

Novák P., Willner W., Zukal D., Kollár J., Roleček J., Świerkosz K., Ewald J., Wohlgemuth T., Csiky J., Onyshchenko V. & Chytrý M. (2020) Oak-hornbeam forests in central Europe: a formalized classification and syntaxonomic revision. – Preslia 92: 1–34

Electronic Appendix 1. Data sources.

Data obtained from the European Vegetation Archive

EU-AT-001 Austrian Vegetation Database (688 plots)

Custodian: Wolfgang Willner, Deputy Custodian: Christian Berg

EU-CZ-001 Czech National Phytosociological Database (1,754 plots)

Custodian: Milan Chytrý, Deputy Custodian: Ilona Knollová

EU-CH-005 Swiss Forest Vegetation Database (250 plots)

Custodian: Thomas Wohlgemuth

EU-FR-003 SOPHY (83 plots)

Custodian: Henry Brisse, Deputy Custodian: Patrice de Ruffray

EU-FR-005 EcoPlant (3 plots)

Custodian: Jean-Claude Gégout, Deputy Custodian: Ingrid Seynave

EU-DE-001 VegMV (227 plots)

Custodian: Florian Jansen, Deputy Custodian: Christian Berg

EU-DE-013 VegetWeb (139 plots)

Custodian: Florian Jansen, Deputy Custodian: Jörg Ewald

EU-DE-014 GVRD Vegetation Reference Database Halle (746 plots)

Custodian: Ute Jandt, Deputy Custodian: Helge Bruelheide

EU-HU-003 CoenoDat Hungarian Phytosociological Database (215 plots)

Custodian: János Csiky, Deputy Custodian: Zoltán Botta-Dukát

EU-PL-001 Polish Vegetation Database (1,156 plots)

Custodian: Zygmunt Kącki, Deputy Custodian: Grzegorz Swacha

EU-SK-001 Slovak Vegetation Database (680 plots)

Custodian: Milan Valachovič, Deputy Custodian: Jozef Šibík

EU-UA-006 Vegetation database of Ukraine and adjacent parts of Russia (11 plots)

Custodian: Viktor Onyshchenko, Deputy Custodian: Vitaliy Kolomiychuk

Other sources

Jan Roleček (225 original plots sampled in the field)

Novák et al. 2017 (35 plots digitized from the paper)

Numbers of relevés per country

Country	Number of relevés
Austria	692
Czech Republic	1,699
Germany	1,119
Hungary	438
Luxembourg	26
Poland	1,159
Slovakia	729
Switzerland	304
Ukraine	46
Σ	6,212

References

Novák P., Zukal D., Večeřa M. & Píšířková K. (2017) Vegetation of oak-hornbeam, scree and ravine forests at lower altitudes in Transcarpathia, Western Ukraine. – *Tuexenia* 37: 47–63.

Electronic Appendix 2. GRIMP-based expert system.

Here we provide a brief description of the GRIMP procedure (Tichý et al. 2019) used to obtain the lists of diagnostic species of oak-hornbeam forest vegetation in the context of other seven major types of central European deciduous forest vegetation. The final version of the GRIMP-based expert system is also provided. All the analyses were performed using Juice 7.0 (Tichý 2002).

We used a dataset of 41,592 relevés obtained from the databases cited in Electronic Appendix 1. Nomenclature of vascular plants was generally unified according to the Euro+Med PlantBase (www.emplantbase.org; accessed August 2018). Prior to the analyses, all the records of the same taxon in different vegetation layers were merged into a single layer. Only relevés with syntaxonomic classification on the association or alliance level provided in the original databases or publications were involved since the assignments to syntaxa were necessary for the next steps of the preparation of the GRIMP expert system. According to the authors' classification, we sorted relevés into eight principal deciduous forest vegetation types:

F01 – Oak-hornbeam forests (*Carpinetalia betuli*)

F02 – Scree and ravine forests (*Aceretalia*)

F03 – Beech forests (*Fagetalia* + *Luzulo-Fagetalia*)

F04 – Acidophytic oak forests (*Quercetea robori-petraeae*)

F05 – Thermophytic oak forests (*Quercetea pubescentis*)

F06 – Alluvial forests (*Alno-Fraxinetalia*)

F07 – Swamp forests (*Alnetea glutinosae*)

F08 – Willow riparian forests (*Salicetea purpureae*)

To avoid major misclassifications in the original sources, relevés had to fulfil conditions based on the total cover of groups of typical tree species recognized as important for certain forest vegetation types. For *Carpinetalia betuli*, relevés were included only if a total cover of *Acer campestre*, *A. platanoides*, *Carpinus betulus*, *Quercus petraea*, *Q. robur*, *Tilia cordata* and *Ulmus minor* was higher than 25%. Other relevés (n = 1,173) were excluded. At the same time, the total cover of other groups of tree species typical of the seven other vegetation types could not exceed 75%. After this step, the whole dataset contained 41,592 relevés. Then, for each vegetation type, we prepared a list of diagnostic species ($\phi > 0.05$, sizes of all groups were virtually standardized according to Tichý & Chytrý 2006). The number of diagnostic species ranged between 113–167 species per vegetation type. Some species were jointly diagnostic for more than one type.

Afterwards, the first classification cycle was performed. A relevé was classified into a vegetation type when the sum of square-rooted percentage cover of diagnostic species for this type was higher than the sum of square-rooted percentage cover of diagnostic species for the other seven types. As an additional condition, a relevé had to be dominated by tree species typical of this vegetation type.

This enabled to distinguish three types of classifications of a relevé:

1) **correct classification** – a relevé was classified to the same vegetation type as indicated by the original authors' classification.

2) **misclassification** – a relevé was classified to another vegetation type than indicated by the original authors' classification.

3) **no classification** – a relevé was not classified to any of the vegetation types. It was a frequent situation when a relevé fulfilled the first part of the definition (diagnostic species) but failed to fulfil the second part (dominant tree species).

After the first cycle, we obtained 82.4% of correctly classified relevés, 12.3% of misclassified relevés and 5.3% of unclassified relevés.

The GRIMP optimization process started afterwards. It was based on iterative removals of certain species from the lists of diagnostic species aiming at improving the number of correct classifications. After 10,000 cycles, the number of correctly classified relevés was not changing significantly. After this optimization of species groups, we had 87.8% of correctly classified relevés, 9.3% misclassified relevés and 3% of unclassified relevés. Based on these results, we prepared the following GRIMP-based expert system for classification of relevés into the eight main deciduous forest vegetation types of central Europe. The syntax used in the expert system is explained in Tichý et al. (2019). This expert system was used to select relevés of oak-hornbeam forests for subsequent analyses. It can be run in the Juice 7.0.210 program after being transformed into plain text (.txt) format.

GRIMP-based expert system

SECTION 1: Species aggregation

Achillea millefolium aggr.	-
0	
Achillea collina	0
Achillea millefolium	0
Achillea pannonica	0
Achillea setacea	0
Carex muricata aggr.	-
0	
Carex divulsa	0
Carex muricata	0
Carex spicata	0
Dryopteris affinis aggr.	-
0	
Dryopteris affinis	0
Dryopteris affinis × borreri	0
Dryopteris borreri	0
Molinia caerulea aggr.	-
0	
Molinia arundinacea	0
Molinia caerulea	0
Polypodium vulgare aggr.	-
0	
Polypodium interjectum	0
Polypodium vulgare	0

Pulmonaria officinalis aggr.	-
0	
Pulmonaria obscura	0
Pulmonaria officinalis	0
Quercus petraea aggr.	-
0	
Quercus dalechampii	0
Quercus petraea	0
Rubus fruticosus aggr.	-
0	
Rubus hirtus	0
Rubus serpens	0
Rubus sulcatus	0
Senecio nemorensis aggr. .	-
0	
Senecio hercynicus	0
Senecio nemorensis subsp. jacquinianus	0
Senecio ovatus	0
Stellaria media aggr.	-
0	
Stellaria media	0
Stellaria neglecta	0
Stellaria pallida	0
Sorbus aria aggr.	-
0	
Sorbus aria	0
Sorbus aria × torminalis	0
Sorbus bohemica	0
Sorbus graeca	0
Sorbus latifolia	0
Sorbus mougeotii	0
Sorbus semiincisa	0
Veratrum album aggr.	-
0	
Veratrum album	0
Veratrum lobelianum	0
Veronica hederifolia aggr.	-
0	
Veronica hederifolia	0
Veronica sublobata	0

SECTION 1: End

SECTION 2: Species groups

##Q +01 Alnglu

Agrostis canina
Agrostis gigantea
Agrostis stolonifera
Alisma plantago-aquatica
Alnus glutinosa
Alopecurus geniculatus
Angelica sylvestris
Athyrium filix-femina
Avenella flexuosa
Betula pubescens
Calamagrostis canescens
Callitriche palustris
Caltha palustris
Cardamine amara
Cardamine pratensis
Carduus acanthoides
Carex acuta
Carex acutiformis
Carex brizoides
Carex canescens
Carex cespitosa
Carex disticha
Carex echinata
Carex elata
Carex elongata
Carex lasiocarpa
Carex paniculata
Carex remota
Carex riparia
Carex rostrata
Carex vesicaria
Circaea alpina
Cirsium oleraceum
Cirsium palustre
Crepis paludosa
Deschampsia cespitosa
Dryopteris carthusiana
Epilobium hirsutum
Equisetum arvense
Equisetum fluviatile
Equisetum palustre
Equisetum sylvaticum
Equisetum x litorale
Erechtites hieracifolius

Eriophorum angustifolium
Eupatorium cannabinum
Filipendula ulmaria
Frangula alnus
Galium palustre
Galium uliginosum
Geum rivale
Glyceria fluitans
Holcus lanatus
Hottonia palustris
Humulus lupulus
Hydrocharis morsus-ranae
Chrysosplenium alternifolium
Chrysosplenium oppositifolium
Juncus effusus
Lemna minor
Lycopus europaeus
Lysimachia vulgaris
Lythrum salicaria
Mentha aquatica
Menyanthes trifoliata
Myosotis laxa
Myosotis scorpioides
Myosoton aquaticum
Osmunda regalis
Persicaria hydropiper
Persicaria minor
Peucedanum palustre
Phragmites australis
Poa trivialis
Prunus padus
Ranunculus flammula
Ranunculus lingua
Ranunculus repens
Ribes nigrum
Rumex hydrolapathum
Salix aurita
Salix cinerea
Scirpus sylvaticus
Silaum silaus
Solanum dulcamara
Sonchus arvensis
Sparganium emersum
Spirodela polyrhiza
Stellaria alsine

Stellaria palustris
Urtica dioica
Valeriana dioica
Valeriana excelsa
Veronica beccabunga
Viola palustris

##Q +01 Alninc

Aegopodium podagraria
Ajuga reptans
Alchemilla vulgaris
Allium ursinum
Alnus glutinosa
Alnus incana
Anemone nemorosa
Angelica sylvestris
Arabidopsis halleri
Asarum europaeum
Athyrium filix-femina
Avenella flexuosa
Bistorta officinalis
Brachypodium sylvaticum
Calamagrostis canescens
Caltha palustris
Cardamine amara
Carduus personata
Carex acutiformis
Carex brizoides
Carex pendula
Carex remota
Carex strigosa
Carex sylvatica
Circaea alpina
Circaea lutetiana
Circaea x intermedia
Cirsium helenioides
Cirsium oleraceum
Cirsium palustre
Cirsium rivulare
Colchicum autumnale
Crataegus x media
Crepis paludosa
Dactylorhiza fuchsii
Dactylorhiza maculata
Doronicum austriacum

Elymus caninus
Equisetum hyemale
Equisetum palustre
Equisetum pratense
Equisetum sylvaticum
Euonymus europaeus
Eupatorium cannabinum
Ficaria verna
Filipendula ulmaria
Fraxinus angustifolia
Fraxinus excelsior
Gagea spathacea
Galium aparine
Geranium phaeum
Geranium robertianum
Geum rivale
Geum urbanum
Glechoma hederacea
Glyceria fluitans
Chaerophyllum aromaticum
Chrysosplenium alternifolium
Impatiens noli-tangere
Jacobaea subalpina
Juncus effusus
Lamium maculatum
Lycopus europaeus
Lysimachia nemorum
Lysimachia vulgaris
Miliun effusum
Myosotis nemorosa
Myosotis scorpioides
Neottia ovata
Paris quadrifolia
Petasites albus
Petasites hybridus
Petasites kablikianus
Poa remota
Poa trivialis
Primula elatior
Prunella vulgaris
Prunus padus
Ranunculus aconitifolius
Ranunculus lanuginosus
Ranunculus repens
Ribes rubrum

Rubus caesius
Rubus idaeus
Rumex conglomeratus
Rumex sanguineus
Salix myrsinifolia
Schedonorus giganteus
Silene dioica
Silene flos-cuculi
Stachys sylvatica
Stellaria nemorum
Telekia speciosa
Thalictrum alpinum
Tussilago farfara

##Q +01 Carbet

Adoxa moschatellina
Aegonychon purpureocaeruleum
Aegopodium podagraria
Ajuga reptans
Anemone nemorosa
Asarum europaeum
Astragalus glycyphyllos
Betula pendula
Brachypodium sylvaticum
Bromopsis benekenii
Calamagrostis arundinacea
Campanula persicifolia
Campanula trachelium
Carex digitata
Carex muricata aggr.
Carex pilosa
Carpinus betulus
Clinopodium vulgare
Cornus sanguinea
Corydalis solida
Crataegus laevigata
Crataegus monogyna
Cruciata glabra
Dactylis glomerata
Daphne mezereum
Epilobium lanceolatum
Euonymus europaeus
Euonymus verrucosus
Euphorbia amygdaloides
Euphorbia dulcis

Ficaria verna
Fragaria moschata
Fragaria vesca
Gagea lutea
Galanthus nivalis
Galium intermedium
Galium sylvaticum
Geum urbanum
Glechoma hirsuta
Hepatica nobilis
Hieracium murorum
Hieracium racemosum
Hypericum hirsutum
Isopyrum thalictroides
Knautia drymeia
Lathyrus linifolius
Lathyrus niger
Lathyrus vernus
Ligustrum vulgare
Lilium martagon
Maianthemum bifolium
Melampyrum nemorosum
Melica nutans
Melica uniflora
Melittis melissophyllum
Miliium effusum
Neottia nidus-avis
Orchis pallens
Platanthera bifolia
Poa nemoralis
Polygonatum multiflorum
Populus tremula
Potentilla sterilis
Primula veris
Prunus avium
Pulmonaria obscura
Pulmonaria officinalis
Quercus petraea aggr.
Quercus robur
Ranunculus lanuginosus
Sanicula europaea
Sorbus torminalis
Stellaria holostea
Symphytum tuberosum
Tilia cordata

Veronica hederifolia aggr.
Veronica chamaedrys
Vicia sepium
Vinca minor
Viola mirabilis
Viola reichenbachiana
Viola riviniana
Waldsteinia geoides

##Q +01 Fagsyl

Abies alba
Acer pseudoplatanus
Actaea spicata
Adenostyles alliariae
Adenostyles alpina
Anemone nemorosa
Anemone trifolia
Aquilegia vulgaris
Athyrium filix-femina
Atropa bella-donna
Bellidiastrum michelii
Calamagrostis varia
Campanula scheuchzeri
Cardamine bulbifera
Cardamine enneaphyllos
Cardamine glanduligera
Cardamine heptaphylla
Cardamine trifolia
Carex alba
Carex digitata
Carex flacca
Carex ornithopoda
Carex pilulifera
Carex sylvatica
Cyanus montanus
Cephalanthera damasonium
Cephalanthera rubra
Clematis alpina
Corallorhiza trifida
Cyclamen purpurascens
Cypripedium calceolus
Daphne laureola
Daphne mezereum
Drymochloa sylvatica
Dryopteris filix-mas

Epilobium montanum
Epipactis atrorubens
Epipactis helleborine
Euphorbia amygdaloides
Fagus sylvatica
Galium odoratum
Hedera helix
Helleborus niger
Hieracium murorum
Homogyne alpina
Hordelymus europaeus
Huperzia selago
Ilex aquifolium
Lactuca alpina
Lactuca muralis
Lamium galeobdolon
Lilium martagon
Lonicera alpigena
Lonicera xylosteum
Luzula luzulina
Luzula luzuloides
Luzula pilosa
Maianthemum bifolium
Melica uniflora
Mercurialis perennis
Miliium effusum
Neottia nidus-avis
Orthilia secunda
Oxalis acetosella
Paris quadrifolia
Petasites albus
Phyteuma spicatum
Picea abies
Polygala chamaebuxus
Prenanthes purpurea
Primula elatior
Ranunculus montanus
Ranunculus polyanthemos
Rosa arvensis
Rubus fruticosus aggr.
Sambucus racemosa
Sanicula europaea
Saxifraga cuneifolia
Senecio nemorensis aggr.
Sesleria caerulea

Solidago virgaurea
Sorbus aria aggr.
Sorbus aucuparia
Taxus baccata
Thelypteris limbosperma
Vaccinium myrtillus
Valeriana tripteris
Veratrum album aggr.
Veronica montana
Vicia sepium
Vicia sylvatica
Viola reichenbachiana

##Q +01 Quepub

Acer campestre
Acer tataricum
Adenophora liliifolia
Aegonychon purpurocaeruleum
Agropyron desertorum
Agrostis capillaris
Agrostis vinealis
Achillea millefolium aggr.
Achnatherum calamagrostis
Ajuga genevensis
Allium carinatum
Allium ericetorum
Allium lusitanicum
Allium scorodoprasum
Alyssum montanum
Amelanchier ovalis
Anthericum liliago
Anthericum ramosum
Anthoxanthum odoratum
Arabidopsis arenosa
Arabidopsis thaliana
Arabis glabra
Arrhenatherum elatius
Artemisia pontica
Asparagus officinalis
Asperula aristata
Asperula cynanchica
Asplenium adiantum-nigrum
Aurinia saxatilis
Avenula pubescens
Berberis vulgaris

Biscutella laevigata
Bothriochloa ischaemum
Brachypodium pinnatum
Brachypodium sylvaticum
Bromopsis erecta
Bromopsis inermis
Bromopsis pannonica
Buphthalmum salicifolium
Buxus sempervirens
Campanula cervicaria
Campanula cespitosa
Campanula glomerata
Campanula rapunculoides
Campanula rotundifolia
Campanula sibirica
Campanula spicata
Campanula trachelium
Carex caryophyllea
Carex filiformis
Carex fritschii
Carex humilis
Carex montana
Carex muricata aggr.
Carlina vulgaris
Centaurea stoebe
Cirsium pannonicum
Clematis recta
Clinopodium nepeta
Clinopodium vulgare
Colutea arborescens
Convallaria majalis
Convolvulus arvensis
Cornus mas
Cornus sanguinea
Cota tinctoria
Cotoneaster tomentosus
Crataegus laevigata
Crataegus monogyna
Cruciata glabra
Cytisus ratisbonensis
Dactylis glomerata
Danthonia decumbens
Daphne cneorum
Dianthus carthusianorum
Dianthus pontederiae

Dianthus seguieri
Dianthus superbus
Dictamnus albus
Digitalis lutea
Dorycnium pentaphyllum
Echium vulgare
Erica carnea
Euonymus verrucosus
Euphrasia cuspidata
Festuca amethystina
Festuca heterophylla
Festuca pallens
Fourraea alpina
Fragaria moschata
Fragaria vesca
Fragaria viridis
Fraxinus ornus
Galeopsis ladanum
Galium album
Galium aristatum
Galium boreale
Galium glaucum
Galium intermedium
Galium lucidum
Galium mollugo
Galium pusillum
Genista germanica
Genista pilosa
Genista sagittalis
Genista tinctoria
Geranium sanguineum
Glechoma hirsuta
Helianthemum nummularium
Helictochloa pratensis
Hieracium lachenalii
Hieracium maculatum
Hieracium murorum
Hieracium porrifolium
Hieracium racemosum
Hieracium sabaudum
Hieracium umbellatum
Hierochloa australis
Hypericum montanum
Hypericum perforatum
Hypochaeris maculata

Inula hirta
Inula salicina
Iris sibirica
Jasione montana
Jovibarba globifera
Juniperus communis
Knautia arvensis
Koeleria macrantha
Laburnum anagyroides
Lactuca perennis
Lactuca quercina
Laser trilobum
Laserpitium latifolium
Lathyrus niger
Lembotropis nigricans
Ligustrum vulgare
Lilium bulbiferum
Limodorum abortivum
Linaria genistifolia
Linaria vulgaris
Lithospermum officinale
Loranthus europaeus
Luzula campestris
Luzula divulgata
Malus sylvestris
Medicago lupulina
Medicago prostrata
Melampyrum nemorosum
Melampyrum pratense
Melica ciliata
Melica nutans
Melica picta
Melittis melissophyllum
Muscari neglectum
Myosotis ramosissima
Myosotis stricta
Noccaea perfoliata
Ornithogalum orthophyllum
Ostrya carpinifolia
Petasites paradoxus
Peucedanum alsaticum
Peucedanum cervaria
Peucedanum oreoselinum
Phleum phleoides
Pilosella cymosa

Pilosella officinarum
Pimpinella saxifraga
Pinus sylvestris
Plantago media
Poa angustifolia
Poa nemoralis
Poa pratensis
Polygala amara
Polygala major
Potentilla alba
Potentilla argentea
Potentilla erecta
Potentilla tabernaemontani
Primula veris
Prunella grandiflora
Prunus avium
Prunus mahaleb
Prunus spinosa
Pulmonaria angustifolia
Pulmonaria dacica
Pulmonaria officinalis aggr.
Pulsatilla vulgaris
Pyrus communis
Quercus cerris
Quercus petraea aggr.
Quercus pubescens
Ranunculus polyanthemus
Reseda lutea
Rhamnus alpina
Rhamnus cathartica
Robinia pseudoacacia
Rosa canina
Rosa gallica
Rosa spinosissima
Rubus saxatilis
Rumex acetosella
Salvia pratensis
Salvia verticillata
Sanguisorba minor
Scabiosa canescens
Scabiosa triandra
Scleranthus perennis
Scorzonera austriaca
Scorzonera humilis
Sedum acre

Sedum album
Sedum rupestre
Sedum sexangulare
Selinum carvifolia
Selinum dubium
Sempervivum tectorum
Serratula tinctoria
Seseli osseum
Silene nemoralis
Silene nutans
Silene viridiflora
Silene viscaria
Silene vulgaris
Solidago virgaurea
Stachys officinalis
Stachys recta
Stipa capillata
Stipa pennata
Succisa pratensis
Symphytum tuberosum
Teucrium chamaedrys
Teucrium montanum
Thalictrum minus
Thymus praecox
Thymus serpyllum
Trientalis europaea
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Vaccinium vitis-idaea
Valeriana saxatilis
Verbascum chaixii
Verbascum phoeniceum
Veronica austriaca
Veronica dillenii
Veronica chamaedrys
Veronica officinalis
Vicia cassubica
Vicia hirsuta
Vicia tenuifolia
Vicia tetrasperma
Vincetoxicum hirundinaria
Viola canina
Viola collina
Viola hirta

Viola odorata
Viola riviniana
Viola rupestris
Viola suavis
Viola tricolor

##Q +01 Querop

Agrostis capillaris
Anthericum liliago
Anthoxanthum odoratum
Asplenium septentrionale
Avenella flexuosa
Betula pendula
Calamagrostis arundinacea
Calamagrostis epigejos
Calluna vulgaris
Campanula rotundifolia
Carex arenaria
Carex pilulifera
Ceratocarpus claviculata
Convallaria majalis
Cytisus scoparius
Digitalis grandiflora
Epilobium angustifolium
Eriophorum vaginatum
Festuca filiformis
Festuca ovina
Galium intermedium
Galium pumilum
Genista germanica
Genista pilosa
Genista tinctoria
Hieracium glaucinum
Hieracium laevigatum
Hieracium lachenalii
Hieracium murorum
Hieracium sabaudum
Hieracium schmidtii
Hieracium umbellatum
Holcus mollis
Hylotelephium maximum
Hypericum perforatum
Hypericum pulchrum
Jasione montana
Lathyrus linifolius

Lembotropis nigricans
Lonicera periclymenum
Luzula campestris
Luzula divulgata
Luzula luzuloides
Luzula pilosa
Melampyrum pratense
Molinia caerulea aggr.
Pilosella officinarum
Pinus sylvestris
Poa nemoralis
Polypodium vulgare aggr.
Populus tremula
Prunus cerasus
Pteridium aquilinum
Quercus petraea aggr.
Quercus robur
Rumex acetosella
Senecio sylvaticus
Silene nutans
Silene viscaria
Sorbus aucuparia
Teucrium scorodonia
Vaccinium myrtillus
Vaccinium vitis-idaea
Veronica officinalis
Viscum album

##Q +01 Salice

Acer negundo
Aegopodium podagraria
Agrostis stolonifera
Alisma lanceolatum
Alliaria petiolata
Alnus incana
Alopecurus pratensis
Angelica sylvestris
Anthemis arvensis
Arctium lappa
Argentina anserina
Atriplex prostrata
Bidens tripartitus
Callitriche cophocarpa
Calystegia sepium
Cardamine amara

Cardamine dentata
Carex acutiformis
Carex riparia
Carex vulpina
Chaiturus marrubiastrum
Cirsium arvense
Cirsium canum
Cirsium oleraceum
Conium maculatum
Cornus sanguinea
Cuscuta europaea
Cuscuta lupuliformis
Echinocystis lobata
Elymus caninus
Epilobium hirsutum
Epilobium parviflorum
Epilobium tetragonum
Equisetum arvense
Fallopia convolvulus
Galeopsis ladanum
Galeopsis tetrahit
Galium aparine
Galium palustre
Glechoma hederacea
Glyceria maxima
Heracleum sphondylium
Humulus lupulus
Chaerophyllum aromaticum
Chaerophyllum bulbosum
Impatiens glandulifera
Lamium album
Lamium maculatum
Leucanthemella serotina
Leucojum aestivum
Lycopus europaeus
Lysimachia nummularia
Lysimachia vulgaris
Mentha arvensis
Myosotis nemorosa
Myosotis scorpioides
Oenanthe aquatica
Persicaria amphibia
Persicaria dubia
Petasites hybridus
Phalaroides arundinacea

Phragmites australis
Poa palustris
Poa trivialis
Populus alba
Populus nigra
Prunus cerasifera
Prunus padus
Ranunculus repens
Reynoutria japonica
Rorippa amphibia
Rorippa sylvestris
Rubus caesius
Rumex aquaticus
Rumex conglomeratus
Rumex crispus
Salix alba
Salix euxina
Salix purpurea
Salix triandra
Salix viminalis
Sambucus nigra
Schedonorus giganteus
Scrophularia umbrosa
Scutellaria hastifolia
Silene baccifera
Silene latifolia
Sium latifolium
Solanum dulcamara
Stellaria media aggr.
Stellaria nemorum
Succisella inflexa
Symphytum officinale
Tanacetum vulgare
Thalictrum flavum
Typha angustifolia
Ulmus minor
Urtica dioica
Utricularia vulgaris
Veronica anagallis-aquatica

##Q +01 TilAce

Acer platanoides
Acer pseudoplatanus
Aconitum degenii
Aconitum lycoctonum

Aconitum napellus
Actaea spicata
Adenostyles alliariae
Adenostyles alpina
Adoxa moschatellina
Achillea macrophylla
Alliaria petiolata
Anemone ranunculoides
Arabis alpina
Arum cylindraceum
Arum maculatum
Aruncus dioicus
Asarum europaeum
Asperula taurina
Asplenium scolopendrium
Asplenium trichomanes
Asplenium viride
Athyrium filix-femina
Bromopsis benekenii
Campanula latifolia
Campanula rhomboidalis
Campanula trachelium
Cardamine enneaphyllos
Cardamine flexuosa
Cardamine glanduligera
Cardamine impatiens
Cardamine raphanifolia
Carduus personata
Corydalis cava
Corylus avellana
Crepis pyrenaica
Cyanus montanus
Cyclamen purpurascens
Cynoglossum germanicum
Cystopteris fragilis
Cystopteris montana
Daphne laureola
Dioscorea communis
Drymochloa sylvatica
Dryopteris affinis aggr.
Dryopteris filix-mas
Epilobium montanum
Euonymus latifolius
Euphorbia dulcis
Fraxinus excelsior

Galanthus nivalis
Galium odoratum
Galium sylvaticum
Gentiana lutea
Geranium robertianum
Geranium sylvaticum
Gymnocarpium robertianum
Helleborus foetidus
Hepatica nobilis
Heracleum sphondylium
Hieracium prenanthoides
Hordelymus europaeus
Chaerophyllum aureum
Chaerophyllum temulum
Impatiens noli-tangere
Knautia dipsacifolia
Laburnum alpinum
Lactuca alpina
Lactuca muralis
Lactuca plumieri
Lamium galeobdolon
Lamium maculatum
Laserpitium latifolium
Lathyrus laevigatus
Lilium martagon
Lonicera alpigena
Lonicera nigra
Lonicera xylosteum
Lunaria rediviva
Mercurialis perennis
Moehringia muscosa
Myosotis sylvatica
Petasites albus
Peucedanum ostruthium
Poa hybrida
Polygonatum multiflorum
Polygonatum verticillatum
Polypodium vulgare aggr.
Polystichum aculeatum
Polystichum braunii
Polystichum lonchitis
Polystichum setiferum
Pseudoturritis turrita
Ribes alpinum
Ribes petraeum

Rosa pendulina
Rumex arifolius
Salvia glutinosa
Sambucus racemosa
Saxifraga rotundifolia
Senecio nemorensis aggr.
Silene dioica
Stachys sylvatica
Staphylea pinnata
Stellaria nemorum
Taxus baccata
Thalictrum alpinum
Tilia cordata
Tilia platyphyllos
Ulmus glabra
Urtica dioica
Valeriana officinalis
Valeriana tripteris
Veronica urticifolia
Vicia sylvatica
Viola biflora

#TC Alninc-woody

Acer campestre
Alnus incana
Alnus glutinosa
Fraxinus excelsior
Fraxinus angustifolia
Prunus padus
Ulmus laevis

#TC Carbet-woody

Acer campestre
Carpinus betulus
Quercus robur
Quercus petraea aggr.
Tilia cordata

#TC Quepub-woody

Fraxinus ornus
Ostrya carpinifolia
Quercus cerris
Quercus frainetto
Quercus petraea aggr.
Quercus pubescens
Quercus robur

#TC Querop-woody

Betula pendula
Quercus petraea aggr.
Quercus robur
Sorbus aucuparia

#TC Salice-woody
Populus alba
Populus nigra
Salix alba
Salix eleagnos
Salix euxina
Salix purpurea
Salix triandra
Salix viminalis

#TC TilAce-woody
Acer platanoides
Acer pseudoplatanus
Fraxinus excelsior
Tilia cordata
Tilia platyphyllos
Ulmus glabra

#TC Alnglu-woody
Alnus glutinosa
Betula pubescens
Salix aurita
Salix cinerea
Salix pentandra

SECTION 2: End
SECTION 3: Group definitions

6 F01 Carbet
<#TC Carbet-woody GR25> AND <##Q +01 Carbet>

6 F02 TilAce
<#TC TilAce-woody GR25> AND <##Q +01 TilAce>

6 F03 Fagsyl
<Fagus sylvatica GR25> AND <##Q +01 Fagsyl>

6 F04 Querop
<#TC Querop-woody GR25> AND <##Q +01 Querop>

6 F05 Quepub
<#TC Quepub-woody GR25> AND <##Q +01 Quepub>

6 F06 Alninc
<#TC Alninc-woody GR25> AND <##Q +01 Alninc>

6 F07 Alnglu
<#TC Alnglu-woody GR25> AND <##Q +01 Alnglu>

6 F08 Salice
<#TC Salice-woody GR25> AND <##Q +01 Salice>

SECTION 3: End

SECTION 4: Similarity

SECTION 4: End

References

Tichý L. (2002) JUICE, software for vegetation classification. – *Journal of Vegetation Science* 13: 451–453.

Tichý L. & Chytrý M. (2006) Statistical determination of diagnostic species for site groups of unequal size. – *Journal of Vegetation Science* 17: 809–818.

Tichý L., Chytrý M. & Landucci F. (2019) GRIMP: A machine-learning method for improving groups of discriminating species in expert systems for vegetation classification. – *Journal of Vegetation Science* 30: 5–17.

Electronic Appendix 3. A list of aggregated species in the final dataset.

Species concepts and nomenclature follow the Euro+Med PlantBase (www.emplantbase.org; accessed August 2018).

Achillea millefolium aggr.: *Achillea collina*, *Achillea millefolium*, *Achillea pannonica*,
Achillea setacea
Bromopsis ramosa aggr.: *Bromopsis benekenii*, *Bromopsis ramosa*
Cardamine pratensis aggr.: *Cardamine dentata*, *Cardamine matthioli*, *Cardamine pratensis*,
Carex muricata aggr.: *Carex divulsa*, *Carex muricata*, *Carex spicata*
Dryopteris affinis aggr.: *Dryopteris affinis*, *Dryopteris affinis* × *borreri*, *Dryopteris borrieri*
Dryopteris carthusiana aggr.: *Dryopteris carthusiana*, *Dryopteris carthusiana* × *dilatata*,
Dryopteris dilatata
Galium palustre aggr.: *Galium elongatum*, *Galium palustre*
Galium pumilum aggr.: *Galium pumilum*, *Galium pusillum*, *Galium valdepilosum*
Luzula campestris aggr.: *Luzula campestris*, *Luzula divulgata*, *Luzula multiflora*, *Luzula*
pallescens, *Luzula sudetica*
Molinia caerulea aggr.: *Molinia arundinacea*, *Molinia caerulea*
Polypodium vulgare aggr.: *Polypodium interjectum*, *Polypodium vulgare*
Pulmonaria officinalis aggr.: *Pulmonaria obscura*, *Pulmonaria officinalis*
Pyrus communis aggr.: *Pyrus communis*, *Pyrus nivalis*
Quercus petraea aggr.: *Quercus dalechampii*, *Quercus petraea*
Rubus fruticosus aggr.: *Rubus hirtus*, *Rubus serpens*, *Rubus sulcatus*, *Rubus fruticosus* aggr.
sensu Ehrendorfer 1973
Senecio nemorensis aggr.: *Senecio hercynicus*, *Senecio nemorensis* subsp. *jacquinianus*,
Senecio ovatus
Sorbus aria aggr.: *Sorbus aria*, *Sorbus aria* × *torminalis*, *Sorbus bohemica*, *Sorbus graeca*,
Sorbus latifolia, *Sorbus mougeotii*, *Sorbus semiincisa*
Stellaria media aggr.: *Stellaria media*, *Stellaria neglecta*, *Stellaria pallida*
Veratrum album aggr.: *Veratrum album*, *Veratrum lobelianum*
Veronica hederifolia aggr.: *Veronica hederifolia*, *Veronica sublobata*
Viola odorata aggr.: *Viola odorata*, *Viola suavis*
Viola reichenbachiana aggr.: *Viola reichenbachiana*, *Viola reichenbachiana* × *riviniana*,
Viola riviniana

References

Ehrendorfer (1973) Liste der Gefäßpflanzen Mitteleuropas. – Fischer, Stuttgart.

Electronic Appendix 5: Expert system for classification of central European oak-hornbeam forests (*Carpinetalia*) to associations.

This expert system can be run in the Juice 7 program after being transformed into plain text (.txt) format. It is expected that the analysed data will use species names following the Euro+Med PlantBase with modifications listed in Electronic Appendix 3. Species groups are provided followed by formulas of all the accepted associations. In the formulas, the number of species of a sociological group required for its presence is given by a two-digit number after “#”. Sociological species groups are connected by logical operators AND, OR and NOT.

SECTION 1: Species aggregation

SECTION 1: End

SECTION 2: Species groups

Boreal

Equisetum pratense
Trientalis europaea
Lycopodium annotinum
Vaccinium vitis-idaea

Carinthia

Anemone trifolia
Galium laevigatum
Vicia oroboides

CE_sstr

Galium sylvaticum
Potentilla sterilis
Rosa arvensis
Phyteuma nigrum
Cyclamen purpurascens

CE_thermo

Aegonychon purpureocaeruleum
Anthericum ramosum
Carex michelii
Cornus mas
Dictamnus albus
Festuca heterophylla
Ligustrum vulgare
Melittis melissophyllum
Primula veris
Quercus cerris
Quercus pubescens
Sorbus torminalis
Tanacetum corymbosum
Trifolium alpestre
Vincetoxicum hirundinaria
Viola hirta

CE_thermo_bas

Aegonychon purpureocaeruleum

Carex michelii
Cornus mas
Dictamnus albus
Ligustrum vulgare
Primula veris
Quercus pubescens
Viola hirta

CE_thermo_neu
Anthericum ramosum
Festuca heterophylla
Melittis melissophyllum
Quercus cerris
Sorbus torminalis
Tanacetum corymbosum
Trifolium alpestre
Vincetoxicum hirundinaria

Cont_nem
Carex pilosa
Cruciata glabra
Euonymus verrucosus
Galium intermedium
Isopyrum thalictroides
Viola mirabilis

CWE_thermo
Acer opalus
Carex flacca
Dioscorea communis
Hippocrepis emerus
Helleborus foetidus
Ilex aquifolium
Primula acaulis
Rosa arvensis
Sorbus aria aggr.
Viburnum lantana

E_C_mesic
Anemone trifolia
Asparagus tenuifolius
Asperula taurina
Dioscorea communis
Doronicum orientale
Erythronium dens-canis
Galium aristatum
Geranium nodosum
Helleborus dumetorum
Helleborus odoratus
Lamium orvala
Luzula forsteri

Luzula nivea
Ostrya carpinifolia
Phyteuma betonicifolium
Polystichum setiferum
Pulmonaria australis
Pulmonaria stiriaca
Ruscus aculeatus
Ruscus hypoglossum
Tilia tomentosa
Veronica urticifolia
Vicia oroboides

Fagus_species
Abies alba
Fagus sylvatica
Aruncus dioicus
Veratrum album aggr.
Prenanthes purpurea

Galium_s_i
Galium sylvaticum
Galium intermedium

Illyr_EA_Boh
Knautia drymeia
Cyclamen purpurascens

Illyr_EA_Boh_vs_WC
Galium sylvaticum
Hepatica nobilis
Hippocrepis emerus
Knautia drymeia
Cyclamen purpurascens
Veratrum nigrum

Mecsek
Helleborus odorus
Doronicum orientale
Tilia tomentosa
Fraxinus ornus
Luzula forsteri
Ruscus hypoglossum

Oceanic
Ilex aquifolium
Luzula sylvatica
Lonicera periclymenum
Poa chaixii
Pulmonaria montana
Teucrium scorodonia

Pannonia_thermo
 Acer tataricum
 Polygonatum hirtum
 Physalis alkekengi
 Viola mirabilis

Pannonia_thermo_Qcerr
 Quercus cerris

Pannonian_wet
 Fraxinus angustifolia
 Acer tataricum
 Aristolochia clematitidis
 Carex strigosa
 Oenanthe banatica

Styria
 Cardamine waldsteinii
 Crocus vernus
 Erythronium dens-canis
 Gentiana asclepiadea
 Pseudostellaria europaea
 Pulmonaria stiriaca

Styria_sstr
 Cardamine waldsteinii
 Crocus vernus
 Erythronium dens-canis
 Pseudostellaria europaea
 Pulmonaria stiriaca

Subboreal
 Dryopteris carthusiana aggr.
 Frangula alnus
 Luzula pilosa
 Maianthemum bifolium
 Oxalis acetosella
 Populus tremula
 Pteridium aquilinum
 Rubus saxatilis
 Sorbus aucuparia
 Vaccinium myrtillus

Ticino
 Castanea sativa
 Geranium nodosum
 Veronica urticifolia
 Phyteuma betonicifolium
 Ostrya carpinifolia
 Luzula nivea
 Asplenium adiantum-nigrum

Thermo_acido
Calamagrostis arundinacea
Carex montana
Convallaria majalis
Festuca ovina
Genista tinctoria
Hylotelephium maximum
Hieracium lachenalii
Hieracium murorum
Hieracium sabaudum
Hypericum montanum
Lembotropis nigricans
Luzula luzuloides
Melampyrum pratense
Veronica officinalis
Avenella flexuosa
Luzula campestris aggr.
Solidago virgaurea
Silene nutans
Vaccinium myrtillus

WCarp_only
Aremonia agrimonioides
Cardamine glanduligera
Carex brevicollis
Hacquetia epipactis
Waldsteinia geoides
Aconitum moldavicum
Symphytum cordatum

WCarp_typical
Aposeris foetida
Arum cylindraceum
Carex alba
Drymochloa drymeja
Euphorbia amygdaloides
Pulmonaria mollis
Salvia glutinosa
Stachys alpina
Staphylea pinnata
Symphytum tuberosum

Wet_coll
Aegopodium podagraria
Anthriscus sylvestris
Carex remota
Carex sylvatica
Circaea lutetiana
Ficaria verna
Lamium maculatum

Prunus padus
Stachys sylvatica
Stellaria nemorum
Urtica dioica
Viburnum opulus

Wet_low

Adoxa moschatellina
Alliaria petiolata
Galium aparine
Geranium robertianum
Geum urbanum
Glechoma hederacea
Chaerophyllum temulum
Sambucus nigra
Urtica dioica
Veronica hederifolia aggr.

#TC Carbet-woody

Acer campestre
Carpinus betulus
Quercus robur
Quercus petraea aggr.
Tilia cordata

SECTION 2: End

SECTION 3: Group definitions

5 01ShC Stellario-Carpinetum

(<#TC Carbet-woody GR25> AND (<#03 Wet_coll> OR <#03
Wet_low>)) NOT (((((((((((<#01 Boreal> OR <#02 Cont_nem>) OR
<#01 CE_sstr>) OR <#01 E_C_mesic>) OR <#02 Oceanic>) OR <#03
CWE_thermo>) OR <#01 WCarp_only>) OR <#04 CE_thermo>) OR <#02
Pannonia_thermo>) OR <#01 Pannonian_wet>) OR <#01
Styria_sstr>) OR <#01 Pannonia_thermo_Qcerr>) OR <#01
WCarp_typical>)

5 02CoC Convallario-Carpinetum

(<#TC Carbet-woody GR25> AND (<#02 Pannonian_wet> OR (<#01
Pannonian_wet> AND <#03 Wet_low>))) NOT (((((((((((<#01 Boreal>
OR <#02 Cont_nem>) OR <#01 CE_sstr>) OR <#01 E_C_mesic>) OR
<#02 Oceanic>) OR <#03 CWE_thermo>) OR <#01 WCarp_only>) OR
<#04 CE_thermo>) OR <#02 Pannonia_thermo>)

5 03PeC Pseudostellario-Carpinetum

(<#TC Carbet-woody GR25> AND (<#02 Styria> OR (<#01
Styria_sstr> AND (<#01 WCarp_typical> OR <#01
Illyr_EA_Boh>)))) NOT (<#01 WCarp_only> OR <#01
Pannonian_wet>)

5 04PcC Poo-Carpinetum
(<#TC Carbet-woody GR25> AND <#02 Oceanic>) NOT ((<#03
CWE_thermo> OR <#04 CE_thermo>) OR <#01 E_C_mesic>)

5 05GsC Galio-Carpinetum
(<#TC Carbet-woody GR25> AND <#01 CE_sstr>) NOT (<#03
Subboreal> OR (((((((<#04 CE_thermo> OR <#01 Ticino>) OR
<#01 E_C_mesic>) OR <#02 WCarp_typical >) OR <#02 Cont_nem>)
OR <#02 Oceanic>) OR <#03 CWE_thermo>) OR <#02 Galium_s_i>)
OR <#01 Pannonian_wet>) OR <#01 WCarp_only>)

5 06TcC Tilio-Carpinetum
(<#TC Carbet-woody GR25> AND ((<#01 Cont_nem> AND <#03
Subboreal>) OR <#01 Boreal>)) NOT (((<#01 WCarp_typical> OR
<#01 WCarp_only>) OR <#01 Fagus_species>) OR <#01 CE_sstr>) OR
<#01 Oceanic>)

5 07CpC Carici-Carpinetum
(<#TC Carbet-woody GR25> AND ((<#02 Cont_nem> AND <#01
WCarp_typical>) OR <#01 WCarp_only>)) NOT (((((((<#01
E_C_mesic> OR <#04 CE_thermo>) OR <#01 CE_sstr>) OR <#02
Pannonia_thermo>) OR <
#01 Boreal>) OR <#01 Pannonian_wet>) OR <#01
Illyr_EA_Boh_vs_WC>)

5 08EaC Epimedio-Carpinetum
<#TC Carbet-woody GR25> AND (<#02 Carinthia> OR (<#01
Carinthia> AND (<#01 WCarp_typical> OR <#01 Illyr_EA_Boh>)))

5 09CgQ Cruciato-Quercetum
<#TC Carbet-woody GR25> AND <#02 Ticino>

5 10LpC Lithospermo-Carpinetum
(<#TC Carbet-woody GR25> AND <#03 CWE_thermo>) NOT (((<#02
Cont_nem> OR <#01 Mecsek>) OR <#01 Ticino>) OR <#01
Illyr_EA_Boh>)

5 11PvC Primulo-Carpinetum
(<#TC Carbet-woody GR25> AND (<#04 CE_thermo> OR (<#03
CE_thermo_bas> OR (<#02 Pannonia_thermo> AND <#04
Thermo_acido>)))) NOT (<#01 E_C_mesic> OR (<#03 CWE_thermo> OR
(<#02 Pannonia_thermo> NOT <#04 Thermo_acido>)))

5 12PlC Polygonato-Carpinetum
(<#TC Carbet-woody GR25> AND <#02 Pannonia_thermo>) NOT (<#01
E_C_mesic> OR (<#04 Thermo_acido> AND <#02 Pannonia_thermo>))

5 13HoC Helleboro-Carpinetum
<#TC Carbet-woody GR25> AND <#02 Mecsek>

SECTION 3: End

SECTION 4: Similarity
SECTION 4: End