	1
Prunella laciniata	4	1	2	2	2	1
Polygala vulgaris	1	2	.	2	2	1
Staphylea pinnata	3	1	8	.	2	1
Silene italica subsp. *nemoralis*	1	2	2	.	2	1
Myosotis sylvatica	1	1	1	.	2	1
Vicia oroboides	.	.	.	.	2	1
Hypericum hirsutum	1	.	1	7	1	1

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Veronica hederifolia	1	.	.	7	1	1
Polygonatum latifolium	1	.	.	3	1	1
Colchicum autumnale	6	2	2	2	1	1
Poa trivialis s.l.	2	7	.	2	1	1
Allium oleraceum	.	.	.	2	1	1
Senecio nemorensis	.	.	1	1	1	1
Juglans regia	3	3	.	1	1	1
Lysimachia punctata	.	.	.	1	1	1
Thalictrum aquilegiifolium	7	6	6	.	1	1
Polystichum setiferum	1	.	2	.	1	1
Prenanthes purpurea	.	.	2	.	1	1
Echinops ritro	.	.	1	.	1	1
Paeonia officinalis	.	5	.	9	.	1
Helianthemum nummularium	9	6	5	5	.	1
Hypochoeris maculata	.	7	.	5	.	1
Rosa gallica	1	2	.	3	.	1
Picea abies	.	.	3	2	.	1
Pulmonaria mollis	.	1	1	2	.	1
Stellaria media	2	.	.	2	.	1
Listera ovata	1	2	5	1	.	1
Scabiosa columbaria s.l.	2	.	2	1	.	1
Digitalis laevigata	5	1	1	1	.	1
Limodorum abortivum	.	4	.	1	.	1
Eupatorium cannabinum	.	.	.	1	.	1
Rosa pimpinellifolia	.	8	8	.	.	1
Aster amellus	.	7	6	.	.	1
Rosa pendulina	.	1	6	.	.	1
Senecio nemorensis subsp. *fuchsii*	.	.	6	.	.	1
Aethionema saxatile	6	6	2	.	.	1
Polystichum aculeatum	1	.	2	.	.	1
Genista januensis	3	3	1	.	.	1
Allium sphaerocephalon	.	2	1	.	.	1
Silene dioica	1	1	1	.	.	1
Athyrium filix-femina	.	1	1	.	.	1
Stachys sylvatica	1	.	1	.	.	1
Lactuca serriola	.	2	.	.	.	1
Seseli libanotis	.	2	.	.	.	1
Dianthus ferrugineus subsp. *liburnicus*	.	2	.	.	.	1
Helleborus dumetorum s.l.	1	1	.	.	.	1
Campanula rotundifolia	1	.	.	.	.	1
Allium schoenoprasum s.l.	1	.	.	.	.	1
Monotropa hypopitys	1	.	.	.	.	1

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Ranunculus acris	.	.	.	.	.	1
Dryopteris carthusiana	.	.	.	.	.	1
Calamagrostis epigejos	.	.	.	.	.	1
Linum flavum	.	.	.	.	.	1
Doronicum austriacum	.	.	.	.	.	1
Vicia sylvatica	.	.	.	.	.	1
Festuca gigantea	.	.	.	.	.	1
Lycopodium clavatum	.	.	.	.	.	1
Medicago carstiensis	.	.	.	.	.	1
Hieracium praecurrens	.	.	.	.	.	1
Doronicum orientale	.	.	.	.	.	1
Maianthemum bifolium	.	.	.	.	.	1
Trifolium campestre	6	1	1	3	9	.
Poa bulbosa	1	3	1	1	9	.
Hieracium hoppeanum	.	1	1	2	8	.
Epilobium lanceolatum	.	.	.	3	7	.
Achillea nobilis s.l.	1	.	.	.	7	.
Centaurium erythraea	4	.	.	4	6	.
Cardamine glauca	.	.	.	.	6	.
Agrimonia eupatoria	9	7	2	7	5	.
Vicia cracca	.	3	3	5	5	.
Bellis perennis	1	.	.	4	5	.
Chamaecytisus heuffelii	.	.	.	3	5	.
Trifolium pratense	1	2	.	2	5	.
Scleranthus annuus	.	1	.	2	5	.
Campanula lingulata	7	.	.	2	5	.
Silene armeria	.	.	.	2	5	.
Rosa rubiginosa agg.	5	1	3	1	5	.
Lychnis flos-cuculi	1	.	.	.	5	.
Cerastium decalvans	.	.	.	.	5	.
Cerastium brachypetalum	3	2	1	3	4	.
Silene italica	4	7	1	2	4	.
Lathyrus pratensis agg.	1	2	5	1	4	.
Euphrasia rostkoviana	.	.	.	.	4	.
Viola odorata	2	2	.	5	3	.
Trifolium arvense	1	1	.	4	3	.
Trifolium repens	1	.	.	4	3	.
Medicago lupulina	4	1	3	2	3	.
Centaurea phrygia	.	2	.	2	3	.
Vicia grandiflora	1	.	.	2	3	.
Linaria genistifolia	.	.	.	2	3	.
Galium tenuissimum	.	.	.	2	3	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Hypochoeris radicata	1	.	1	1	3	.
Logfia arvensis	.	.	.	1	3	.
Acinos arvensis	1	.	1	.	3	.
Carlina vulgaris	1	3	.	.	3	.
Plantago media	7	2	1	8	2	.
Stachys scardica	3	2	2	6	2	.
Stachys germanica	2	.	.	6	2	.
Potentilla argentea	1	2	.	5	2	.
Fraxinus excelsior	1	.	2	4	2	.
Fallopia convolvulus	.	.	.	4	2	.
Lathyrus laxiflorus	1	6	2	3	2	.
Smyrnium perfoliatum	4	2	2	3	2	.
Arenaria serpyllifolia s.l.	1	.	1	3	2	.
Vicia cassubica	.	2	.	3	2	.
Ranunculus auricomus	.	.	1	2	2	.
Cynosurus echinatus	.	2	.	2	2	.
Verbascum phlomoides	.	1	.	2	2	.
Chaerophyllum temulentum	1	.	.	2	2	.
Sedum rubens	.	.	.	2	2	.
Filago lutescens	.	.	.	2	2	.
Digitalis ferruginea	.	3	2	1	2	.
Petrorhagia saxifraga	7	2	2	1	2	.
Thymus serpyllum agg.	1	3	1	1	2	.
Sedum acre	4	2	1	1	2	.
Potentilla recta	2	2	.	1	2	.
Convolvulus cantabrica	1	2	.	1	2	.
Plantago lanceolata	6	1	.	1	2	.
Vicia tetrasperma	1	.	.	1	2	.
Aira caryophyllea	1	.	.	1	2	.
Vicia lathyroides	1	.	.	1	2	.
Trifolium dubium	.	.	.	1	2	.
Cerastium arvense	.	.	.	1	2	.
Rubus caesius	.	2	6	.	2	.
Sorbus aucuparia	1	1	2	.	2	.
Veronica urticifolia	1	.	2	.	2	.
Cardamine hirsuta	1	.	2	.	2	.
Arabidopsis thaliana	.	.	1	.	2	.
Thlaspi kovatsii	.	.	1	.	2	.
Hieracium bifidum	.	.	1	.	2	.
Luzula multiflora	.	6	.	.	2	.
Holcus mollis	.	1	.	.	2	.
Coronilla vaginalis	.	1	.	.	2	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Draba muralis	1	.	.	.	2	.
Bromus squarrosus	1	.	.	.	2	.
Cruciata pedemontana	1	.	.	.	2	.
Rorippa pyrenaica	1	.	.	.	2	.
Veronica arvensis	1	.	.	.	2	.
Erophila verna	1	.	.	.	2	.
Cerastium semidecandrum	1	.	.	.	2	.
Poa annua	.	.	.	.	2	.
Veronica verna	.	.	.	.	2	.
Ranunculus cassubicus	.	.	.	.	2	.
Hieracium prenanthoides	.	.	.	.	2	.
Erysimum diffusum	.	.	.	.	2	.
Campanula sparsa s.l.	.	.	.	.	2	.
Bromus hordeaceus	.	.	.	.	2	.
Herniaria glabra	.	.	.	.	2	.
Bellardiochloa violacea	.	.	.	.	2	.
Senecio rupestris	.	.	.	.	2	.
Crucianella angustifolia	.	.	.	.	2	.
Onopordum acanthium	.	.	.	.	2	.
Carex muricata s.l.	1	.	2	5	1	.
Scutellaria altissima	3	.	4	4	1	.
Ranunculus ficaria s.l.	1	2	.	4	1	.
Verbascum phoeniceum	.	.	.	4	1	.
Campanula cervicaria	1	4	1	3	1	.
Sedum hispanicum	.	.	2	2	1	.
Daucus carota	.	2	.	2	1	.
Myosotis discolor	2	1	.	2	1	.
Ornithogalum umbellatum	4	.	.	2	1	.
Muscari comosum	2	.	.	2	1	.
Agrostis stolonifera	.	.	.	2	1	.
Conyza canadensis	.	.	.	2	1	.
Melampyrum cristatum	.	.	.	2	1	.
Sedum album	2	.	3	1	1	.
Urtica dioica	.	.	2	1	1	.
Cerastium glomeratum	2	.	1	1	1	.
Arum maculatum	8	2	.	1	1	.
Anemone ranunculoides	3	1	.	1	1	.
Cytisus procumbens	.	1	.	1	1	.
Sherardia arvensis	3	.	.	1	1	.
Epipactis microphylla	1	.	.	1	1	.
Viola tricolor s.l.	1	.	.	1	1	.
Epipactis atrorubens	.	7	2	.	1	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Chamaecytisus tommasinii	1	6	2	.	1	.
Laserpitium krapfii subsp. *krapfii*	1	2	2	.	1	.
Convolvulus arvensis	.	.	2	.	1	.
Helianthemum oelandicum s.l.	.	.	2	.	1	.
Primula elatior	.	.	2	.	1	.
Scilla bifolia	4	1	1	.	1	.
Trifolium ochroleucon	.	1	1	.	1	.
Sedum dasyphyllum	1	.	1	.	1	.
Phleum pratense	.	.	1	.	1	.
Chelidonium majus	.	.	1	.	1	.
Medicago minima	.	.	1	.	1	.
Koeleria pyramidata	.	.	1	.	1	.
Potentilla hirta	2	1	.	.	1	.
Rorippa lippizensis	.	1	.	.	1	.
Petrorhagia prolifera	1	.	.	.	1	.
Vicia villosa s.l.	1	.	.	.	1	.
Arabis glabra	1	.	.	.	1	.
Linaria vulgaris	1	.	.	.	1	.
Lunaria rediviva	1	.	.	.	1	.
Silene otites	1	.	.	.	1	.
Carex pendula	.	.	.	.	1	.
Festuca curvula	.	.	.	.	1	.
Achillea grandifolia	.	.	.	.	1	.
Nepeta nuda	.	.	.	.	1	.
Thymus striatus	.	.	.	.	1	.
Nardus stricta	.	.	.	.	1	.
Alyssum markgrafii	.	.	.	.	1	.
Solanum nigrum	.	.	.	.	1	.
Hypericum richeri subsp. *grisebachii*	.	.	.	.	1	.
Euphorbia epithymoides	.	1	2	5	.	.
Ranunculus bulbosus	1	3	1	5	.	.
Rumex sanguineus	.	.	1	5	.	.
Chrysopogon gryllus	5	7	.	5	.	.
Carex michelii	.	2	.	5	.	.
Carex tomentosa	1	1	.	5	.	.
Rhinanthus rumelicus	.	.	.	5	.	.
Lysimachia nummularia	.	.	.	5	.	.
Arum besserianum	.	.	.	5	.	.
Hieracium boreale	.	.	.	5	.	.
Dianthus cruentus	.	.	.	5	.	.
Lathyrus pannonicus s.l.	.	.	.	5	.	.
Trifolium pignantii	2	.	3	4	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Anthyllis vulneraria s.l.	2	.	2	4	.	.
Laser trilobum	4	.	1	4	.	.
Euphorbia platyphyllos	.	.	1	4	.	.
Lithospermum officinale	.	.	1	4	.	.
Briza media	1	2	.	4	.	.
Urtica urens	.	.	.	4	.	.
Sambucus racemosa	.	.	.	4	.	.
Piptatherum virescens	.	1	3	3	.	.
Campanula rapunculus	2	2	1	3	.	.
Elymus repens	2	2	.	3	.	.
Carex brizoides	1	.	.	3	.	.
Moltkia doerfleri	.	.	.	3	.	.
Verbascum chaixii subsp. *austriacum*	.	.	.	3	.	.
Quercus robur agg.	.	.	.	3	.	.
Gymnadenia conopsea	.	.	.	3	.	.
Corydalis pumila	.	.	.	3	.	.
Lathyrus sylvestris	.	.	.	3	.	.
Gentiana cruciata	.	.	.	3	.	.
Centaurea triumfetti s.l.	1	3	8	2	.	.
Eryngium palmatum	5	.	6	2	.	.
Prunella grandiflora	.	2	5	2	.	.
Leontodon crispus	2	5	3	2	.	.
Picris hieracioides	1	2	2	2	.	.
Poa compressa	1	2	2	2	.	.
Viola mirabilis	1	.	2	2	.	.
Salix caprea	.	.	2	2	.	.
Veronica spicata	.	.	2	2	.	.
Solanum dulcamara	.	.	2	2	.	.
Corydalis cava	2	1	1	2	.	.
Dichanthium ischaemum	1	1	1	2	.	.
Lepidium campestre	.	1	1	2	.	.
Dianthus carthusianorum	.	.	1	2	.	.
Acanthus balcanicus	7	2	.	2	.	.
Rosa tomentosa	1	2	.	2	.	.
Carum carvi	.	2	.	2	.	.
Rumex acetosa	.	2	.	2	.	.
Ranunculus polyanthemos	1	1	.	2	.	.
Viola suavis	3	.	.	2	.	.
Galium glaucum	1	.	.	2	.	.
Cirsium vulgare	1	.	.	2	.	.
Astrantia major	1	.	.	2	.	.
Reseda lutea	1	.	.	2	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Holcus lanatus	.	.	.	2	.	.
Helleborus purpurascens	.	.	.	2	.	.
Anthriscus cerefolium	.	.	.	2	.	.
Cynosurus cristatus	.	.	.	2	.	.
Luzula sylvatica	.	.	.	2	.	.
Crataegus nigra	.	.	.	2	.	.
Allium ursinum	.	.	.	2	.	.
Hieracium echioides	.	.	.	2	.	.
Hieracium maculatum	.	.	.	2	.	.
Verbascum glabratum subsp. *bosnense*	.	.	.	2	.	.
Achillea pannonica	.	.	.	2	.	.
Euphrasia salisburgensis	.	.	.	2	.	.
Silene flavescens	.	.	.	2	.	.
Cynoglossum officinale	.	.	.	2	.	.
Bromus sterilis	.	.	.	2	.	.
Prunus cerasifera	.	.	.	2	.	.
Lactuca quercina	.	.	.	2	.	.
Daphne laureola	.	.	6	1	.	.
Scabiosa cinerea	4	2	3	1	.	.
Galanthus nivalis	7	.	3	1	.	.
Koeleria splendens	6	5	2	1	.	.
Salvia pratensis	6	4	2	1	.	.
Veronica austriaca	1	4	2	1	.	.
Muscari botryoides	1	2	2	1	.	.
Dioscorea balcanica	3	1	2	1	.	.
Scutellaria columnae	1	.	2	1	.	.
Veronica montana	.	.	2	1	.	.
Lysimachia vulgaris	.	.	2	1	.	.
Platanthera chlorantha	2	7	1	1	.	.
Lactuca saligna	.	1	1	1	.	.
Coronilla elegans	.	.	1	1	.	.
Oenanthe pimpinelloides	9	5	.	1	.	.
Leontodon hispidus s.l.	1	4	.	1	.	.
Medicago sativa subsp. *falcata*	3	2	.	1	.	.
Torilis arvensis	2	2	.	1	.	.
Asperula taurina	1	2	.	1	.	.
Plantago major	1	1	.	1	.	.
Symphytum officinale	.	1	.	1	.	.
Thlaspi perfoliatum	6	.	.	1	.	.
Comandra elegans	1	.	.	1	.	.
Lamium purpureum	1	.	.	1	.	.
Ranunculus millefoliatus	1	.	.	1	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Valerianella dentata	1	.	.	1	.	.
Muscari racemosum	1	.	.	1	.	.
Asphodeline liburnica	1	.	.	1	.	.
Epipactis palustris	1	.	.	1	.	.
Viola elatior	1	.	.	1	.	.
Lathyrus nissolia	1	.	.	1	.	.
Bromus commutatus	.	.	.	1	.	.
Carthamus lanatus	.	.	.	1	.	.
Allium scorodoprasum	.	.	.	1	.	.
Verbascum glabratum	.	.	.	1	.	.
Medicago arabica	.	.	.	1	.	.
Alopecurus pratensis	.	.	.	1	.	.
Euphorbia serrulata	.	.	.	1	.	.
Euphrasia stricta	.	.	.	1	.	.
Vicia sativa s.l.	.	.	.	1	.	.
Carex spicata	.	.	.	1	.	.
Adonis vernalis	.	.	.	1	.	.
Anthemis tinctoria	.	.	.	1	.	.
Erysimum odoratum	.	.	.	1	.	.
Hordelymus europaeus	.	.	.	1	.	.
Ailanthus altissima	.	.	.	1	.	.
Elymus caninus	.	.	.	1	.	.
Medicago orbicularis	.	.	.	1	.	.
Physalis alkekengi	.	.	.	1	.	.
Orchis papilionacea	.	.	.	1	.	.
Paeonia peregrina	.	.	.	1	.	.
Selinum carvifolia	.	.	.	1	.	.
Sedum sexangulare	.	.	.	1	.	.
Artemisia alba	.	.	.	1	.	.
Carex alba	.	2	9	.	.	.
Osyris alba	3	2	8	.	.	.
Saxifraga rotundifolia	3	.	8	.	.	.
Asplenium scolopendrium	1	.	8	.	.	.
Helleborus niger s.l.	.	2	7	.	.	.
Melica ciliata	6	4	6	.	.	.
Quercus ilex	4	2	6	.	.	.
Festuca rubra	.	2	6	.	.	.
Lilium bulbiferum	.	2	6	.	.	.
Ruta graveolens	1	1	6	.	.	.
Rhamnus alpinus subsp. *fallax*	1	.	6	.	.	.
Corylus colurna	.	.	6	.	.	.
Campanula carnica	.	.	6	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Molopospermum peloponnesiacum	.	.	6	.	.	.
Primula auricula	.	.	6	.	.	.
Aconitum angustifolium	.	.	6	.	.	.
Saxifraga petraea	.	.	6	.	.	.
Sorbus austriaca	.	.	6	.	.	.
Teucrium montanum	6	3	5	.	.	.
Coronilla coronata	1	1	5	.	.	.
Euonymus latifolius	.	1	5	.	.	.
Laserpitium siler s.l.	.	1	5	.	.	.
Stachys alopecuros	.	.	5	.	.	.
Lilium carniolicum	.	.	5	.	.	.
Asperula cynanchica	1	7	4	.	.	.
Sedum ochroleucum	4	1	4	.	.	.
Polygala chamaebuxus	.	1	4	.	.	.
Inula spiraeifolia	.	1	4	.	.	.
Doronicum columnae	1	.	4	.	.	.
Sempervivum tectorum	.	.	4	.	.	.
Genista radiata	.	.	4	.	.	.
Valeriana tripteris	.	.	4	.	.	.
Helianthemum nummularium subsp. *obscurum*	.	3	3	.	.	.
Thesium bavarum	.	2	3	.	.	.
Lonicera alpigena	.	1	3	.	.	.
Globularia cordifolia	.	1	3	.	.	.
Daphne blagayana	.	1	3	.	.	.
Orchis mascula subsp. *signifera*	2	.	3	.	.	.
Micromeria thymifolia	1	.	3	.	.	.
Laburnum anagyroides	.	.	3	.	.	.
Sorbus umbellata	.	.	3	.	.	.
Spiraea cana	.	.	3	.	.	.
Sideritis montana	.	.	3	.	.	.
Cystopteris fragilis	.	.	3	.	.	.
Allium ericetorum	.	.	3	.	.	.
Verbascum chaixii	.	.	3	.	.	.
Genista sericea	1	4	2	.	.	.
Ferulago campestris	.	4	2	.	.	.
Centaurea scabiosa agg.	.	3	2	.	.	.
Arum italicum	6	2	2	.	.	.
Linum tenuifolium	3	2	2	.	.	.
Peucedanum carvifolia	1	2	2	.	.	.
Potentilla tommasiniana	1	2	2	.	.	.
Centaurea rupestris	1	2	2	.	.	.
Asphodelus albus	.	2	2	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Scabiosa triandra	.	2	2	.	.	.
Achnatherum calamagrostis	5	1	2	.	.	.
Geranium lucidum	1	1	2	.	.	.
Hieracium glaucum	1	1	2	.	.	.
Veratrum album	.	1	2	.	.	.
Dryopteris pallida	.	1	2	.	.	.
Dianthus seguieri subsp. *glaber*	.	1	2	.	.	.
Calamintha nepeta s.l.	.	1	2	.	.	.
Salvia officinalis	8	.	2	.	.	.
Acer hyrcanum subsp. *intermedium*	6	.	2	.	.	.
Quercus trojana	5	.	2	.	.	.
Celtis australis	4	.	2	.	.	.
Lactuca perennis	2	.	2	.	.	.
Dianthus petraeus	1	.	2	.	.	.
Thymus praecox s.l.	1	.	2	.	.	.
Arabis alpina	1	.	2	.	.	.
Orchis simia	1	.	2	.	.	.
Minuartia verna s.l.	1	.	2	.	.	.
Melampyrum hoermannianum	1	.	2	.	.	.
Symphyandra hofmannii	1	.	2	.	.	.
Dorycnium hirsutum	1	.	2	.	.	.
Euphorbia esula	.	.	2	.	.	.
Rosa glauca	.	.	2	.	.	.
Melampyrum scardicum	.	.	2	.	.	.
Sesleria caerulea	.	.	2	.	.	.
Spiraea media	.	.	2	.	.	.
Saxifraga paniculata	.	.	2	.	.	.
Carduus defloratus	.	.	2	.	.	.
Acinos alpinus s.l.	.	.	2	.	.	.
Hacquetia epipactis	.	.	2	.	.	.
Omphalodes verna	.	.	2	.	.	.
Paederota lutea	.	.	2	.	.	.
Saxifraga cuneifolia	.	.	2	.	.	.
Campanula justiniana	.	.	2	.	.	.
Polypodium interjectum	.	.	2	.	.	.
Silene saxifraga	.	.	2	.	.	.
Saxifraga crustata	.	.	2	.	.	.
Saxifraga hostii	.	.	2	.	.	.
Scabiosa lucida	.	.	2	.	.	.
Geranium macrorrhizum	.	.	2	.	.	.
Hieracium glabratum	.	.	2	.	.	.
Betula pubescens	.	.	2	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Pseudofumaria alba s.l.	.	.	2	.	.	.
Actaea spicata	.	.	2	.	.	.
Calamintha brauneana	.	.	2	.	.	.
Centaurea angustifolia	.	.	2	.	.	.
Cerastium tomentosum	.	.	2	.	.	.
Arabis collina	.	.	2	.	.	.
Aurinia petraea	.	.	2	.	.	.
Cardamine impatiens	.	.	2	.	.	.
Campanula thyrsoides	.	.	2	.	.	.
Seseli elatum subsp. *gouanii*	.	.	2	.	.	.
Lathyrus sphaericus	.	.	2	.	.	.
Teucrium flavum	.	.	2	.	.	.
Potentilla heptaphylla	3	7	1	.	.	.
Cephalaria leucantha	4	4	1	.	.	.
Asperula scutellaris	.	4	1	.	.	.
Serratula radiata subsp. *cetingensis*	.	4	1	.	.	.
Knautia arvensis	4	3	1	.	.	.
Vitis vinifera subsp. *sylvestris*	1	3	1	.	.	.
Leontodon incanus	1	2	1	.	.	.
Scilla lakusicii	1	2	1	.	.	.
Euphorbia fragifera	.	2	1	.	.	.
Iris illyrica	.	2	1	.	.	.
Scabiosa fumarioides	.	2	1	.	.	.
Knautia integrifolia	.	2	1	.	.	.
Asperula aristata s.l.	4	1	1	.	.	.
Centaurea pannonica	1	1	1	.	.	.
Tanacetum cinerariifolium	1	1	1	.	.	.
Corydalis solida	1	1	1	.	.	.
Thesium divaricatum	1	1	1	.	.	.
Euphorbia carniolica	.	1	1	.	.	.
Hieracium caespitosum	.	1	1	.	.	.
Euphorbia myrsinites	.	1	1	.	.	.
Phleum phleoides	.	1	1	.	.	.
Fragaria viridis	4	.	1	.	.	.
Rhamnus intermedius	4	.	1	.	.	.
Calystegia silvatica	2	.	1	.	.	.
Geranium pusillum	1	.	1	.	.	.
Polygala amara	1	.	1	.	.	.
Peltaria alliacea	1	.	1	.	.	.
Calamintha grandiflora	1	.	1	.	.	.
Eryngium campestre	1	.	1	.	.	.
Marrubium incanum	1	.	1	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Veronica austriaca subsp. *teucrium*	1	.	1	.	.	.
Euphorbia spinosa	1	.	1	.	.	.
Arabis serpillifolia	.	.	1	.	.	.
Peucedanum officinale	.	.	1	.	.	.
Jovibarba heuffelii	.	.	1	.	.	.
Ribes uva-crispa	.	.	1	.	.	.
Pimpinella major	.	.	1	.	.	.
Trinia glauca	.	.	1	.	.	.
Centaurea haynaldii	.	.	1	.	.	.
Sesleria sadlerana	.	.	1	.	.	.
Edraianthus graminifolius	.	.	1	.	.	.
Rubus saxatilis	.	.	1	.	.	.
Centaurea cyanus	.	.	1	.	.	.
Carex pallescens	.	.	1	.	.	.
Campanula crassipes	.	.	1	.	.	.
Sesleria robusta	.	.	1	.	.	.
Iberis sempervirens	.	.	1	.	.	.
Senecio ovirensis	.	.	1	.	.	.
Veronica fruticans	.	.	1	.	.	.
Phyteuma ovatum	.	.	1	.	.	.
Stipa pennata s.l.	.	.	1	.	.	.
Erysimum sylvestre	.	.	1	.	.	.
Arabis nova	.	.	1	.	.	.
Linum viscosum	.	.	1	.	.	.
Carlina acaulis	.	.	1	.	.	.
Dactylorhiza maculata	.	.	1	.	.	.
Cachrys alpina	.	.	1	.	.	.
Geranium nodosum	.	.	1	.	.	.
Parietaria judaica	.	.	1	.	.	.
Cleistogenes serotina	.	.	1	.	.	.
Hieracium caesium	.	.	1	.	.	.
Trifolium diffusum	.	.	1	.	.	.
Scorzonera austriaca	.	.	1	.	.	.
Verbascum densiflorum	.	.	1	.	.	.
Erysimum crepidifolium	.	.	1	.	.	.
Ribes alpinum	.	.	1	.	.	.
Ptilostemon strictus	3	6	.	.	.	.
Rosa sempervirens	1	6	.	.	.	.
Centaurea napulifera subsp. *tuberosa*	1	6	.	.	.	.
Hippocrepis comosa	3	5	.	.	.	.
Polygala nicaeensis s.l.	2	5	.	.	.	.
Agrostis castellana	1	5	.	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Scorzonera villosa	1	4	.	.	.	.
Knautia illyrica	.	3	.	.	.	.
Euphorbia nicaeensis	.	3	.	.	.	.
Tragopogon tommasinii	.	3	.	.	.	.
Danthonia alpina	.	3	.	.	.	.
Cyclamen repandum	7	2	.	.	.	.
Spartium junceum	6	2	.	.	.	.
Leucanthemum atratum subsp. *platylepis*	6	2	.	.	.	.
Fritillaria messanensis subsp. *gracilis*	4	2	.	.	.	.
Teucrium polium subsp. *capitatum*	3	2	.	.	.	.
Piptatherum miliaceum	2	2	.	.	.	.
Silene latifolia subsp. *alba*	2	2	.	.	.	.
Cirsium erisithales	1	2	.	.	.	.
Geranium purpureum	1	2	.	.	.	.
Melampyrum arvense	1	2	.	.	.	.
Orchis tridentata	1	2	.	.	.	.
Vicia tenuifolia agg.	1	2	.	.	.	.
Anthericum liliago	1	2	.	.	.	.
Muscari neglectum	1	2	.	.	.	.
Inula oculus-christi	1	2	.	.	.	.
Orlaya grandiflora	1	2	.	.	.	.
Satureja cuneifolia	.	2	.	.	.	.
Ajuga laxmannii	.	2	.	.	.	.
Coronilla scorpioides	.	2	.	.	.	.
Anacamptis pyramidalis	.	2	.	.	.	.
Thlaspi praecox	.	2	.	.	.	.
Salvia argentea	.	2	.	.	.	.
Pulmonaria angustifolia	.	2	.	.	.	.
Crataegus laciniata	.	2	.	.	.	.
Hypericum barbatum	.	2	.	.	.	.
Ranunculus neapolitanus	4	1	.	.	.	.
Anemone apennina	4	1	.	.	.	.
Rubia peregrina	4	1	.	.	.	.
Alyssum alyssoides	2	1	.	.	.	.
Rhamnus orbiculatus	1	1	.	.	.	.
Plantago holosteum	1	1	.	.	.	.
Dianthus giganteus subsp. *croaticus*	1	1	.	.	.	.
Pyrus amygdaliformis	1	1	.	.	.	.
Cirsium acaule	1	1	.	.	.	.
Gladiolus illyricus	1	1	.	.	.	.
Orchis militaris	1	1	.	.	.	.
Linum catharticum	1	1	.	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Convolvulus altheoides subsp. *tenuissimus*	1	1	.	.	.	.
Inula ensifolia	1	1	.	.	.	.
Bupleurum praealtum	1	1	.	.	.	.
Dianthus sylvestris subsp. *tergestinus*	1	1	.	.	.	.
Thesium linophyllon	1	1	.	.	.	.
Cerinthe minor	.	1	.	.	.	.
Taraxacum hoppeanum	.	1	.	.	.	.
Micromeria juliana	.	1	.	.	.	.
Acanthus spinosus	.	1	.	.	.	.
Achillea crithmifolia	.	1	.	.	.	.
Huetia cynapioides	.	1	.	.	.	.
Chaerophyllum coloratum	.	1	.	.	.	.
Onobrychis arenaria	.	1	.	.	.	.
Hierochloë odorata	.	1	.	.	.	.
Bromus arvensis	.	1	.	.	.	.
Sedum rupestre	.	1	.	.	.	.
Astragalus illyricus	.	1	.	.	.	.
Plantago argentea	.	1	.	.	.	.
Fumana procumbens	.	1	.	.	.	.
Bupleurum baldense subsp. *gussonei*	4	.	.	.	.	.
Carex distachya	4	.	.	.	.	.
Thalictrum flavum	4	.	.	.	.	.
Euphorbia characias subsp. *wulfenii*	4	.	.	.	.	.
Bromus japonicus	3	.	.	.	.	.
Erica arborea	3	.	.	.	.	.
Geranium columbinum	3	.	.	.	.	.
Myrtus communis	3	.	.	.	.	.
Hieracium florentinum	3	.	.	.	.	.
Verbascum lychnitis	2	.	.	.	.	.
Orchis pallens	2	.	.	.	.	.
Punica granatum	2	.	.	.	.	.
Medicago prostrata	2	.	.	.	.	.
Festuca altissima	1	.	.	.	.	.
Bupleurum affine	1	.	.	.	.	.
Aegopodium podagraria	1	.	.	.	.	.
Scabiosa ochroleuca	1	.	.	.	.	.
Cardamine graeca	1	.	.	.	.	.
Viola canina	1	.	.	.	.	.
Crepis biennis	1	.	.	.	.	.
Fumana ericoides	1	.	.	.	.	.
Lathyrus aphaca	1	.	.	.	.	.
Brachypodium retusum	1	.	.	.	.	.

Vegetation type	**1**	**2**	**3**	**4**	**5**	**6**
Elymus hispidus	1	.	.	.	.	.
Silybum marianum	1	.	.	.	.	.
Allium flavum	1	.	.	.	.	.
Desmazeria rigida	1	.	.	.	.	.
Ballota nigra	1	.	.	.	.	.
Taraxacum erythrospermum	1	.	.	.	.	.
Reichardia picroides	1	.	.	.	.	.
Carlina corymbosa	1	.	.	.	.	.
Carduus nutans	1	.	.	.	.	.
Parietaria officinalis	1	.	.	.	.	.
Malus florentina	1	.	.	.	.	.
Knautia dipsacifolia	1	.	.	.	.	.
Linum trigynum	1	.	.	.	.	.
Colchicum hungaricum	1	.	.	.	.	.
Bupleurum glumaceum	1	.	.	.	.	.
Trifolium dalmaticum	1	.	.	.	.	.
Cistus incanus subsp. *creticus*	1	.	.	.	.	.
Cynodon dactylon	1	.	.	.	.	.
Euphorbia falcata	1	.	.	.	.	.
Asplenium onopteris	1	.	.	.	.	.
Campanula sibirica	1	.	.	.	.	.
Linum austriacum	1	.	.	.	.	.
Trifolium scabrum	1	.	.	.	.	.
Potentilla cinerea	1	.	.	.	.	.
Globularia punctata	1	.	.	.	.	.
Geranium molle	1	.	.	.	.	.
Stipa bromoides	1	.	.	.	.	.
Achillea virescens	1	.	.	.	.	.
Vicia pannonica	1	.	.	.	.	.
Poa stiriaca	1	.	.	.	.	.
Isopyrum thalictroides	1	.	.	.	.	.
Thlaspi goesingense	1	.	.	.	.	.
Echium vulgare	1	.	.	.	.	.
Carduus acanthoides	1	.	.	.	.	.
Vinca herbacea	1	.	.	.	.	.
Delphinium fissum	1	.	.	.	.	.
Muscari tenuiflorum	1	.	.	.	.	.
Centaurea alba subsp. *deusta*	1	.	.	.	.	.
Carex praecox	1	.	.	.	.	.

ANNEX G

Photo plates of TDF types described in chapter 2.2 (therein referred to as Supplement S5)

Fig. 1. Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/ or *Carpinus orientalis* - climax type (high forest) with Mediterranean evergreen elements (Kravice near Ljubuški, S B&H; photo by V. Stupar)

Fig. 2. Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/ or *Carpinus orientalis* - pure *Carpinus orientalis* scrub (structural degradation of climax type) with Mediterranean evergreen elements (Duži near Trebinje, S B&H; photo by V. Stupar)

Fig. 3. Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/ or *Carpinus orientalis* - extrazonal continental communities without Mediterranean evergreen elements (high forest; between Grude and Posušje, SW B&H; photo by V. Stupar)

Fig. 4. Type 1: Sub-Mediterranean forests dominated by *Quercus pubescens* and/ or *Carpinus orientalis* - extrazonal continental communities without Mediterranean evergreen elements structurally degraded to pure *Carpinus orientalis* scrub (Sana River source, W B&H; photo by Đ. Milanović)

Fig. 5. Type 2: Sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis* (Bijela gora near Trebinje, S B&H; photo by Đ. Milanović)

Fig. 6. Type 2: Sub-Mediterranean and continental *Quercus pubescens* forests without *Carpinus orientalis* (Ruj near Doboj, N B&H; photo by V. Stupar)

Fig. 7. Type 3: Meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia* (Bijela gora near Trebinje, S B&H; photo by Đ. Milanović)

Fig. 8. Type 3: Meso-thermophilous supra-Mediterranean and/or relict communities dominated by *Ostrya carpinifolia* (Vrbas River canyon, W B&H; photo by V. Stupar)

Fig. 9. Type 4: Thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris* (*Quercus frainetto* forest, Majevica Mt. near Ugljevik, NE B&H; photo by V. Stupar)

Fig. 10. Type 4: Thermophilous continental forests of deep, neutral to slightly acidic soils dominated by *Quercus frainetto* and/or *Quercus cerris* (*Quercus cerris* forest near Bosanski Petrovac, W B&H; photo by V. Stupar)

Fig. 11. Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* agg. and/or *Quercus cerris* (Brod near Foča, E B&H; photo by Đ. Milanović)

Fig. 12. Type 5: Dry acidophilous continental forests dominated by *Quercus petraea* agg. and/or *Quercus cerris* (Bistrica River valley near Miljevina, E B&H; photo by Đ. Milanović)

Fig. 13. Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests (Kozara Mt., N B&H; photo by V. Stupar)

Fig. 14. Type 6: Acido-thermophilous northern Dinaric-southern Pannonian *Quercus petraea* dominated forests (Krnjin Mt., N B&H; photo by V. Stupar)

ANNEX H

List of species merged to aggregates (agg.), broadly defined taxa (s.l.) or taxa deviating from Tutin et al. (1968-1993) or not included therein used in chapter 2.3 (therein referred to as Appendix S1).

Acer hyrcanum subsp. *intermedium* = *Acer hyrcanum* subsp. *intermedium* sensu The Plant List (2013) [= *Acer hyrcanum* subsp. *intermedium* (Pančić) Palam.]

Allium carinatum s.l.: *A. carinatum* subsp. *carinatum* and subsp. *pulchellum*

Anthyllis vulneraria s.l.: *A. vulneraria* subsp. *polyphylla* and subsp. *vulneraria*

Brachypodium pinnatum s.l.: *B. pinnatum* subsp. and subsp. *rupestre*

Bromus erectus agg.: *B. erectus* subsp. *condensatus, B. erectus* and *B. pannonicus*

Bromus ramosus agg.: *B. benekenii* and *B. ramosus*

Carex divulsa s.l.: *C. divulsa* subsp. *divulsa* and subsp. *leersii*

Carex flacca s.l.: *C. flacca* subsp. *flacca* and subsp. *serrulata*

Carex muricata s.l.: *C. muricata* subsp. *muricata* and subsp. *lamprocarpa*

Centaurea scabiosa agg.: *C. scabiosa* and *C. grinensis* subsp. *fritschii*

Chamaecytisus hirsutus agg.: *C. ciliatus* and *C. hirsutus*

Coronilla emerus s.l.: *C. emerus* subsp. *emeroides* and subsp. *emerus*

Dactylis glomerata s.l.: *D. glomerata* subsp. *aschersoniana* and subsp. *glomerata*

Festuca pseudovina agg.: *F. rupicola, F dalmatica, F. ovina* and *F. pseudovina*

Galium mollugo agg.: *G. album* and *G. mollugo*

Genista sylvestris subsp. *dalmatica*: *Genista sylvestris* subsp. *dalmatica* sensu The Plant List (2013) [= *Genista sylvestris* subsp. *dalmatica* (Bartl.) H.Lindb.]

Lamiastrum galeobdolon s.l.: *L. galeobdolon* subsp. *flavidum,* subsp. *galeobdolon* and subsp. *montanum*

Poa trivialis s.l.: *P. trivialis* subsp. *sylvicola* and subsp. *trivialis*

Potentilla tommasiniana: *Potentilla tommasiniana* sensu The Plant List (2013) [= *Potentilla tommasiniana* F.W.Schultz]

Primula veris s.l.: *P. veris* subsp. *columnae* and subsp. *veris*

Pseudofumaria alba s.l.: *P. alba* subsp. *alba* and subsp. *leiosperma*

Quercus petraea agg.: *Q. dalechampii, Q. petraea* and *Q. polycarpa*

Rhamnus saxatilis s.l.: *R. saxatilis* subsp. *saxatilis* and subsp. *tinctorius*

Rubus fruticosus agg.: *R. candicans, R. discolor* and *R. fruticosus*

Sanguisorba minor s.l.: *S. minor* subsp. *minor* and subsp. *muricata*

Satureja montana s.l.: *S. montana* subsp. *illyrica* and subsp. *montana*

Scilla lakusicii: *Scilla lakusicii* sensu The Plant List (2013) [= *Scilla lakusicii* Šilić]

Stachys recta s.l.: *S. recta* subsp. *recta* and subsp. *subcrenata*

Verbascum nigrum s.l.: *V. nigrum* subsp. *abietinum* and subsp. *nigrum*

Viola hirta agg.: *V. hirta* and *V. alba*

References

The Plant List (2013). Version 1.1. Published on the Internet; http://www.theplantlist.org/

Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., & Webb, D. A. (Eds.). (1968-1993). Flora Europaea (Vols. 1–5). Cambridge University Press.

ANNEX I

Phytosociological table of the association *Carici hallerianae-Quercetum pubescentis* presented in chapter 2.3 (therein referred to as Supplement S1).

Stupar et al.: Thermophilous deciduous forests (*Quercetalia pubescentis*) of Bosnia and Herzegovina

Supplement S1. *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco, holotypus: relevé 4 (A - lower tree layer, B - shrub layer, C - herb layer.

Beilage S1. *Carici hallerianae-Quercetum pubescentis* ass. nov. hoc loco, Holotypus: Aufnahme 4 (A - untere Baumschicht, B - Strauchschicht, C - Krautschicht

Relevé number		1	2	3	4	5	6	7	8	9	10
Characteristic species of the association											
Quercus pubescens	A	3	4	2	4	3	2	4	2	3	4
	B	2	2	2	2	1	1	2	2	2	+
Carpinus orientalis	A	.	.	.	.	.	.	3	.	.	.
	B	2	2	3	3	2	4	2	4	2	4
Sesleria autumnalis	C	3	4	4	3	2	3	3	3	.	3
Carex halleriana	C	r	+	+	1	–	+	.	+	.	2
Carpinion orientalis											
Acer monspessulanum	A	.	.	.	.	.	.	1	.	.	.
	B	.	.	2	.	1	1	1	2	.	+
Lonicera etrusca	B	+	+	.	+	1	.	1	+	.	.
Coronilla emerus s.l.	B	+	.	r	.	–	1	–	+	.	.
Hieracium tommasinianum	C	+	.	.	r	–	.	–	.	.	.
Quercetalia pubescentis											
Fraxinus ornus	A	.	+	.	.	.	1	2	.	2	.
	B	2	.	2	2	2	+	2	2	2	2
Quercus cerris	A	1	.	.	.	.	1	.	1	.	.
	B	2	.	2	2	.	2	.	2	.	.
Cornus mas	B	.	.	2	r	1	+	.	2	.	+
Euonymus verrucosus	B	.	.	+	.	–	+	r	1	.	1
Sorbus torminalis	B	.	.	+	r	2	.	–	.	.	+
Acer obtusatum	B	.	.	2	.	.	.	.	.	.	2
Viola hirta agg.	C	r	+	+	+	–	+	r	+	r	.
Campanula persicifolia	C	+	+	+	+	.	+	.	.	.	+
Silene nutans	C	r	+	.	r	.	1	.	.	.	r
Clinopodium vulgare	C	.	.	+	.	.	1	.	+	.	+
Buglossoides purpurocaerulea	C	.	.	1	.	1	+	.	+	.	.
Tanacetum corymbosum	C	+	.	+	.	.	.	.	+	r	.
Tamus communis	C	.	.	.	.	–	.	–	.	r	1
Lathyrus niger	C	.	.	1	r	.	1	.	.	.	.
Asperula purpurea	C	.	.	.	+	–	.	1	.	.	.
Campanula bononiensis	C	.	.	.	.	–	r	.	+	.	.
Querco-Fagetea* and *Rhamno-Prunetea											
Crataegus monogyna	B	+	.	+	+	–	1	1	+	r	+
Rosa arvensis	B	.	.	+	+	r	+	–	.	+	.
Acer campestre	B	r	.	.	.	.	2	.	+	.	+
Ligustrum vulgare	B	.	.	+	.	.	.	.	+	.	+
Cruciata glabra	C	r	+	+	.	.	+	.	r	.	1
Dactylis glomerata s.l.	C	.	.	+	.	.	.	–	+	r	1
Veronica chamaedrys	C	.	.	.	+	–	.	–	.	.	+
Brachypodium sylvaticum	C	+	.	.	.	.	.	–	.	.	1
Trifolio-Geranietea											
Trifolium alpestre	C	+	r	r	+	.	.	.	.	.	r
Dorycnium pentaphyllum subsp. *germanicum*	C	1	.	.	.	.	1	.	1	1	.
Helleborus multifidus	C	+	+	.	.	.	r	.	r	.	.
Polygonatum odoratum	C	.	.	+	.	.	.	.	.	1	r
Festuco-Brometea											
Teucrium chamaedrys	C	+	+	+	+	–	r	–	+	+	.
Brachypodium pinnatum s.l.	C	2	.	1	1	.	2	–	1	2	1
Bromus erectus agg.	C	1	.	.	1	.	1	1	1	3	.
Festuca pseudovina agg.	C	.	2	+	+	–	+	–	.	+	.
Asperula cynanchica	C	r	.	.	r	–	.	–	r	+	.
Carex humilis	C	.	+	.	.	–	2	2	+	.	.
Euphorbia cyparissias	C	.	.	r	.	.	+	r	.	+	.
Genista sylvestris subsp. *dalmatica*	C	.	+	.	.	–	.	1	.	.	.
Lotus corniculatus	C	+	.	.	+	r	.	.	.	.	.
Thymus pulegioides	C	.	r	.	.	.	.	.	r	+	.
Helianthemum nummularium	C	.	.	.	.	.	1	.	r	+	.
Companions											
Chamaecytisus hirsutus agg.	B	.	.	.	+	.	.	1	+	+	.
Fragaria vesca	C	.	+	+	1	–	+	.	+	.	.
Elymus repens	C	.	.	.	.	1	.	–	r	.	.

In one or two relevés:

A: *Ostrya carpinifolia* 9:+;

B: *Acer tataricum* 1:+; *Clematis vitalba* 3:r, 7:+; *Colutea arborescens* 10:+; *Cornus sanguinea* 1:+; *Corylus avellana* 2:1; *Cotinus coggygria* 3:1, 10:2; *Frangula rupestris* 5:+, 7:+; *Genista tinctoria* 3:r; *Juglans regia* 1:r; *Juniperus communis* 10:r; *Lonicera xylosteum* 6:r; *Ostrya carpinifolia* 4:+, 7:r; *Prunus spinosa* 8:1; *Pyrus pyraster* 6:+, 10:r; *Rhamnus orbiculatus* 7:+; *Rosa canina* 1:1, 2:+; *Sorbus aria* 3:+, 7:r; *Sorbus domestica* 10, r; *Viburnum lantana* 10, r;

C: *Achillea nobilis* 7:r; *Aethionema saxatile* 8:r; *Agrostis castellana* 4:+; *Anemone ranunculoides* 2:+; *Anthericum ramosum* 1:r, 9:3; *Arabis hirsuta* 9:r; *Arabis turrita* 3:+, 10:+; *Aremonia agrimonoides* 4:r, 6:r; *Asparagus tenuifolius* 10:+; *Betonica officinalis* 1:–, 3:–; *Bunium alpinum* subsp. *montanum* 4:+; *Buphthalmum salicifolium* 9:1; *Calamintha sylvatica* 10:+; *Campanula glomerata* 2:1; *Campanula trachelium* 3:+; *Carex caryophyllea* 10:+; *Carum carvi* 5:+, 7:+; *Centaurea napulifera* subsp. *tuberosa* 1:+, 3:r; *Clematis recta* 9:1; *Convolvulus cantabrica* 6:–; *Coronilla coronata* 1:+; *Cotoneaster nebrodensis* 4:r; *Crataegus laevigata* 2:1; *Dictamnus albus* 3:+, 5:+; *Epipactis atrorubens* 1:r; *Eryngium amethystinum* 6:r; *Festuca heterophylla* 3:r, 10:+; *Filipendula vulgaris* 3:+, 4:r; *Fritillaria orientalis* 2:r; *Galium lucidum* 8:+, 9:+; *Geranium lucidum* 8:+; *Geranium robertianum* 10:r; *Geranium sanguineum* 4:r; *Geum urbanum* 8:r; *Glechoma hirsuta* 3:+, 10:+; *Globularia punctata* 9:+; *Helleborus odorus* 10:+; *Hieracium hoppeanum* 5:r; *Hieracium murorum* 9:r; *Hieracium piloselloides* 4:r; *Hieracium praealtum* subsp. *bauhinii* 9:–; *Hieracium sabaudum* 9:+; *Hippocrepis comosa* 1:+, 9:+; *Hypochaeris maculata* 3:–; *Inula spiraeifolia* 3:r; *Iris graminea* 3:–; *Lathyrus venetus* 3:r, 10:1; *Leontodon hispidus* 1:+; *Leontodon incanus* 9:r; *Lilium martagon* 3:r; *Medicago falcata* 7:+; *Medicago lupulina* 8:r; *Melica ciliata* 8:r; *Melica uniflora* 3:+; *Melittis melissophyllum* 3:r, 9:+; *Orchis simia* 9:r; *Origanum vulgare* 3:+; *Ornithogalum pyrenaicum* 3:–; *Petrorhagia saxifraga* 6:–; *Peucedanum austriacum* 3:r; *Peucedanum cervaria* 3:+; *Peucedanum oreoselinum* 7:+, 9:2; *Pimpinella saxifraga* 9:r; *Platanthera bifolia* 1:r; *Poa angustifolia* 10:+; *Poa trivialis* s.l. 1:+, 6:+; *Potentilla erecta* 9:+; *Potentilla heptaphylla* 2:–, 4:r; *Potentilla hirta* 5:–, 7:+; *Potentilla micrantha* 4:+, 10:+; *Potentilla tommasiniana* 6:+; *Primula vulgaris* 3:r; *Sanguisorba minor* s.l. 6:r; *Scabiosa cinerea* 9:+; *Scutellaria altissima* 10:+; *Sedum acre* 6:+, 8:r; *Sedum ochroleucum* 6:r; *Sedum telephium* subsp. *maximum* 3:r, 8:r; *Serratula tinctoria* 3:+; *Silene nemoralis* 3:+; *Silene vulgaris* 9:+; *Smyrnium perfoliatum* 10:+; *Solidago virgaurea* 9:+; *Stachys recta* s.l. 9:r; *Teucrium montanum* 7:+; *Thalictrum minus* 7:r; *Thesium linophyllon* 4:+; *Thlaspi goesingense* 9:+; *Thymus longicaulis* 1:–, 4:–; *Trifolium montanum* 1:+; *Trifolium rubens* 3:r; *Veratrum nigrum* 3:r; *Verbascum nigrum* s.l. 8:r; *Vicia incana* 3:r;

Details of relevés (indicated in the following order: relevé number, GIVD EU-BA-001 relevé number, relevé area (m^2), altitude (m), aspect, slope (degrees), cover (%) A-B-C, species richness (total), date (year/ month/day), description of locality, latitude, longitude) : 1, 70, 400, 650, NE, 20, 60-50-40, 40, 20110608, Oreči (Posušje), 43.433086, 17.369203; 2, 4, 600, 920, SW, 15, 60-25-80, 25, 20110422, Brina (Cincar), 43.852217, 16.972696; 3, 243, 400, 670, S, 3, 20-80-70, 60, 20120627, Tarovine (Osječenica), 44.467614, 16.253619; 4, 318, 400, 880, S, 12, 70-70-70, 39, 20140701, između Posušja i Mesihovine, 43.530835, 17.284225; 5, 475, 100, 786, S, 20, 50-60-40, 34, 20140723, između Posušja i Mesihovine, 43.511384, 17.270108; 6, 116, 400, 655, S, 15, 30-90-50, 42, 20110725, Guvno (Drvar), 44.402031, 16.365373; 7, 330, 400, 808, SW, 15, 80-50-30, 40, 20140723, između Posušja i Mesihovine, 43.511836, 17.27035; 8, 244, 400, 680, S, 20, 40-70-30, 43, 20120627, Guvno (Drvar), 44.40562, 16.356532; 9, 16, 900, 440, S, 35, 50-40-95, 42, 20110511, Gomjenica-Prisoje (Manjača), 44.700182, 16.923974; 10, 306, 400, 340, NE, 20, 70-70-60, 43, 20140624, Kamenice (Bočac), 44.511213, 17.152517.

ANNEX J

Phytosociological table of the association *Asparago tenuifolii-Quercetum pubescentis* presented in chapter 2.3 (therein referred to as Supplement S2).

Stupar et al.: Thermophilous deciduous forests (*Quercetalia pubescentis*) of Bosnia and Herzegovina

Supplement S2. *Asparago tenuifolii-Quercetum pubescentis* (A - lower tree layer, B - shrub layer, C - herb layer).
Beilage S2. *Asparago tenuifolii-Quercetum pubescentis* (A - untere Baumschicht, B - Strauchschicht, C - Krautschicht).

Relevé number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Characteristic species of the association																			
Quercus pubescens	A	4	1	4	5	3	4	4	3	3	2	5	4	2	5	4	3	3	4
	B	1	2	2	2	1	2	1	1	2	3	2	2	2	2	3	2	1	.
Brachypodium sylvaticum	C	3	+	4	1	1	2	+	1	1	3	2	1	2	+	1	-	2	.
Helleborus odorus	C	-	.	-	+	.	r	+	-	r	1	r	+	+	.	r	r	+	+
Brachypodium pinnatum s.l.	C	2	3	3	1	.		1	.	1	4	3	1	1	1	.	2	1	.
Carex flacca s.l.	C	1	1		1	.		.	.		r		3	+	+	2	2	2	+
Quercetalia pubescentis																			
Fraxinus ornus	A		3		.	1		2	.	1	.		.	.	2	2	2	.	2
	B	3	3	-	3	2	2	1	2	2	.	2	2	4	5	2	2	2	+
Sorbus torminalis	A	.	1	.	.	.	1	.	.	.	.	2	.	.	1	.	.	.	.
	B	2	+	-	1	+	2	.	.	.	+	2	.	+	2	.	.	+	+
Quercus cerris	A		.	1	1	3		.	.		.		.	.		.		3	.
	B		.		+	1		.	-	.	.		.	.	r	.		.	.
Acer obtusatum	A	.	.	.	.	.	3	.	.	1	.	2	.	.	.	.	.	.	.
	B		2		.	.	2	.	.	2	.	2	.	.		.	.	.	.
Cornus mas	B		.	2	2	+		.	1	+	.		.	+	.	.	2	2	4
Clinopodium vulgare	C	-	r	.	.	+	1	1	-	+	r	-	+	1	r	+	-	.	r
Tamus communis	C	r	1		.	1		r	.		1	.	r	1	1	.	.	1	1
Melittis melissophyllum	C	1	+		1	.	-	.	.	+	.	.	.	.	.	.	-	.	+
Festuca heterophylla	C	-	+	.	+	1	1	.	.	2	.	1	.	.	.	.	.	.	.
Iris graminea	C	.	1		1	1	1	.	.	1	.	1	.	.	.	.		.	.
Lathyrus venetus	C	1	.		1	.		+	-		.		+	.		+		+	.
Buglossoides purpurocaerulea	C	.	1	.	.	+	r	.	.	.	.	.	.	1	.	.	1	2	+
Vincetoxicum hirundinaria	C		1		.	r	r	1	.	r	.	.	.	.	.	.	1	.	1
Tanacetum corymbosum	C	r	.		1	.	-	.	.	+	.	-	.	.	.	.	-	.	.
Lathyrus niger	C	r	+	.	.	+	.	.	.	.	.	.	.	1	.	.	.	+	r
Calamintha sylvatica	C	.	.		.	.		1	.	.			1	1	.	1		1	.
Viola hirta agg.	C		.		.	.		r	r	+	.	r	r	.	.	.	r	.	.
Potentilla micrantha	C	.	.	.	.	.	.	r	.	.	.	-	r	+	.	r	.	.	.
Galium lucidum	C		.	.	.	.		.	.	.	1		1	.	.	1	.	.	.
Betonica officinalis	C	.	1		1	.		.	.	1	.	r	.			.		.	.
Peucedanum austriacum	C		+		.	.	r	.	.	.	.	-	.	.	.	.	.	.	.
Inula conyza	C	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.
Querco-Fagetea																			
Quercus petraea agg.	A	3	1		1	.	3	.		2	.		.			.		.	
	B	-	r	.	r	.	2	.	.	.	.	.	.	.	r	.	.	.	.
Acer campestre	A	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1	.	1	.
	B	2	.		2	1		1	.		1		.		2	2		2	1
Tilia tomentosa	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
	B	.	.	.	1	.	.	.	.	.	.	.	.	.	2	1	.	2	.
Rosa arvensis	B	1	1	1	1	1	1	1		2	1	1	1	1	1	3		1	1
Pyrus pyraster	B	-	+	.	+	+	.	+	.	.	+	.	+	r	+	2	-	+	.
Hedera helix	B	.	.	.	1	.	.	.	r	.	.	.	.	1	1	.	.	.	1
Rubus hirtus	B	.	.	.	r		r	.					.			.		.	
Corylus avellana	B	.	.	.	.	+	2	.	.	2	.	.	.	.	+	.	.	.	.
Cruciata glabra	C	.	1	.	1	.	.	1	.	1	1	.	1	.	.	1	.	.	.
Fragaria moschata	C	1	1	.	1	r	1	.	.	1	1	.	.		1	.		.	
Dactylis glomerata s.l.	C	r	.	.	.	+	-	.	.	.	.	-	.	+	.	r	-	+	+
Veronica chamaedrys	C	r	.	.	.	.	.	.	.	r	.	r	.	r	.	.	.	.	.
Geum urbanum	C		.		.	1	.	.	r	1	.	r	.			.		.	.
Melica uniflora	C		.		.	4	1	.	.		.	-	.	.		r		.	.
Glechoma hirsuta	C	.	.	.	.	+	.	+	-	.	.	.	.	.	.	.	.	.	.
Carex montana	C	2	1		r	.		.	.	1	.		.	.	.	.	.	.	.
Galium schultesii	C	-	.		.	.		.			.		.			.		+	1
Melica nutans	C	-	1	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Carpinion, Erythronio-Carpinion																			
Carpinus betulus	A		.		.	.		.		r	.		.			.		.	.
	B	-	.	-	2	.	2	.	1	.	+	.	.	.	2	.	.	.	.
Prunus avium	A		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
	B	-	+		2	+	r	.	-		.	r	.		+	.		.	.
Tilia platyphyllos	B	.	+	.	.	.	.	.	-	r	.	.	.	.	.	.	.	.	.
Primula vulgaris	C	.	.	.	1	.	r	.	.	.	.	.	.	.	1	.	.	.	.
Fagetalia																			
Symphytum tuberosum	C	-	.	-	.	+	-	r	.	r	+	.	r	.	+	.	r	.	.
Aremonia agrimonoides	C	r	1	.	r	1	.	.	r	r	.	.	.	.	.	.	.	.	.
Poa nemoralis	C		.	.			.	.			1	r	.	r		.		.	
Pulmonaria officinalis	C	-	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Salvia glutinosa	C	.	.	.	r	.	r	.	.	.	.	.	.	.	r	.	.	.	.
Campanula trachelium	C	.	.					.					.		r	.	1	.	r
Epimedium alpinum	C	r	.	r	r	.		.	.		.		.			.		.	r
Sanicula europaea	C	-	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Asarum europaeum	C		1		r	.		.	r	.	.		.	.		.		.	.
Geranium robertianum	C		r		.	r		.	-		.		.	.		.		.	.
Euphorbia amygdaloides	C	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r
Epipactis helleborine	C	r	.	r	.	.		.	.	.	.	.	.	.	.	.		.	r
Rhamno-Prunetea																			
Crataegus monogyna	B	2	2	-	2	+	r	1	-	+	r	-	+	.	+	+		.	+
Prunus spinosa	B	r	r	-	+	r	.	r	.	r	+	-	r	+	.	r	.	+	.
Clematis vitalba	B		1	.	1	1		1	1		.		r	1	1	r	.	.	1
Rubus canescens	B	-	.	1	+	.		.	.	r	1	1	+	+	.	+		r	.
Ligustrum vulgare	B	.	1	.	+	2	.	.	.	.	+	.	+	1	.	+	.	.	.
Cornus sanguinea	B		.	.	1	.		1	2		.	.	1	.		1		.	.
Cotinus coggygria	B		.		.	.		3	.	.	.		+	.	.	r		.	.
Trifolio-Geranietea																			
Dorycnium pentaphyllum subsp. *germanicum*	C	r	.	2	r	.		1	.		1		1	1		1	1	1	.
Peucedanum cervaria	C	r	.		r	.		.	.	.	.		r	1	r	r	r	.	.
Astragalus glycyphyllos	C	-	.	.	r	+	.	.		.	.		.	.	.	.	1	r	.
Coronilla varia	C		.		.	.		2	.		.		1	r		.	1	1	.
Trifolium alpestre	C	-	.		.	.		r	.	.	.		+	.	.	+	.	.	.
Hypericum perforatum	C	.	.	.	.	.	.	+	-	.	.	.	.	r	r	.	.	.	.
Lathyrus pratensis	C	.	.	.	.	.	.	.	r	.	.	.	1	.	.	r	.	.	.
Silene viridiflora	C		.	r	.	.		r		.	.		r			.	.	.	.
Vicia incana	C	-	.	.	.	.	r	.	-	.	.	.	.	.	.	.	.	.	.

Festuco-Brometea																			
Teucrium chamaedrys	C	r	1	1	r	.		1	1		1		1	1	r	1	.	1	.
Euphorbia cyparissias	C	r	r	−	.	.		.	.	r	+	r	.	+	.	.		+	.
Filipendula vulgaris	C	.	.	−	.	+	−	.	.	+	+	r	.	.	.	.	.	.	.
Carex caryophyllea	C	.	.	.	1	.	.	1	.	1	.	.	.	.	.	1	.	.	.
Allium carinatum	C		.		.	.	r	r				.	.	r		.		.	
Thymus pulegioides	C	.	.	r	.	.	.	.	.	.	+	.	.	1	.	.	.	+	.
Lotus corniculatus	C	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Galium verum	C	r	.		r			.			1		.			.		.	
Trifolium montanum	C	r	.	−	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Scabiosa cinerea	C	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Pimpinella saxifraga	C	.	.	.				.	.				.			.		.	
Companions																			
Juniperus communis	B	.	.	.	1	.	.	.	.	.	.	.	r	1	.	.	.	1	.
Chamaecytisus supinus	B	.	1		r			.					.			.	1	.	
Chamaecytisus hirsutus agg.	B	.	.	−	.	.	.	.	.	.	.	.	r	.	.	r	.	.	.
Juglans regia	B	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r
Pteridium aquilinum	C	.	.	1	r		.	.	.	r	1	r	.		r	.		.	
Verbascum nigrum s.l.	C	r	.	−	.	r	.	.	.	r	.	.	r	.	.	r	.	.	.
Hieracium sabaudum	C	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	r	.	.
Galium mollugo agg.	C		r				.	.		1		.	.			.		.	
Galium aparine	C	.	.	.	.	+	.	r	.	.	.	r	.	.	.	.	.	.	.

In one or two relevés:

A. *Ostrya* carpinifolia 18:1. Sorbus *aria* 9.1. *Ulmus minor* 7.−:

B: *Acer platanoides* 6:r: *Acer pseudoplatanus* 1:r, 14:r: *Acer tataricum* 14:r; *Euonymus verrucosus* 2:−; *Fagus sylvatica* 3:r, 14:r: *Lonicera xylosteum* 2:1; *Malus sylvestris* 2:r, 12:+; *Ostrya* carpinifolia 11:−. 15:−: Populus *tremula* 3.r. *Rhamnus catharticus* 5:r: *Rosa canina* 3:1. 8.+. *Rosa gallica* 5:+: *Salix caprea* 3:r: *Sorbus aria* 2.+. *Sorbus domestica* 1:r. 4:r: *Staphylea pinnata* 18:r. *Tilia cordata* 1:r: *Ulmus minor* 2.+. 7:−: *Viburnum lantana* 16.1. 18.2:

C: *Achillea millefolium* 3:r; *Ajuga reptans* 3:r: *Anemone nemorosa* 2:1, 6:+: *Anthericum ramosum* 16:1: *Aposeris foetida* 1:1, 4:1: *Arabis hirsuta* 2:r: *Arabis turrita* 2:r. 8:1; *Arum maculatum* 5:r: *Asperula purpurea* 7:+. 15:+: *Asplenium trichomanes* 2:−. 8:1: *Briza media* 10:+: *Bromus erectus* agg. 2:−. 9:+: *Bromus ramosus* agg. 2:r. 5:−: *Buphthalmum salicifolium* 5:+. *Calluna vulgaris* 3:−: *Calystegia silvatica* 7:−. 12:r: *Campanula patula* 3:r: *Campanula persicifolia* 4:r. 16:+: *Cardamine enneaphyllos* 2.r. *Cardamine impatiens* 7.1: *Carex digitata* 2:1. *Carex divulsa* s.l. 7.1. 13:r: *Carex sylvatica* 4:r. 14:r: *Cirsium arvense* 3.r. 10:+: *Colchicum autumnale* 2:+. 9:r; *Cruciata laevipes* 5:r; *Cyclamen purpurascens* 2:+; *Daucus carota* 10:r; *Digitalis ferruginea* 2:r; *Digitalis grandiflora* 15:r, 16:+; *Dryopteris filix-mas* 2:r; *Elymus repens* 7:+, 13:1; *Epipactis atrorubens* 10:r; *Epipactis microphylla* 1.r. *Ferulago sylvatica* 5.1: *Festuca pseudovina* agg. 8:−: *Helianthemum nummularium* 3.−. *Helleborus multifidus* 5.+. *Hepatica nobilis* 2:r. *Heracleum sphondylium* 9.+. *Hieracium murorum* 1.−. *Hieracium piloselloides* 7:r; *Hieracium praealtum* subsp. *bauhinii* 3:1; *Inula hirta* 16:2; *Knautia drymeia* 1:1; *Lapsana communis* 5:r; *Lathyrus vernus* 2:r. 18:+; *Lilium martagon* 2:1; *Limodorum abortivum* 13:+; *Linum usitatissimum* 3:−: *Listera ovata* 2:−: *Luzula forsteri* 6:+: *Lychnis coronaria* 5:r. *Medicago falcata* 13:−: *Medicago lupulina* 8:−: *Melica ciliata* 7:r: *Melilotus officinalis* 10:r: *Mercurialis perennis* 6:r: *Mycelis muralis* 9:r: *Myosotis sylvatica* 7:1: *Neottia nidus-avis* 6:r; *Orchis mascula* subsp. *signifera* 3:r; *Orchis purpurea* 5:1; *Origanum vulgare* 7:1; *Ornithogalum pyrenaicum* 5:r. 11:r: *Peucedanum carvifolia* 3:+. 10:+; *Peucedanum oreoselinum* 1:r. 3:−: *Picris hieracioides* 3:+. 10:+; *Plantago lanceolata* 3:−; *Plantago media* 10:+; *Platanthera bifolia* 3:r: *Platanthera chlorantha* 2:−; *Poa angustifolia* 5:r. 9:−: *Poa pratensis* 1:r, 13:+: *Poa trivialis* s.l. 3:−: *Polygala comosa* 3.−. 10.+: *Polypodium vulgare* 8.+. *Ranunculus serpens* 3:r. 10.r. *Sanguisorba minor* s.l. 3.+. 10:+. *Scutellaria altissima* 12.r. 15.r. *Sedum album* 8:2. *Sedum hispanicum* 8:−. *Sedum telephium* subsp. *maximum* 2.r. 11.r: *Serratula tinctoria* 4:r: *Silene italica* 6:+; *Silene nemoralis* 1:r; *Silene vulgaris* 10:−. 13:1; *Smyrnium perfoliatum* 5:+; *Solidago virgaurea* 16:−; *Stachys recta* s.l. 7:−: *Stellaria holostea* 7:−. 15:r: *Taraxacum officinale* 5:r: *Torilis arvensis* 8:+. *Trifolium pratense* 10:r. 12:−. *Trifolium rubens* 1:r. *Veronica officinalis* 3:r: *Veronica urticifolia* 18:r. *Vicia cassubica* 4:r. 9:r: *Vicia cordata* 1.r. 8.r. *Vicia cracca* 3.+. *Vicia hirsuta* 12.r.

Details of relevés (indicated in the following order: relevé number, GIVD EU-BA-001 relevé number, relevé area (m^2), altitude (m), aspect, slope (degrees), cover (%) A-B-C, species richness (total), date (year/ month/day), description of locality, latitude, longitude) : 1, 175, 400, 605, SE, 25, 100-90-80, 72, 20120608, Gornja Paklenica (Ozren), 44.629666, 18.162072; 2, 26, 200, 830, W, 7, 60-70-70, 63, 20110518, Lunjevac-Grabež (Grabež), 44.616287, 17.036486; 3, 37, 400, 610, S, 15, 60-30-100, 60, 20110529, Preslica-Kremenjak (Ozren), 44.632978, 18.160477; 4, 176, 400, 620, SE, 25, 100-90-50, 56, 20120608, Gornja Paklenica (Ozren), 44.629253, 18.161252; 5, 58, 600, 750, S, 10, 70-70-90, 49, 20110602, Gornja Suvaja (Bos. Petrovac), 44.620666, 16.308606; 6, 190, 400, 890, S, 15, 80-90-60, 44, 20120615, Lisina (Kozara), 44.968003, 16.971268; 7, 214, 400, 480, S, 27, 70-60-30, 45, 20120622, Ruj (Ozren), 44.626437, 18.116014; 8, 36, 200, 607, SE, 35, 40-80-10, 47, 20110529, Preslica-Kremenjak (Ozren), 44.633685, 18.160882; 9, 189, 900, 890, S, 11, 60-50-60, 43, 20120615, Lisina (Kozara), 44.968057, 16.973232; 10, 38, 200, 603, S, 15, 60-50-100, 45, 20110529, Preslica-Kremenjak (Ozren), 44.632674, 18.160281; 11, 193, 400, 740, E, 16, 90-80-60, 38, 20120615, Lisina (Kozara), 44.964543, 16.975779; 12, 217, 400, 500, S, 20, 60-80-60, 41, 20120622, Ruj (Ozren), 44.626173, 18.118823; 13, 90, 100, 375, S, 30, 40-90-90, 41, 20110701, Doborovci-Prisoje (Majevica), 44.754918, 18.377155; 14, 177, 400, 450, S, 25, 100-90-10, 34, 20120608, Gornja Paklenica (Ozren), 44.620548, 18.163193; 15, 216, 400, 530, S, 28, 70-80-50, 37, 20120622, Ruj (Ozren), 44.626669, 18.118257; 16, 86, 300, 281, SE, 22, 50-70-80, 38, 20110630, Ugljevik (Prokos), 44.683993, 18.993239; 17, 87, 200, 370, S, 40, 60-10-40, 29, 20110701, Doborovci-Prisoje (Majevica), 44.754763, 18.377393; 18, 85, 200, 285, S, 18, 70-90-10, 30, 20110630, Prokos (Ugljevik), 44.683786, 18.992483

ANNEX K

Phytosociological table of the association *Aceri obtusati-Quercetum petraeae* presented in chapter 2.3 (therein referred to as Supplement S3).

Stupar et al.: Thermophilous deciduous forests (*Quercetalia pubescentis*) of Bosnia and Herzegovina

Supplement S3. *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco, holotypus: relevé 9 (A1 - upper tree layer, A2 - lower tree layer, B - shrub layer, C - herb layer).

Beilage S3. *Aceri obtusati-Quercetum petraeae* ass. nov. hoc loco, Holotypus: Aufnahme 9 (A1 - obere Baumschicht, A2 - untere Baumschicht, B - Strauchschicht, C - Krautschicht).

Relevé number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Characteristic species of the association																			
Quercus petraea agg.	A1	4	4	5	4	3	5	5	3	3	3	3	3	3	3	3	3	4	3
	B	.	2	2	.	3	.	1	.	1	1	2	2	1	.	.	.	.	ı
	C	3	.	.	.	.	1	.	+	1	3	1	1	1	+	.	–	.	.
Carpinus orientalis	A2	4	4	1	2	5	3	4	3	2	3	3	2	5	1	2	.	2	5
	B	.	1	2	1	1	4	2	4	1	1	1	1	2	4	1	2	ı	.
Carpinus betulus	A2	1	+	+	r	.	.	1	.	2	2	4	3	1	+	4	.	1	.
	B	+	+	.	.	r	+	1	r	2	–	–	.	.	.	–	–	.	+
Acer obtusatum	A2	ı	2	2	.	.	.	ı	1	2	.	.	ı	2	ı	2	.	.	.
	B	ı	1	2	.	.	ı	ı	.	.	1	.	ı	1	.	.	1	ı	.
Helleborus odorus	C	+	+	r	–	–	+	+	r	–	1	–	+	+	+	–	–	1	+
Cruciata glabra	C	1	r	+	1	–	+	1	+	–	–	–	+	+	1	–	–	+	1
Quercetalia pubescentis																			
Fraxinus ornus	A2	+	1	1	–	1	+	1	1	.	1	.	+	1	+	2	2	.	.
	B	1	1	2	1	1	+	1	.	1	1	.	1	1	2	1	2	+	+
Sorbus torminalis	A2	.	.	.	.	.	.	ı	.	.	1	2	.	1	.	.	.	ı	.
	B	ı	ı	2	.	.	2	1	ı	1	1	.	ı	1	ı	r	.	ı	ı
Quercus pubescens	A2	.	.	.	.	.	.	1	.	.	1	2	.	.	.	1	.	.	.
	B	.	.	.	.	.	.	+	.	.	.	–	.	.	.	–	.	.	.
Cornus mas	B	.	.	2	2	1	.	1	1	1	2	2	ı	.	ı	.	2	2	2
Euonymus verrucosus	B	.	.	.	–	.	.	.	1	.	.	.	.	.	r	.	.	+	+
Tamus communis	C	2	+	.	–	r	+	+	+	–	–	1	+	+	+	–	–	.	+
Festuca heterophylla	C	1	.	2	1	.	2	1	r	.	1	1	.	.	ı	.	2	.	.
Potentilla micrantha	C	.	ı	ı	.	.	1	1	r	.	.	.	.	.	.	.	.	ı	.
Lathyrus niger	C	+	+	r	.	–	.	1	+	2	2	.	+	.	.	r	.	+	.
Lathyrus venetus	C	.	.	.	–	–	1	+	.	–	.	.	.	1	+	.	–	+	.
Melittis melissophyllum	C	1	.	.	.	.	.	.	.	.	.	.	ı	.	r	.	.	.	.
Tanacetum corymbosum	C	r	r	.	.	r	+	.	.	–	–	.	.	.	.	r	–	.	.
Viola hirta agg.	C	.	r	r	–	.	r	.	.	r	.	r	.	.	.	.	–	+	.
Buglossoides purpurocaerulea	C	.	.	.	.	.	ı	r	ı	r	1	.	.	ı	.	.	.	.	.
Carex flacca s.l.	C	.	ı	.	.	.	.	ı	2	.	.	1	.	.	.	.	.	.	.
Veratrum nigrum	C	.	r	.	.	r	.	.	.	–	–	.	.	.	.	–	.	.	.
Clinopodium vulgare	C	.	r	+	.	.	.	.	.	.	.	–	.	.	.	.	–	.	+
Luzula forsteri	C	.	ı	ı	.	.	ı	.	.	.	.	.	.	.	r	.	.	.	.
Calamintha sylvatica	C	.	ı	.	.	.	.	.	.	.	.	.	ı	.	.	.	.	ı	.
Asparagus tenuifolius	C	ı	.	.	.	.	ı	.	.	.	r	.	.	.	.	.	.	.	.
Sesleria autumnalis	C	.	r	.	.	3	.	.	.	4	.	.	.	2	.	.	.	.	.
Campanula persicifolia	C	r	.	r	–	.	.	.	.	.	.	.	.	r	.	.	.	.	.
Platanthera chlorantha	C	.	.	.	.	.	ı	.	.	.	r	.	ı	.	.	.	.	.	.
Iris graminea	C	.	.	.	.	.	+	.	r	.	r	.	.	.	.	.	.	.	.
Betonica officinalis	C	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	–	.	.
Querco-Fagetea																			
Acer campestre	A2	ı	ı	.	.	1	.	ı	.	.	1	1	ı	1	ı	.	.	.	ı
	B	1	+	+	–	1	1	1	+	–	–	1	1	1	.	.	1	1	1
Pyrus pyraster	A2	.	1	.	–	.	.	.	1	.	.	.	.	.	.	.	.	.	.
	B	2	ı	ı	.	.	2	ı	2	.	2	.	.	.	.	.	.	ı	ı
Malus sylvestris	B	1	r	.	.	r	1	.	.	.	.	.	.	.	.	.	–	.	.
Rosa arvensis	B	2	+	1	.	–	2	1	r	–	–	–	2	+	+	1	2	1	+
Hedera helix	B	.	ı	ı	.	.	.	ı	2	r	.	.	2	r	1	r	.	.	ı
Corylus avellana	B	1	.	ı	.	.	.	.	.	.	.	.	ı	.	ı	.	.	.	r
Rubus hirtus	B	.	r	r	.	.	.	.	.	.	.	.	.	1	r	.	.	.	+
Glechoma hirsuta	C	.	.	.	3	.	1	+	+	–	r	.	+	+	+	–	–	.	4
Brachypodium sylvaticum	C	ı	.	1	.	.	1	1	.	.	1	1	1	1	.	.	.	.	.
Melica uniflora	C	2	+	+	1	r	.	.	.	2	.	.	.	2	+	2	.	+	+
Dactylis glomerata s.l.	C	r	.	.	1	r	1	r	.	–	–	–	.	+	.	.	–	.	.
Ajuga reptans	C	ı	r	r	.	.	.	ı	r	.	.	.	.	.	.	r	.	ı	ı
Veronica chamaedrys	C	.	ı	r	1	.	.	ı	.	.	.	r	.	.	ı	r	.	.	ı
Galium schultesii	C	.	+	r	.	r	.	.	+	–	2	1	.	.	+	1	.	.	.
Geum urbanum	C	1	.	.	1	.	+	.	.	–	.	.	.	.	+	.	–	.	1
Fragaria moschata	C	.	.	.	.	.	.	ı	ı	.	.	1	.	1	.	.	.	.	ı
Poa nemoralis	C	+	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	1
Hepatica nobilis	C	.	.	.	.	.	.	.	.	–	.	.	.	.	.	–	.	+	.
Carpinion, Erythronio-Carpinion																			
Prunus avium	A2	.	ı	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.
	B	1	+	.	–	r	+	r	2	–	1	1	2	+	+	.	1	.	.
Tilia platyphyllos	A1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
	B	.	.	.	.	.	.	.	.	r	.	.	ı	r	.	.	.	.	.

Primula vulgaris	C	–	.	r	+	+	r	+	.	1	1	+	.	+	+	1	1	–	–
Aposeris foetida	C	.	.	r	.	.	.	1	.	+	1	.	1	.	.	.	.	1	.
Cyclamen purpurascens	C	.	.	.	.	.	.	.	r	+	.	.	.	r	.	–	–	–	–
Ornithogalum pyrenaicum	C	r	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Fagetalia																			
Fagus sylvatica	B	.	r	.	.	.	.	.	.	+	.	+	.	.	.	r	.	.	.
Sanicula europaea	C	1	.	.	+	r	.	+	.	1	+	+	2	+	+	r	.	.	.
Symphytum tuberosum	C	1	.	.	+	.	+	r	r	+	+	.	+	+	+	–	.	.	–
Aremonia agrimonoides	C	1	+	.	1	+	.	1	.	.	.	r	.	+	+	–	–	–	1
Stellaria holostea	C	1	.	+	1	.	1	.	.	+	+	.	.	1	.	.	.	.	2
Pulmonaria officinalis	C	.	.	.	+	.	.	.	.	+	+	.	+	+	+	–	.	.	–
Lathyrus vernus	C	1	r	+	.	.	+	.	r	.	+	.	.	.	.	.	.	.	.
Cephalanthera longifolia	C	.	+	.	.	.	.	r	.	.	.	+	+	r	r	.	.	.	.
Cardamine bulbifera	C	.	.	.	.	.	.	.	r	.	r	.	.	+	+	–	.	.	–
Carex sylvatica	C	.	.	.	.	r	.	.	+	+	1	.	2	+	.	.	.	.	.
Asarum europaeum	C	–	.	r	.	.	.	.	.	+	.	.	.	r	.	.	.	–	.
Lilium martagon	C	.	r	.	.	r	.	.	r	+	.	.	.	.	.	.	.	.	.
Galium odoratum	C	.	r	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.
Campanula trachelium	C	.	.	r	.	.	.	.	.	r	.	r	.	.	.	r	.	.	.
Polygonatum multiflorum	C	.	+	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.
Euphorbia amygdaloides	C	.	.	.	.	.	.	.	.	r	+	.	.	.	+	.	.	.	.
Anemone nemorosa	C	.	.	.	.	.	.	.	r	1	.	.	.	.	.	1	.	.	.
Polystichum setiferum	C	.	r	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.
Geranium robertianum	C	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	–	.
Rhamno-Prunetea																			
Crataegus monogyna	B	2	+	+	+	2	+	+	+	+	2	2	+	+	2	r	2	.	2
Ligustrum vulgare	B	2	.	+	1	+	+	+	+	+	+	1	+	1	2	.	2	–	2
Viburnum lantana	B	2	.	.	+	.	.	r	+	+	2	.	+	.	.	.	2	.	2
Clematis vitalba	B	.	.	.	.	.	+	.	.	.	.	+	+	+	.	.	–	–	–
Cornus sanguinea	B	.	+	+	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Prunus spinosa	B	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.
Companions																			
Acer tataricum	B	.	.	.	+	.	.	.	2	+	+	1	+	.	.	.	.	.	.
Juniperus communis	B	.	+	.	.	.	1	r	.	.	+	r	.	.	.	.	.	.	.
Fragaria vesca	C	.	.	.	.	.	.	.	.	+	+	.	+	+	+	.	.	.	.
Hieracium sabaudum	C	.	.	.	.	r	1	1	.	.	r	r	.	r	.	.	.	.	.
Pteridium aquilinum	C	.	.	r	r	.	.	.	.	.	r	+	+	.	.	.	.	.	.
Smyrnium perfoliatum	C	.	.	.	+	.	r	.	.	.	+	.	.	.	.	1	.	.	.
Asplenium trichomanes	C	.	.	.	.	r	.	.	.	.	.	.	.	+	+	.	.	.	.
Galium mollugo agg.	C	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	r	.	.
Colchicum autumnale	C	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Serratula tinctoria	C	.	.	.	.	.	r	.	.	+	+	.	.	.	.	.	.	.	.

In one or two relevés:

A1: *Acer pseudoplatanus* 15:1; *Fagus sylvatica* 9:1; *Quercus cerris* 11:2; *Tilia tomentosa* 8:2;

A2: *Acer hyrcanum* subsp. *intermedium* 16:+; *Acer monspessulanum* 15:1; *Cotinus coggygria* 8:1; *Populus tremula* 4:r; *Quercus robur* 4:r, 16:1;

B: *Acer hyrcanum* subsp. *intermedium* 16:+; *Acer monspessulanum* 9:+; *Acer pseudoplatanus* 12:r; *Chamaecytisus hirsutus* agg. 10:r; *Cotinus coggygria* 8:2; *Euonymus europaeus* 16:+; *Genista tinctoria* 2:r; *Ilex aquifolium* 12:+; *Juglans regia* 6:r; *Rosa canina* 16:+; *Rosa gallica* 4:+; *Rubus canescens* 11:r, 17:+; *Rubus fruticosus* agg. 16:+; *Ruscus aculeatus* 8:1; *Ruscus hypoglossum* 8:+; *Sorbus domestica* 10:+; *Tilia tomentosa* 16:+; *Ulmus glabra* 12:+;

C: *Acer tataricum* 4:+, 8:–; *Aegopodium podagraria* 4:r; *Agrimonia eupatoria* 12:+; *Allium carinatum* 16:r, 17:+; *Anemone ranunculoides* 13:+; *Anthyllis vulneraria* s.l. 16:r; *Arabis turrita* 13:r; *Aristolochia lutea* 12:+, 14:+; *Arum maculatum* 15:–; *Asplenium adiantum-nigrum* 5:–; *Brachypodium pinnatum* s.l. 10:r, 11:1; *Bromus ramosus* agg. 15:r; *Campanula rapunculus* 4:r; *Carex caryophyllea* 3:r, 11:+; *Carex digitata* 13:+; *Carex divulsa* s.l. 3:r; *Carex humilis* 17:+; *Carex montana* 10:–, 18:r; *Carex pilosa* 9:1, 15:2; *Centaurium erythraea* 17:r; *Cephalanthera damasonium* 10:r; *Crocus vernus* 10:–, 15:+; *Daucus carota* 16:r; *Dorycnium pentaphyllum* subsp. *germanicum* 11:r; *Dryopteris filix-mas* 15:+; *Epimedium alpinum* 8:+, 12:3; *Epipactis helleborine* 12:r; *Erythronium dens-canis* 15:r; *Euphorbia cyparissias* 11:r, 16:r; *Fagus sylvatica* 17:+; *Festuca drymeja* 8:–; *Festuca pseudovina* agg. 11:–; *Filipendula vulgaris* 17:–; *Fragaria viridis* 6:1, 16:2; *Galanthus nivalis* 15:–; *Galium lucidum* 3:–, 17:r; *Geranium phaeum* 16:r; *Heracleum sphondylium* 12:+; *Hieracium pilosella* 17:r; *Knautia drymeia* 10:r, 12:+; *Lamiastrum galeobdolon* s.l. 15:r, 18:1; *Lapsana communis* 3:+, 4:r; *Limodorum abortivum* 12:r; *Luzula pilosa* 18:+; *Melampyrum nemorosum* 5:r, 10:+; *Melica nutans* 8:+, 10:+; *Mercurialis perennis* 13:r; *Milium effusum* 3:r; *Moehringia trinervia* 2:r; *Monotropa hypopitys* 1:r; *Mycelis muralis* 4:r, 12:+; *Neottia nidus-avis* 1:1; *Orchis mascula* subsp. *signifera* 8:r; *Orchis pallens* 8:r; *Orchis purpurea* 10:+; *Peltaria alliacea* 16:r; *Peucedanum cervaria* 10:r; *Pimpinella saxifraga* 11:+; *Poa angustifolia* 11:+; *Poa bulbosa* 18:+; *Poa pratensis* 18:+; *Poa stiriaca* 1:+; *Poa trivialis* s.l. 11:+; *Prunella laciniata* 17:r; *Prunella vulgaris* 16:+, 18:+; *Quercus robur* 16:+; *Salvia glutinosa* 11:r; *Scabiosa cinerea* 17:r; *Scrophularia canina* 4:r; *Sedum ochroleucum* 4:+; *Sedum telephium* subsp. *maximum* 5:r; *Silene viridiflora* 3:r, 10:r; *Taraxacum officinale* 7:r, 18:r; *Teucrium chamaedrys* 17:+; *Torilis arvensis* 3:r; *Vicia incana* 6:r; *Vicia sepium* 16:+; *Vincetoxicum hirundinaria* 5:r, 8:r;

Details of relevés (indicated in the following order: relevé number, GIVD EU-BA-001 relevé number, relevé area (m^2), altitude (m), aspect, slope (degrees), cover (%) A1-A2-B-C, species richness (total), date (year/ month/day), description of locality, latitude, longitude): 1. 357, 600, 630, W, 7, 70-90-40-70, 42, 20060714, Lokvari (Čemernica), 44.478096, 17.221944; 2. 273, 900, 670, SE, 20, 60-80-20-20, 44, 20120715, Macanovići (Gornji Ribnik), 44.414359, 16.791114; 3. 205, 900, 550, S, 20, 80-20-90-40, 44, 20120619, Pod Kozaračkim kamenom (Kozara), 44.999114, 16.851495; 4. 353, 400, 390, SW, 24, 70-10-20-50, 47, 20060622, Zanjive (Čemernica), 44.482548, 17.189132; 5. 272, 400, 630, SW, 25, 50-90-10-60, 43, 20120715, Macanovići (Gornji Ribnik), 44.415449, 16.79457; 6. 382, 400, 740, S, 16, 80-30-80-75, 42, 20070428, Gradina-Lakići (Čemernica), 44.481725, 17.232884; 7. 308, 400, 330, S, 12, 90-70-40-50, 40, 20140624, Ćićina kosa-Gradina (Bočac), 44.545322, 17.147555; 8. 20, 400, 390, SE, 22, 40-60-75-35, 49, 20110512, Orlovača (Starčevica), 44.746764, 17.183268; 9. 124, 900, 575, W, 15, 60-90-20-70, 57, 20120519, Šehovci-Kalabuša (Manjača), 44.47012, 17.153803; 10. 117, 400, 545, W, 15, 35-70-30-70, 67, 20120519, Šehovci-Kojići (Manjača), 44.47, 17.151052; 11. 140, 400, 396, SE, 15, 40-90-20-20, 49, 20120528, Čokori (Manjača), 44.792985, 17.106228; 12. 1083, 400, 350, SW, 22, 40-30-70-70, 50, 20030514, Cer (Starčevica), 44.750141, 17.210474; 13. 125, 400, 508, NE, 20, 40-90-50-80, 49, 20120519, Dabrac-Bujadnica (Manjača), 44.486072, 17.157986; 14. 1099, 400, 560, SE, 20, 50-70-90-20, 40, 20100615, Međugorje-Gajići (Manjača), 44.680146, 17.068446; 15. 123, 900, 573, NE, 22, 50-40-10-60, 59, 20120519, Šehovci-Budelj (Manjača), 44.466552, 17.158128; 16. 391, 400, 505, -, 4, 45-10-80-40, 56, 20070811, Gajevi (Čemernica), 44.498221, 17.193166; 17. 355, 400, 480, W, 14, 70-20-5-10, 42, 20060711, Papazov do (Čemernica), 44.51283, 17.1908; 18. 403, 400, 550, W, 7, 40-90-30-90, 44, 20090513, Duge njive (Čemernica), 44.542332, 17.18897.

ANNEX L

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Zagreb May 23rd, 2016.

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