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Forest habitats on the territory of the National Park "Central Balkan" Bulgaria

Ivaylo Dimitrov Nikolov[1] & Marius Alipiev Dimitrov[2]

Key words: classification, diagnostic species, environmental variables, syntaxa.

Ključne besede: klasifikacija, diagnostične vrste, okoljske spremenljivke, sintaksoni.

Abstract

Identification and characterization of forest habitats on the territory of the "Central Balkan" National Park in Bulgaria was carried out. The national park is one of the most valuable and largest protected areas in Europe – second category according to the International Union for Conservation of Nature (IUCN). Based on 786 phytosociological relevés, a total of 17 different habitat types, according to EUNIS were identified and mapped. The habitats were ecologically characterized by Ellenberg indicator values and their area was determined. A comparison was made with the areas determined in previous works. The applied method is suitable for the purposes of managing protected territories and zones, for monitoring the status and especially the conservation status of the habitats. The results and especially the established new habitats support this point of view.

Izvleček

V članku predstavljamo gozdne habitate, ki smo jih prepoznali in opisali na območju nacionalnega parka "Centralni Balkan" v Bolgariji. Nacionalni park je eno najpomebnejših in največjih zaščitenih območij v Evropi – spada v drugo kategorijo v skladu z Mednardno zvezo za ohranjanje narave (IUCN). Na osnovi 786 fitocenoloških popisov smo prepoznali in kartirali 17 različnih habitatnih tipov po EUNIS tipologiji. Habitate smo ekološko opisali z Ellenbergovimi indikatorskimi vrednostmi in opredelili njihovo območje razširjenosti. Velikost območij smo primerjali z dosedaj objavljenimi površinami. Uporabljena metoda je primerna za namene gospodarjenja z zaščitenimi območji in conami in za monitoring ohranitvenega statusa habitatov. Rezultati in predvsem prikazani novi habitatni tipi to podpirajo.

Corresponding author:
Marius Alipiev Dimitrov
E-mail: mariusdimitrov@ltu.bg

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1 Directorate of National Park „Central Balkan", office Troyan, Bulgaria.

2 University of forestry, Sofia, Bulgaria.

Introduction

Natural habitats are an important element of biological diversity. They are prioritized in major environmental protection documents on a global and European level: Convention on Biological Diversity (1992), Pan-European Strategy for the Protection of the Biological and Landscape Diversity (1996), Directive 92/43/EEC for the conservation of habitats and wild flora and fauna (1992), Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979; Tzonev et al., 2015). Plant communities are the most recongizable part of habitats. In this sense, the defining of the habitats is directly related and depends on the classification of plant communities. The most widely applied classification of plant communities follows the principles of Braun-Blanquet's approach (Braun-Blanquet, 1964). Habitats are identified by the appearance of certain communities assigned to syntaxa from different syntaxonomic categories and under certain environmental conditions (Spribille et al., 2001; Rodwell et al., 2002).

National Park Central Balkan (NPCB) has been the subject of several studies related to biological diversity, including ones related to the ascertainment, charactherisation and mapping of plant communities and natural habitats (Michalik, 1990, 1992, 1993; Penev & Georgiev, 1958; Kočev, 1969; Bondev, 1991; Apostolova & Meshinev, 2000; Pachedjieva, 2012; Stefanov, 2013; Nikolov & Dimitrov, 2015; Tzonev et al., 2006, 2009, 2012, 2013, 2017, 2019).

The most complete classification of the habitat communities was made during the development of the management plan of the NPCB (Stefanov, 2013). The classification scheme includes syntaxa identified in the territory, both as a result of phytosociological studies (incl. relevés) (Tzonev et al., 2006, 2017, 2019; Nikolov & Dimitrov, 2015), and based on data from studies of a mostly descriptive and heuristic nature (without relevés) (Tzonev et al., 2013). The identification of forest habitats was also done by carrying out activities under several projects financed by the European Union, which have been implemented by modeling the database of forest inventory. During the implementation of various projects 12 (Marin, 2007; Nedyalkov, 2013) or 13 (Dragolov et al., 2013) habitats were identified and mapped, but the total area and the area of individual habitat types differed significantly. The reasons for the area differences are mainly because much of the previous mapping was made using rigid short field seasons of 2–4 months, without the use of numerical methods and without physociological analysis. The largest differences in area are found in habitat 91M0 (Pannonian-Balkanic Turkey oak-sessile oak forests). For beech habitats, only a redistribution of areas between 9130 (*Asperulo-Fagetum* beech forests), 9150 (Medio-European limestone beech forests of the *Cephalanthero-Fagion*) and 9110 (*Luzulo-Fagetum* beech forests) is reported.

To a large extent, the previous mappings of habitats was carried out by modelling and using the database of forest inventory without serious phytocoenotic field surveys. This determines the need for the accumulation of quantitative data and the use of actual, objective methods for the classification and ecological analysis of forest habitats, necessary for the sustainable management. In addition, some of the forest habitat types on the territory of the NPCB are not included in Annex 1 of Directive 92/43 and the Biodiversity Act in Bulgaria. Due to the mentioned facts in the present mapping the forest habitats are classified according to EUNIS (Davis et al., 2004) linking to relevant habitats according Annex 1 of Directive 92/43 where possible.

The scope of study is the forest habitats on the territory of "Central Balkan" National Park.

Object and Methods

Study area

Morpho-structurally, it is part of the orogenic (alpine) mountain system of Stara Planina, which belongs to the Alpine folded system (Dilinska, 2013). Phytogeographically, the Park falls within the Meridional Zone, Sub-Mediterranean Region, Balkan Province (Meusel & Jäger, 1992). In a national context, the study area is part of the European Broadleaf Forest Area, Balkan Province, Central Balkan District (Bondev, 2002).

The lowest point of the NPCB is 600 m and the highest is 2376 m. The predominant part of the park's territory is located at an altitude of more than 1000 m, in the zone of the mountain climatic region. The climate in the northern parts of NPCB is moderately continental, in the south parts is transitional continental. The northern part of muontain is characterized by a cold winter with average January temperatures of -1.5 °C – 3.5 °C and a cool summer with temperatures of 16 °C – 22 °C. The southern part has average January temperatures of 0 °C – 1.5 °C and summer 17 °C – 21 °C. Four main zones are outlined in the study area, depending on the temperature-precipitation regime, differentiated by altitude: sub-mountainous, low-mountaious, high-mountainous, sub-alpine (Mirchev, 2013).

On the territory of the NPCB the main rocks are granites, sandstones, diorites, South Bulgarian granites, schists, porphyries, sometimes dolomites, etc. The most common soil types are Cambisols (Dystric and Eutric), on which 97% of forest communities develop. Chro-

Table 1: Climatic zones on the territory of National Park Central Balkan.
Tabela 1: Klimatske cone na območju Nacionalnega parka Centralni Balkan.

Climate zones	Slope elevation m.a.s.l.	Days with temperature above 10 °C num. of days	Duration of the vegetation season num. of months	Average annual temperature	Average annual precipitation mm/m²
Sub-mountainous	600–1000	160–190	5,5–6,0	8,0–9,0	560–680
Low-mountainous	1000–1500	115–150	4,0–5,0	4,5–7,0	830–950
High-mountainous	1500–2000	90–100	2,0–4,0	3,3–5,1	860–1050
Sub-alpine	2000–2376	60–90	1,0–2,0	(– 3,2)–2,1	1050–1300

mic Luvisols occupy 2.0% of the forest area in the park. About 0.8% of the forest communities are distributed on Umbric Cambisols, mainly in the high mountain boreal zone. Rendzinas are common in the karst areas of the park, consisting of rock fragments of the hard carbonate rock and with a thickness of 10 to 30 cm (Petrova, 2013).

Forests occupy around 57% of the entire territory of the park. A significant part of the total forest area (83%) is occupied by deciduous trees, and about 42% of the total park territory is covered with beech forests. The forests in the NPCB are in the altitude range of 600–1850 m a.s.l. and over 88% of the forests are located in the zone with altitude above 1000 m. Coniferous forests occupy a limited area mainly in the higher western and eastern parts of the park. The area of mixed forests is also relatively small. The beech forests together with those in the immediate vicinity of the park represent one of the most extensive and compact, relatively little affected by human activity, forest massifs of this kind in Europe. Thus, with Decisions adopted during the 41st session of the World Heritage Committee – WHC/17/41.COM/18 Krakow, 12 July 2017, the primeval beech forests in NPCB, as part of Ancient and Primeval Beech Forests of the Carpathians and other Regions of Europe, have been declared a natural

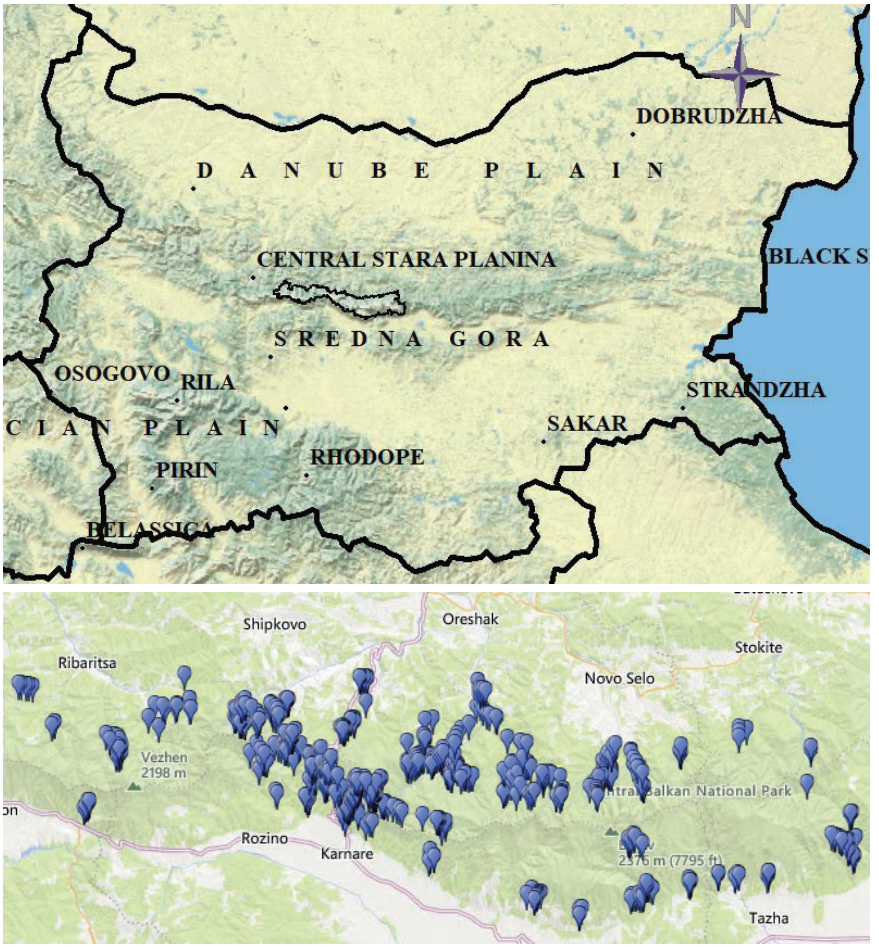

Figure 1: Location of study area and relevés.
Slika 1: Lokacija preučevanega območja in vegetacijskih popisov.

world heritage site by UNESCO (https://whc.unesco.org/archive/2017/whc17-41com-18-en.pdf). According to the last previous mapping the area of common beech forests is 29761 ha, of *Picea abies* forests is 1825 ha, of *Pinus peuce* communities is 338 ha, of *Abies alba* forests is 1243 ha, of *Pinus sylvestris* forests is 89 ha, of *Pinus nigra* ssp. *pallassiana* forests is 82 ha, Oak forests (mainly of *Quercus petraea*) cover an area of 963 ha (Sugarev & Stanev, 2013).

Vegetation data collection and processing

The Braun-Blanquet's approach was applied for classification of plant communities (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1978; Kent & Coker, 1992). Fieldwork includes 786 relevés made within four growing seasons 2011–2014. The Braun-Blanquet's combined scale (van der Maarel, 1979; Kent & Coker, 1992) was used to quantify taxa presence and cover. The surface of the relevés was 600 m^2 and is in accordance with the concept of minimum area of communities (Knapp, 1984; Chytrý & Otýpková, 2003).

The nomenclature of vascular plants is according to Delipavlov & Cheshmedzhiev (2003), and Euro+Med PlantBase (Euro+Med, 2006–2020).

JUICE software (Tichý, 2002) was used for data analysis. Vegetation classification was performed using Modified Twinspan (Roleček et al., 2009). For the pre-processing of the information, values indicated by numbers from 0 to 9 have been determined and assigned to the participation of species in the different floors according to their height (TURBOVEG). Sorensen similarity indices ≥ 0.3 were used. Floristic analysis was performed by creating three cluster models with the algorithms TWINSPAN (Hill, 1979), Modified TWINSPAN (Roleček & al., 2009) and K-means (MacQueen, 1967). A comparative analysis of these base matrices was made and the Modified TWINSPAN matrix (Roleček et al., 2009) was selected as the most reliable for vegetation. Subsequently, its environmental variables were subjected to multiple analyzes – PCA, DCA, MCA, cluster, etc. When describing the syntaxa themselves, the clusters from 51 increased to 58, and thanks to this, the groupings of *Morus alba*, *Tilia tomentosa, Abies alba*, etc. were separated. Within the present study, Fisher's exact test ($P < 0.05$) was applied to ensure statistical significance of the data. The Phi-coefficient (coefficient of association between species and plant units) was used to determine diagnostic species (Tichý et al., 2010). All values of Phi ≤0.05 were excluded from the study. After standardization, the fidelity measure 'phi' depends only on the relative frequencies within each group. In the present analysis, a "C" model is adopted which defines the target group of the specified size and then defines all other groups to be the same size as each other. As a threshold for the differentiation of the diagnostic species for each cluster, two values of the Phi coefficient were used (Sokal & Rohlf, 1995; Chytrý et al., 2002), Phi ≥ 0.3 for the differentiation of all diagnostic species and Phi ≥ 0.6 for the separation of the diagnostic species with high diagnostic value. Those with frequency threshold ≥ 50 (lower), ≥60 (higher) are considered constant species. Those with cover threshold ≥ 20 (lower), ≥ 60 (higher) are considered dominant species. StatSoft (2011) was used for the overall processing of the database.

Syntaxonomic classification follows Mucina et al. (2016) and the referenced literature (Horvat et al., 1974; Kojić et al., 1998; Roussakova & Dimitrov, 2005; Vukelić et al., 2007; Tzonev et al., 2006, 2009, 2017, 2019; Čarni et al., 2009; Matevski et al., 2011; Pachedzhieva, 2012; Apostolova & Meshinev, 2000, 2012; Chytrý, 2013; Vasilev & Gavrilova, 2015; Coldea et al., 2015; Nikolov & Dimitrov, 2015; Duda et al., 2016; Čarni, 2016a, b, Willner et al., 2017; Alexandrova et al., 2020; Petrova & Tzonev, 2020; Kalníková et al., 2021). The classification scheme also includes "communities" – syntaxa of undetermined rank, wich cannot be carried away to association due to the regional nature of the study. Phytocoenoses are classified to the variant level within the association and communities. The variants are perceived as local, floristic, differentiated parts of the association or communities. They reflect the ecological and syntaxonomic continuum within habitats.

Ecological characteristics

Indicator values of species were defined according to Ellenberg et al. (1992) and Tichy et al. (2023) imported into the JUICE 7.1.31. The following environmental variables are used "L" (Light) "T" (Temperature), "C" (Continentality), "M" (Moisture), "R" (Reaction), "N" (Nutrient). Since Ellenberg values were not standardized for the whole flora of Bulgaria, we set indicator values for species not present in Central Europe. To assess the reliability of the degrees of attachment to environmental factors, a post-hoc analysis was made by calculation of the Kendall-Tau rank correlation (Hill et al., 2000; Hays 1988; Kendall, 1975; Everitt, 1977). The coefficient in this case was used to assess the consistency of the Ellenberg scale scores for the purpose of populating the database for South-Eastern Europe. The Concordance coefficient (Kendall, 1975) is equal to 0.78977 with an average rank correlation of 0.78950, which means that the thus made additional assessments of the ecological indicators of some species are compatible with the available database of the already known indicator values.

Classification of habitats

The habitats are identified by their correlating plant communities, which are classified using the Braun-Blanquet (1964) approach. Natural habitats are according to the EUNIS Habitat Classification (https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1), Schaminée et al. (2018) and FloraVeg.EU (https://www.synbiosys.alterra.nl/evc/).

The relationship between alliances and habitats was done according to Rodwell et al. (2018) and Chytrý et al. (2020).

Natural habitats have also been identified according to Biodiversity Act (BDA) and Habitat Directive 92/43/EEC. In determining the habitats, additional sources were also used (Kavrakova et al., 2009; Biserkov et al., 2015), as the territory protects rare and valuable habitats at the national and local level. Vegetation was mapped based on the existing algorithm for mapping natural habitats in Bulgaria, used in determining habitats in previous design and inventory studies (Tzonev et al., 2012). Out of the total of 4056 base map polygons, 786 are mapped directly because they have relevés embedded in them. The relevés correspond to the same number of existing small forest plots, each of which has a unique ecological record substantially similar to that of the Ellenberg values used for Central Europe. Through linear regression of the standardized common database, a statistical correlation and close dependence was found between the values of these unique ecological records and the Ellenberg values. As a result, each forest plot acquires specific Ellenberg values, which are additionally used in the mapping of the vegetation to upgrade and sort the plots. The resulting of correlation between the Ellenberg values and the available ecological records helps in assigning new Ellenberg values to species that do not have such but inhabit territories with already described ecological records. 58 mapping keys were developed, ie. for each cluster there is a key. The keys where applied to the remaining 3270 polygons, each of which is assigned to a relevant plant community. GIS environment (Global Mapper v21.01.) was used to map and perform spatial analyses and considering the information of each relevé.

The algorithm has been upgraded by incorporating Ellenberg indicator values. The assignment of Ellenberg indicator values is based on an established statistical correlation between the database of relevés and the values of the descriptions of the forest inventory abiotic indicators. PCA analysis of environmental variables was performed with the StatSoft (2011). Analysis was applied to all relevés, after which a spatial grouping of the values of the individual EUNIS groups was performed based on their medians. The analysis, in addition to simplifying the ecological classification, was also used to prove the floristic separation of EUNIS groups.

The generated map, as well as the entire georeferenced database, was developed in the WGS 84 UTM 35 N (UTM Zone 35 / WGS84 / meters) coordinate system, and the exported raster map is at a scale of 1:200,000. 4,054 map units were mapped in 58 plant units which were subsequently united thematically into 17 habitats.

The map was created on the basis of a cadastral map for forest areas of Bulgaria on a scale of 1:10000. The accuracy of the graphic database used in the present study depends on the permissible errors in the depicted situation (position error) in the range 0.4–1.0 mm at the map scale (4–10 m in absolute value for M 1:10000).

Results and discussion

As a result of the cluster analysis, the 786 relevés were classified into 58 groups (Figure 2). Each group is considered as a separate syntaxon, and the established syntaxa

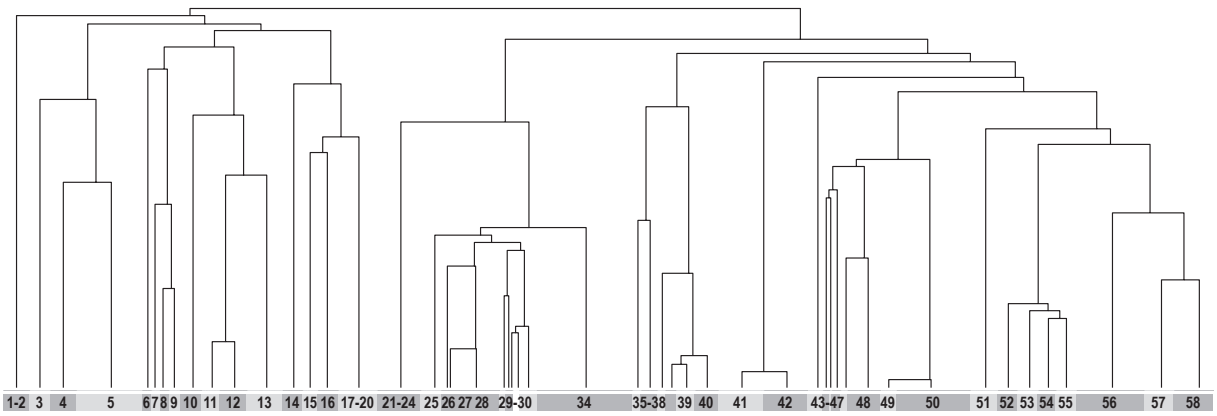

Figure 2: Twinspan classification three of the forest plant communities on the territory of the NPCB.
Slika 2: Twinspan klasifikacija treh gozdnih rastlinskih združb na območju NPCB.

Table 2: Forest habitats and average Ellenberg's indicator values.
Tabela 2: Gozdni habitatni tipi in povprečne Ellenbergove indikatorskevrednosti.

№	EUNIS habitat type	Light	Tempe-rature	Contin-entality	Mois-ture	Soil reaction	Nutri-ents
1	S913 Montane river gravel low brush	**5.84**	5.57	3.50	**6.09**	6.90	5.75
2	T12116 Dacio-Moesian ash-alder woods	5.37	5.50	**3.22**	**6.09**	7.03	**6.05**
3	T1741 Middle European dry-slope limestone Fagus forests	4.63	5.57	3.46	5.00	6.81	4.74
4	T177311 Balkan Range bedstraw-*Fagus* forests	4.41	5.10	3.26	5.27	6.16	5.55
5	T177312 Balkan Range fir-*Fagus* forests	4.47	5.19	3.30	5.27	6.20	5.65
6	T17733 Balkan Range thermophile *Fagus* forests	5.23	6.11	3.84	4.62	6.52	4.87
7	T18631 Balkan Range woodrush-*Fagus* forests	4.50	5.11	3.29	5.15	5.35	5.08
8	T19641 Helleno-Moesian *Quercus petraea* forests	5.50	6.20	3.62	4.47	6.98	4.76
9	T19B411 Moesian silver lime woods	5.23	**6.25**	3.66	4.61	7.03	4.80
10	T19B13 Montane hop-hornbeam forests	5.15	6.00	3.64	4.62	6.90	4.92
11	T1C133 Illyro-Moesian montane birch woods	5.13	4.40	**3.93**	5.00	4.40	4.60
12	T1E322 Dacio-Moesian hornbeam forests	4.55	5.36	3.32	5.29	6.42	5.82
13	T1F621 Moesian *Fagus*-ash-sycamore ravine forests	4.96	5.56	3.55	5.16	6.68	5.89
14	T3145 Balkan Range *Picea abies* forests	5.38	4.21	3.90	5.15	4.93	5.17
15	T3253 Balkan Range fir forests	**4.20**	5.57	3.51	5.06	5.88	5.49
16	T36719 Balkan Range Pallas' pine forests	5.75	5.91	3.74	**4.43**	**7.09**	**4.11**
17	T3925 Balkan Macedonian pine forests	4.99	**4.20**	3.80	5.46	**4.67**	5.17

are included in a general syntaxonomic scheme, which includes 18 associations, 3 subassociations and 15 communities not assigned to formal rank, but assignet to alliance, and 22 variants of association or community. They are grouped into 12 alliances, 8 orders and 5 phytosociological classes (see syntaxonomic synopsis, Annex 1).

The distinguished syntaxa were classified into 17 EUNIS habitat types (Table 1) among them 14 habitat types Natura 2000 were classified into units of Annex I of the Directive 92/43/EEC.

Information on the floristic composition and diagnostic species for the identified habitats is presented in Annex 2. The characteristics of the habitats indicate the species that give the appearance of communities and habitats. Most of them are diagnostic, others are dominant and/or constant.

Description of habitats

1. EUNIS: S913 Montane river gravel low brush.

HD (Habitat Directive): 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos.*

Syntaxa: alliance *Salicion eleagno-daphnoidis* – community of *Salix elaeagnos* and *Petasites hybridus* (cluster 2, 7 relevés).

It includes low forest and shrub vegetation with limited distribution. It is widespread along the banks and in the riverbeds of the rivers Cherni Osam, Vidima, Beli and Cherni Vit in their middle and upper reaches, where big alluvial cones of rock and gravel material have been formed, because of frequent sedimentation. The habitat occupies small patches mainly on island formations with an area of 2–50 m^2. Slopes average about 10 degrees with predominantly northern aspect. The rocks are various. The soils are Alluvial, medium nutrient-rich, medium-deep, sandy loam or sandy, highly skeletal. According to species indicator values (Table 1, Figure 3) these are lower montane, moist, and wet creek scrubs. They can be found on gravel material of the largest river basins on the territory of the Central Stara Planina, mainly in the temperate continental zone.

The first layer rich a height of up to 10 m, but for the major part is less than 2 m and with a coverage of about 60%. A shrub layer is established with a coverage of about 15% and appereance of *Clematis vitalba, Rubus hirtus, Acer campestre, Cornus sanguinea, Corylus avellana* and *Crataegus monogyna*. The herb layer has an average cover of 35% and is formed mainly by *Agrimonia eupatoria, Ajuga reptans, Anemone ranunculoides, Angelica sylvestris, Chrysosplenium alternifolium, Cichorium intybus, Dactylis glomerata, Dipsacus fulonum, Epilobium hirsutum, Geranium robertianum, Hedera helix, Juncus effusus, Ranunculus repens, Rumex acetosella, Scirpus silvaticus, Stellaria media, Taraxacum officinale* and *Veronica anagalis.*

2. EUNIS: T12116 Dacio-Moesian ash-alder woods.

HD: 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*).

RB (Red Book of habitats in Bulgaria): 04G1 Riverside woodlands of Alder (*Alnus* spp.) and Common ash (*Fraxinus excelsior*) – category *vulnerable*.

Syntaxa: alliance *Alnion incanae* – ass. *Stellario nemorum-Alnetum glutinosae* (cluster 1, 12 relevés).

It includes hygrophilous and mesohygrophilous riparian forests located locally along the valleys of the rivers Cherni Osam, Vidima, Beli and Cherni Vit. They occupy the first river terrace on aerated Alluvial soils, and in some cases waterlogged places near springs, slopes, traps, etc. Groundwater is high and starts at 1 m below the surface. Small periodic floods due to heavy rains or rapid melting of the snow in the high part of the mountain are common. The habitat is distributed in the range of 600–800 m above sea level. Slopes average 10 degrees, aspect varies but it is predominantly northern. The rocks are mostly silicate, sometimes dolomites. The soils are medium-rich, medium-deep, sandy clay, sandy, very stony. According to species indicator values (Table 1, Figure 3), these are lower montane and foothill, riparian forests, along the courses of the deepest rivers north of the main Stara Planina range.

In the tree layer, the cover is on average 50%. *Fraxinus excelsior, Salix fragilis, S. elaeagnus, Carpinus betulus* and *Alnus glutinosa* dominate. In the shrub layer, the coverage is about 25%. Most common participants are *Rubus hirtus, Acer campestre, Acer platanoides, Carpinus betulus, Cornus sanguinea, Corylus avellana, Crataegus monogyna, Sambucus nigra*. The herb layer has an average of 35% coverage. The floristic composition is species-rich, especially the spring spectrum. High hygrophilous species is absent. The participation of many forest mesophilic species from the neighboring beech massifs is characteristic for the alliance. The herb layer is most often represented by *Angelica sylvestris, Arctium lappa, Chrysosplenium alternifolium, Digitalis viridiflora, Dipsacus fullonum, Equisetum hyemale, Geranium robertianum, Lathraea squamaria, Lysimachia nummularia, Petasites hybridus, Pulmonaria rubra, Ranunculus repens, Rorippa nasturtium-aquaticum, Scirpus silvaticus, Stellaria media.*

3. EUNIS: T1741 Middle European dry-slope limestone Fagus forests.

HD: 9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion*.

RB: 11G1 Limestone forests of Common beech (*Fagus sylvatica*) – category *nearly threatened*.

Syntaxa: alliance *Fagion sylvaticae* – ass. *Seslerio latifoliae-Fagetum sylvaticae* var. *Ostrya carpinifolia* (group 37, 5 relevés), var. *typicum* (group 38, 7 relevés), var. *Abies alba* (group 39, 12 relevés), var. *Luzula luzuloides* (group 40, 15 relevés); comm. of *Fagus sylvatica* and *Corydalis incisa* (group 43, 10 relevés); comm. of *Fagus sylvatica* and *Carpinus betulus* var. *Sesleria latifolia* (group 44, 3 relevés), var. *Ostrya carpinifolia* (group 45, 2 relevés); ass. *Aremonio agrimonoidis-Fagetum sylvaticae violetosum* subass. *reichenbachianae* (group 47, 5 relevés), subass. *allietosum ursini* (group 48, 24 relevés).

It includes calciphilous forests of *Fagus sylvatica*, developing in a wide altitude range (700–1450 m a.s.l., average altitude is 1230 m), both in the transitional continental and in the moderately continental part of the mountain. The rocks are mainly limestone and dolomite. The soils are mainly Rendzinas, shallow, medium nutrient-rich, very skeletal. According to species indicator values (Table 1, Figure 3), these are forests with a preference for relatively high temperatures and moderately nutrient-rich soils with a neutral toward slightly acidic reaction.

The coverage of the tree layer is on average 50%. The main dominant is *Fagus sylvatica*, in some places co-dominants are *Carpinus betulus, Ostrya carpinifolia, Abies alba, Fraxinus excelsior, Acer pseudoplatanus*. The coverage of the shrub layer is about 10%, the most common participants are *Lonicera xylosteum, Crataegus monogyna* and *Carpinus betulus*. The herb layer has an average of 50% coverage. The herb layer is most often represented by *Sesleria latifolia, Euphorbia amygdaloides, Cardamine bulbifera, Mercurialis perennis, Galium odoratum, Festuca heterophylla, Helleborus odorus, Prenanthes purpurea, Viola odorata, Luzula sylvatica* var. *croatica, Dryopteris filix-mas, Arabis procurrens*.

4. EUNIS: T177311 Balkan Range bedstraw-*Fagus* forests.

HD: 9130 *Asperulo-Fagetum* beech forests.

RB: 09G1 Neutrophilic common beech forests – category *nearly threatened*.

Syntaxa: alliance *Fagion sylvaticae* – ass. *Galio odorati-Fagetum sylvaticae* (group 34, 62 relevés); comm. of *Fagus sylvatica* and *Valeriana tripteris* (group 51, 17 relevés); ass. *Umbilico erecti-Fagetum sylvaticae laurocerasetosum* var. *typicum* (group 52, 13 relevés), var. *Allium ursinum* (group 53, 14 relevés); ass. *Umbilico erecti-Fagetum sylvaticae typicum* var. *Lunaria rediviva* (group 54, 9 relevés), var. *typicum* (group 55, 15 relevés).

The habitat is neutrophilic mesophilous beech forests. They are located in a large altitude belt range both in the transition-continental and in the moderately continental part of the mountain (750–1650 m a.s.l., average altitude 1150 m). They develop mainly on silicate rocks. The soils are Cambisols, medium deep, medium nutrient-rich to

nutrient-rich, slightly stony. According to species indicator values (Table 1, Figure 3), these are shady forests, on nutrient-rich soils, developing at relatively lower temperatures.

The coverage of the tree layer is on average 60%. The main dominant is *Fagus sylvatica*, and in some sites co-dominants are *Acer pseudoplatanus* and *Picea abies*. The cover of the shrub layer is about 10%. The most common species are *Lonicera xylosteum, Laurocerasus officinalis* and *Taxus baccata*. The herb layer has an average of 45% coverage, is most often represented by *Cardamine bulbifera, Mercurialis perennis, Galium odoratum, Sanicula europaea, Mycelis muralis, Prenanthes purpurea, Festuca drymeja, Carex sylvatica, Luzula sylvatica* var. *croatica, Luzula luzuloides, Valeriana tripteris, Dryopteris filix-mas, Poa nemoralis, Hordelymus europaeus, Allium ursinum, Lunaria rediviva, Epilobium montanum, Veronica urticifolia, Lamiastrum galeobdolon*.

5. EUNIS: T177312 Balkan Range fir-Fagus forests.

HD: 9130 *Asperulo-Fagetum* beech forests.

RB: 09G1 Neutrophilic common beech forests – category *nearly threatened*.

Syntaxa: alliance *Fagion sylvaticae* – comm. of *Fagus sylvatica* and *Abies alba* var. *typicum* (group 56, 44 relevés), var. *Luzula sylvatica* (group 57, 19 relevés), var. *Hordelymus europaeus* (group 58, 30 relevés).

The habitat is neutrophilic mesophytic beech forests. They are located in a large altitude belt range both in the transition-continental and in the moderately continental part of the mountain (750–1650 m a.s.l., average altitude 1150 m). They develop mainly on silicate rocks. The soils are mainly Cambisols, medium-deep, medium nutrient-rich to rich, slightly skeletal. According to species indicator values (Table 1, Figure 3), these are shady forests on rich and medium rich soils, developing at relatively low temperatures.

The projective coverage of the tree layer is on average 60%. The main dominant *is Fagus sylvatica*, and co-dominants are *Abies alba, Acer pseudoplatanus* and *A. heldreichii*. The cover of the shrub layer is about 10%, the most often participants are *Salix caprea* and *Rubus idaeus*. The herb layer has an average of 50% coverage. The herb layer is most often represented by *Galium odoratum, Sanicula europaea, Mycelis muralis, Luzula sylvatica* var. *croatica, Luzula luzuloides, Dryopteris filix-mas, Poa nemoralis, Hordelymus europaeus, Impatiens noli-tangere, Polygonatum verticillatum, Lamiastrum galeobdolon*.

6. EUNIS: T17733 Balkan Range thermophile *Fagus* forests.

HD: 91W0 Moesian beech forests.

RB: 10G1 Moesian beech forests– category *nearly threatened*.

Syntaxa: alliance *Fagion sylvaticae* – ass. *Anthemido sanctijoannis-Fagetum sylvaticae* (group 14, 13 relevés).

The association includes thermophilous beech forests developing in the range 600–1000 m a.s.l. (average altitude 870 m) and slopes average 35°. The aspects are diverse, but the southern and eastern predominate. The rocks are mainly granites and sandstones. The soils are Cambisols medium nutrient-rich, medium deep, sandy, skeletal. According to species indicator values (Table 1, Figure 3), these are warm, open light beech forests, on moderately rich and moderately moist soils. They mainly occupy the southern parts of the mountain, where they are adjacent to mixed thermophilous *Quercus cerris* and *Q. petraea* forests.

The coverage of the tree layer is on average 50%. The main dominant is *Fagus sylvatica*, and in places co-dominants are *Quercus petraea, Q. cerris, Q. frainetto* and *Carpinus betulus*. The cover of the shrub layer is about 15%, the most common species are *Rosa arvensis* and *Clematis vitalba*. The herb layer has an average of 40% coverage. The herb layer is represented by *Urtica dioica, Luzula luzuloides, Mycelis muralis, Helleborus odorus, Poa nemoralis, Clinopodium vulgare, Euphorbia amygdaloides, Luzula forsteri, Campanula sparsa, Cruciata laevipes*.

7. EUNIS: T18631 Balkan Range woodrush-*Fagus* forests.

HD: 9110 *Luzulo-Fagetum* beech forests.

RB: 08G1 Acidophilic common beech (*Fagus sylvatica*) forests – category *vulnerable*.

Syntaxa: alliance *Luzulo-Fagion sylvaticae* – comm. of *Fagus sylvatica* and *Dryopteris filix-mas* (group 25, 14 relevés); comm. of *Fagus sylvatica* and *Vaccinium myrtillus* var. *Vaccinium vitis-idaea* (group 26, 2 relevés), var. *Arctostaphylos uva ursi* (group 27, 1 relevé), var. *typicum* (group 28, 34 relevés); ass. *Luzulo luzuloidis-Fagetum sylvaticae* var. *Polypodium vulgare* (group 29, 2 relevés), var. *Taxus baccata* (group 30, 3 relevés), var. *Geranium macrorrhizum* (group 31, 2 relevés), var. *Rubus hirtus* (group 32, 4 relevés), var. *typicum* (group 33, 11 relevés).

The acidophilous beech forests are located in a large altitude range, both in the transition-continental and in the moderately continental part of the mountain (600–1600 m a.s.l., average altitude 1290 m), mainly on silicate rocks. The soils are Cambisols and in Chromic Luvisols, medium nutrient-rich, sandy, and very stony. According to species indicator values (Table 1, Figure 3), these are forests with not closed canopy, on medium nutrient-rich and nutrient-poor soils. They appear on acidophilic silicate environments, developing at low values of continentality, moderate to low temperatures and low moisture content.

The coverage of the tree layer is on average 50%. The main dominant is *Fagus sylvatica*, and in places co-dominants are *Abies alba, Carpinus betulus* and *Acer heldreichii*. The cover of the shrub layer is about 10%, *Juniperus communis* most often appears in it, and in certain communities also *Taxus baccata*. The herb layer has an average of 50% coverage whith appereance of *Luzula sylvatica* var. *croatica, Vaccinium myrtillus, Luzula luzuloides, Geranium macrorrhizum, Prenanthes purpurea, Dryopteris filix-mas, Calamagrostis arundinacea, Bruckenthalia spiculifolia, Arctostaphylos uva-ursi* and *Poa nemoralis*.

8. EUNIS: T19641 Helleno-Moesian *Quercus petraea* forests.

HD: 91M0 Pannonian-Balkanic Turkey oak-sessile oak forests.

RB: 16G1 Thracian mixed thermophilic oak forests – category *endangered*.

Syntaxa: alliance *Quercion petraeo-cerridis* – ass. *Haberleo-Quercetum petraeae fritillarietosum ponticae* (group 4, 19 relevés), *typicum* (group 5, 43 relevés); ass. *Moehringio pendulae-Quercetum petraeae* (group 15, 7 relevés); ass. *Genisto carinalis-Quercetum petraeae* var. *Genista ovata* (group 16, 16 relevés), var. *Calamintha nepeta* (group 17, 6 relevés), var. *Knautia drymeia* (group 18, 7 relevés), var. *typicum* (group 20, 6 relevés).

The thermophilic Sessile Oak forests in the Central Stara Planina are located in the mid-mountain mesoarid zone (600–1300 m a.s.l.), mainly on southern Bulgarian granites, the soils are Chromic Luvisols, and at higher altitudes and Cambisols. Many heliophytes predominate in this habitat, and typical petrophilic species also develop on exposed rock patches. They are distributed mainly on the southern slopes of the Central Stara Planina. The once widespread Sessile oak forests have now been replaced almost entirely by Oriental hornbeam forests.

According to species indicator values (Table 1, Figure 3), the habitat is characterized by opened forest communities, moderately high air temperatures, low to medium soil nutrient richness, low values of continentality, moderately moist and neutral soil reaction.

In the tree layer the coverage is on average 50%. The main dominant is *Quercus petraea*, and in places co-dominants are *Carpinus betulus, Tilia tomentosa, Fagus sylvatica, Acer hyrcanum* and *Ulmus minor*. In the shrub layer, the coverage is about 15%. *Acer campestre* is most often present. *Staphylea pinnata* is also present in certain communities. The herb layer has an average of 55% coverage. The herb layer is most often represented by *Veronica hederifolia, Ranunculus ficaria, Cardamine bulbifera, Campanula rapunculoides, Festuca heterophylla, Vicia incana, Galium odoratum, Dianthus petraeus, Lathyrus laxiflorus, Chamaespartium sagittale, Lapsana communis, Clinopodium vulgare, Ranunculus ficaria, Euphorbia amygdaloides, Viscaria vulgaris* and *Helleborus odorus*.

9. EUNIS: T19B411 Moesian silver lime forests.

HD: 91Z0 Moesian Silver lime woods.

RB: 23G1 Silver lime (*Tilia tomentosa*) woods – category *endangered*.

Syntaxa: alliance *Quercion petraeo-cerridis*: ass. *Genisto carinalis-Quercetum petraeae* var. *Tilia tomentosa* (group 19, 5 relevés).

The habitat includes Moesian forests of *Tilia tomentosa*. It covers karst terrains at the southern foothills of the Botev peak and the Ravnets massif. It is widespread in the range of 800–1000 m a.s.l. (average altitude 940 m) and slopes about 35°. The aspects are southern, the rocks are mainly limestones with small intrusions of South Bulgarian granites. The soils are medium nutrient-rich, medium deep, sandy and very skeletal. According to species indicator values (Table 1, Figure 3), these are warm and dry forests, on soils with slightly alkaline reaction.

Coverage of the tree layer is 80%. The main dominant is *Tilia tomentosa*, but in some places *Tilia cordata* and *Corylus colurna* have a high participation. *Carpinus betulus* and *Quercus petraea* have high constancy. Shrub cover is around 20%, with *Ulmus minor* and *Acer campestre* being the most common participants. Herb cover is about 60%. With the highest constancy are *Poa nemoralis, Mercurialis perennis, Fragaria vesca, Euphorbia amygdaloides, Cardamine bulbifera* and *Festuca heterophylla*.

10. EUNIS: T19B13 Montane hop-hornbeam forests.

RB: 21G1 Hop-hornbeam (*Ostrya carpinifolia*) woods – category *vulnerable*.

Syntaxa: alliance *Fraxino orni-Ostryion* – comm. of *Ostrya carpinifolia* and *Taxus baccata* (group 7, 6 relevés); comm. of *Ostrya carpinifolia* and *Carex pilosa* (group 8, 4 relevés); ass. *Daphno-blagayanae-Ostryetum carpinifoliae* (group 9, 11 relevés); ass. *Anthyllio vulnerariae-Ostryetum carpinifoliae* (group 10, 13 relevés); comm. of *Ostrya carpinifolia* and *Asplenium septentrionale* (group 11, 11 relevés); comm. of *Carpinus betulus* and *Acer hyrcanum* (group 12, 18 relevés); ass. *Umbilico erecti-Ostryetum carpinifoliae* (group 13, 23 relevés).

The habitat includes thermophilous forests of *Ostrya carpinifolia*, developing in the lower and middle montane transitional continental zone of the mountain. They develop predominantly in the southern parts of the mountain but sometimes also in upper soutern parts due to the strong sub-Mediterranean influence in the range of 600–1500 m a.s.l. (average altitude 1100 m). The main rocks

are limestones, granites and granodiorites. The soils are predominantly Rendzinas and few of them are Dystric Cambisols, in the lowest areas also Chromic Luvisols. They are nutrient-poor, medium deep, clayey-sandy and very skeletal. According to species indicator values (Table 1, Figure 3), these are forests with open canopy, with a preference for relatively high temperatures and soils with a basic reaction. In some places (the southern parts of the Troyan pass) communities of *Ostrya carpinifolia* and *Asplenium septentrionale* form the timberline.

In the tree layer, the coverage is on average 50%. The main dominant is *Ostrya carpinifolia*, and in places co-dominants are *Abies alba, Fagus sylvatica, Acer hyrcanum, Quercus petraea* and *Corylus colurna*. In the shrub layer, the coverage is about 20%. The most often participants are *Carpinus orientalis, Cornus mas, Fraxinus ornus*, *Spiraea chamaedrifolia*. In some communities, *Taxus baccata* and *Daphne blagayana* play a significant role. The herb layer has an average of 55% coverage, is often represented by *Sesleria latifolia, Mercurialis perennis, Carex pilosa, Galium schultesii, Prenanthes purpurea, Euphorbia amygdaloides, Polystichum aculeatum, Helleborus odorus, Luzula luzuloides, Melica uniflora, Poa nemoralis* and *Umbilicus erectus*.

11. EUNIS: T1C133 Balkano-Rhodopide birch forests.

RB: 25G1 Birch (*Betula pendula*) forests – category *nearly threatened*.

Syntaxa: alliance *Piceion excelsae* – comm. of *Betula pendula* (group 21, 3 relevés).

The habitat includes forests of *Betula pendula*, developing in patches around the upper forest limit in areas dominated by spruce forests, mainly south of the main ridge of the mountain. They are spread in the range of 1400–1600 m a.s.l. (average altitude 1450 m). The slopes are about 30–35 degrees. The slope aspect varies, but the southern predominate. The rocks are South Bulgarian granites, slates, diorites, etc. The soils are Umbric Cambisols, and in the lower parts Dystric Cambisols. They are medium nutrient-rich, medium-deep, sandy, highly skeletal. According to species indicator values (Table 1, Figure 3), these are light acidophilous oligotrophic forests developing at low temperatures and modarately moist soils.

In the tree layer, the coverage averages 50%, *Betula pendula* predominates and in some sites co-dominant is *Picea abies. Fagus sylvatica, Betula pendula* and *Juniperus sibirica* are sporadically present in the shrub layer. The herb layer has an average of 30% coverage. *Luzula luzuloide*s and *Vaccinium myrtillus* dominate and are most common.

12. EUNIS: T1E322 Dacio-Moesian hornbeam forests.

HD: 9170 Dacio-Moesian hornbeam forests.

RB: 27G1 Mountain forests of *Carpinus betulus* and *Quercus dalechampii* – category *nearly threatened*.

Syntaxa: alliance *Erythronio-Carpinion betuli* – ass. *Galio intermediae-Carpinetum betuli* var. *typicum* (group 50, 52 relevés) and var. *Bupleurum falcatum* (group 49, 3 relevés).

The habitat is mesophytic mountain hornbeam forests, occupying small moist depressions. They are in the middle montane subboreal mesoarid zone of 750–1200 m a.s.l. (average altitude 1000 m above sea level) and slopes about 20°. The soils are moderately moist, medium deep, highly stony and loamy-sandy. According to species indicator values (Table 1, Figure 3), these are forests, with low values of continentality, moderate temperatures and a strong affinity for the soils with slightly acid and neutral reaction.

The coverage of the tree layer averages 55%. The main dominant is *Carpinus betulus*, and in some areas *Fagus sylvatica* is co-dominanat. *Acer pseudoplatanus, Ulmus glabra, Ostrya carpinifolia* and *Fraxinus excelsior* are also found there. The shrub layer has a coverage of around 10% and it is formed from uderstorey of *Carpinus betulus, Ulmus glabra* and *Quercus petraea*. The herb layer has a cover of 45% on average. *Luzula luzuloides, Festuca drymeja, Galium odoratum, Lunaria rediviva, Prenanthes purpurea, Mycelis muralis, Dryopteris filix-mas, Lamiastrum galeobdolon* dominate and are the most common.

13. EUNIS: T1F621 Moesian *Fagus*-ash-sycamore ravine forests.

HD: 9180 *Tilio-Acerion forests of slopes, screes and ravines.

RB: 28G1 Mixed forests on screes, steep slopes and mountain ravines – category *endangered*.

Syntaxa: alliance *Fraxino excelsioris-Acerion pseudoplatani* – comm. of *Fagus sylvatica* var. *Ostrya carpinifolia* (group 41, 29 relevés) and var. *Acer heldreichii* (group 42, 29 relevés).

The mixed gorge forests are located in the middle montane subboreal mesoarid zone of 700–1500 m a.s.l. (average altitude 1200 m) and average slope of 45°. The slope aspects are diverse, predominantly western and southern. The main rocks are predominantly South Bulgarian granites, but crystalline slates, sandstones, dolomites and others are also present. The soils are predominantly Chromic Luvisols and Dystric Cambisols. Rendzinas soils are limitedly found. The soils are saturated with pieces of rock and different-sized scree and gravel fractions. In some places, big screes of large-sized rock materials have been formed. According to species indicator

values (Table 1, Figure 3), these are rocky mountain forests with medium soil moisture, relatively good nitrogen availability, relativly high air temperatures, with a affinity for the neutrophilic substrate.

The tree layer has a mixed composition and the coverage is around 55%. In some areas *Fagus sylvatica, Ostrya carpinifolia, Corylus colurna, Fraxinus excelsior, Carpinus betulus, Acer pseudoplatanus, Abies alba, Alnus glutinosa* and *Acer heldreichii* dominate. The shrub layer has a coverage of about 15%, with *Carpinus betulus, Ulmus glabra* and *Sambucus nigra* being the most common species. The herb layer has an average of 60% coverage. *Mercurialis perennis, Luzula luzuloides, Lunaria rediviva, Geranium macrorrhizum, Cardamine bulbifera, Poa nemoralis, Fragaria vesca, Euphorbia amygdaloides* dominate and are the most common.

14. EUNIS: T3145 Balkan Range *Picea abies* forests.

HD: 9410 Acidophillous Picea forests of the montane to alpine levels (*Vaccinio-Piceetea*).

RB: 34G3 Norway spruce (*Picea abies*) forests – category *nearly threatened*.

Syntaxa: alliance *Piceion excelsae* – ass. *Ranunculo oreophili-Piceetum abietis* (group 22, 11 relevés) and comm. of *Picea abies* and *Luzula sylvatica* (group 23, 4 relevés).

The acidophilous forests of *Picea abies* are widespread in the range of 1400–1800 m a.s.l. (average altitude 1650 m). Slopes average 10 degrees. The slope aspects are diverse, but northern predominate. The rocks are South Bulgarian granites, slates, diorites, etc. The soils are Umbric Cambisols, more rarely Dystric Cambisols or Modic Cambisols – medium-rich, medium-deep, sandy-loamy. The ecological analysis shows (Table 1, Figure 3) that these are cool high montane forests, inhabiting sites with a good supply of nitrogen and water, which in certain sections at the upper border of the forest transition into open forests.

Dominant in the tree layer (with total coverage around 70%) is *Picea abies*, in some places *Pinus peuce* is co-dominant, and in others *Fagus sylvatica* and *Abies alba* participate. In the shrub layer, the coverage is round 10%, and it includes *Picea abies, Juniperus sibirica, Ribes alpinum, Sorbus aucuparia* and *Rubus idaeus*. The herb layer has a coverage of 35% on average. The most common participants are *Vaccinium myrtillus, V. vitis-idaea, Ranunculus oreophilus, Rumex alpinus, Veronica alpina, Luzula sylvatica, L. luzuloides, Senecio nemorensis* and *Dryopteris filix-mas*.

15. EUNIS: T3253 Balkan Range fir forests.

HD: 91BA Moesian Silver fir forests.

RB: 32G3 Silver fir (*Abies alba* subsp. *alba*) forests – category *endangered*.

Syntaxa: alliance *Fagion sylvaticae* – comm. of *Fagus sylvatica* and *Carpinus betulus* var. *Abies alba* (group 46, 6 relevés).

Forests of *Abies alba* have a fragmentary distribution on the territory of the NPCB, mainly on moist slopes above large streams, in some sites on limestone. They are distributed in the range of 1000–1250 m. a.s.l. (average 1200 m). Slopes average 40 degrees. The aspects are diverse, but those with a westhern component predominate. The rocks are mostly silicate, occasionally dolomites. The soils are medium nutrient-rich, medium-deep, sandy-loam and sandy, very skeletal. The ecological analysis shows (Table 1, Figure 3) that these are midle and high mountain forests located in deep and cool valleys, canyons and gorges.

The cover of the tree layer averages 50%. Dominant is *Abies alba,* in some places *Fagus sylvatica* and *Fraxinus excelsior* are co-dominants, *Acer pseudoplatanus* is constant. Cover of herb layer averages 5%, the most constant are *Daphne mezereum* and *Sorbus aucuparia* and understorey of dominant species. The herb layer has a coverage of 35% on average. The constant are *Ajuga reptans, Asarum europaeum, Cardamine bulbifera, Dryopteris filix-mas, Euphorbia amygdaloides, Galium odoratum, Hieracium murorum* gr., *Luzula luzuloides, L. sylvatica, Mercurialis perennis, Polystichum aculeatum, Prenanthes purpurea.*

16. EUNIS: T36719 Balkan Range Pallas' pine forests.

HD: 9530 *(Sub-) Mediterranean pine forests with endemic black pines.

RB: 36G3 Forests of Black pine (*Pinus nigra* subsp. *pallasiana*) – category *vulnerable*.

Syntaxa: alliance *Fraxino orni-Pinion nigrae* – ass. *Seslerio latifoliae-Pinetum nigrae typicum* var. *typicum* (group 35, 5 relevés) var. *Laserpitium siler* (group 36, 11 relevés); alliance *Carpinion orientalis* – ass. *Junipero deltoidi-Pinetum pallasianae* (group 3, 11 relevés); alliance *Fraxino orni-Ostryion* – comm. of *Pinus pallasiana* and *Jurinea anatolica* (group 6, 4 relevés).

The forests of *Pinus nigra* subsp. *pallasiana* are distributed on the transitional continental southern slopes in the range of 600–1500 m a.s.l. (average altitude 1110 m). Slopes average 40 degrees. The slope aspects are varied, but the western component predominate. The rocks are dolomite and limestone. The soils are Rendzinas, Chromic Luvisols and Dystric Cambisols, nutrient-poor, medium-deep, sandy-loam and sandy, very skeletal. The ecological analysis shows (Table 1, Figure 3) that these are lightened, and rocky forests, in places on almost vertical rock blocks and small terraces, on poor in nutrients and moisture alkaline soils.

Dominant in the tree layer (total coverage about 45%) is *Pinus pallasiana*, other species are *Quercus petraea* and *Q. pubescens*. In the shrub layer, the coverage is around 25%, and it includes *Carpinus orientalis*, *Sorbus aria*, *Ostrya carpinifolia, Rubus saxatilis*. The herb layer has an average of 50% coverage. The most common are *Sesleria latifolia, Clinopodium vulgare, Cruciata glabra, Aremonia agrimonoides, Galium schultesii, Ranunculus rumelicus, Dianthus petraeus* and *Euphorbia amygdaloides*.

17. EUNIS: T3925 Balkan Macedonian pine forests.

HD: 95A0 High oro-Mediterranean pine forests.

RB: 38G3 Macedonian pine (*Pinus peuce*) forests – category *endangered*.

Syntaxa: alliance *Pinion peucis* – ass. *Adenostylo alliariae-Pinetum peucis* (group 24, 12 relevés).

The distribution of its communities is in the range 1600–1900 m a.s.l. (average altitude 1700 m). Slopes average about 35 degrees. The slope aspects are diverse, but the western and northern on predominate, and south of Mount Vežen – southern component. The rocks are silicate – South Bulgarian granites, diorites, etc. The soils are mainly Umbric Cambisols, medium nutrient-rich to rich, medium-deep, sandy, very stony, moist and wet in some sites. The ecological analysis shows (Table 1, Figure 3) that these are cold high montane and subalpine acidophilic forests, on moist soils.

Coverage of the tree layer averages around 60%. *Pinus peuce, Picea abies, Pinus sylvestris* and *Abies alba* are dominant in different proportion, most often with predominance of the *Pinus peuce*. The coverage of the shrub layer is in most cases low (below 10%). *Sorbus aucuparia* and *Rubus idaeus* are most often involved in it. The herb layer has a cover of 40% on average. Most often dominant and constant species are *Athyrium filix-femina, Adenostyles alliariae, Gentiana asclepiadea, Gymnocarpium dryopteris, Homogine alpina, Lamium garganicum, Calamagrostis arundinacea* and *Stellaria nemorum*.

The variety of habitats on the territory of the NPCB is suported both by its relatively large area and by the specific geographical location on the border of the moderately continental and transitional continental climate, as well as by the relatively large altitude range. The comparison of Ellenberg's indicator values for the different habitats shows that they move in relatively small intervals. However, it can be noted that the habitats of the beech forests and especially the mesophilous beech forests (T177311 and T177312) have the largest areas and the largest ecological range (Table 2, Figures 3 and 4). Black pine forests develop (T36719) under the driest and poorest-nutrient and most carbonate soils. The richest and wettest is the habitat of riparian forests, which also develop at low altitudes within a moderately continental zone (T12116). *Tilia tomentosa* forests are the most thermophilic (T19B411), while high montane forests of *Pinus peuce* (T3925) and *Picea abies* (T3253) develop in low temperatures and acidic soils.

Fagus sylvatica and *Abies alba* are known to have similar ecological niches. Under very similar environmental

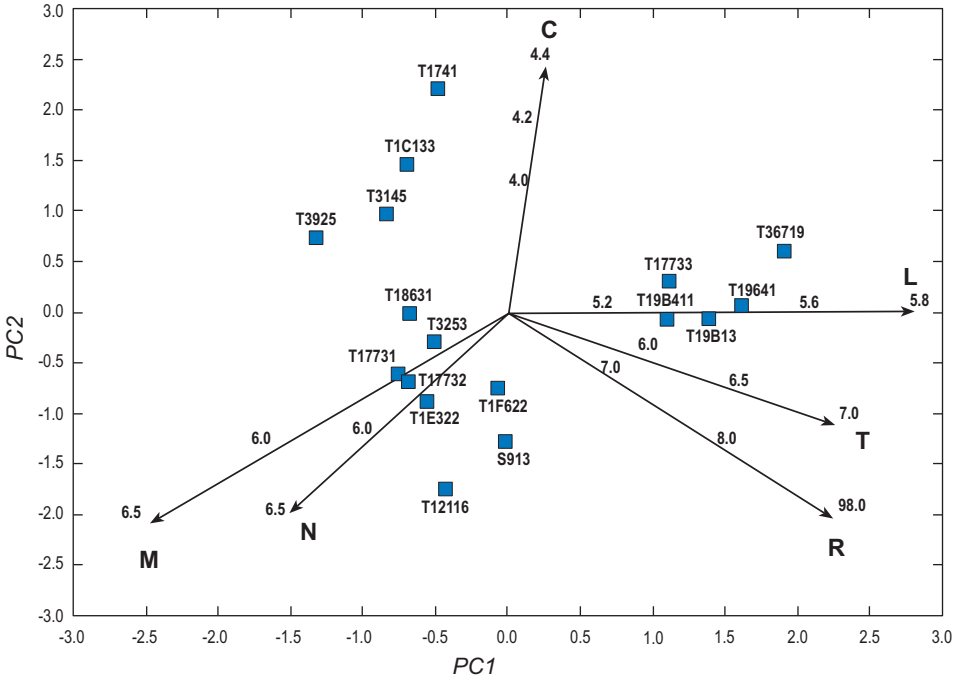

Figure 3: PCA of habitats with ecological indicator values. L (Light), T (Temperature), C (Continentality), M (Moisture), R (Soil reaction), N (Nutrients), A (Altidude).

Slika 3: PCA habitatnih tipov z ekološkimi indikatorskimi vrednostmi. L (svetloba), T (temperatura), C (kontinentalnost), M (vlažnost), R (reakcija tal), N (hranila), A (nadmorska višina).

conditions, the communities dominated by them also develop. The same can be said for the few habitats dominated by common beech. This reflects the fundamental question: which are the leading criteria for habitat identification – plant communities or abiotic factors? If abiotic factors are leading, a forest habitat would combine communities with different dominant species as a manifestation of ecological substitutability. According to the initial approach, the leading criterion is the dominant species in forest habitats, which explains the fact that different habitats are identified under very similar enviđronmental conditions. Another problem, especially in the assessment of the conservation status of habitats, is created by changes in the proportion of dominant tree species, as a result of natural dynamics observed e.g. in mixed fir-spruce-beech forests. Each classification is artificial and made for a specific purpose. The main objectives in the identification of natural habitats are their conservation and sustainable management.

The reason for the existing habitat diversity on the territory of NPCB is also related to the history and management of the territory. After the declaration of the territory as a National Park in 1991, economic activities and logging are not conducted in the forests. Before that, apart from the reserve territories, various silvicultural activities were carried out in the forests, which are reflected the characteristics of the communities and habitats. As a result, the actual vegetation in the park was formed. The number of plant communities is greater, that it would be in case of existence of the potential vegetation. The establishment of a large number of variants within plant associations and plant communities probably is related to this. The presence of a greater diversity of phytocoenoses within a given habitat represents great diversity at the level of micro-habitats, respectively the presence of greater biological diversity and the importance of the territory for its protection.

As a result of the current study, four new types of habitats (S913, T12116, T19B13 and T1C133) were identified in the territory of the NPCB, which were not identified through the previous mapping studies using different modelling approaches. Another result is ascertainment of different habitat areas were compare to the previous mappings (Table 2). This should be taken into account in the future management of the territory, because the area is a basic parameter in assessing the environmental protection status of the habitats.

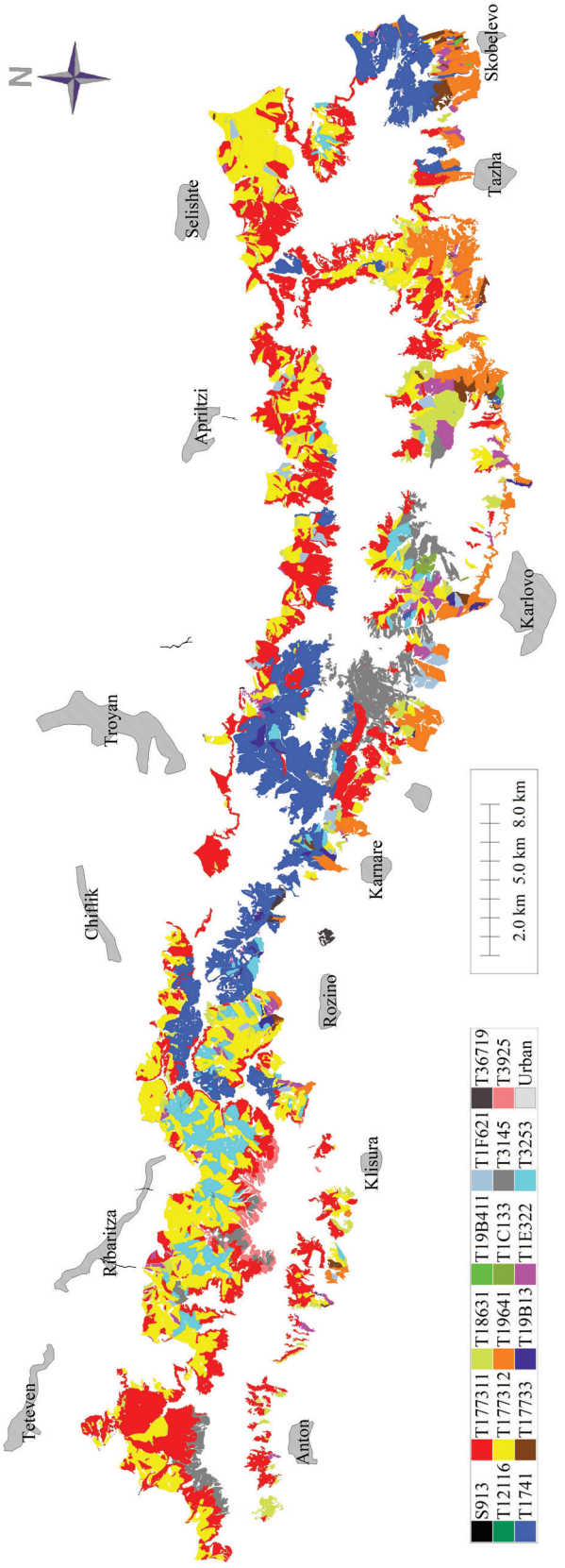

Figure 4: Map of forest natural habitats (EUNIS) on the territory of the Central Balkan NP.

Slika 4: Karta naravnih gozdnih habitatnih tipov (EUNIS) v območju NP Centralni Balkan.

Table 3: Area of forest habitats, according to different mappings.
Tabela 3: Površina gozdnih habitatnih tipov glede na različna kartiranja.

№	EUNIS 2021	Natura 2000	Marin 2007, ha	Nedyalkov 2013, ha	Stefanov 2013, ha	Dragolov 2013, ha	2022, ha
1	S913	3240	–	–	–	–	**18.8**
2	T12116	91E0	–	–	–	–	**3.1**
3	T1741	9150	1146.7	1720.4	2309.0	1394.1	**6421.1**
4	T177311	9130	15729.3	25388.9	23207.9	25516.6	**11980.0**
5	T177312						**9684.4**
6	T17733	91W0	10771.5	1660.3	338.3	1927.5	**426**
7	T18631	9110	310.3	598.1	1849.2	1984.2	**1874.3**
8	T19641	91M0	46.5	–	962.9	1171.8	**3218.7**
9	T19B13	91Z0	–	–	–	–	**294.4**
10	T19B411	–	5.5	3.8	13.0	12.9	**41.4**
11	T1C133	–	–	–	–	–	**89.9**
12	T1E322	9170	971.8	2 579.7	1690.8	1566.4	**1068.7**
13	T1F621	9180	106.1	1309.1	191.3	195.2	**660.8**
14	T3145	9410	485.9	1684.2	1825.1	2122.6	**2240.1**
15	T3253	91BA	1949.4	1950.6	1243.4	1798.4	**2198.7**
16	T36719	9530	72.5	57.8	81.9	73.7	**85.4**
17	T3925	95A0	181.3	128.9	338.3	297.7	**407.0**
	Total		**31788.3**	**37098.9**	**34139.8**	**38095.1**	**40137.0**

Identification and mapping of habitats can be done in different ways and methods. The choice of the appropriate method depends on the objective. The determination of the habitats and the characterization of the plant communities in the territory of some sites in Bulgaria were made in accordance with the principles of the Braun-Blanquet phytosociological school. The habitats were characterized on the basis of floristic and ecological features of the plant communities and determined according to the classification of EUNIS (Neykova et al., 2019). In Germany, forest habitats from Natura 2000 are identified by the dominant tree species, according to data from the national forest inventory. When the designation of habitats by the presence of certain dominant tree species and their combinations is impossible, indicator species of the ground vegetation are required for the designation and the verification of the designation of certain forest habitat types (Kroiher et al., 2012). In the appendices, the relationships between the plant communities of the real vegetation, the corresponding syntaxa (associations) forest habitats from Natura 2000 are indicated. The additional indicator species for the habitats are also indicated. The identification of habitats in Greece is based on Braun-Blanquet's approach by phytocenological relevés and identification of syntaxa and diagnostic species (Sarika et al., 2015, 2018; Xystrakis et al., 2022). Xystrakis et al. (2022) note that numerous crosswalks aiming in matching habitat types to one (or more) vegetation types and vice versa exist. Moreover, this method allows for the compilation of typical species inventories for habitat types that are not included in the Habitats Directive. The classification of vegetation is also used in the classification of ecosystems and ecoregions in Italy (Rosati et al., 2008; Capotorti et al., 2014; Blasi et al., 2014). Blasi et al. (2014) write that, classification and mapping is vegetation-oriented, because vegetation represents the most discernible, relatively stable and representative component of ecosystems at any level of detail. It is fundamental to recognise and map ecosystems from relatively fine scales, as in the case of the ecosystem map. More detailed classifications are needed that properly take into account the varying ecological and biogeographical contexts and contents of the individual countries. Regardless of the expressed critiques about crosswalks between vegetation classification and habitat mapping, Spribille et al. (2001) note that population structure of the total plant composition is more stable than of any single component species. The disparity between habitat types and associations could in theory be attributed to imperfect identification keys.

The identification and mapping of habitats is the basis of biodiversity conservation at the species, plant community, habitat and landscape level. Regardless of the accumulated experience in different countries, there is currently no universally accepted international methodology. This is largely impossible due to the differences in existing accumulated information, its degree of detail and reliability. This poses great challenges in the implementation of this important process for nature protection. The application of remote sensing methods and modeling is undoubtedly mandatory, especially in large areas and at

the national level. In all cases, we believe that the more detailed and qualitative information collected in field studies is used, the better and more useful the final results will be. Our opignion is that for the management of protected territories and zones, for monitoring the conservation status of the habitats, it is suitable to carry out detailed phytocoenotic studies. The presented results and especially the established new habitats support this point of view.

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Marius Dimitrov https://orcid.org/0000-0002-2632-7883

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Annex 1

Syntaxonomical scheme (№ of the syntaxa, according figure 2)

Class *Salicetea purpureae* Moor 1958
Order *Salicetalia purpureae* Moor 1958
Alliance *Alnion incanae* Pawłowski et al. 1928
Ass. *Stellario nemorum-Alnetum glutinosae* Lohmeyer 1957, № 1
Alliance *Salicion eleagno-daphnoidis* (Moor 1958) Grass 1993
Comm. of *Salix elaeagnos* and *Petasites hybridus,* № 2
Class *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959
Order *Quercetalia pubescenti-petraeae* Klika 1933
Alliance *Carpinion orientalis* Horvat 1958
Ass. *Junipero deltoidi-Pinetum pallasianae* Tzonev et al. 2018, № 3
Alliance *Fraxino orni-Ostryion* Tomažič 1940
Comm. of *Pinus nigra* ssp. *pallasiana* and *Jurinea anatolica,* № 6
Comm. of *Ostrya carpinifolia* and *Taxus baccata*, № 7
Comm. of *Ostrya carpinifolia* and *Carex pilosa,* № 8
Ass. *Daphno blagayanae-Ostryetum carpinifoliae* nom. prov., № 9
Ass. *Anthyllio vulnerariae-Ostryetum carpinifoliae* nom. prov., № 10
Comm. of *Ostrya carpinifolia* and *Asplenium septentrionale*, № 11
Comm. of *Carpinus betulus* and *Acer hyrcanum,* № 12
Ass. *Umbilico erecti-Ostryetum carpinifoliae* nom. prov., № 13
Alliance *Quercion petraeo-cerridis* Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015
Ass. *Haberleo-Quercetum petraeae* Tzonev et al. 2019 *fritillarietosum ponticae*, № 4
Ass. *Haberleo-Quercetum petraeae* Tzonev et al. 2019 *typicum*, № 5
Ass. *Moehringio pendulae-Quercetum petraeae* Tzonev et al. 2019, № 15
Ass. *Genisto-Quercetum petraeae* Bergmeier in Bergmeier et Dimopoulos 2008 var. *Genista ovata*, № 16
Ass. *Genisto-Quercetum petraeae* Bergmeier in Bergmeier et Dimopoulos 2008 var. *Calamintha nepeta,* № 17
Ass. *Genisto-Quercetum petraeae* Bergmeier in Bergmeier et Dimopoulos 2008 var. *Knautia drymeja,* № 18
Ass. *Genisto-Quercetum petraeae* Bergmeier in Bergmeier et Dimopoulos 2008 var. *Tilia tomentosa,* № 19
Ass. *Genisto-Quercetum petraeae* Bergmeier in Bergmeier et Dimopoulos 2008 var. *typicum*, № 20
Class *Carpino-Fagetea* Jakucs ex Passarge 1968
Order *Luzulo-Fagetalia sylvaticae* Scamoni et Passarge 1959
Alliance *Luzulo-Fagion sylvaticae* Lohmeyer et Tx. In Tx. 1954
Comm. of *Fagus sylvatica* and *Dryopteris filix-mas,* № 25
Comm. of *Fagus sylvatica* and *Vaccinium myrtillus* var. *Vaccinium vitis-idaea*, № 26
Comm. of *Fagus sylvatica* and *Vaccinium myrtillus* var. *Arctostaphylos uva ursi*, № 27
Comm. of *Fagus sylvatica* and *Vaccinium myrtillus* var. *typicum*, № 28
Ass. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937 var. *Polypodium vulgare,* № 29
Ass. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937 var. *Taxus baccata*, № 30
Ass. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937 var. *Geranium macrorrhizum,* № 31
Ass. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937 var. *Rubus hirtus,* № 32
Ass. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937 var. *typicum*, № 33
Order *Fagetalia sylvaticae* Pawłowski 1928
Alliance *Fagion sylvaticae* Luquet 1926
Ass. *Anthemido sancti-joannis-Fagetum sylvaticae* nom. prov., № 14
Ass. *Galio odorati-Fagetum sylvaticae* Sougnez et Thill 1959, № 34
Ass. *Seslerio latifoliae-Fagetum sylvaticae* nom. prov. var. *Ostrya carpinifolia*, № 37
Ass. *Seslerio latifoliae-Fagetum sylvaticae* nom. prov. var. *typicum*, № 38
Ass. *Seslerio latifoliae-Fagetum sylvaticae* nom. prov. var. *Abies alba,* № 39
Ass. *Seslerio latifoliae-Fagetum sylvaticae* nom. prov. var. *Luzula luzuloides,* № 40
Comm. of *Fagus sylvatica* and *Corydalis solida* ssp. *incisa*, № 43
Comm. of *Fagus sylvatica* and *Carpinus betulus* var. *Sesleria latifolia*, № 44
Comm. of *Fagus sylvatica* and *Carpinus betulus* var. *Ostrya carpinifolia*, № 45
Comm. of *Fagus sylvatica* and *Carpinus betulus* var. *Abies alba*, № 46
Ass. *Aremonio-Fagetum sylvaticae* subass. *violetosum reichenbachianae* Tzonev et al. 2006, № 47
Ass. *Aremonio-Fagetum sylvaticae* subass. *allietosum ursini* Tzonev et al. 2006, № 48
Comm. of *Fagus sylvatica* and *Valeriana tripteris,* № 51
Ass. *Umbilico-Fagetum sylvaticae laurocerasetosum officinalis* Tzonev et al. 2006 var. *typicum*, № 52
Ass. *Umbilico-Fagetum sylvaticae laurocerasetosum officinalis* Tzonev et al. 2006 var. *Allium ursinum*, № 53

Ass. *Umbilico-Fagetum sylvaticae typicum* Tzonev et al. 2006 var. *Lunaria rediviva*, № 54
Ass. *Umbilico-Fagetum sylvaticae typicum* Tzonev et al. 2006 var. *typicum,* № 55
Comm. of *Fagus sylvatica* and *Abies alba* var. *typicum*, № 56
Comm. of *Fagus sylvatica* and *Abies alba* var. *Luzula sylvatica*, № 57
Comm. of *Fagus sylvatica* and *Abies alba* var. *Hordelymus europaeus,* № 58

Order *Aceretalia pseudoplatani* Moor 1976
Alliance *Fraxino excelsioris-Acerion pseudoplatani* P. Fukarek 1969
Comm. of *Fagus sylvatica* var. *Ostrya carpinifolia,* № 41
Comm. of *Fagus sylvatica* var. *Acer heldreichii,* № 42

Order *Carpinetalia betuli* P. Fukarek 1968
Alliance *Erythronio-Carpinion betuli* (Horvat 1958) Marinček in Wallnöfer et al. 1993
Ass. *Galio intermediae-Carpinetum betuli* nom. prov. var. *Bupleurum falcatum*, № 49
Ass. *Galio intermediae-Carpinetum betuli* nom. prov., № 50

Class *Erico-Pinetea* Horvat 1959
Order *Erico-Pinetalia* Horvat 1959
Alliance *Fraxino orni-Pinion nigrae* Em 1978
Ass. *Seslerio latifoliae-Pinetum nigrae* Em 1978 subass. *typicum* var. *typicum*, № 35
Ass. *Seslerio latifoliae-Pinetum nigrae* Em 1978 subass. *typicum* var. *Laserpitium siler*, № 36

Class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939
Order *Piceetalia excelsae* Pawłowski et al. 1928
Alliance *Piceion excelsae* Pawłowski et al. 1928
Comm. of *Betula pendula,* № 21
Ass. *Ranunculo oreophili-Piceetum abietis* I. Dimitrov et M. Dimitrov 2015, № 22
Comm. of *Picea abies* and *Luzula sylvatica,* № 23
Alliance *Pinion peucis* Horvat 1950
Ass. *Adenostylo alliariae-Pinetum peucis* I. Nikolov et M. Dimitrov 2015, № 24

Annex 2

Synoptic table of habitats with diagnostic taxa and fidelity. The fidelity of each species was presented by their phi-coefficient per group multiplied by 100.

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Habitat type		S913	T12116	T1741	T177311	T177312	T17733	T18631	T19641	T19B411	T19B13	T1C133	T1E322	T1F621	T3145	T3253	T36719	T3925
Diagnostic taxa																		
Cichorium inthybus	c	**100**																
Rumex acetosella	c	**100**																
Veronica anagalis	c	**100**																
Morus alba	a	**98**																
Morus alba	b	**100**																
Morus alba	c	**100**																
Agrimonia eupatoria	c	**96**																
Taraxacum officinale	c	**92**	10															
Juncus effusus	c	**89**	9															
Cornus sanguinea	c	**87**	16															
Salix alba	b	**86**	16															
Salix alba	a	**85**	16															
Salix alba	c	**85**	16															
Anemone ranunculoides	c	**77**		11							24							
Epilobium hirsutum	c	**73**	13															
Corylus avellana	c	57											13	22				
Geranium macrorrhizum	c	35				14					12		10	24				
Petasites hybridus	c		**74**															
Lysimachia nummularia	c		**72**															

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Juglans regia	b	23	**70**															
Lathraea squamaria	c		**61**								3							
Sambucus nigra	b		58	6									20	29				
Arctium lappa	c		57															
Tussilago farfara	c		57														15	
Equisetum hiemale	c		40															
Digitalis viridiflora	c		40															
Pulmonaria rubra	c		40		7	20							17					
Rorippa nasturtium-aquaticum	c		38															
Ranunculus ficaria	c		35	18					27									
Tanacetum macrophyllum	c		34			9							8					
Orthilia secunda	c			41														
Hepatica nobilis	c			38							14							
Amelanchier ovalis	c			37														
Isopyrum thalictroides	c			34	12						12							
Doronicum columnae	c			32	15						24							
Allium ursinum	c			31	22													
Bupleurum sibthorpianum	c			30														
Galanthus gracilis	c			30														
Carex sylvatica	c				45													
Moehringia trinervia	c				35													
Laurocerasus officinalis	b				32													
Scrophularia nodosa	c				21	31												
Pyrus communis	a						**85**											
Pyrus communis	c						**72**											
Festuca pseudovina	c						**78**				2							
Quercus cerris	c						**77**		5									
Cruciata laevipes	c						**76**		7					13				
Campanula sparsa	c			6			**75**											
Luzula forsteri	c						**73**		20									
Quercus cerris	a						**72**		8								7	
Quercus frainetto	a						**70**		1									
Quercus frainetto	b						**70**											
Campanula sibirica	c						**61**											
Fragaria viridis	c						58				12							
Anthemis sancti-joannis	c				2		58											
Digitalis lanata	c						57				6						8	
Quercus frainetto	c						56										24	
Galium album	c						54											
Cruciata glabra	c			14			52							19				
Aremonia agrimonoides	c			22	8		51											
Veronica chamaedrys	c						47		13								17	
Verbascum phoeniceum	c						47										26	
Ligustrum vulgare	c						40		11									
Rosa arvensis	c						32		11									
Galium schultesii	c						32				16			12			16	
Lamium purpureum	c								**67**									
Cardamine hirsuta	c								57									
Carpinus orientalis	a								57								29	
Geranium lucidum	c								56									

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Euphorbia myrsinites	c								42									
Chamaecytisus hirsutus	c								40		15							
Poa bulbosa	c								39									
Lamium amplexicaule	c								38									
Veronica hederifolia	c								36		10						27	
Tamus communis	c								34									
Fragaria moschata	c								34		17							
Fumaria vailantii	c								33									
Alyssum alyssoides	c								32									
Hieracium pilosella	c								31									
Genista ovata	c								37	**99**								
Campanula trachelium	c					11				**98**			17					
Vicia sepium	c									**98**								
Koeleria eriostachia	c									**97**								
Acer campestre	a									**97**								
Sedum cepaea	c									**97**								
Cynosurus echinatus	c								1	**97**								
Ulmus minor	b								1	**97**								
Tilia tomentosa	b								1	**97**								
Ulmus minor	c								0	**96**								
Tilia tomentosa	c								5	**94**								
Buglossoides purpurocaerulea	c								5	**94**								
Epipactis helleborine	c			23		8				**92**								
Tilia tomentosa	a								10	**91**								
Fritillaria pontica	c								19	**91**								
Glechoma hirsuta	c								14	**89**								
Lathyrus laxiflorus	c								16	**86**								
Lathyrus niger	c						14		3	**85**								
Ruscus aculeatus	c								17	**85**								
Cephalanthera rubra	c									**84**							19	
Scutellaria albida	c									**84**								
Lychnis coronaria	c								5	**82**								
Prunella vulgaris	c						12		4	**79**			2					
Corylus colurna	c									**76**	11			17				
Lathyrus venetus	c								25	**74**								
Corylus colurna	b									**74**	16			20				
Vicia cracca	c								1	**73**								
Galium pseudoaristatum	c								1	**72**	″3							
Bromus ramosus	c									**72**				29				
Trifolium medium	c								25	**70**	8							
Cornus mas	c								31	**69**	18							
Corylus colurna	a									**69**	22			21				
Fraxinus ornus	c			17					19	**66**	16							
Tilia cordata	b								11	**65**								
Symphytum bulbosum	c									**64**	4			9				
Arabis turrita	c								27	**63**	10			13				
Tilia cordata	a								19	**61**								
Alliaria petiolata	c								8	**61**	12			22				
Campanula rapunculoides	c			9					18	59				25				
Melica uniflora	c								22	58	19			8				

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tilia cordata	c								13	56	8							
Lapsana communis	c		15						10	52				16		20		
Lamiastrum galeobdolon	c					17				38			21	15				
Clinopodium vulgare	c		24				25		12	37	3			6				
Fragaria vesca	c			8					7	32				28				
Cardamine bulbifera	c			16	21					32				11				
Poa nemoralis	c						23		17	30	14			15				
Arabis procurrens	c			27					19		42							
Asplenium ruta-muraria	c										34							
Sagina procumbens	c										33							
Convallaria majalis	c										32							
Symphytum otomanum	c										30							
Betula pendula	a											**75**						
Betula pendula	b											**72**						
Phyllitis scolopendrium	c				10								46	13				
Lunaria rediviva	c					22							45	26				
Salvia glutinosa	c				11	21							45					
Petasites albus	c				21	22							36					
Sambucus nigra	c					11							31	13				
Parietaria officinalis	c												31	23				
Polypodium vulgare	c					10					17		30					
Telekia speciosa	c												30	11				
Circaea lutetiana	c				16	11							30	19				
Heracleum sibiricum	c													55				
Achillea grandifolia	c				14									54				
Acer heldreichii	b					14		19						53				
Hesperis sylvestris	c													50				
Geranium sanguineum	c													46				
Valeriana oficinalis	c													46				
Symphytum tuberosum	c				26									44				
Polygonatum multiflorum	c										13			43				
Anthriscus sylvestris	c													42				
Silene vulgaris	c				17									40				
Hedera helix	b													37				
Acer pseudoplatanus	b			17		9	27							37				
Impatiens noli-tangere	c				10								17	36				
Acer heldreichii	c							18						36				
Rosa pendulina	c													36				
Acer heldreichii	a													36				
Galeopsis speciosa	c							17						35				
Silene alba	c													35				
Alopecurus gerardii	c													34				
Geranium phaeum	c													33				
Stellaria holostea	c								12		22			33				
Ulmus glabra	b										9		24	33				
Viola tricolor	c								10					32				
Erysimum diffusum	c													31				
Sambucus ebulus	c													31				
Pulmonaria officinalis	c			18							12		14	30				
Ranunculus oreophilus	c														77			

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rumex alpinus	c														**77**			
Ribes alpinum	b														**71**			
Ribes alpinum	c														**67**			
Juniperus sibirica	c														**64**			
Juniperus sibirica	b														**61**			
Potentila haynaldiana	c														**61**			
Vaccinium vitis-idaea	c							9							57			
Veronica alpina	c														44			
Dryopteris expansa	c														36			
Scilla bifolia	c		18	8					16						31		14	
Populus tremula	a															**65**		
Daphne mezereum	b			24	17	14										59		
Sorbus aucuparia	b															50		
Asarum europaeum	c					6					5		25	13		43		
Abies alba	b			13		10								24		36		16
Hieracium sabaudum s.l.	c															36		
Polystichum aculeatum	c				12	17							24			31		
Abies alba	c			16		7		8					7	14		30		
Pinus nigra ssp. *pallasiana*	a			6													**77**	
Dianthus petraeus	c										11						**67**	
Pinus nigra ssp. *pallasiana*	c										7						**69**	
Pinus nigra ssp. *pallasiana*	b																**65**	
Juniperus deltoides	b																55	
Jurinea mollis	c																53	
Quercus pubescens	c																50	
Thesium bavarum	c			7													46	
Ranunculus rumelicus	c								9		7						46	
Genista rumelica	c								11								46	
Campanula glomerata	c										7						44	
Laserpitium siler	c																44	
Sedum ohroleucum	c																43	
Quercus pubescens	b																42	
Convolvulus arvensis	c																42	
Seseli rigidum	c								11								42	
Quercus petraea	a								6								41	
Galium verum	c					6											38	
Sesleria latifolia	c			28							18						38	
Iberis sempervirens	c										13						37	
Cotoneaster nebrodensis	b			11							12						37	
Atropa bella-donna	c					6											37	
Euphorbia helioscopia	c								9								36	
Moehringia pendula	c								19								35	
Muscari armeniacum	c																35	
Daphne blagayana	c				13												34	
Chamaecytisus ciliatus	c										8						34	
Campanula cervicaria	c																33	
Quercus petraea	b								11								33	
Stachys sylvatica	c																32	
Campanula rotundifolia	c																32	
Coronilla varia	c																30	

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pinus peuce	a														7			**89**
Milium effusum	c													11				**87**
Homogine alpina	c														25			**81**
Cicerbita alpina	c																	**79**
Stellaria nemorum	c					7		12						6	15			**65**
Gentiana asclepiadea	c				16													**64**
Pinus peuce	b																	**63**
Pinus peuce	c																	**63**
Gymnocarpium dryopteris	c																	**62**
Dryopteris dilatata	c				21													**62**
Lamium garganicum	c				2	11					18		16	18				**60**
Sorbus aucuparia	b														28			60
Hieracium murorum s.l.	c							7										38
Pinus sylvestris	c																	37
Luzula sylvatica	c				18	18		17								27		36
Pinus sylvestris	b																	33
Rubus idaeus	c				11	10	16						14	15	23			33
Juglans regia	c	83	30															
Ranunculus repens	c	79	36															
Salix fragilis	c	76	48															
Juglans regia	a	76	41															
Scirpus silvaticus	c	74	53															
Dipsacus filonum	c	74	46											41				
Salix elaagnus	c	73	46															
Rubus hirtus	c	73	39															
Salix fragilis	b	72	52															
Clematis vitalba	b	72	52															
Cornus sanguinea	b	71	58															
Salix fragilis	a	70	57															
Salix elaagnus	a	69	56															
Rubus hirtus	b	69	66															
Salix elaagnus	b	69	56															
Angelica sylvestris	c	69	56											0				
Acer campestre	b	60	48				17		1									
Prunus cerasifera	c	66								66								
Sorbus torminalis	a						39		8	69	1							
Sorbus torminalis	b						39		4	68	5							
Sorbus torminalis	c						44		3	68	5							
Fagus sylvatica	b			15	21	21	52	19	5	64	5		19	22				
Fagus sylvatica	c			13	26	18	55	16	1	60	12		20	16				
Carpinus orientalis	b								44	68							13	
Cornus mas	b								33	66	20							
Quercus petraea	b								42	65	9							
Carpinus orientalis	c								44	62							13	
Acer hyrcanum	a								29	80	47			31				
Acer hyrcanum	c			23					27	79	40			37				
Picea abies	a														62			62
Picea abies	b														65			45
Picea abies	c														46			73
Stellaria media	c	54	32						19								12	

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fraxinus excelsior	b	54	48											32				
Fraxinus excelsior	a	48	48											25		18		
Corylus avellana	b	45	40								2		19	19				
Acer platanoides	b	44	44								16		6	25				
Acer platanoides	a	40	31								15		10	21				
Geranium robertianum	c	39	39			23							27					
Chrysosplenium alternifolium	c	38	52			3							5					
Prunus cerasifera	a	56	34							56								
Prunus cerasifera	b	56	39							56								
Fraxinus excelsior	c	56				3	30							22				
Crataegus monogyna	c	45					41		14	45				1				
Clematis vitalba	c	43		2			30			43						14		
Crataegus monogyna	b	43	19				34			43								
Dactylis glomerata	c	42							18	42				25				
Acer platanoides	c	39								39	19			19		21		
Hedera helix	c	38	24						12	38	13			12				
Ajuga reptans	c	31								31					18	31		
Mercurialis perennis	c		30	19		14				35			14	17				
Acer campestre	c						51		32									
Fagus sylvatica	a			22	22	22	53	22	6	58	14		17	16				
Brachypodium sylvaticum	c						46		15	51	6							
Lathyrus vernus	c						43		31									
Helleborus odorus	c		26	7			31		20	35	17							
Veronica officinalis	c				15		31								37			
Quercus petraea	a								46	58	19							
Quercus petraea	c								41	56	19						13	
Fraxinus ornus	b								39	59	19							
Fraxinus ornus	a								39	57	32							
Primula veris	c								34	50	17						11	
Acer hyrcanum	b								33		32			59				
Galium aparine	c								29	56				33				
Geum urbanum	c		25						11	52	9			21				
Ostrya carpinifolia	a			16							43			17		32	16	
Ostrya carpinifolia	c			10							43			10		30		
Ostrya carpinifolia	b			12							33			14		35	18	
Urtica dioica	c					13							31	32				
Acer pseudoplatanus	c			5	6	12	26	4						43		35	12	
Myosotis sylvatica	c				13									37	44			
Senecio nemorensis	c				14										52			47
Vaccinium myrtillus	c				3			26							41			41
Athyrium filix-femina	c				16	26							24		34			58
Sorbus aucuparia	c				2										33		6	55
Other taxa																		
Carpinus betulus	a	27	27				27		3	27	15		12	10				
Carpinus betulus	b	27	23				20			27	8		14	12		28		
Carpinus betulus	c	21	24				28			28	5		6	13		20		
Euphorbia amygdaloides	c		26	19	8						9			16				
Rumex conglomeratus	c		23										9					
Arum maculatum	c		20	23					8				17					
Veronica beccabunga	c		16												27			

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lonicera xylosteum	b			26							9			20				
Carex digitata	c			24							11							
Polygonatum odoratum	c			23					22									
Allium flavum	c			23					11									
Corydalis slivenensis	c			22					19									
Cotoneaster nebrodensis	c			21							9						24	
Sorbus aria	c			21				9										
Haberlea rhodopensis	c			19					13		24							
Neottia nidus-avis	c			18		11												
Potentilla micrantha	c			18							28							
Viola odorata	c			17					15					19				
Origanum vulgare	c			17							17						15	
Corydalis solida	c			16					21		17			18				
Teucrium chamaedrys	c			16					10		26							
Polygonatum verticillatum	c			15	21													
Juniperus communis	c			15							15							
Sorbus aria	a			15													16	
Asplenium trichomanes	c			13					18		18		17					
Senecio doria	c			13							8						24	
Lilium martagon	c			12	12												26	
Solidago virgaurea	c			12		20		12										
Inula hirta	c			11					15									
Viola sylvatica	c			10							20							
Lonicera xylosteum	c			10							13			27				
Acer pseudoplatanus	a			9		12	19						24	29				
Salix caprea	a			8									23					
Abies alba	a			7		13		7						10				
Galium odoratum	c				29	22							27	18				
Sanicula europaea	c				28	25	27						17					
Veronica urticifolia	c				28	16							22					
Astrantia major	c				26									16				
Thalictrum aquilegiifolium	c				25									24				
Veronica montana	c				24	19												
Epilobium montanum	c				24	12							15					
Geranium sylvaticum	c				24													28
Achillea distans	c				23									22				
Luzula luzuloides	c				19	15		23	5					22				22
Galium rotundifolium	c				19	29		25					15					
Festuca drymeja	c				19	13							12					22
Actaea spicata	c				19									18				
Oxalis acetosella	c				17	16							21					23
Dryopteris filix-mas	c				17	21		12					19	10	16			26
Campanula patula	c				15	19		16					25					
Saxifraga rotundifolia	c				15	11					20							
Mycelis muralis	c				12	13	24						22					28
Prenanthes purpurea	c				12	17		15						22				25
Polystichum setiferum	c				12	11												
Achillea ageratifolia	c				12												18	
Lerchenfeldia flexuosa	c				11			13										
Rubus idaeus	b				8			17										

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hordelymus europaeus	c					29							22					
Cardamine pectinata	c					23							24					
Angelica pancicii	c					21							12					
Epipactis atrorubens	c					10					18							
Festuca heterophylla	c							24	8		10							
Pyrola minor	c							14					12					
Hieracium umbellatum	c							11					23					
Cystopteris fragilis	c								28		25							
Ceterach officinarum	c								23		11							
Quercus pubescens	a								23								26	
Sedum maximum	c								21		17							
Viscaria vulgaris	c								20		17			17				
Asplenium adiantum-nigrum	c								19		22							
Lunaria annua	c								18		17			23				
Syringa vulgaris	b								16		22							
Sedum album	c								15		11							
Vincetoxicum hirundinaria	c								15		12			21				
Digitalis grandiflora	c								14		12			26				
Polygala major	c								14		14							
Euphorbia cyparissias	c								14		14							
Prunus avium	c								14		12							
Satureja pilosa	c								12		19							
Umbilicus erectus	c								11		17							
Genista tinctoria	c								11		13							
Melica ciliata	c								10		13							
Euphorbia polychroma	c								10		19							
Prunus avium	a								6		8							
Chamaecytisus austriacus	c										16						18	
Evonymus latifolius	b										13			16				
Salix caprea	c										10		17					
Ulmus glabra	a												29	23				
Ulmus glabra	c												24	27				
Cirsium appendiculatum	c												14	26				27
Calamagrostis arundinacea	c												12				27	
Pinus sylvestris	a																15	28
Equisetum sylvaticum	c		26															
Gagea lutea	c			29														
Asplenium viride	c			29														
Cephalanthera damasonium	c			28														
Scabiosa argentea	c			26														
Carlina acanthifolia	c			26														
Anthericum ramosum	c			24														
Acinos rotundifolius	c			24														
Pteridium aquilinum	c			22														
Sorbus aria	b			19														
Colchicum autumnale	c			19														
Galium tenuissimum	c			15														
Laserpitium latifolium	c			19														
Iris reichenbachii	c			15														
Globularia aphyllanthes	c			15														

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Carex pilosa	c			15														
Veratrum lobelianum	c				27													
Polystichum lonchitis	c				25													
Aquilegia nigricans	c				23													
Epilobium angustifolium	c				22													
Salvia nemorosa	c				21													
Paris quadrifolia	c				19													
Achillea clusiana	c				19													
Laurocerasus officinalis	c				19													
Aconitum variegatum	c				19													
Stachys alpina	c				17													
Campanula latifolia	c				17													
Dactylorhiza saccifera	c				16													
Valeriana tripteris	c				16													
Dryopteris carthusiana	c				15													
Doronicum austriacum	c				15													
Sorbus aucuparia	a				14													
Aegopodium podagraria	c				12													
Senecio fuchsii	c				12													
Moehringia muscosa	c				12													
Rhynchocorys elephas	c				10													
Dactylorhiza cordigera	c					20												
Helianthemum nummularium	c					18												
Atropa bella-donna	b					17												
Festuca gigantea	c					12												
Sambucus racemosa	c					10												
Calamagrostis epigeios	c					10												
Smyrnium perfoliatum	c					10												
Crocus veluchensis	c					4												
Rosa canina	b						27											
Rosa arvensis	b						27											
Brachypodium pinnatum	c						27											
Tilia platyphyllos	c						27											
Staphylea pinnata	c						27											
Scrophularia scopolii	c							20										
Agrostis capillaris	c							19										
Bruckenthalia spiculifolia	c							18										
Hieracium vulgatum s.l.	c							18										
Thymus pulegioides	c							16										
Rumex sanguineus	c							15										
Muscari neglectum	c								28									
Muscari comosum	c								27									
Silene italica	c								27									
Polygonatum latifolium	c								25									
Vicia incana	c								25									
Ranunculus millefoliatus	c								25									
Anthriscus nemorosa	c								23									
Vicia lathyroides	c								23									
Primula elatior	c								21									
Carex remota	c								21									

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chamaespartium sagittale	c								21									
Knautia drymeia	c								21									
Astragalus glycyphyllos	c								21									
Matricaria perforata	c								21									
Doronicum orientale	c								21									
Potentilla neglecta	c								21									
Calamintha nepeta	c								21									
Quercus cerris	b								21									
Tanacetum corymbosum	c								21									
Ajuga genevensis	c								20									
Pyrus communis	b								19									
Inula ensifolia	c								19									
Luzula multiflora	c								19									
Sedum hispanicum	c								18									
Chamaecytisus supinus	c								17									
Orchis simia	c								17									
Hypericum cerastoides	c								17									
Lathyrus pannonicus	c								17									
Dichanthium ischaemum	c								17									
Ornithogalum gussonii	c								17									
Veronica prostata	c								17									
Buglossoides arvensis	c								16									
Cephalanthera longifolia	c								15									
Chamaecytisus calcareus	c								17									
Sedum acre	c								14									
Cerasus mahaleb	b								14									
Euphorbia thessala	c								14									
Cerasus mahaleb	a								14									
Iris pumila	c								14									
Lathyrus aphaca	c								14									
Cerasus mahaleb	c								14									
Sedum stefco	c								14									
Lathyrus sylvestris	c								14									
Prunus mahaleb	c								14									
Tilia platyphyllos	a								14									
Anthemis austriaca	c								12									
Poa pratensis	c								11									
Staphylea pinnata	a								10									
Populus tremula	c								10									
Glechoma hederacea	c								10									
Hypericum perforatum	c								8									
Euonymus verrucosus	c										28							
Galium spurium	c										26							
Asplenium septentrionale	c										26							
Evonymus verrucosus	b										23							
Trifolium alpestre	c										23							
Anthyllis vulneraria	c										21							
Rosa canina	c										21							
Achillea clypeolata	c										21							
Juniperus communis	b										21							

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Campanula persicifolia	c										21							
Achillea millefolium	c										20							
Lysimachia vulgaris	c										19							
Minuartia saxifraga	c										18							
Senecio procerus	c										18							
Evonymus latifolius	c										17							
Taxus baccata	b										17							
Taxus baccata	c										16							
Spiraea chamaedryfolia	c										16							
Lamium maculatum	c										16							
Viola aetolica	c										15							
Spiraea chamaedrifolia	b										15							
Thlaspi perfoliatum	c										15							
Viola riviniana	c										15							
Platanthera bifolia	c										15							
Adoxa moschatellina	c										15							
Senecio macrophyllus	c										15							
Alyssum murale	c										14							
Stachys recta	c										14							
Eupatorium cannabinum	c										14							
Prunus avium	b										13							
Potentilla pilosa	c										12							
Geranium pyrenaicum	c										11							
Salix caprea	b												28					
Cardamine flexuosa	c												19					
Sambucus nigra	a												19					
Betula pendula	c												19					
Tanacetum parthenium	c												19					
Buplerium falcatum	c												14					
Bellis sylvestris	c													29				
Ribes uva-crispa	c													29				
Ribes petraeum	c													29				
Asperula taurina	c													26				
Ribes petraeum	b													24				
Geranium molle	c													24				
Campanula lanata	c													23				
Turritis glabra	c													22				
Phleum montanum	c													22				
Cardamine raphanifolia	c													22				
Rosa pendulina	b													20				
Equisetum arvense	c													20				
Ribes uva-crispa	b													19				
Alnus glutinosa	a													13				
Alnus glutinosa	b													18				
Alnus glutinosa	c													18				
Achillea nobilis	c													18				
Corylus avellana	a													18				
Corydalis bulbosa	c													17				
Tilia platyphyllos	b													15				
Arabis alpina	c													15				

№ of habitats		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Potentilla rupestris	c													10				
Geum coccineum	c														25			
Chaerophyllum hirsutum	c														25			
Cirsium vulgare	c																29	
Carex divulsa	c																23	
Carlina vulgaris	c																23	
Corallorhiza trifida	c																22	
Chelidonium majus	c																20	
Euonymus europaeus	b																19	
Rubus serpens	c																17	
Rubus caesius	b																17	
Veronica rotundifolia	c																17	
Rubus caesius	c																17	
Rosa obtusifolia	c																17	
Heracleum verticillatum	c																	26

Acinos arvensis c, *Anemone nemorosa* c, *Anthoxanthum odoratum* c, *Arctostaphylos uva-ursi* c, *Asplenium montanum* c, *Calamintha sylvatica* c, *Caltha palustris* c, *Calystegia silvatica* c, *Cardamine impatiens* c, *Cirsium oleraceum* c, *Crepis biennis* c, *Cyclamen hederifolium* c, *Dianthus pinifolius* c, *Echinops ritro* c, *Erythronium dens-canis* c, *Euonymus europaeus* c, *Fumana procumbens* c, *Geum rivale* c, *Gymnocarpium robertianum* c, *Heracleum ternatum* c, *Hieracium hoppeanum* c, *H. villosum* c, *Hypericum rochelii* c, *Ilex aquifolium* c, *Melampyrum sylvaticum* c, *Micromeria frivaldskyana* c, *Nasturtium officinale* c, *Ornithogalum umbellatum* c, *Quercus petraea* c, *Ranunculus auricomus* c, *R. ophioglossifolius* c, *Rubus saxatilis* b, *Ruscus hypoglossum* c, *Sagina saginoides* c, *Salvia verticillata* c, *Sambucus racemosa* b, *Scutellaria altissima* c, *S. galericulata* c, *Selaginella helvetica* c, *Senecio papposus* c, *S. sylvaticus* c, *Stachys bulgarica* c, *Thalictrum minus* c, *Verbascum abietinum* c, *V. longifolium* c, *Verbena montana* c, *Veronica teucrium* c, *V. triloba* c, *Viola canina* c, *V. reichenbachiana* c.